96-326a

Puyallup River Total Maximum Daily Load for Biochemical Oxygen Demand, Ammonia, and Residual Chlorine

A study was initiated to develop waste load allocations (WLAs) for point sources of biochemical oxygen demand (BOD), ammonia, and chlorine in the Puyallup River basin. Wastewater dischargers permitted through the National Pollutant Discharge Elimination System (NPDES) include ten municipalities, four industries, and four fish hatcheries. Background and nonpoint source loads were also assessed. In addition to considering existing discharges and nonpoint loads, the potential impact of future dischargers was examined. This study approach is consistent with Ecology's Total Maximum Daily Load (TMDL) process, which was recently approved by the Environmental Protection Agency to fulfill the requirements of Section 303(d) of the federal Clean Water Act.

Dissolved oxygen standards in the lower Puyallup River would not be met if significant additional BOD sources were introduced, unless currently permitted BOD loads (nitrogenous BOD from ammonia and/or carbonaceous BOD) are reduced. Reductions in ammonia loading were found to have greater potential to improve dissolved oxygen than reductions of carbonaceous BOD. Ammonia loads from existing permittees are likely to exceed mixing zone limits for most municipal discharges. Implementing mixing zone regulations (Chapter 173-201A WAC) is expected to protect the water quality criteria in all segments of the Puyallup River basin. Modeling of ammonia and chlorine shows that assigning WLAs based on allowable dilution flows in mixing zones would meet water quality criteria for protection of aquatic life for existing and currently proposed discharges.

TMDLs are recommended that establish WLAs based on mixing zone limitations for existing dischargers with an allocation for future growth or water quality protection. The critical condition for the TMDL is the 7-day-10-year low river flow. The proposed TMDLs are 19,500 lbs/day of 5-day BOD, 3,330 lbs/day of ammonia as N, and 45.9 lbs/day of total residual chlorine. With existing technology-based limits for 5-day BOD and proposed mixing zone limits for ammonia and chlorine, a reserve for protection of water quality or additional loading from future growth is included in the proposed TMDLs.

Water Body No. WA-10-1010
July 1993

acute means a stimulus severe enough to rapidly induce an effect on aquatic organisms.

biochemical oxygen demand (BOD) is the amount of oxygen required to stabilize biologically oxidizable materials in water.

carbonaceous biochemical oxygen demand (CBOD) is the BOD exerted by oxidation of organic carbon.

chronic means a stimulus that lingers or continues for a relatively long period of time.

5-day biochemical oxygen demand (BOD5) is the BOD exerted in a 5-day BOD test.

7-day-10-year low flow (7Q10) is the lowest 7-day-average river flow that has a 10 percent chance of occurring in any given year.

dilution factor (DF) is the reciprocal of the volumetric fraction of effluent in a waterbody.

dissolved inorganic nitrogen (DIN) is the sum of ammonia, nitrate, and nitrite expressed as nitrogen. DIN is the form of nitrogen that is immediately available for plant nutrition.

design flow is the flow used for steady-state waste load allocation modeling.

Ecology is the Washington State Department of Ecology.

EPA is the U.S. Environmental Protection Agency.

load allocations (LA) are the portion of a receiving water's total maximum daily load attributed to existing or future nonpoint sources of pollution or natural background sources.

loading capacity is the maximum pollutant load that a waterbody can receive and still meet water quality standards.

mixing zone is an area where an effluent discharge undergoes initial dilution. A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented.

nitrification is the biological oxidation of ammonia by bacteria.

nitrogenous biochemical oxygen demand (NBOD) is the BOD exerted by oxidation of organic and inorganic nitrogen, including ammonia.

nonpoint sources are diffuse sources of pollutants from watershed processes.

NPDES is the National Pollutant Discharge Elimination System.

point sources are discrete sources of pollutants such as from municipal or industrial wastewater treatment plants.

soluble reactive phosphorus (SRP) is the dissolved form of phosphorus that is immediately available for plant nutrition.

QUAL2E is a steady-state model of water quality developed by the EPA.

steady-state model is a fate and transport model that uses constant values of input variables to predict constant values of receiving water concentrations.

technology-based limits are effluent quality limits based on minimum required levels of wastewater treatment for individual categories of discharges. These minimum treatment levels are based on national standards for available and affordable treatment processes.

total maximum daily load (TMDL) is the sum of the individual waste load allocations and load allocations. The TMDL is also the loading capacity of the receiving water.

un-ionized ammonia is the portion of ammonia present in water that is not the ammonium ion. Un-ionized ammonia is the most toxic form of ammonia for aquatic life. The total ammonia present in water consists of the amount present as un-ionized and ammonium ion.

WAC 173-201A is Chapter 173-201A of Washington Administrative Code, which contains the water quality standards for the state of Washington.

waste load allocation (WLA) is the portion of a receiving water's total maximum daily load that is allocated to one of its existing or future point sources of pollution.

water quality-based limits are effluent quality limits based on maintaining water quality standards in the receiving water.

water quality criteria are comprised of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations to protect human health and aquatic life. Narrative criteria statements describe a water quality goal.

water quality standard (WQS) is a law or regulation that consists of the beneficial designated uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the uses of that particular waterbody, and an anti-degradation statement.

WTP is a wastewater treatment plant.

Background

A process for meeting Washington's water quality standards is provided under Section 303 of the Clean Water Act. Section 303(d) requires the states and EPA to establish total maximum daily loads (TMDLs) for all water quality limited segments (*i.e.*, those waters which cannot meet water quality standards after application of technology-based source controls). The TMDL for a given pollutant is then apportioned between point sources (waste load allocations--WLAs) and nonpoint/background sources (load allocations-- LAs). The allocations (WLAs and LAs) are implemented through NPDES permits, grant projects, and nonpoint source controls.

This study was initiated because the combined effects of all permitted discharges in the Puyallup River basin were unknown. Future development in the basin will result in requests for increased pollutant loading from municipal and industrial sources. New municipal and industrial dischargers are also likely. Given the large number of existing permits, a basin-wide evaluation of waste loads and water quality-based limits was considered necessary. The major water quality concerns include the potential for low dissolved oxygen from the discharge of oxygen demanding pollutants, and toxicity from the discharge of ammonia, chlorine, and unidentified toxic chemicals. This report is a summary of a study (Ecology, 1993) examining the effects of 18 NPDES permits for point source discharges directly to rivers and creeks in the Puyallup basin (Figure 1, Table 1). The permitted dischargers include ten municipalities, four industries, and four fish hatcheries. The Puyallup Tribe and Muckleshoot Tribe operate two additional fish hatcheries.

The Puyallup River drainage basin occupies approximately 970 square miles in the Puget Lowland of Washington State (Figure 1). The major streams of the basin are the Puyallup River and its two largest tributaries, the White and Carbon Rivers. The lower reach of the Puyallup River is a relatively flat floodplain ranging in elevation from sea level at Commencement Bay to approximately 50 feet above sea level at the confluence of the White and Puyallup Rivers. The lower Puyallup River is a salt-wedge estuary, with deeper marine water overlain by a layer of fresh water. The salt wedge generally extends less than 2.5 miles upstream from the river mouth (Ebbert *et al.*, 1987).

Project Goals and Objectives

The major goal of the Puyallup River study is to develop WLAs for point sources of BOD, ammonia, and total residual chlorine. These pollutants were selected to address the potential for dissolved oxygen depletion from carbonaceous and nitrogenous BOD (CBOD and NBOD) and potential toxic impacts from specific chemicals known to be present in potentially toxic amounts (un-ionized ammonia and total residual chlorine).

Pollutant loading from background and nonpoint sources (LAs) was also estimated. In addition to considering existing discharges and nonpoint loads, WLAs and LAs were also examined for potential future discharges. This study approach is consistent with Ecology's TMDL/WLA/LA process (Ecology, 1991), which was recently approved by EPA to fulfill the requirements of Section 303(d) of the federal Clean Water Act.

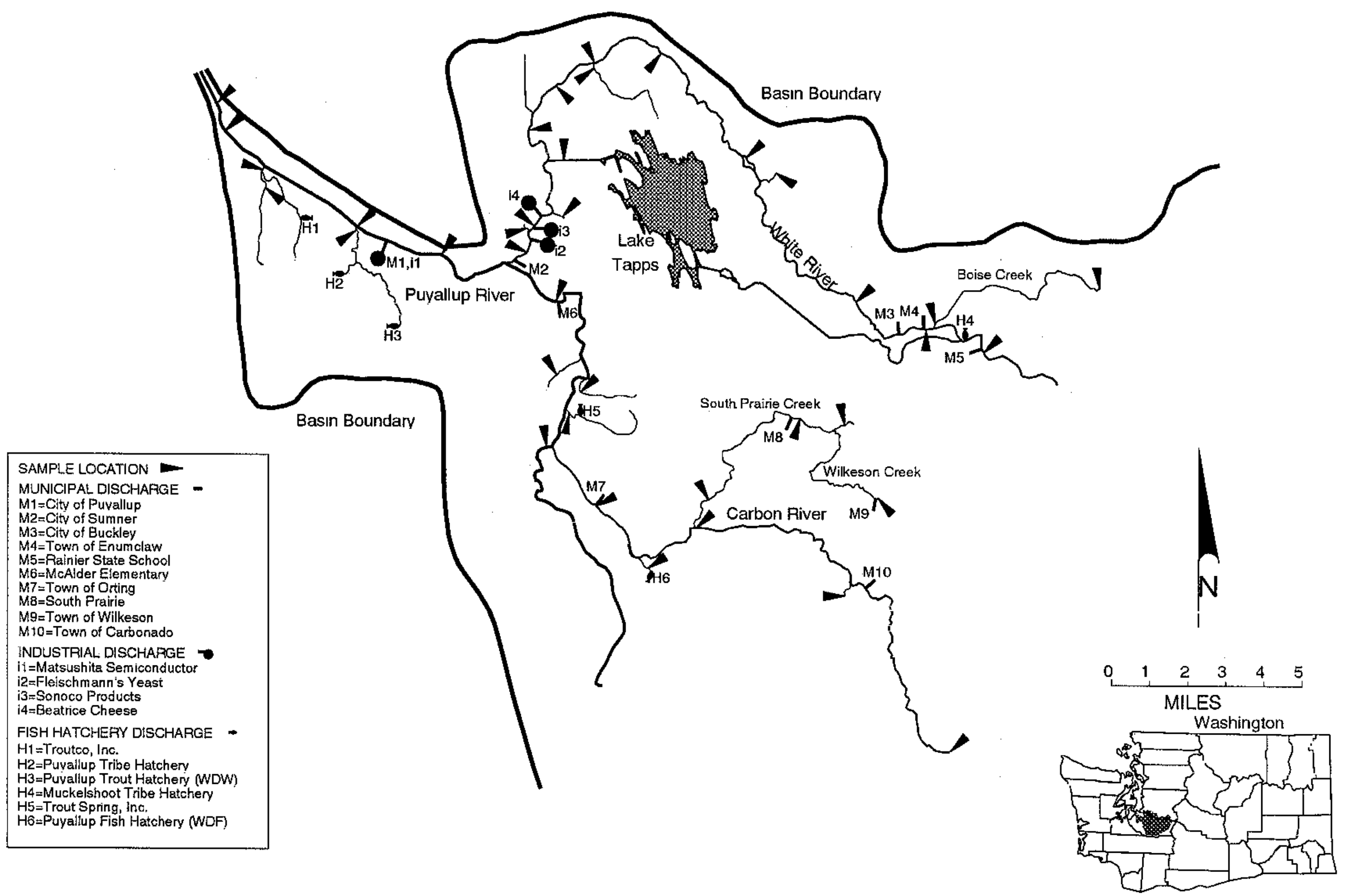

Figure 1. Study area map showing locations of NPDES discharges.

Table 1. Summary of Puyallup River basin NPDES permits for flow, 5-day BOD, ammonia-N, and chlorine.

Permittee	Permit Expiration Date	Receiving Waters (1)	FLOW Monthly Avg (mgd)	FLOW Daily Max (mgd)	BOD Monthly Avg Conc. (mg/L)	BOD Monthly Avg Load (#/d)	BOD Weekly Max Conc. (mg/L)	BOD Weekly Max Load (#/d)	AMMONIA-N Monthly Avg Conc. (mg/L)	AMMONIA-N Monthly Avg Load (#/d)	AMMONIA-N Daily Max Conc. (mg/L)	AMMONIA-N Daily Max Load (#/d)	CHLORINE Monthly Avg (mg/L)	CHLORINE Daily Max (mg/L)
MUNICIPAL														
Puyallup, City of (WTP)	7/94	Puy	10.720	--	30	1390	45	2085	--	--	--	--	--	--
Sumner, City of (WTP)	9/97	Puy/Whi	3.420	--	30	855	45	1284	6.1	--	13.7	--	0.022	0.058
Buckley, City of (WTP)	8/85	Puy/Whi	(5) 1.000	--	30	250	45	375	--	--	--	--	--	--
Enumclaw, Town of (WTP)	7/95	Puy/Whi	(5) 2.400	--	30	336	45	504	--	--	--	--	--	--
Rainier State School (WTP)	2/85	Puy/Whi	0.420	--	30	105	45	158	--	--	--	--	--	--
McAlder Elementary (WTP)	8/95	Puy	0.009425	--	30	2.4	45	3.6	--	--	--	--	--	--
Orting, Town of (WTP)	1/94	Puy/Car	0.750	--	30	90	45	135	--	--	--	--	(6)	(6)
South Prairie, Town of (WTP)	2/97	Puy/Car/SPr	(5) 0.0382	--	20	6.3	30	9.5	--	--	--	--	--	--
Wilkeson, Town of (WTP)	4/85	Puy/Car/SPr/Wilk	0.070	--	30	18	45	26	--	--	--	--	--	--
Carbonado, Town of (WTP)	2/85	Puy/Car	0.100	--	30	25	45	38	--	--	--	--	--	--
INDUSTRIAL (2)														
Matsushita Semiconductor Corp.	6/96	Puy	0.7	1.0	15	88	30	175	20	117	32	187	--	--
Fleischmann's Yeast Co.	5/82	Puy/Whi	--	1.092	--	--	--	--	--	--	--	--	(7)	(7)
Sonoco	10/95	Puy/Whi	(5) 0.313	0.563	--	348	--	673	--	--	--	--	--	--
Beatrice Cheese Co.	4/94	Puy/Whi	0.350	0.500	30	17	--	35	23	--	32	--	--	--
FISH HATCHERY (3)														
Troutco, Inc.	(4)	Puy/Clear	6.552	--	--	--	--	--	--	--	--	--	--	--
Puyallup Tribe Hatchery	NA	Puy/Clarks/Diru	--	--	--	--	--	--	--	--	--	--	--	--
Puyallup Trout Hatchery (WDW)	(4)	Puy/Clarks	7.800	--	--	--	--	--	--	--	--	--	--	--
Muckleshoot Tribe Hatchery	NA	Puy/Whi	--	--	--	--	--	--	--	--	--	--	--	--
Trout Springs, Inc.	(4)	Puy/Canyon Falls	9.720	--	--	--	--	--	--	--	--	--	--	--
Puyallup Fish Hatchery (WDF)	(4)	Puy/Car/Voight	16.200	--	--	--	--	--	--	--	--	--	--	--

1) Puy=Puyallup R; Whi=White R; Car=Carbon R; SPr=South Prairie Creek; Wilk=Wilkeson Creek

2) Treated process except Fleischmann's, which is non-contact cooling water. Excludes storm water and discharges to municipal facilities. Matsushita mass limits based on maximum flow of 0.7 mgd for BOD and ammonia. Beatrice ammonia limits are for November 1 - April 30; ammonia-N limits from May 1 - October 31 are 17 and 24 mg/L for monthly average and daily maximum.

3) Includes unpermitted Puyallup and Muckleshoot Tribe hatcheries. Maximum fish on hand is reported in permit applications as follows: Troutco 100,000 lbs rainbow trout; WDW 59,600 lbs rainbow, steelhead, kokanee; Trout Springs 175,000 lbs rainbow; WDF 80,000 lbs coho, chinook.

4) General permit expires 1/95.

5) For municipal WTPs, these values are design criteria and are not included as effluent limits. For Sonoco, 0.313 mgd and 0.563 mgd are the highest monthly average and daily maximum flows reported in the permit fact sheet for 1987-88 and are not effluent limits.

6) No detectable residual in final effluent. Test method not specified in permit.

7) Permit allows discharge to increase concentration in White (Stuck) River to less than 0.002 mg/L after complete mix.

Ammonia toxicity is caused by the un-ionized fraction present in water, which is a function of temperature and pH. The amount of total ammonia that contains an un-ionized portion that meets the criteria may also be determined for a given temperature and pH (EPA, 1986; EPA, 1988). For simplicity of comparison with effluent data and integration with dissolved oxygen models, all ammonia criteria, TMDLs, WLAs and LAs are expressed in this report as total ammonia as N.

The boundary for the present study extends to convenient sampling locations above the most remote permitted loads in the basin (Figure 1). The upstream boundaries of rivers in the study area are Puyallup River mile 18.4, White River mile 25.4, Carbon River mile 17.8, and South Prairie Creek mile 7.2.

Historical Data and Critical Conditions

When a steady-state water quality model is used to determine the TMDL and WLAs, pollutant loading is introduced into the model under a given set of assumed water quality design conditions (e.g., flow, temperature, pH). The TMDL is the sum of the individual WLAs for point sources and LAs for nonpoint sources and natural background (EPA, 1991a). The TMDL must not exceed the loading capacity that meets water quality criteria at the design condition (EPA, 1988).

Data sources used for the TMDL include routine monitoring data collected by Ecology and USGS (monthly and quarterly water quality and daily flows). Routine monitoring data was supplemented by additional data collected during September and October, 1990. Intensive studies provided greater coverage throughout all critical areas of the basin and provided information for some areas that either had never been sampled or had not been sampled within the past several years.

Lowest flows in the Puyallup River usually occur during August through October. Temperatures are generally highest and dissolved oxygen lowest during summer months. Seasonal dissolved oxygen concentration trends are caused mainly by temperature changes that affect equilibrium saturation. Since water quality is more sensitive to oxygen demanding pollutants at higher temperature, the combination of high temperature, low dissolved oxygen, and low flow are critical conditions for dissolved oxygen impacts. Summer pH also tends to be elevated probably because of photosynthesis by aquatic plants and algae. Ammonia criteria are most limiting during summer periods of high temperature and pH.

White River pH exceeded Class A standards during intensive surveys in September and October 1990. Periphyton productivity is the most likely explanation of high pH in the White River. Concentrations of dissolved inorganic N (DIN) and soluble reactive P (SRP) both exceeded limiting concentrations immediately below WTP inputs at Enumclaw and Buckley. Nitrogen limitation probably begins at some point within the reach as DIN levels are reduced from periphyton uptake, whereas SRP is in excess throughout the reach. Although periphyton productivity appears to be high, periphyton biomass was well below nuisance levels, probably because of scouring by relatively rapid flow. Reductions in DIN loading from municipal WTPs (Enumclaw, Buckley, and Rainier School) would probably be more effective at reducing productivity than controls on phosphorus.

The design flow for the TMDL is the 7-day-10-year low river flow (7Q10). The major water quality design parameters for WLA modeling of dissolved oxygen and ammonia are temperature, ammonia criteria, and dissolved oxygen criteria. Ammonia criteria depend on temperature and pH. A summary of these design conditions is presented in Table 2.

TMDL/WLA/LA Development

The general approach used to develop TMDLs, LAs, and WLAs is outlined as follows:

- A water quality model for dissolved oxygen and ammonia was calibrated and confirmed based on data collected during September and October, 1990 (Figure 2). The QUAL2E model (EPA, 1987) was used to model water quality in the Puyallup, White, and Carbon Rivers, and South Prairie Creek.
- Existing and currently proposed permits were summarized;
- Load allocations for background and nonpoint sources were estimated;
- The QUAL2E model was used to evaluate cumulative water quality impacts of existing and currently proposed permits at 7Q10 river flow without regard for water quality-based limits;
- Waste load allocations (WLAs) based on allowable dilution flows in mixing zones for water quality-based limits were estimated for ammonia and chlorine; and
- The QUAL2E model was used to evaluate cumulative water quality impacts of mixing zone WLAs at 7Q10 river flow and explore further loading reductions and provisions for future loading increases.

If the cumulative impact of mixing zone WLAs results in meeting water quality criteria, then no further limits on dischargers would be required. Therefore, since each discharger is required to comply with mixing zone regulations, evaluation of individual mixing zone WLAs was the first step in a strategy for developing water quality-based limits.

QUAL2E Model of NPDES Alternatives

Four alternatives of existing and proposed NPDES-permitted pollutant loads were examined. Alternative 1 represents the base condition of existing permittees discharging at WTP design flows and loads at 7Q10. Alternative 2 increases municipal and industrial NPDES loads by 50 percent over Alternative 1 to evaluate effects of growth without consideration of water quality. Alternative 3 is the same as Alternative 1 except WLAs based on allowable dilution flows in mixing zones were used for NPDES ammonia and chlorine loads unless technology-based limits were more restrictive. Alternative 4 is the same as Alternative 3 except all municipal and industrial design flows of WTPs were increased by 50 percent and mixing zone WLAs were recalculated accordingly.

Table 2. Summary of model design conditions for temperature, ammonia, and dissolved oxygen criteria.

	Design Temperature (degrees C)	Acute Total Ammonia Criterion (mg N/L)	Chronic Total Ammonia Criterion (mg N/L)	Dissolved Oxygen Criteria (3) (mg/L)
Puyallup River (1)				
RM 0.0 - 1.0	15	8.0 (4.2)	1.5 (0.63)	6.5(5.0)
RM 1.0 - 2.2	15	8.0 (4.2)	1.5 (0.63)	8.0(6.0)
RM 2.2 - 18.4	15	6.8	1.3	8.0
White River (1)				
RM 0.0 - 3.6	18	4.5	0.87	8.0
RM 3.6 - 24.3	18	0.84	0.16	8.0
RM 24.3 - 25.4	13	0.84	0.16	8.0
Carbon River (1)				
RM 0.0 - 2.0	15	6.8	1.3	8.0
RM 2.0 - 17.7	15	5.9	1.1	8.0
Miscellaneous Modeled Tributaries (2)				
Boise Creek	14	0.84	0.16	8.0
Canyon Falls Creek	14	4.6	0.89	8.0
Clarks Creek	11	6.8	1.3	8.0
Clear Creek	11	6.8	1.3	8.0
Diru Creek	11	6.8	1.3	8.0
South Prairie Creek	15	4.6	0.89	8.0
Swan Creek	14	6.8	1.3	8.0
Voights Creek	15	5.9	1.1	8.0
Wilkeson Creek	14	3.7	0.72	8.0

1) Critical ambient annual 5 percentile or September-October 1990 observation, whichever is more limiting. For any given segment, if criteria based on downstream stations were more restrictive, then downstream criteria were continued upstream until a more restrictive condition was encountered for ammonia criteria.
Ammonia and dissolved oxygen criteria were based on WAC 173-201A.

2) For any given tributary the ammonia criteria were assumed to be based on stations in that tributary or downstream receiving water criteria, whichever was more restrictive. Design temperatures were based on September-October 1990 data.
Ammonia and dissolved oxygen criteria were based on WAC 173-201A.

3) Values in parentheses are marine dissolved oxygen criteria. Marine ammonia criteria are fifth percentiles of surface samples from CMB003, 1980-91.

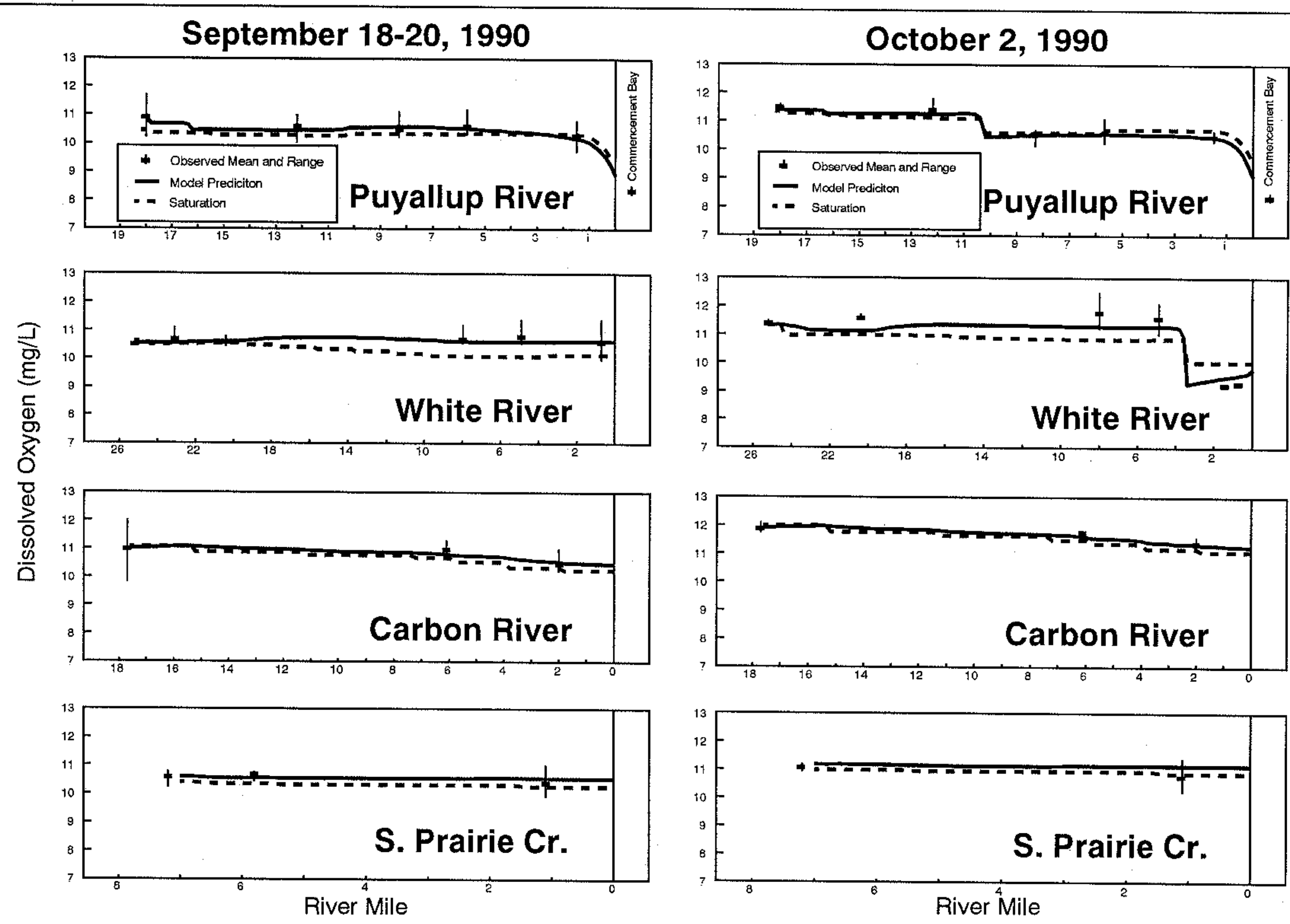

Figure 2. Calibration and confirmation of the QUAL2E dissolved oxygen model.

Results of QUAL2E runs for the four alternatives showed the following specific areas of concern for dissolved oxygen, ammonia, and chlorine:

- Dissolved oxygen in the lower Puyallup is predicted to violate the water quality standard above Puyallup RM 1.0 for Alternatives 1 (freshwater standard) and 2 (freshwater and marine standards). Puyallup RM 1.0 to 2.2 was the critical segment within the basin for compliance with dissolved oxygen standards.

- Ammonia in the Puyallup River is expected to exceed chronic toxicity criteria under Alternative 2.

- Ammonia in the White River is expected to exceed chronic toxicity criteria under Alternatives 1 and 2.

- The Carbon River and South Prairie Creek appear to meet dissolved oxygen and ammonia criteria under all evaluated alternatives. However, ammonia concentrations in the lower Carbon river are predicted to approach chronic criteria under Alternative 2.

- Cumulative concentrations of chlorine are predicted to be well below the chronic criterion in all modeled segments if mixing zone WLAs are applied to all dischargers (Alternatives 3 and 4).

In summary, the existing permits may not provide adequate protection to assure that standards for dissolved oxygen and ammonia are met at critical points in the White and Puyallup Rivers. The following section presents a strategy for establishing WLAs.

Waste Load Allocations Based on Mixing Zone Regulations

Water quality standards need to be met at the boundaries of mixing zones for point sources. The maximum amount of pollutant loading that meets water quality standards at mixing zone boundaries varies from one discharger to another. Therefore, WLAs to meet mixing zone requirements may differ between dischargers depending on the amount of available dilution and background sources.

Dilution factors (DF) based on allowable dilution flows (173-201A WAC) were calculated from discharger design flows (Q_{NPDES} based on maximum monthly average design flows) and river flow (7Q10). The dilution factors, using percentages of river flows allowed in WAC 173-201A, were calculated as follows:

$$\text{Chronic DF} = (Q_{NPDES} + (.25 * 7Q10)) / (Q_{NPDES})$$

$$\text{Acute DF} = (Q_{NPDES} + (.025 * 7Q10)) / (Q_{NPDES})$$

WLAs for individual dischargers were calculated based on the dilution factors using a simple mass balance equation. Each mixing zone WLA (acute and chronic) was calculated from water quality standards (acute and chronic WQS), background ambient concentrations (CA), and dilution factors (acute and chronic DF) as follows:

$$\text{Mixing Zone WLA} = (WQS * DF) - (CA * (DF - 1))$$

The WLAs to meet acute and chronic criteria were compared for each discharger to determine which would be more limiting by calculating the long-term average effluent concentrations which would be required (EPA, 1991b). In general the acute criteria result in more restrictive limits than chronic criteria.

Cumulative Effect of Mixing Zone WLAs

Dissolved oxygen in the lower Puyallup River was predicted to be more sensitive to changes in NBOD loading than CBOD. If the proposed mixing zone WLAs for ammonia are adopted for all existing discharges there will be a surplus amount of dissolved oxygen throughout the river system compared with state standards, including at Puyallup RM 1.0. The surplus dissolved oxygen could be reserved for water quality protection or allocated to additional future NBOD and CBOD discharges as long as water quality standards are met.

The proposed WLAs for total residual chlorine generally maintain river concentrations below 50 percent of the water quality criterion for chronic toxicity in all modeled segments. Therefore, the existing discharges would use less than 50 percent of the loading capacity if mixing zone WLAs are implemented. The remainder of the loading capacity could be reserved for future growth or water quality protection.

Recommended Waste Load Allocations

Table 3 and Figure 3 summarize the recommended TMDLs and WLAs for 5-day BOD (BOD5), ammonia, and total residual chlorine. The critical condition for the TMDL is the 7-day-10-year low river flow. The proposed TMDLs are 19,500 lbs/day of BOD5, 3,330 lbs/day of ammonia as N, and 45.9 lbs/day of total residual chlorine. The TMDLs are the total of all WLAs and LAs for the critical condition in the river.

WLAs and LAs are proposed to meet the TMDLs and protect water quality standards. WLAs for BOD5 are based on existing WTP design loads. WLAs for ammonia and chlorine are based on mixing zone regulations for available river flow or reasonable potential for maximum loading from existing effluents, depending on whichever was more restrictive. LAs for nonpoint and background sources are based on reasonable potential for maximum loading at design conditions. Municipal dischargers account for most of the TMDL for ammonia (Figure 3). WLAs for NPDES dischargers of BOD and chlorine are relatively small percentages of the TMDLs.

Table 3. Summary of recommended TMDLs, WLAs, and LAs.

TMDLs, WLAs and LAs in lbs/day			
	BOD5	Ammonia-N	Chlorine
MUNICIPAL WLAs			
Buckley	375	21	0.49
Carbonado	38	21	0.29
Enumclaw	504	30	0.70
McAlder School	3.6	2.0	0.86
Orting	939	282	0.79
Puyallup	2085	1271	3.6
Rainier School	158	33	0.81
South Prairie	9.5	8.0	0.080
Sumner	1284	389	1.7
Wilkeson	26	6.6	0.034
INDUSTRIAL WLAs			
Beatrice	35	134	1.2
Fleischmann's	45	3.7	1.3
Matsushita	175	83	0.23
Sonoco	673	1.1	1.2
HATCHERY, NONPOINT, BACKGROUND, AND RESERVE WLA/LA			
Fish Hatchery WLA	994	76	0.0
Nonpoint/Background LA	10,100	241	0.0
WLA for Growth/Reserve	2,100	730	32.6
TMDLs	19,500	3,330	45.9

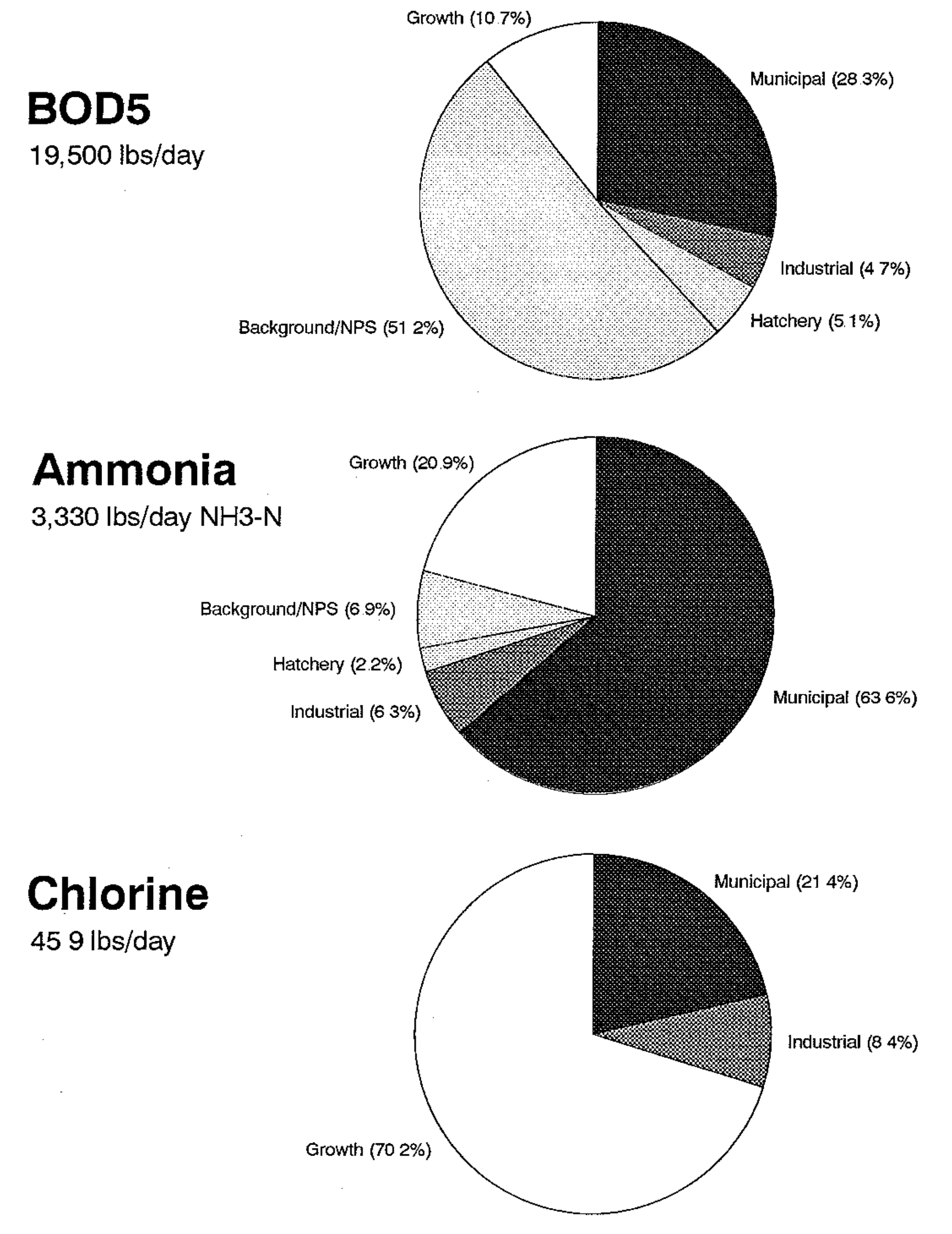

Figure 3. Puyallup River TMDLs for BOD5, ammonia, and total residual chlorine.

Effluent concentrations corresponding to ammonia WLAs proposed for municipal discharges range between 1.5 and 25 mg/L as N at WTP design flows. Three minor municipal WTP discharges -- Carbonado, McAlder Elementary School, and South Prairie -- are not expected to require more advanced treatment processes than are currently designed. Ammonia limits for these three facilities should be based on the performance of the existing treatment processes (*i.e.*, technology-based).

Ammonia limits for the other seven municipal WTPs are likely to require some degree of nitrification in the treatment process. The most restrictive ammonia limits are proposed for Enumclaw, Buckley, and Rainier School WTPs (ammonia limits of 1.5, 2.5, and 9.5 mg/L as N at WTP design flows). Ammonia WLAs proposed for the Orting, Puyallup, Sumner, and Wilkeson WTPs are between 10 and 25 mg/L as N, which may require operational changes or improvements to provide for nitrification at design flows. All of the ammonia WLAs recommended are within the range of technological feasibility for biological treatment processes (Metcalf and Eddy, 1991). Engineering analyses will be necessary to determine the feasibility of meeting effluent limits based on the proposed WLAs for individual dischargers.

Existing ammonia limits for the Sumner and Beatrice discharges meet the proposed WLAs. The Matsushita discharge uses the same outfall as the Puyallup WTP. Therefore, the Matsushita and Puyallup WTP ammonia WLAs may be apportioned in any combination provided that the sum of both permit loads does not exceed the total for both in Table 3 (*i.e.*, the total ammonia load from both facilities should not exceed 1,354 lbs/day as N). The Fleischmann's and Sonoco ammonia loads are relatively minor. Therefore, ammonia limits based on existing loading (*i.e.*, technology-based) are recommended for these two facilities.

Load allocations for fish hatcheries and background/nonpoint sources were set at conservatively high estimates for existing conditions. If nonpoint sources are significantly reduced through future controls, then additional loading capacity may become available. A reasonable approach to including hatcheries and background/nonpoint sources in the present WLA would be to allocate nonpoint loading at the current levels, since they are dominated by headwater background loads. However, if loading from these sources increases (e.g., through addition or expansion of hatcheries), then the increased load should be subtracted from the WLA for future growth.

Proposed WLAs for ammonia will prevent violations of un-ionized ammonia criteria in the White River, but the high pH from algal productivity will probably continue. There are currently no Washington State standards for nutrients in rivers. It is probably not necessary to limit discharges of both nitrogen and phosphorus to control algal productivity. Available data suggest that reduction of DIN concentrations would be more effective than reduced SRP. A restrictive target of 0.10 mg/L of DIN would probably not achieve compliance with the pH criterion since the DIN in the White River averaged 0.10 mg/L during September-October 1990 and the pH criterion was still exceeded. Enumclaw and Buckley WTPs combined would be limited to less than 20 lbs/day of DIN or 8 lbs/day of SRP and Rainier School WTP would be limited to less than 3 lbs/day of DIN or 1 lb/day of SRP if White River nutrients are to be maintained below concentrations that limit algal growth (approximately 0.10 mg/L DIN or 0.025 mg/L SRP).

The recommended strategy for managing Enumclaw, Buckley, and Rainier School permits is to proceed with limits on effluent ammonia to achieve proposed WLAs. A feasibility analysis of reducing DIN or SRP loads should also be performed. A phased TMDL for nutrients in the White River (RM 4 to 24) could include the following elements:

- detailed analysis of pH response to nutrient loading and concentration and development of ambient targets for N or P;
- feasibility analysis of reducing nutrient loading from Rainier School, Enumclaw and Buckley WTPs;
- implementation of feasible loading reductions if appropriate;
- measurement of response of White River pH; and
- reassessment of loading capacity for nutrients in the White River.

Available data show that if the target for ambient nutrient concentration is not less than the amount which can limit algal productivity (approximately 0.10 mg/L DIN or 0.025 mg/L SRP), then pH criteria may not be met. WTP improvements would not be worthwhile unless ambient DIN or SRP targets are met.

Monitoring

Effluent quality for NPDES-permitted dischargers will need to be characterized for flow, BOD5, total ammonia, and total residual chlorine to evaluate compliance or reasonable potential to exceed the recommended WLAs. Existing NPDES permits typically require testing for BOD5 and total residual chlorine, but not for ammonia. Selection of parameters to test at specific facilities depends on several factors, including: mixing zone WLAs; type of municipal WTP; type of industry; and history of compliance problems.

The method of total residual chlorine determination is a consideration since the recommended WLAs for chlorine are less than the detection limit of the tests typically used. For effluent chlorine WLAs less than 0.2 mg/L, the low-level amperometric titration method should be used (method 4500 Cl E from the 18th edition of Standard Methods; APHA *et al.*, 1992). This test has a detection limit of 0.01 mg/L.

Water quality conditions in surface waters of the basin are presently monitored monthly by Ecology (Puyallup RM 8.3 and 22; White RM 0.7) and quarterly by USGS (Puyallup RM 5.7). Possible locations for additional ambient monitoring stations include the White River upstream from the Lake Tapps outflow at Dieringer, and in the headwaters of the White and Carbon Rivers. A detailed study of nutrient loading and pH response in the White River (RM 4 to 24) is warranted if the possibility of reducing ambient pH through reductions in effluent loading of nutrients is pursued. Other possibilities for expanded ambient monitoring could include metals sampling to address the issue of possible water quality limitation. At a minimum, the existing Ecology ambient monitoring network should be maintained.

- The existing NPDES permits may not provide adequate protection to assure that standards for dissolved oxygen and ammonia are met at critical points in the White and Puyallup Rivers. Dissolved oxygen in the lower Puyallup River may not meet fresh water quality standards if existing facilities reach their design capacity. Less restrictive marine dissolved oxygen criteria would be met in the lower Puyallup when existing dischargers reach design capacities. However, marine criteria may be violated if design loads from permitted discharges are increased substantially (e.g., by 50 percent). Reductions in ammonia loading are predicted to have greater potential to improve dissolved oxygen than reductions of carbonaceous BOD.

- Ammonia WLAs for individual dischargers based on mixing zone regulations would suffice to protect dissolved oxygen standards.

- Ammonia criteria in the White River are likely to be exceeded under existing NPDES permits. Ammonia loads potentially exceed proposed mixing zone WLAs for most municipal discharges.

- Mixing zone ammonia and chlorine WLAs for existing discharges are expected to protect the aquatic life criteria for these parameters in all segments of the Puyallup River. Modeling of these parameters shows that WLAs based on mixing zones would not result in cumulative violation of water quality criteria by the existing dischargers.

- TMDLs are recommended for the entire basin to prevent violation of water quality criteria for dissolved oxygen, un-ionized ammonia, and total residual chlorine. The TMDLs represent the sum of all permitted NPDES loads (WLAs) plus conservative assumptions for nonpoint and natural background loading (LAs), as well as a reserve for future growth or water quality protection. Loading capacity at the 7-day-10-year low river flow was used for the TMDLs. The proposed TMDLs are as follows: 19,500 lbs/day for BOD5; 3,330 lbs/day for total ammonia as N; and 45.9 lbs/day for total residual chlorine.

- WLAs and LAs are proposed to meet the TMDLs and protect water quality standards. WLAs for BOD5 are based on existing WTP design loads. WLAs for ammonia and chlorine are based on mixing zone regulations for volumes of river flow available or reasonable potential for maximum loading from existing effluents, depending on whichever is more restrictive. LAs for nonpoint and background sources are based on reasonable potential for maximum loading at design conditions.

- If the proposed WLAs are implemented in NPDES permits, then a surplus of loading capacity will be available for either future growth or water quality protection. The surplus WLA would be 2,100 lbs/day of BOD5, 730 lbs/day of ammonia as N, and 32.6 lbs/day of total residual chlorine for new sources, expansion of existing sources, or set-aside for water quality protection.

- The WLAs proposed in this report can be adjusted for each discharger provided that the TMDLs are not exceeded and regulations in WAC 173-201A are followed.

- The recommended strategy for managing Enumclaw, Buckley, and Rainier School permits for nutrient loading is to proceed with limits on effluent ammonia to achieve proposed ammonia WLAs. A feasibility analysis of reducing nutrient loads should also be performed. A phased approach of implementing feasible nutrient reductions and measuring response of White River pH may be appropriate to achieve Class A standards for pH. However, WTP improvements to achieve DIN of greater than 0.10 mg/L or SRP greater than 0.025 mg/L in the river may not meet pH criteria.

- The recommended strategy for determining WLAs for other toxic parameters (e.g., metals) which could potentially exceed aquatic life criteria is to first estimate the WLAs based on allowable dilution flows in the mixing zone. If background concentration is appreciable or unknown, development of WLAs should be preceded by background characterization. After mixing zone WLAs are estimated, the cumulative effect of multiple discharges could be evaluated using a conservative mass balance model. If the cumulative impact based on a conservative model maintains the water quality criteria throughout the river, then the mixing zone WLAs would be adequate for water quality-based permitting.

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