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State of Washington

Water Quality Program Guidance Manual

Procedures to Implement the State's Temperature Standards through NPDES Permits

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Updated by

Temperature Work Team
Washington State Department of Ecology
Water Quality Program

For more information contact:

WQ Program
P.O. Box 47600
Olympia, WA 98504-7600

Phone: 360-407-6600

Washington State Department of Ecology - www.ecy.wa.gov

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

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Washington State Department of Ecology
Olympia, Washington

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1. Overview: Meeting the Water Quality Standards for Temperature

Ecology staff must design surface water discharge permits, 401 certifications, total maximum daily loads (TMDLs), and other pollution control programs in Washington to meet the state's temperature standards for protection of aquatic life uses (mainly salmonids). This document provides guidance and recommendations for implementing the temperature standards for these programs.

The surface water quality standards can be found at: *http://www.ecy.wa.gov/programs/wq/swqs/rev_rule.html*.

1.A. *Fresh water temperature criteria*

Ecology updated temperature criteria for fresh water streams and rivers in Washington's water quality standards in 2003 and 2006 to better account for the protection of the various life stages of cold water fisheries (salmonids and char). The 2003 standards also added new uses and criteria limits for interior redband trout and warm water species, although to date these uses have not been identified for any waters of the state. You can find the fresh water temperature criteria at WAC 173-201A-200(1)(c) and Table 602. Temperature standards include:

- Annual maximum threshold criteria.
- A natural conditions provision that provides for a human allowance of 0.3 degrees over natural conditions.
- Incremental warming restrictions when the water is cooler than the standards.
- Supplemental spawning-season criteria where applicable.
- Protections against acute lethal effects.

This guidance focuses primarily on the implementation of fresh water temperature criteria because of its significance to healthy salmonid habitat. See Chapters 2 – 4 for details.

1.B. *Marine water temperature criteria*

You can find marine water temperature criteria at WAC 173-201A-210(1)(c) and Table 612, which contain many of the same elements identified for fresh water temperature criteria.

For many discharges into marine water (maximum effluent temperature of 25 °C or less and a chronic dilution factor above 30), there will be no reasonable potential to violate the maximum or incremental temperature criteria, regardless of ambient temperature. A permit writer can demonstrate this with the conservative screening equation found in section 3.A.
For lower dilutions, confined river estuaries, or other complex situations, follow the process described in this guidance. See Chapter 5 for more specific information on implementing temperature criteria for marine waters.

1.C. *Treatment of temperature as a non-conservative pollutant*

Non-conservative pollutants are defined as those that are mitigated by natural biodegradation or other environmental decay or removal processes in the receiving stream after in-stream mixing and dilution have occurred. The concentration of non-conservative pollutants is reduced after they are discharged into the receiving stream as a result of these removal processes.

The temperature in effluent is considered a non-conservative pollutant and is reduced (i.e., cooled) after it is discharged into a cooler receiving stream. Cooling happens as a result of the transfer of thermal energy from the warmer effluent to the cooler stream and the thermal energy loss associated with evaporation of the effluent/ receiving water mixture. The rate of effluent temperature reduction is dependent upon many factors: dew point, radiant energy from the sun, receiving water surface temperature, flow, and currents and tides.

It is important to remember that thermal energy is not "in" the water in the same sense that copper atoms and ammonium ions are in water. Thermal energy is absorbed by the water molecules, which is manifested as temperature and a property of the water.

1.D. *Water quality antidegradation requirements.*

Permit writers should consult the antidegradation guidance any time a permit would allow an increase in temperature at the edge of a mixing zone greater than 0.3°C [$(T_{ambient}) + (DF)(0.3)$] from a **new or expanding facility**.

You can find guidance for implementing the antidegradation Tier II requirements at http://www.ecy.wa.gov/programs/wq/swqs/antideg-tier2-guidance.pdf

2. Process Flow Charts for Implementing Temperature Criteria in NPDES Permits

To assist the permit manager in implementing temperature criteria, this document includes two process flow charts.

Figure 2.1 provides the process that a permit writer should use to determine temperature effluent limits in permits. The boxes in Figure 2.1 correspond to subsections in Chapters 3 and 4 for more details and descriptions.

Figure 2.2 provides the process that a permit writer should use when the determined numeric effluent limit is not attainable and the manager must determine performance-based or narrative limits. Boxes in Figure 2.2 correspond to subsections in Chapter 4 for more details and descriptions.

Figure 2.1
Setting temperature WQ-based effluent limits in permits

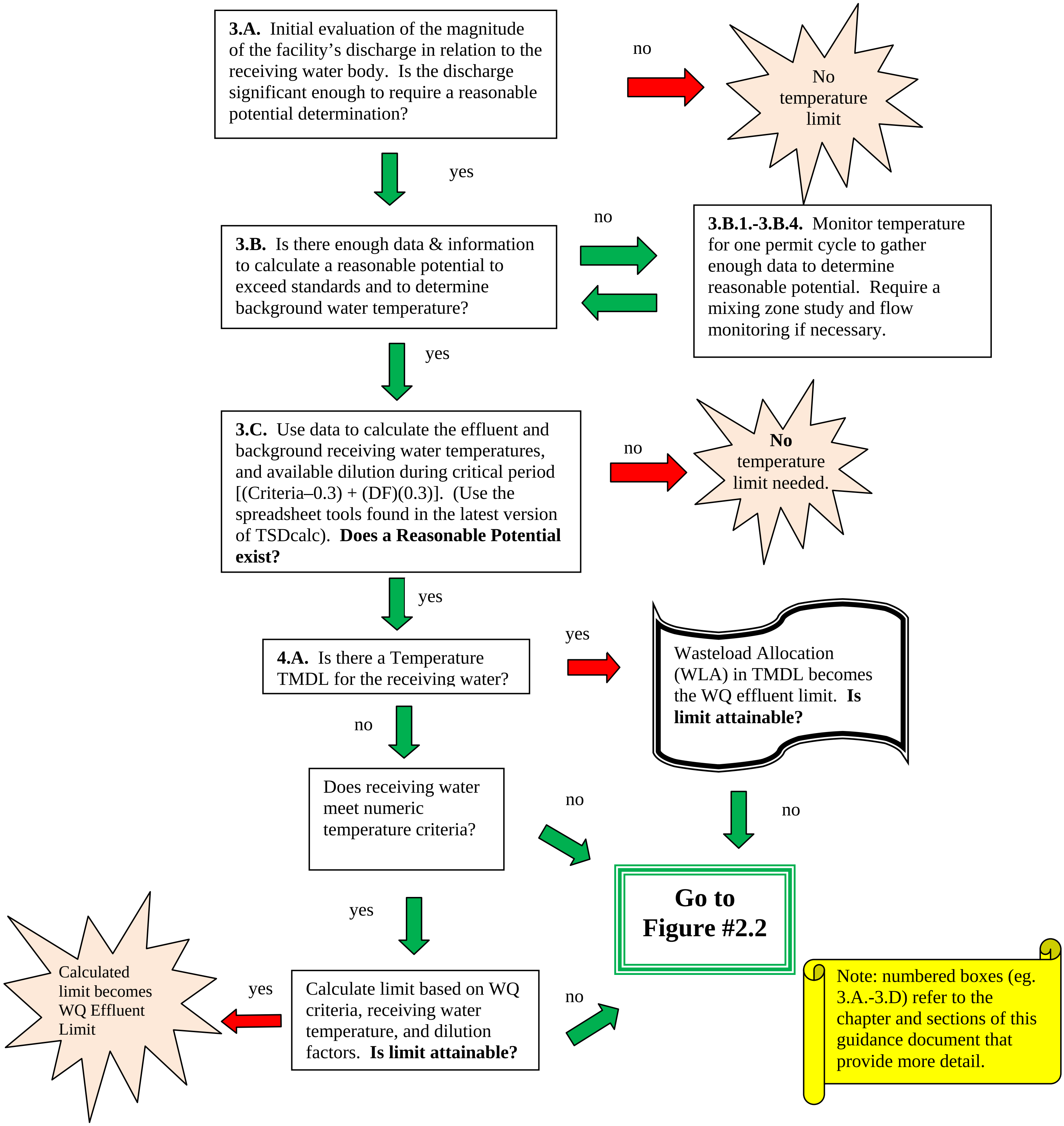
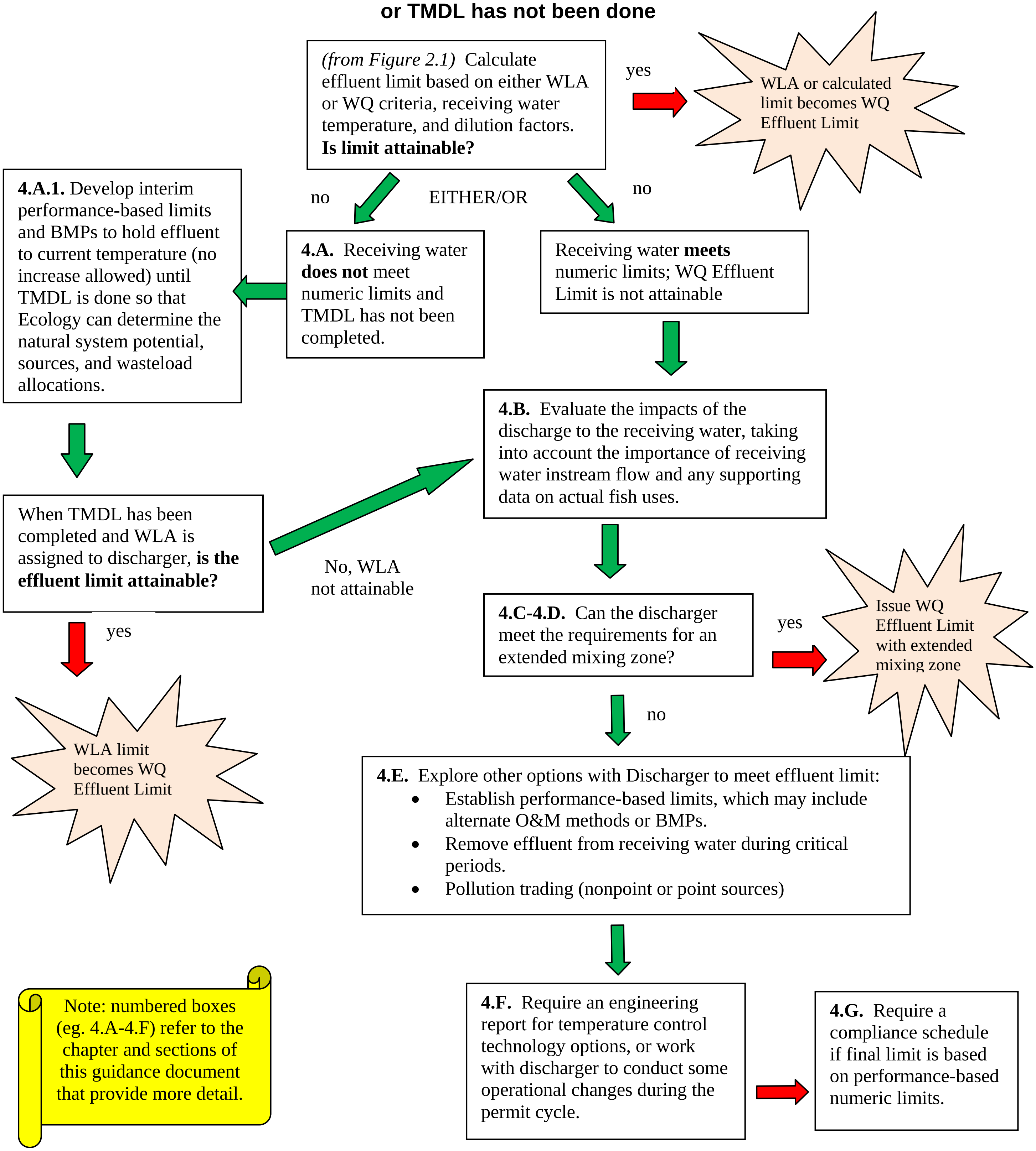


Figure 2.2
When WQ effluent limit is not attainable or TMDL has not been done



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3. Setting Temperature Effluent Limits in Permits

Procedures for determining reasonable potential to violate water quality standards and for deriving effluent limits to meet the standards are provided in the *Water Quality Program Permit Writer's Manual* (Publication Number 92-109). This guidance updates and supplements the manual regarding application of the state's temperature standards.

3.A. Initial evaluation of the facility's discharge

The first step in determining whether there is a reasonable potential for the facility to exceed temperature criteria includes a qualitative and quantitative evaluation of the facility's discharge in relation to the receiving water body. If the permit manager determines that the magnitude of the discharge's impact is not significant, then he/she can determine that there is not a reasonable potential to exceed temperature, and thus a temperature effluent limit is not needed. Criteria for determining the magnitude of the discharge's impact include:

- Flow rate of the discharge (GPD) and extent discharge occurs (daily vs. sporadic over time).
- The extent that the treatment process adds heat to the effluent.
- The pathway taken by the effluent as it flows to the receiving water.
- Flows of the receiving water during the critical period (an indication of intermittent or ephemeral streams)
- For marine waters, consider the area of discharge (thermal mass and circulation) and whether an effluent has the potential to impact the surrounding marine water temperatures.
- The relative influence of natural warming of the receiving water during the critical period.

The permit manager should:

- Clearly describe the basis for a decision that the magnitude of the discharge's impact is not significant in the permit fact sheet.
- Include performance-based limits and BMPs to prevent further temperature impacts, in the permit as appropriate.

When the permit manager already knows the effluent temperature and the chronic dilution factor for a facility, he/she can perform a conservative screening analysis based on the assigned numeric criteria with just effluent temperature data and the dilution factor to show that a reasonable potential clearly does not exist. Use the temperature screening tool in the latest version of the TSDcalc spreadsheet. No reasonable potential exists to exceed the temperature criterion where:

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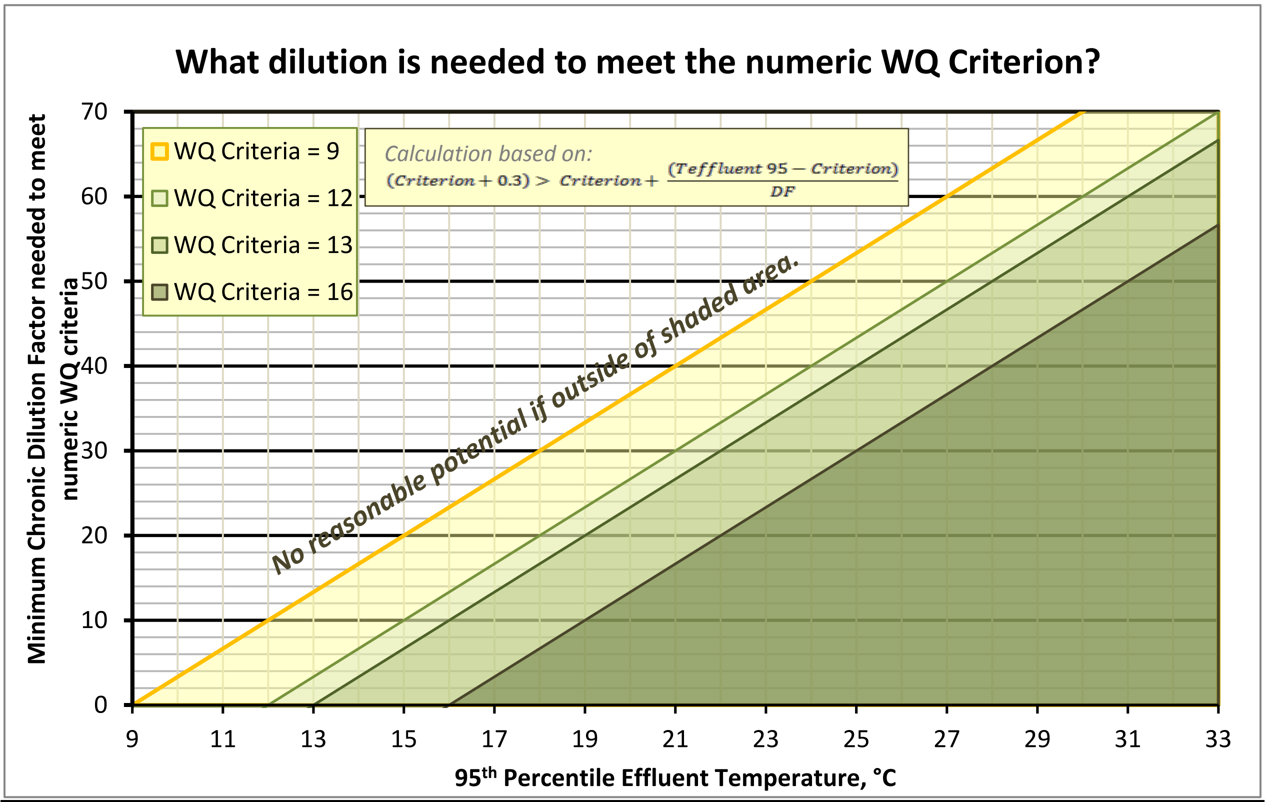

Figure 3.1: Dilution needed to meet temperature criteria from 9 to 16 degrees

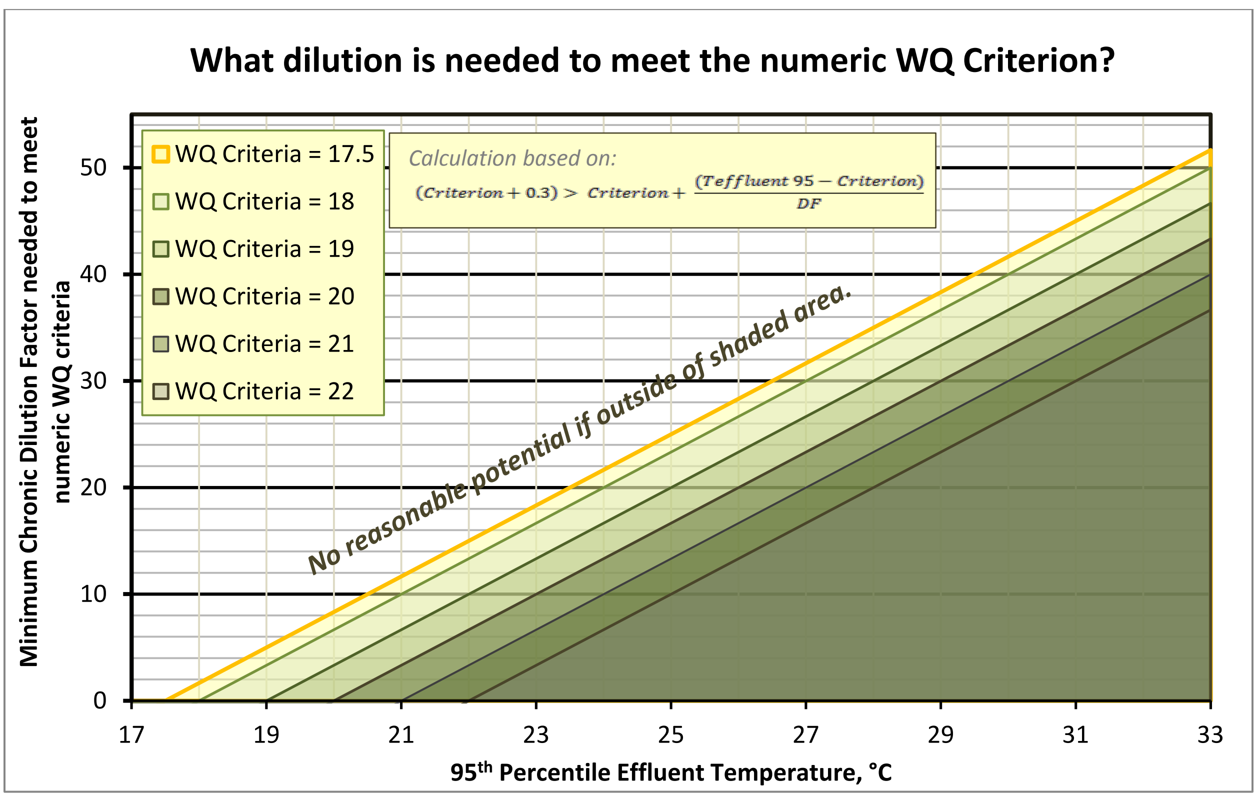

Figure 3.2: Dilution needed to meet temperature criteria from 17.5 to 22 degrees

Figures 3.1 and 3.2 provide additional information for the permit manager to quickly apply the conservative screening equation**.**

The figures show plots that will help the permit manager visualize when a reasonable potential will definitely not be an issue based on the chronic dilution factor and the WQ criteria. This will be helpful for fresh and marine discharges that have large dilution factors (for example, >60) and in these cases there will never be a reasonable potential to exceed the temperature criterion. Using the plots to determine that there is definitely not a reasonable potential will save the permit manager from:

a. Finding and digesting receiving water data (figuring out the 1DADMax Ambient Temperature (Background 90th percentile)).
b. Figuring out the 1DADMax Effluent Temperature (95th percentile).
c. Performing the TSD calculation for temperature.
d. Requiring the facility to monitor for temperature.

3.B. Information needed to determine reasonable potential

If the magnitude of the discharge indicates there may be a reasonable potential to pollute, and the facility does not meet the conservative screening analysis above, then monitoring data and dilution analyses are needed for the facility in order to determine reasonable potential for temperature. The state temperature standards include multiple criteria, each with different durations of exposure and points of application. You must independently evaluate each criterion when determining reasonable potential and deriving permit limits.

If the permit manager determines that the magnitude of the discharge could cause a reasonable potential to exceed temperature criteria, the next steps in the permit process will depend on whether the discharger or Ecology has collected enough data to make a defensible reasonable potential determination. Because many NPDES permits have not regulated temperature as a problem pollutant, the permit manager should use the first permit cycle to collect enough temperature data during the critical season to make this determination. Collect enough data to characterize effluent and background receiving water temperatures, and the available dilution during critical conditions. Consideration should be given to monitoring the temperature changes in the wastewater as it passes through the treatment process.

3.B.1. Temperature monitoring

Permit managers should use at least three to four years of effluent and upstream receiving water temperature data to determine reasonable potential and to set water quality-based limits. This should include data for June-August and the first 30 days of any supplemental fall spawning criteria (or last 30 days for spring-only spawning windows). For example, the discharger should measure temperature during the summer (July-August) <u>and</u> the fall critical period of September 15 to October 14 for a stream having a supplemental spawning criterion of 13ºC from September 15 to June 15. Dischargers must measure temperature using continuous recording thermistors set at a one-half hour sampling interval. Information for permit managers and permittees on using thermistors and other relevant information on monitoring temperature can be found in the following TMDL reference:

Bilhimer, D., and A. Stohr. 2009. “SOP for continuous temperature monitoring of fresh water rivers and streams conducted in a TMDL project for stream temperature”.

Templates of a quality assurance project plan (QAPP) for use by those facilities whose NPDES permit requires them to conduct an effluent/receiving water temperature study can be found at:

- Quality Assurance Project Plan (Template) for Temperature Study – Municipal
- Quality Assurance Project Plan (Template) for Temperature Study – Industrial

Water quality-based limits are based, in part, on using the 7Q10 flow of the receiving water. If the 7Q10 flow of the receiving water is ‘zero’ during the critical and/or spawning period, then no temperature monitoring would be necessary. The permitted facility should note on monitoring reports when ’zero’ flow conditions exist in order to establish a record. The permit shells include an optional permit condition for permit writers to use. The condition also requires facilities to monitor the air temperature so that you can determine if stream flow is present.

3.B.2. Dilution analyses for mixing zones

If the decision is made to require a mixing zone study, it should be timed to match the critical conditions for meeting the standards in the water body. In some cases, you will need dilution factors for locations and times other than just the acute and chronic mixing zone boundaries during the summer 7Q10 low flow period. If dilution factors do not exist for the critical conditions under evaluation, then require flow monitoring and dilution zone analyses in the permit. Where this is necessary, use at minimum three to four years of effluent and upstream receiving water flow data. You should require data collection at least for July-September and the first 30 days of any supplemental fall spawning criteria windows (or last 30 days for spring-only spawning windows). Guidance for determining stream flow is available online at: http://www.ecy.wa.gov/biblio/0510070.html

In some cases, an extended mixing zone may be granted by the department, in accordance with WAC 173-201A-400(12). Before an exception can be made, it must be demonstrated to Ecology that:

- AKART is applied.
- All other options that are *economically achievable* are being utilized. And
- Granting the exception would not have the *reasonable potential* to cause a loss of sensitive or important habitat, substantially interfere with the existing or characteristic uses of the water body, result in damage to the ecosystem, or adversely affect public health.

See Chapter 4.C for more details on the use of an extended mixing zone for temperature.

3.B.3. Selecting background temperatures

Temperatures can change significantly over the course of rivers due to the physical changes in channel configuration and altitude (air temperature), and in response to inflow from tributaries and ground water. For this reason, it is always preferable to collect background data at a location immediately upstream of a discharge. You can use this data directly or with the aid of models to estimate background temperature statistics.

Ambient background temperatures should be determined for the 90th percentile annual maximum 7 Day Average Daily Maximum (DADMax), or 90th percentile of annual maximum 1 Day Maximum (Dmax); depending on the criterion metric. Unless a long-term monitoring station is available, you will not likely have sufficient data to reasonably calculate or estimate (using a confidence interval) a 90th percentile annual maximum background temperature. It is recommended, therefore, that you use the highest annual temperature observed from the 3 or more years of monitoring to represent the 90th percentile background temperature. If at least three years of data is not available, use streamflow measurements taken during the critical period for temperature to calculate effluent temperature limits.

You may also use alternative methods to estimate the 90th percentile background temperatures. Mechanistic or empirical models may be used. An example of a possible mechanistic model is Ecology's rTemp model, which calculates hourly water temperatures (http://www.ecy.wa.gov/programs/eap/models/) using records from a long-term meteorological station representing the background location.

An example of an empirical model is a regression analysis that relates 7DADMax data from the location of interest to local meteorological data. You can develop an empirical model (regression analysis) between the temperature at the site and the temperature at a long-term water monitoring station in the water body. The daily average difference between the long-term monitoring station and the immediate upstream waters could be determined. You would then use this to adjust the data collected at the discharge site to match metrics such as the 10 percentile exceedance frequency associated with the numeric criteria (e.g., warmest 90th percentile year).

For the situation where a single facility has multiple points of discharge, the background temperature is the temperature above the farthest upstream discharge, and the incremental warming allowance is applied to the cumulative effect of all of the outfalls.

3.B.4. Design conditions for effluent and receiving waters

Guidance on effluent and receiving water design conditions recommended for determining reasonable potential and for setting water quality-based effluent limits to meet the temperature criteria can be found in Table VI-2 in the Permit Writer's Manual on page VI-22.

3.C. *Determining reasonable potential to exceed criteria*

The Water Quality Program has developed spreadsheets for the permit writer to use in determining reasonable potential to exceed temperature criteria. The spreadsheets for fresh and marine temperature in the most recent version of TSDCALC may be used to determine reasonable potential and effluent limits based on the maximum, supplemental, and incremental criteria. The permit writer may also need to evaluate acute conditions**.**

Appendix 1 provides specific details and equations that are the basis for the spreadsheets in TSDCALC.

3.C.1. Potential to exceed maximum threshold criteria

Annual summer maximum criteria. Each water body has an annual maximum temperature criterion [WAC 173-201A-200(1)©, 210(1)©, and WAC 173-201A-602, Table 602]. These threshold criteria (e.g., 12, 16, 17.5, 20, 21°C) protect specific categories of aquatic life by controlling the effect of human actions on temperature during the warmest part of the year.

Supplemental spawning criteria. In some waters, a second threshold criterion is assigned to protect the spawning and incubation of salmonids (9°C for char and 13°C for salmon and trout) [WAC 173-201A-200(1)©(iv), and Ecology publication 06-10-038]. These criteria include explicit calendar intervals for application, and you must apply them in addition to the annual summer maximum criteria discussed above.

The threshold criteria represent chronic criteria with the point of compliance at the edge of the chronic mixing zone boundary. Criteria are expressed as either the highest one-day annual maximum temperature (1-Dmax) or as the highest seven-day average of the daily maximum temperatures (7-DADMax). The 7-DADMax temperature is the arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax value is a 'rolling' seven day value. Permit writers should use the temperature spreadsheet tools in the latest version of TSDcalc to make the calculations, which are described in Appendix 1.A.

3.C.2. Reasonable potential for naturally warm waters.

Some waters are naturally incapable of meeting their assigned threshold temperature criteria. At locations and times when a threshold criterion is being exceeded due to *natural conditions*, all human sources, considered cumulatively, must not warm the water more than 0.3°C above the naturally warm condition [WAC 173-201A-200(1)©(i), and 210(1)©(i)].

See Appendix 1.B for application of the equations. If the ambient background temperature ($T_{ambient90}$) is warmer or within 0.3°C of the threshold criterion, and if $T_{chronic}$ is greater than $(T_{ambient90} + 0.3)$, a reasonable potential exists and an effluent limit is needed.

3.C.3. Reasonable potential when waters are cooler

In addition to the threshold criteria, the water quality standards limit the amount of warming human sources can cause at times when water temperatures are cooler than the assigned threshold criteria. This standard is designed to provide protection for the overall temperature regime [See WAC 173-201A-200(1)©(ii), 210(1)©(ii)].

The incremental warming limit at 173-201A-200(1)©(ii)(A) is applied to point sources as a part of the NPDES permit process. Subpart (A) specifically describes individual activities based on background conditions at the edge of the mixing zone. The incremental warming limit at 173-201A-200(1)(c)(ii)(B) is applied to nonpoint sources during the development of a nonpoint source program (for example, forest practices). Because this temperature requirement is applied directly to source controls and only when the water is cooler than the standards, it is not appropriate to apply to a water body during the TMDL process. See Appendix 1.C. for application of the equations to determine reasonable potential.

3.C.4. Criteria to prevent acutely harmful and lethal conditions

Permit limits must not allow detrimental acute effects (e.g., lethality, migration blockage). Criteria to prevent such effects are established in WAC 173-201A-200(1)©(vii). See Appendix 1.D. for equations used to determine if acute or lethal conditions may exist.

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4. Considerations for Meeting Water Quality-based Limits

The process for establishing water quality–based limits for temperature that can be feasibly met relies heavily on the ability of the river or stream to bring the effluent’s temperature into equilibration with that of the receiving water. For discharges to larger streams that are not significantly warmer, the associated dilution factor will allow permit writers to establish a mixing zone that ensures the discharger will meet the water quality-based limit without requiring additional resources to cool the effluent temperature.

However, when the discharge has little or no dilution available, it creates a situation where the effluent dominates the receiving water, creating an effluent dominant or effluent dependent water body. This scenario may be more common where watersheds have naturally occurring intermittent or ephemeral streams due to summer heat and sparse rainfall, and therefore limited vegetation. In these situations, Ecology cannot authorize a standard mixing zone to bring the water into equilibrium the receiving water.

Numeric effluent limitations can be difficult for municipal or industrial discharges to meet when discharging to water bodies with naturally low flows (often accompanied by naturally high air temperatures) during the critical season. Ambient water body temperatures can be highly variable and dependent on many natural factors, such as stream hydrology, air temperatures, flow, and other factors (see section 1.C. for information on how temperature acts as a non-conservative pollutant).

The variability of temperature in relation to the receiving water and effluent, and efficacy of appropriate control measures, makes meeting effluent limits for temperature extremely difficult when adequate dilution is not available. There is a high level of variability in the receiving water temperatures, in terms of both flow rates and volumes and degree of heating, since the temperature regime in a water body is dependent on a number of factors.

One must also consider how much a point source is contributing to a temperature impairment in a water body in relation to nonpoint sources. Temperature TMDLs have consistently shown that reductions in riparian shade due to nonpoint source activities (e.g. agriculture, logging, urban development) are major contributors that cause increased heating to a stream from human actions. Ground water exchange can also be a significant factor for temperature.

Shade is less significant as a temperature moderator on large rivers systems than for small streams (groundwater likely has a bigger impact than shade in these larger systems.) However, no two situations are the same; factors such as depth and velocity must be considered as they dramatically affect the overall surface water temperature. It may, for example, be more beneficial to cool the water upstream in narrow tributaries through riparian shade, which then feeds into the larger river system.

Factors contributing to the variability in implementing temperature criteria include:

- How water temperature is affected by air temperature in the critical season.
- The hydrology of the system.
- The amount of stream flow in relation to the effluent flow (dilution factor).

- The relative contribution of the point source in relation to natural conditions.
- The relative nonpoint source contributions to the temperature impairment.
- Site-specific conditions at the facility that limit available control technologies.

4.A. When receiving water exceeds the temperature criteria

When a water body does not meet its assigned temperature criteria, the water is considered impaired and a total maximum daily load (TMDL) analysis is required. The TMDL assigns warming allowances to all human sources of warming in the watershed. These load allocations are designed to bring the water body into compliance with the temperature standards. Approved TMDLs will include wasteload allocations (WLA) for the existing point source discharges. The WLA becomes the basis for setting the water quality effluent limit in the permit.

Where documented data indicates that the receiving water background temperature at the point of discharge during critical conditions *does not meet the aquatic life temperature criteria and a TMDL has not been completed,* the permit writer should verify if the receiving water is listed on the 303(d) list: (http://www.ecy.wa.gov/programs/wq/303d/index.html).

If the receiving water is not on the 303(d) list, the permit writer should review the data to determine if it meets the criteria for 303(d) listing (see the WQ Policy 1-11 at: http://www.ecy.wa.gov/programs/wq/303d/wqp01-11-ch1Final2006.pdf). Staff in the Watershed Management Section who work on the Water Quality Assessment and 303(d) list are available to help if needed (email requests can be sent to 303d@ecy.wa.gov).

The permit writer should ensure that ambient receiving water data received from dischargers that meets the 303(d) listing criteria is placed in EIM for Watershed Management Section staff to use in the next Water Quality Assessment. If you have facility continuous temperature monitoring data or other receiving water data to add to EIM contact the 303(d) Coordinator in the Watershed Management Section by phone or email at 303d@ecy.wa.gov. Ecology will subsequently place the water body segment on the 303(d) list and prioritize it for a TMDL.

4.A.1. Setting effluent limits prior to completion of TMDL

In many cases, permit writers can establish final effluent limits that meet the applicable numeric temperature standards for point sources prior to completing a TMDL. However, in situations where the discharge cannot attain effluent limits and the receiving water does not meet numeric limits, the permit manager should apply interim performance-based limits while awaiting the outcome of a TMDL. This is especially appropriate where Ecology is conducting TMDLs for multiple source and additional parameters, and the combined results may better dictate the significance of the point source to the problem and the best course of action to bring the water body into compliance with the standards.

If the water body is on the 303(d) list or if the data indicates Ecology will place the water body on the next 303(d) list, the permit writer should develop and place in the permit interim performance-based limits that allow no increase in thermal loading. This approach is supported by EPA Region 10 temperature guidance to Pacific Northwest states and tribes, which states that numeric criteria end-of-pipe effluent limits for temperature may not be necessary to meet applicable standards and protect salmonids in impaired waters. This is because the temperature effects from point source discharges generally diminish downstream quickly as heat is added and removed from a water body through natural equilibrium processes. See "EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards, 2003" at http://yosemite.epa.gov/R10/water.nsf/6cb1a1df2c49e4968825688200712cb7/b3f932e58e2f3b9488256d16007d3bca/$FILE/TempGuidanceEPAFinal.pdf.

Permit writers may issue permits prior to a TMDL that are based on a human warming allowance. *Prior to a TMDL, each point source may warm the receiving water at the edge of a mixing zone (i.e., 25% flow or 300 feet) by 0.3°C***.** This is true regardless of the background temperature and even if doing so would cause the temperature at the edge of a mixing zone to exceed the numeric threshold criteria. Allowing a 0.3°C warming for each point source is reasonable and protective where the dilution factor is based on 25 percent or less of the critical flow. This is because the fully mixed effect on temperature is only a fraction (0.075°C or less) of the 0.3°C cumulative allowance for all human sources combined. A compliance schedule is not needed until Ecology completes the TMDL and establishes the natural system potential and wasteload allocations.

4.A.2. Setting performance-based interim limits

If performance-based interim limits are used, permit writers should establish both monthly average and maximum daily average temperature limits performance-based limits consistent with guidance in the permit writer's manual (Chapter IV). Formulas to derive performance limits are incorporated into PERFORMLIM in TSDCALC11.XLW (PERFORMLIM assumes the data is non-normally distributed.) Where the data are normally distributed, the permit writer can calculate the z-score for the percentile of the standardized normal distribution and apply it directly. (See Appendix E of the EPA TSD, 1991.)

Permit writers may use a performance-based interim limit while necessary monitoring and engineering studies are conducted. Where cost-effective remedies are linked to watershed-wide programs (e.g., trading), permit writers may continue to use an interim limit until a TMDL is developed.

Ecology cannot issue interim limits for new dischargers. Effluent limits for new discharges must meet both technology and water quality-based requirements when the discharge begins. New discharges to waters not meeting temperature criteria are allowed only if they are: (1) incorporated under a future reserve allocation of an established TMDL, or (2) if the effluent temperature would be no warmer than the conservative screening analysis described in Chapter 3.A: (Threshold Criteria - 0.3) + (Dilution Factor)(0.3).

Ecology cannot issue a permit to a new discharger if it will cause or contribute to the violation of water quality standards. It must limit conservative parameters to the water quality standard in the discharge (at end of pipe). Ecology concluded that a 0.3 increase in temperature at the edge of a mixing zone will measurably increase the impairment.

Permit writers should not include structural changes as interim limits for existing dischargers; the permit should require these only in association with final effluent limits designed to meet both technology and water quality-based requirements. Changes in *operation*, however, should be considered in setting interim limits where (1) the discharge causes receiving water to warm above the acute temperature thresholds established in WAC 173-201A-200(1)(c)(vii), or (2) reasonable changes in operation may result in compliance with temperature standards.

4.A.3. Establishing effluent limits using WLAs in a TMDL

When a temperature TMDL is approved, it will include WLAs for existing dischargers. It is important that permit managers work with TMDL staff in establishing WLAs for point source discharges, especially where the data indicates that a standard mixing zone may be infeasible because of low flow streams or minimal dilution factors. Ideally, the TMDL study will include data and information that will assist both TMDL staff and the permit manager in establishing effluent limits from WLAs that are reasonable and feasible, and can be implemented in a manner that will result in cooler water for the system.

While TMDL/WLA values must be expressed as daily loads, NPDES permit regulations do not require that effluent limits in permits be expressed as maximum daily limits or even as numeric limitations in all circumstances, and such discretion exists regardless of the time increment chosen to express the TMDL. This was clarified in EPA guidance from Benjamen Grumbles, 11/15/2006: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/dailyloadsguidance.cfm. Therefore, expressing a TMDL as a daily load does not interfere with a permit writer's authority under the regulations to translate that daily load into the appropriate permit limitation, which in turn could be expressed as an hourly, weekly, monthly or other measure as appropriate.

The 2006 EPA guidance clarifies that there is flexibility to translate TMDL/WLA values into effluent limits for an NPDES permit so long as the limits are ‘consistent with the assumptions and requirements of any available wasteload allocation. So, for example, a WLA of 1 unit/day could be translated into a permit limit of 100 units/season if the WLA was based on a season of 100 days. The permit manager should work closely with the TMDL lead in translating applicable TMDL WLAs into effluent limits for NPDES permits.

4.B. Evaluating human impacts to the receiving water

When dealing with temperature, the effluent limits for a facility and the extent of the limits are based, in part, on the dilution factor (DF) available. In many cases an effluent discharges to a stream that provides a significant DF, and thus Ecology can authorize the facility a mixing zone and the discharger is not required to resort to costly remedies to cool the water to meet downstream temperature criteria.

When no DF is available, a standard mixing zone is not allowed as a means to meet numeric temperature effluent limits. The permit manager and facility must then consider other methodologies to either treat the effluent or remove it from the receiving water in order to meet effluent limits at the end-of-pipe.

The standards allow for natural conditions to be considered when determining effluent limits. This can be challenging when trying to factor in the complicating natural aspects of water temperature--how water temperature is affected by air temperature, the hydrology of the system, stream flows, the relative contribution of the point source in relation to natural conditions, and the relative nonpoint source contributions.

The requirement to meet end-of-pipe limits for temperature does not take into consideration the added environmental costs if, for example, the discharger cools the effluent using mechanical means. Additionally, it is not reasonable to require a municipality to indebt itself for a treatment system upgrade to cool the effluent temperature that discharges into a naturally dry or intermittent stream that typically has little or no flow during the critical period in the summer. Even when the wastewater treatment facility does not "add" heat during processing, the temperature of the influent wastewater is often higher than ambient upstream water temperatures during the critical periods (due to uses of water, such as showers or dishwashers).

In these situations, the permit manager should consider setting limits other than numeric (e.g., best management practices or BMPs) based on an evaluation of the impacts of the effluent upon the natural characteristic uses of the stream and its water volume, including seasonal fluctuations. It may also be notable to compare the temperature impacts to the beneficial effects of the effluent volume going to an otherwise dry stream reach. The permit manager should evaluate the following information with the discharger:

- Explore a treatment/disposal system that meets all numeric criteria and characteristic uses for the receiving water body. This may suggest removal of the discharge from the stream either seasonally or completely, or the installation of a costly cooling tower.
- Use available WDFW fish data and/or WDFW staff expertise to determine the appropriate characteristic uses of the receiving water.
- Consider the benefits of having warm water in a stream vs. no water at all before deciding that the best alternative for improving temperature is to get the discharge out of the stream. It is important that permit managers include cross program discussions in their decision-making process on quality of water vs. quantity of water if an initial decision is made to remove the discharge from the stream. The permit writer should consult with the Water Resources (WR) and Shoreline and Environmental Assessment (SEA) programs on any instream flow decisions or to gather information on keeping the watershed healthy as a whole that might influence the decision to get the effluent out of the river (see Appendix 1).
- If the permit manager concludes that warm water is better than no water in the receiving stream, then other options should be considered, such as extended mixing zones or other treatment options (see Appendix 2 and 3).

4.C. The use of extended mixing zones for temperature

In some cases, an extended mixing zone may be granted by the department, in accordance with WAC 173-201A-400(12). Subsections (12)(c) and (12)(d) may be particularly relevant for implementation of temperature criteria (see bolded below):

WAC 173-201A-400(12): Exceedances from the numeric size criteria in subsections (7) and (8) of this section and the overlap criteria in subsection (9) of this section may be considered by the department in the following cases:

(a) For discharges existing prior to November 24, 1992, (or for proposed discharges with engineering plans formally approved by the department prior to November 24, 1992).

(b) Where altering the size configuration is expected to result in greater protection to existing and characteristic uses;

(c) Where the volume of water in the effluent is providing a greater benefit to the existing or characteristic uses of the water body due to flow augmentation than the benefit of removing the discharge, if such removal is the remaining feasible option; or

(d) Where the exceedance is clearly necessary to accommodate important economic or social development in the area in which the waters are located.

(13) Before an exceedance from the numeric size criteria in subsections (7) and (8) of this section and the overlap criteria in subsection (9) of this section may be allowed under subsection (12) of this section, it must clearly be demonstrated to the department's satisfaction that:

(a) AKART appropriate to the discharge is being fully applied;

(b) All siting, technological, and managerial options which would result in full or significantly closer compliance that are economically achievable are being utilized; and

(c) The proposed mixing zone complies with subsection (4) of this section.

Before an exception can be made, it must be demonstrated to Ecology that

- AKART is applied.
- All other options that are *economically achievable* are being utilized. and
- Granting the exception would not have the *reasonable potential* to cause a loss of sensitive or important habitat, substantially interfere with the existing or characteristic uses of the water body, result in damage to the ecosystem, or adversely affect public health.

AKART is covered in Chapter IV, Part 3 of the Permit Writer's Manual. A permit writer who makes a determination that a larger mixing zone is required or the percent of flow limitations are not applicable should discuss, in the fact sheet, the determinations of AKART, economically achievable options, and receiving water impacts. This determination should be discussed with the Watershed Planning Section.

As an example, the Selah POTW permit has an extended mixing zone for its discharge to Selah Ditch, which is an effluent dominated, irrigation return ditch. By allowing the extra length of the chronic mixing zone, extra dilution was realized. The permit writer must be sure to justify in the fact sheet that the requirements in subsection (12) and (13) of the mixing zone provisions are met.

4.D. Options for reducing thermal impacts from POTWs

In 2007, the Water Quality Program contracted with Skillings Connolly, Inc. to produce a document that would provide the reader with an overview of methods to reduce or eliminate thermal impacts from municipal wastewater treatment plant discharges to surface water. The resulting manual, "Methods to Reduce or Avoid Thermal Impacts to Surface Water" can be found on Ecology's website at: http://www.ecy.wa.gov/pubs/0710088.pdf. This guidance expands on the information provided in the manual.

There are a wide range of technologies and methods that can reduce thermal impacts to receiving waters from publically owned treatment plants. Each method has a unique cost, benefit, challenge and effectiveness. Accomplishing the goal of reducing temperature impacts from a POTW can include:

- Reducing the temperature of the effluent.
- Reducing the temperature of stream (thereby changing the mixing zone formula).
- Increasing the flow in the stream (also changing the mixing zone formula).
- Removing all or part of the effluent from the receiving water during the critical period.

Several major issues influence the decision-making process in choosing a technique to reduce effluent impacts to a receiving water:

- Cost (construction and O&M).
- Effectiveness.
- In-stream flow/water rights.
- Available land for water storage and/or cooling.
- Partners for cooperative projects.
- Long-term maintenance.

The permit manager should work with the discharger and other appropriate programs to gather the necessary information to determine a treatment option where the benefits of maintaining cooler water in the system outweigh the costs of the treatment. Treatment techniques that have high operation and maintenance costs with minimal benefits to the receiving water may not be considered reasonable and feasible (for example, chillers and cooling towers). Appendices 2 and 3 provide a summary of some available temperature control techniques and factors influencing their choice. It is intended to assist permit writers, and ultimately treatment plant operators, to identify potential solutions for their unique situation.

Many of these techniques not only reduce temperatures in receiving waters but some are effective in reducing nutrients, solids and heavy metals. Achieving several goals simultaneously (such as temperature and TSS reduction) could offset some of the investment required to change the business practice at the POTW.

Each situation is unique; a method that functions well in one location may fail in another. Prior to investing significantly in one of these options the discharger must assess the cost-benefit, effectiveness, and public support. The analysis may find that one method alone cannot reduce the temperature sufficiently to meet the numeric criterion (or natural condition level). On the other hand, the assessment may point to added benefits of a method not originally considered such as a cost-generating method (e.g. sale of pretreated water for irrigation).

In spite of the numerous alternatives identified, two commonly considered options still stand out as "best alternatives" in many situations:

- Providing full riparian shade.
- Eliminating the discharge from the receiving water during the critical season (unless the discharge is required to meet in-stream flow).

Several other methods may have promise for reducing temperatures but are currently not used in Washington (as reported by regional permit staff that assisted in identifying current practices of POTWs). These more innovative options are:

- Constructed wetlands, coupled with infiltration to the hyporheic zone.
- Transferring heat from the warmer effluent to a colder water supply within the system, thereby reducing effluent temperatures.
- Temperature Trading.
- Water Rights Trading.

All of these options are discussed in detail in *Appendix 2, Reducing Thermal Impacts from Discharges*, and *Appendix 3, Factors Affecting Temperature Control Options*, which provides information on cost, effectiveness, and other factors that will influence the preferred option.

4.E. Engineering report or operational changes

After enough monitoring data and information are collected to determine that the discharger cannot reasonably meet water quality-based effluent limits, the permit manager should work with the operator to select and apply some operational BMPs to conduct and evaluate during the next five-year permit. The discharger should complete an engineering report evaluating temperature control technology options; unless it is clear that the options are limited, depending on the facility and site. A technology review consists of an engineering analysis of temperature controls and wastewater disposal alternatives available for the facility. The discharger should consider both passive and active forms of temperature controls.

4.F. Compliance schedules

A compliance schedule in the permit to provide time for monitoring (instream and inplant) and study plans to develop BMPs and effluent and receiving water data collection may be appropriate. This could also include a study of the characteristic uses present, especially if Ecology believes the designated use protection is not present (i.e. salmonids). Ecology could also establish performance-based limits to maintain the current quality (performance) of the discharge.

Permits can include compliance schedules (WAC 173-201A-510(4)) to provide time for:

- Monitoring and study plans, as well as effluent and receiving water data collection.
- Studies to determine feasible treatment and disposal alternatives to meet final effluent limits (both operational and structural changes should be considered).
- Construction schedules or changes in operations needed to come into compliance.

Compliance schedules are typically issued as part of an NPDES permit when it will take less than one permit period to come into compliance. Permit writers should include schedules in a companion order if it will take more than a single permit period for the dischargers to come into compliance.

The compliance schedule must be as short as practicable and must include specified required actions that demonstrate reasonable progress toward attainment of the final limit or water quality criteria. The permit writer should describe the final limit in the fact sheet if compliance with those limits is expected to exceed five years. Compliance schedules must include milestones in the form of dates, decision criteria, and deliverables. They should also typically include a requirement to review less degrading alternatives. A technology review consists of an engineering analysis of temperature controls and wastewater disposal alternatives available for the facility.

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5. Special Considerations for Implementing Temperature Limits in Marine Waters

The influence of human-caused temperature warming in coastal marine waters is different from that in fresh water riverine systems because of the more extreme dynamics of coastal waters. Determining an effluent's impacts on a tidally influenced environments can be complex. Factors to consider include tidal cycles, current patterns, bottom currents and counter-currents, stratification, climatic conditions, seasonal fluctuations, dispersion of discharges, and wind induced surface currents.

5.A. Determining reasonable potential in marine waters

If a discharge into marine water does not pass the screening test for no reasonable potential (section 3.A.), the permit writer must do a more complete analysis using the ambient background temperature.

The water quality standards specify that "Temperature measurements should be taken to represent the dominant aquatic habitat of the monitoring site. This typically means samples should not be taken from shallow stagnant backwater areas, within isolated thermal refuges, at the surface, or at the water's edge."

Ecology's Environmental Assessment Program provides marine water quality data monitored at several stations within the Puget Sound. This data can be found online at: http://www.ecy.wa.gov/apps/eap/marinewq/mwdataset.asp. In many circumstances the permit writer can use this ambient data to perform a reasonable potential analysis, however, it is up to the individual permit manager to determine if the temperature data from the nearest monitoring station is representative of the water in the vicinity of the outfall. The database often contains data from several depths, from 0 to 100 meters in some cases. If a Plumes mixing model study was performed for the given outfall, the permit writer should use the maximum ambient temperature measured at the plume trapping depth for the reasonable potential calculation.

In most cases a discharger is able to meet temperature limits at the edge of the chronic mixing zone because of the dilution factors that typically exist. In areas where mixing is limited (for example in an enclosed estuarine area) the permit writer will need to consider stratification of the salt and fresh water, as well as other issues, in determining where to appropriately monitor to set background temperatures that are representative of the water body.

5.B. Monitoring considerations in marine waters

Considerable stratification can occur in estuaries because of the differing densities of saltwater and freshwater. Freshwater flows enter estuaries as point source discharges, stormwater, or riverine systems. Freshwater is more buoyant than saltwater, and will rise to the surface unless it is entrained in a current underneath a salt water layer. It is essential to determine the extent of stratification when starting a survey of an unknown estuarine area. This is accomplished by determining salinity at different locations and depths over tidal cycles and over seasons.

Because it is important to know about stratification when calculating effluent limits and when designing a field survey, the dischargers should always consider it during survey design.

It is possible for stratification to occur in one part of an estuary and not in another. A wedge of fresh river water overriding more dense saltwater is a specific mechanism of stratification commonly seen at and in the vicinity of river mouths. In that situation, when the discharge of pollution is in the saltwater layer, the contamination concentrates near the bottom of the freshwater wedge at the flood tide. Where stratification is suspected, the discharger must collect samples at different depths to measure vertical distribution. Dilution studies will generally be needed to determine plume movement and dispersion during times of stratification. Dischargers must conduct these studies under the perceived "worst case" dilution conditions (e.g., time of least flushing flows, accounting for low slack tides and ebb tides).

The permit writer should take into account the area of discharge and whether an effluent has the potential to impact the surrounding marine water temperatures. If the receiving water exceeds the standard, unless there are significant human-caused sources identified, the warm water would be considered a natural condition for purposes of regulation.

Significant human activity that could reasonably be expected to have altered the water temperature may include other thermal discharges or geomorphologic or hydrologic alterations that would be expected to affect water temperature. If there has been an activity that would be expected to have modified the water temperature, Ecology must determine how best to estimate the natural temperature of the receiving water. This may be done by monitoring similar nearby waters outside the influence of the human activity, or by back-calculating out the effect of a nearby thermal discharge. In addition, a discharge plume or mixing model may be used to determine whether a nearby source is affecting the receiving water at the location of the proposed discharge. That temperature is then used as the reference temperature for calculating the permitted load.

5.C. Human influences on marine water environments

The coastal waters of Puget Sound and the outer coast are vast, highly dynamic, and naturally very cool. Many areas are typically large unenclosed or semi-enclosed water bodies with sufficient thermal mass and large-scale circulation to rule out potential human causes. In other areas, one can find small and/or shallow enclosed or semi-enclosed water bodies, many of which have relatively low flushing rates. As a result, they may all be subject to substantial increases in temperature resulting from natural thermal warming.

Ecology has reviewed data showing historic temperature exceedances in Puget Sound and coastal waters and found that it was naturally occurring due to the naturally high thermal mass and circulation of many areas of Puget Sound, or it determined that temperatures exceeding the standards in smaller enclosed areas are occurring naturally and any human-caused sources are insignificant in impacting marine water temperatures. While it is important to ensure that thermal effluent from industrial discharges into marine waters provide adequate treatment to control thermal impacts to the surrounding area, it is generally assumed that POTWs or other dischargers that do not add heat to their effluent do not affect the overall natural temperature regime of coastal waters in a significant manner and the discharge equilibrates quickly with the ocean temperatures.

In situations where not enough dilution is available to quickly dispel effluent temperature, the incremental warming equations (for ambient water warmer or cooler than the maximum criterion) may indicate a reasonable potential to exceed the criteria. Ecology may consider issuing an extended mixing zone for these situations if a source can demonstrate to our satisfaction that the greater increase would not reasonably be expected to adversely affect fish or other aquatic life. If needed, the permit writer should consult biologists or other experts on the ocean waters, bay, or estuary in question from staff in the marine unit at EAP, or academic institutions if available. Pertinent information would include current ambient temperatures, the species present and their thermal requirements, physical characteristics of the water body (i.e. currents, tides, river inflows, etc.), whether the water body has been altered or impacted by human activity in the past, and the magnitude, duration and frequency of the proposed temperature increase. *Results should be written into the Fact Sheet* to demonstrate why an extended mixing zone is appropriate for situations where application of the incremental warming criteria is not necessary because information indicates that aquatic life will not be impacted.

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6. Other Considerations

6.A. Low flow streams

Many states have developed alternate water quality uses that apply seasonally or during low flow periods. This approach acknowledges that some water bodies have distinctly different water regimes either periodically or seasonally and therefore different characteristic uses that depend on stream flow. For example, a stream with abundance fall-winter-spring flow may have no flow in summer. In the "high flow" time this stream might have migrating salmon but during the "low flow" macro invertebrates and amphibians might survive in the small isolated pools or in the subsurface gravels. The intent of this provision is to provide full protection of existing and attainable uses during typical natural cycles and flow regimes. Some states have defined the use categories based on the stream's flow in cubic feet per second.

At this time, low flow is neither defined nor alternate uses determined in the Washington Standards. However, these conditions are eligible for seasonal/low flow uses as defined in the Clean Water Act. Until such time that the water quality standards are updated to include provisions for implementing standards in these types of waters, the process for developing alternate uses would involve a downgrade of uses for part of the year, involving a UAA (see section 5.H. below). In the meantime, permit managers can consider the naturally low flow conditions as part of their evaluation of a facility's discharge impacts on the receiving water, as described in Chapter 4, sections 4.B-4.F.

6.B. Requesting changes to designated uses of a water body

Regional staff should notify WQ standards staff at HQ when information strongly indicates the state standards are incorrect. Standards staff will review information provided by regional (and/or TMDL) staff to determine if further study is warranted. A UAA is an in-depth process involving exhaustive data collection and analysis to determine the attainable uses of the water body. The conclusion of a successful UAA *may* result in a change to the water quality standards regulation.

The UAA process would be time consuming. In the meantime, the permit manager should work with the facility to establish performance based limits that provide affordable and reasonable corrections that do not require major capital improvements.

To prepare for a headquarters standards staff review, data should be collected from state, federal, local and tribal data, and various internal programs such as Water Resources and SEA. The following are particularly relevant:

- Available WDFW and tribal fish and other aquatic life data to determine the appropriate characteristic uses of the receiving water. Note: fish may not be the most sensitive species in the stream.
- Historic records of weather (precipitation, temperature), stream flow, aquatic life uses, vegetation, and human uses (such as agriculture, logging, industry and manipulation of water flows) will help to determine the 'natural condition' of the stream and its attainable

uses. Natural condition is defined as the "…surface water quality that was present before any human-caused pollution."

6.C. Other program and agency contacts

Water Resources Program

In evaluating waters that are warmer than the criterion (or steams with insufficient DF to bring effluent to numeric criterion) the facility and permit writer may explore the possibility of seasonal removal of the discharge.

If removal of the discharge from the water body is a consideration, permit writers should work with their regional section manager to submit information to the Regional Water Management Team for their weekly meeting. Coordination and further direction will occur through the Regional Management Team.

The following web site has information on in-stream flow, including a map showing where existing and future in-stream flow rules are located:

http://www.ecy.wa.gov/programs/wr/instream-flows/isfhm.html

There are also sixteen watersheds that have been designated as "Shortage of Water for Fish". In 2003, the state launched the Washington Water Acquisition Program, a voluntary program to increase stream flows in 16 watersheds with vulnerable salmon and trout populations. The program coordinates with farmers, ranchers and other water-right holders to participate in salmon recovery by selling, leasing or donating their water where critically low stream flows limit fish survival. All water obtained through the program will be returned to the creeks, streams and rivers where it was originally withdrawn. Program sponsors have developed criteria and guidance to help ensure water-right acquisitions receive fair market value and are targeted in areas that will most benefit fish.

Map showing the 16 affected basins:

http://www.ecy.wa.gov/programs/wr/instream-flows/Images/pdfs/16basinsmap.pdf

Shorelands and Environmental Assistance Program (SEA)

In evaluating whether seasonal removal of the discharge to waters that are warmer than the criterion is feasible, the permit writer may also choose to gather information on keeping the watershed healthy as a whole that might influence the decision to get the effluent out of the river. Information may be obtained from the SEA Program, which has staff assigned to Watershed Planning Units in the state. Contacts for the planning units can be found at the following website:

http://www.ecy.wa.gov/watershed/pdf/wscontact_may_2010.pdf

Washington Department of Fish and Wildlife (WDFW)

Permit writers who are interested in gathering available fish habitat data for the area in the vicinity of the facility's discharge should contact the WDFW nearest them. Go to the WDFW website at http://wdfw.wa.gov/about/contact/ and scroll to Regional Offices or Field Facilities. Ask for the regional fish manager to obtain available information.

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Glossary

AKART - An acronym for "all known, available, and reasonable methods of prevention, control, and treatment." AKART shall represent the most current methodology that can be reasonably required for preventing, controlling, or abating the pollutants associated with a discharge. The concept of AKART applies to both point and nonpoint sources of pollution. The term "best management practices," typically applied to nonpoint source pollution controls is considered a subset of the AKART requirement.

Best management practice (BMP) - Permit condition used in place of or in conjunction with effluent limits to prevent the discharge of pollutants. May include schedules of activities, prohibitions, maintenance procedures, treatment requirements, and operating procedures.

Compliance schedule - A schedule of remedial measures included in a permit or an enforcement order, including an enforceable sequence of actions or operations leading to compliance with an effluent limitation, other limitation, prohibition, or standard.

Critical condition - The time during which the combination of receiving water and waste discharge conditions have the highest potential for causing toxicity in the receiving water environment. This situation usually occurs when the flow within a water body is low, thus, its ability to dilute effluent is reduced.

Dilution factor - A measure of the amount of mixing of effluent and receiving water that occurs at the boundary of the mixing zone. Expressed as the inverse of the effluent fraction e.g., a dilution factor of 16 means the effluent comprises 6.25% by volume and the receiving water 93.75% at the compliance boundary or volume restriction (DF = 1/.0625). The applicable dilution factor is the minimum of volume/volume fraction or effluent concentration at the distance boundary.

Effluent dependent stream - Discharge makes up all of the surface water flow during the critical season. (This would occur in streams with intermittent and ephemeral flows; however, nationally the greatest support for creative solutions is for those ephemeral waters.)

Effluent dominant stream - Discharge is much larger in volume than the receiving water at critical season. This would occur in streams with perennial flows, intermittent flows, and ephemeral flows.

Effluent limitation - Any restriction established by a permitting authority on quantities, rates, and concentrations of chemical, physical, biological pollutants discharged to waters of the state.

Ephemeral stream - flows only in direct response to precipitation. Water typically flows only during and shortly after large precipitation events. An ephemeral stream may or may not have a well-defined channel, the stream bed is always above the water table, and stormwater runoff is the primary source of water. An ephemeral stream typically lacks biological, hydrological, and physical characteristics commonly associated with the continuous or intermittent conveyance of water.

Hyporheic zone - The zone under and adjacent to the channel where stream water infiltrates, mixes with local and/or regional groundwater, and returns to the stream. The dimensions of the hyporheic zone are controlled by the distribution and characteristics of alluvial deposits and by hydraulic gradients between streams and local groundwater. It may be up to two to three feet deep in small streams, and is the site of both biological and chemical activity associated with stream function.

Interim limits - is an informal term for effluent limits that do not fully meet the water quality standards. Interim limits may be imposed while a discharger is collecting data or making physical changes to the facility that will bring it into compliance with the standards.

Intermittent stream - is a channel that contains water for only part of the year, typically during winter and spring when the stream bed may be below the water table and/or when snowmelt from surrounding uplands provides sustained flow. The channel may or may not be well-defined. The flow may vary greatly with stormwater runoff. An intermittent stream may lack the biological and hydrological characteristics commonly associated with the continuous conveyance of water.

Load allocation (LA) – Within a TMDL, the allocation for the nonpoint sources of a pollutant.

Perennial stream - contains water continuously during a year of normal rainfall, often with the stream bed located below the water table for most of the year. Groundwater supplies the baseflow for perennial streams, but flow is also supplemented by stormwater runoff and snowmelt. A perennial stream exhibits the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water.

Performance-based limits - A form of interim limit where effluent monitoring data are used to maintain the current quality (performance) of the discharge.

Non-conservative pollutant - Pollutants that are mitigated by natural biodegradation or other environmental decay or removal processes in the receiving stream after in-stream mixing and dilution have occurred.

Technology-based effluent limit - A permit limit for a pollutant, which is based on the capability of a treatment method to reduce the pollutant to a certain concentration.

Total maximum daily load (TMDL) – A determination of the amount of pollutant that a water body can receive and still meet water quality standards.

Wasteload allocation (WLA) – Within a TMDL, the allocation for point sources of a pollutant. For an individual water quality-based effluent limit, the WLA is the numeric water quality criteria times the dilution factor.

Water quality-based effluent Limit (WQBEL) - A permit limit for a pollutant that limits the concentration such that it will not cause a violation of water quality standards.

Appendix 1: Calculations for Effluent Limits

The following sections describe the calculations used to determine whether there is a reasonable potential to exceed temperature criteria in the receiving water. The spreadsheets for fresh and marine temperature in the most recent version of TSDCALC may be used to determine reasonable potential and effluent limits based on the maximum, supplemental, and incremental criteria. The permit writer may also need to evaluate acute conditions**.**

1.A.   Determining reasonable potential to exceed criteria

To determine reasonable potential for either the annual summer maximum or supplementary spawning criteria, calculate the temperature at the edge of the chronic mixing zone ($T_{chronic}$) during critical condition(s):

$$T_{chronic} = T_{ambient90} + (T_{effluent95} - T_{ambient90})/DF.$$

If $T_{chronic}$ is greater than the applicable criterion, an effluent limit is needed:

$$\text{Maximum Daily Effluent Limit} = T_{ambient90} + (\text{Criterion} - T_{ambient90})(DF)$$

Where:

$T_{chronic}$ = receiving water temperature at the chronic mixing zone boundary.
$T_{ambient90}$ = 90th percentile annual maximum 7-DADMax background temperature (or 1-DMax, whichever matches the criterion)*
$T_{effluent95}$ = 95th percentile 7DADMax (or 1-Dmax) effluent temperature.
DF = the dilution factor at the critical condition. It is equal to the monthly average effluent flow + critical condition stream flow divided by the monthly average effluent flow.

Criterion = the assigned threshold temperature criterion.

1.B.   Reasonable potential for naturally warm waters.

At locations and times when a threshold criterion is being exceeded due to natural conditions, all human sources, considered cumulatively, must not warm the water more than 0.3°C above the naturally warm condition [WAC 173-201A-200(1)(c)(i), and 210(1)(c)(i)].

If the ambient background temperature ($T_{ambient90}$) is warmer or within 0.3°C of the threshold criterion, and if $T_{chronic}$ is greater than $(T_{ambient90} + 0.3)$, a reasonable potential exists and an effluent limit is needed:

$$\text{Effluent Limit} = (\text{Criterion} - 0.3) + (DF)(0.3).$$

Where:

$$T_{chronic} = T_{ambient90} + (T_{effluent95} - T_{ambient90})/DF.$$

* For waters with supplemental spawning criteria, non-summer critical conditions will also need to be evaluated in early fall (e.g., 90th percentile October temperature) and/or the late spring (e.g., 90th percentile May temperature).

$T_{ambient90}$ = 90th percentile annual maximum 7-DADMax background temperature (or 1-DMax whichever matches the criterion)
$T_{effluent95}$ = 95th percentile 7DADMax (or 1-Dmax) effluent temperature.
DF = the dilution factor at the critical condition.
Criterion = the assigned threshold temperature criterion.

Example: a water body with a criterion of 16°C (7DADMax) and a dilution factor (DF) of 35 would require a 95th percentile maximum daily effluent temperature limit of 26.2°C.

Permit writers should use the temperature spreadsheet tools in the latest version of TSDcalc to make the above calculations.

The **default equation *(Criterion - 0.3) + (DF)(0.3)*** describes the condition where the incremental allowance for warming in relation to the background temperature is at a minimum for waters warmer than their established temperature criteria. As such, it represents a critical effluent temperature for complying with the water quality standards.

Effluent limits derived using this default equation will generally meet:

- Both the threshold and incremental warming criteria[†].
- Any eventual TMDL waste load allocations (WLA).

This approach also requires data only on effluent flow and stream flow at the summer critical condition to calculate the dilution factor. It is still necessary, however, to ensure that acutely harmful conditions do not occur (see subsection 2 below).

***Two-season alternative*:** One concern with using the default approach described above is that at times it may provide more protections than required.

In some situations it may be worth assessing the benefits of assigning effluent limits for both the wet and dry seasons. This approach may apply where the dry season **effluent** flow is lower than the wet season effluent flow. In such a case, a higher dilution factor may apply when you calculate an effluent limit for the critical dry season using the equation:

Effluent Limit = (Criterion – 0.3) + (DF)(0.3).

In this situation, you would use the 7Q20 river flow and the maximum monthly average effluent flow for the dry season to develop the dilution factor for the critical summer season. You would use the 7Q20 river flow and the maximum monthly average effluent flow for the wet season to develop the dilution factor for the wet season.

The approach described above uses only the difference between wet and dry season dilution rates to determine reasonable potential and set limits. It is also acceptable to develop dynamic limits using the critical effluent temperatures, dilution factors, and ambient

[†] This is true at any background temperature where the dilution factor is greater than 7.4 in waters with a 20ºC criterion, greater than 6.0 with an 18ºC criterion, greater than 5.2 with a 16ºC criterion, and greater than 3.5 with a 12ºC criterion.

temperatures for both the wet and dry seasons. While there is no single procedure for developing dynamic limits, it is important that you identify the critical conditions for each season and ensure that the discharger will meet all applicable temperature criteria in each season. Key elements to consider include:

- Use the highest 7-DADMax (or 1DMax depending on the criterion) effluent temperature for each season.
- Use the equation Effluent Limit = Criterion – 0.3 + (DF)(0.3) in dry seasons where the ambient temperature is warmer than the threshold criteria.
- Warming during the wet season must not exceed either the threshold criteria (annual maximum and any supplementary spawning), or the incremental warming allowance criteria (t’) when ambient temperatures are cooler than the numeric criteria.

1.C. Reasonable potential when waters are cooler

At times when the background ambient temperature is cooler than the assigned threshold criterion, point sources are permitted to warm the water by only a defined increment, *t*. Incremental temperature increases resulting from individual point source activities must not, at any time, exceed the equation below as measured at the edge of a mixing zone boundary. "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge. Calculate *t* as follows:

- *t = 28/(Tambient + 7) in freshwaters, or*
- *t = 12/(Tambient – 2) in marine waters.*

These warming increments are permitted only to the extent doing so does not cause temperatures to exceed either the annual maximum or supplemental spawning criteria. Therefore, the actual warming allowance (t’) is the lesser of:

- *t, or*
- *the ambient temperature minus the numeric criteria (except that 0.3ºC of warming is allowed even if the background temperature is within 0.3ºC of the criterion).*

An effluent limit is needed any time the ambient background temperature ($T_{ambient}$) is cooler than the assigned criterion and the temperature at the edge of the chronic mixing zone ($T_{chronic}$) is greater than ($T_{ambient}$ + *t’*):

Effluent Limit = $(T_{ambient}) + (DF)(t)$

Where:

$T_{chronic}$ = $T_{ambient} + (T_{effluent95} – T_{ambient})/DF)$
$T_{ambient}$ = background water temperatures colder than the threshold criterion.
$T_{effluent95}$ = 95th percentile 7DADMax (or 1-Dmax) effluent temperature.
t' = the allowable increment of warming to ambient waters.
DF = the dilution factor at the critical condition.

Permit writers should use the temperature spreadsheet tools in the latest version of TSDcalc to make the above calculations.

Selecting $T_{ambient}$: The incremental warming criteria apply at all ambient temperatures cooler than the maximum criterion. However, the warmest ambient temperature cooler than the established numeric criteria will typically be the critical background temperature for setting effluent limits. For an annual maximum criterion (12, 16. 17.5, 21ºC), the critical cooler temperature is generally 0.3ºC below the criterion. For a supplemental spawning temperature, the critical temperature is 0.3ºC below those seasonally applied criterion (9, 13ºC).

Permit writers should recognize that in cases where dilution factors are approximately 6 or less, an effluent limit derived for the critical mid-summer or supplemental period may cause a slight exceedance of the incremental allowance during the colder season (late fall or winter). This probability of exceedance depends on changes in dilution factor and effluent temperature from summer to winter. Ecology formulated the incremental restriction in the water quality standards to prevent a change of temperature regime in situations where the ambient temperature was well below the criteria. An incremental rise of 1 or 2 degrees is well within the normal daily fluctuation in mid-winter and will not cause a change in the temperature regime.

1.D. Criteria to prevent acutely harmful and lethal conditions

Permit limits must not allow detrimental acute effects (e.g., lethality, migration blockage). Criteria to prevent such effects are established in WAC 173-201A-200(1)(c)(vii).

Instantaneous Lethality to Passing Fish

The upper 99th percentile daily maximum effluent temperature must not exceed 33°C; unless a dilution analysis indicates ambient temperatures will not exceed 33°C within 2 seconds after discharge. If a discharger has conducted such a near-field dilution analysis, a reasonable potential exists if T_{2sec} is greater than 33°C:

$$T_{2sec} = T_{ambient90} + (T_{effluent99} - T_{ambient90})/(DF@2seconds).$$

Where:
T_{2sec} = plume temperature 2 seconds after discharge.
$T_{ambient90}$ = 90th percentile of annual maximum 1DMax background temperatures.
$T_{effluent99}$ = 99th percentile of maximum 1DMax effluent temperatures.
DF@2seconds = centerline dilution factor at 2 seconds of plume travel during a 7Q10 period.

Consistent with the *Water Quality Program Permit Writer's Manual*, use the 33°C criterion centerline for uni-directional waters and flux average for refluxing, or bi-directional waters such as estuarine-influenced rivers.

General lethality and migration blockage

Measurable (0.3°C) increases in temperature at the edge of a chronic mixing zone should not be allowed when the receiving water temperature exceeds either a 1DMax of 23°C or a 7DADMax of 22°C [e.g., (*Background of 24*°C*) + (Dilution Factor of 19)(0.3) = 29.7°C Effluent Limit*].

Lethality to incubating fish

Human actions must not cause a measurable (0.3°C) warming above 17.5°C at locations where eggs are incubating. A reasonable potential for lethality exists if $T_{spawning}$ is greater than 17.5°C:

$$T_{spawning} = T_{ambient90} + (T_{effluent99} - T_{ambient90})/(DF_{spawning}).$$

Where:

$T_{spawning}$ = the temperature at times and locations used for spawning.

$T_{ambient90}$ = 90th percentile of annual maximum 1-DMax background temperatures during first month of fall spawning or last month of spring spawning.

$T_{effluent99}$ = 99th percentile of maximum 1DMax effluent temperatures.

$DF_{spawning}$ = dilution factor at times and locations used for spawning.

You should apply this criterion with the assistance of local fish biologists if spawning is identified as a downstream concern.

A dilution analysis for the spawning period may be needed if redds occur within or adjacent to the chronic mixing zone, or if ambient temperatures exceed 17.5°C during the incubation period. However, you may not need to require a second dilution study where ambient flows increase prior to the incubation period. If you can determine compliance with the criterion using the dilution factor for the 7Q10 summer low flow and effluent and ambient temperatures for the spawning period, you can assume the discharge will meet the criterion.

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Appendix 2: Reducing Thermal Impacts from Discharges

2.A. *Cooling off-site (stream or influent cooling)*

- **Riparian Restoration –** restore native streamside vegetation to stabilize stream banks; fence streams to eliminate livestock; provide buffers for sediment and nutrient capture; and reduce solar gain in stream channel by maximizing shade on water surface. Fencing livestock prevents degradation of riparian corridor and sedimentation/nutrient loading.
  - *Benefits:* Modeling indicates this is very effective at temperature reduction; also decreases sediment and nutrient loading; improves DO and other water quality improvements.
  - *Disadvantages:* Generally, voluntary cooperation by landowners is needed. Takes years for vegetation to mature and provide full shade (after 20 years canopy density may be 60% of mature height/breath).

- **Temperature trading (pollutant trading) –** Pollutant trading or water quality offsets can be an option where a discharger can't meet criteria but even if they spent money at site to cool water, it would not make a difference downstream because of natural heating from solar and the natural conditions of that stream (i.e., lack or absence of a riparian area). In particular, the permit writer should consider allowing pollutant trading where costly remedies to cool water at the site would not result in cooler water downstream. Mitigation and restoration would provide better on the ground improvements to bring temperatures down and create a healthier habitat for fish (from a common sense, economic, and environmental perspective).

  Trading is based on the premise that different sources in a stream system can face very different costs to control the same pollutant. This mechanism allows facilities to meet regulatory obligations by purchasing equivalent or superior pollution reductions from another source -- achieving water quality improvements in a cost-effective manner. For example, cooperators (landowners or other dischargers) are identified upstream of the POTW that can reduce temperature of the receiving water body. If this temperature reduction is maintained throughout the system, the downstream discharger might find it easier to meet its temperature limit. Washington does not have a trading policy or a negotiator to assist in this process.

  The water quality standards at WAC 173-201A-450 contain provisions that must be met to use water quality offsets. If a discharger is interested in using offsets as part of its compliance with temperature standards, the permit writer should contact water quality standards staff at headquarters to assist them.

  EPA also allows pollutant trading to occur where it is found to be appropriate. Pollutant trading is a business-like way of helping to solve water quality problems by focusing on cost effective, local solutions to problems caused by pollutant discharges to surface waters. Pollutant trading is voluntary and allows parties to decide how to best reduce pollutant loadings within the limits of certain requirements. Trading becomes more attractive as pollutant sources face substantially higher pollutant reduction costs. Typically, pollutant trading has been used when a party facing relatively high pollutant reduction costs compensates another party to achieve an equivalent, though less costly, pollutant reduction. For more information, see guidance provided by the state of Idaho at:

http://www.deq.state.id.us/water/prog_issues/waste_water/pollutant_trading/pollutant_trading_guidance_entire.pdf

- *Benefits*: Could be effective for POTW that have limited other options; most effective when coupled with full shade to maintain upstream temperature reduction.
- *Disadvantages*: An unusual option, especially for small POTWs. Could be difficult to predict downstream temperatures. Would need a guarantee of continued cooperation from upstream participants.

- **Water rights trading –** partnering with one or more water right holder to leave water in the stream (or put allocated amount from groundwater to stream) in exchange for pre-treated water from the WWTP to be used for irrigation.
  - *Benefits:* would re-use water and keep water in stream. Could reduce nutrient load in stream. Best if coupled with full riparian shade between site of water right holder and treatment plant.
  - *Disadvantages*: May be difficult to get cooperators; could be hard to predict downstream temperatures. Would need a guarantee of continued cooperation from upstream participants.

- **Flow augmentation –** add sufficient quantity of water to stream (above outfall) from cool source that would both reduce stream temperature and increase flow. Usually water from a reservoir (lower strata) is used to augment flow.
  - *Benefits:* Predictable reduction of temperature in stream; increased stream flow and DO. Potentially better attainment of designed uses in critical period.
  - *Disadvantages:* Must have cool source of water and water right to use it. Takes time and effort to negotiate agreement.

Flow Augmentation Example from Oregon

TEMPERATURE changes associated with flow augmentation

Flow augmentation results in lower summer temperatures in the mainstream Tualatin River by several processes.

1. Flow augmentation during the summer is generally an input of cold water. This is because the intake structure in Scoggins Reservoir is located in the hypolimnion (the lower, colder layer of a thermally stratified water body).
2. Water released from the reservoirs increases the total mass of river water. When the same thermal load is imposed, a greater water mass will experience a smaller temperature increase than a smaller water mass.
3. Water released from the reservoirs increases the velocity of the river flow, which decreases the time the river water is exposed to solar insolation. This reduces the amount of solar energy received by the water.

Thermal budget explained:

http://www.deq.state.or.us/WQ/wqpermit/docs/individual/npdes/cws/tmp/appxb.pdf

- **Pretreatment (source control) -** Industrial sources that discharge to the municipal treatment plant pre-treats (in this case cool) their wastewater to a standard set by the receiving treatment plant. If the incoming waste water is cooler the final effluent will correspondingly be cooler. This method is only cost-effective when one or more large industrial facilities with warm effluent discharge into the collection system.
    - *Benefits*: Transfers burden of heat reduction on source rather than public facility. Creates predictable heat reduction in WWTP's effluent.
    - *Disadvantages:* Could be prohibitive for commercial/industrial facilities due to costs or logistics; not feasible for individual households. Costs for WWTP are to identify and educate potential pretreatment customers.

2.B. Cool effluent on-site

- **Shade/cover for clarifier and/or conveyances –** metal, fabric, or fiberglass cover for clarifiers in areas of high solar gain. Vegetated shade can be used in lieu or in addition to manufactured cover. Some fabric shades (or sails) are available. For new construction or significant upgrades, the operator may consider placing clarifiers below grade to use the coolness of the earth to keep effluent cool. This could also minimize surface area needed by building deeper tanks.
    - *Benefits:* Inexpensive; reduces algae growth and odor issues.
    - *Disadvantages:* Not predictable temperature reduction. If clarifier enclosed with no overhead shade it may act as a solar collector.

- **Aeration/spray cooling –** evaporative cooling from aeration device in clarifiers or ponds; minimal temperature decrease during hottest time period; most effective when sufficient difference between air and effluent temperature.
    - *Benefits:* Can provide minimal cooling through evaporation; reduces algae growth; increases DO concentrations. Inexpensive to purchase and operate.
    - *Disadvantages*: Must maintain mechanical devices; water lost to evaporation also loss to in-stream flow

- **Chillers –** Mechanical cooling using refrigeration technology. Transfers heat from the effluent to the refrigerant loop of the chiller station.
    - *Benefits:* Very dependable temperature reduction; has small footprint, thus may be suitable for facilities with in-stream flow issues that have no land for other cooling systems or partners for water reuse.
    - *Disadvantages:* One of the most equipment- and energy-intensive options; should exhaust other options before choosing a chiller.

- **Cooling towers -** Contained unit that uses cooler ambient air temperature to reduce effluent temperature through evaporation. Operates best in low humidity with difference in air/effluent temperature of 10°C.

- *Benefits:* Uncomplicated and easy to operate. Dependable temperature reduction; has small footprint, thus may be suitable for facilities with in-stream flow issues that have no land for other cooling systems or partners for water reuse.
- *Disadvantages:* Capital expense is moderate to high. Operational and maintenance costs are high (power usage and costly to clean).

- **Multiple port diffusers –** Discharge pipe(s) in stream has multiple orifices; that allows faster mixing. Most effective for large mixing zones with minimal temperature reduction needed.
    - *Benefits:* Inexpensive; no major plant modifications required thus minimal investment for WWTP.
    - *Disadvantages:* Not appropriate in areas with small to no mixing zone; difficult to clean diffuser heads.

- **Effluent blending –** Addition of cooler water from groundwater or storage to the effluent prior to discharge to reduce discharge temperature to permit limit. Can be used in areas where other technologies not feasible; can be applied seasonally and in low flow situations.
    - *Benefits:* Can be used when other technologies not feasible; predictable reduction of temperature in stream; increased stream flow and DO. Potentially better attainment of designed uses in critical period.
    - *Disadvantages*: Must have cool source of water; must have water right for blending water.

- **Geothermal loop** - Enclosed network of pipes installed underground (preferably in groundwater); when effluent water pumped through the system cooler the subsurface temperature (or groundwater) reduces effluent temperature. Enclosed loop could be submerged in or under constructed pond.
    - *Benefits:* Effective cooling; maintains in-stream flow; once constructed, low maintenance cost.
    - *Disadvantages:* Must have property to construct; substantial structural investment.

- **Non-contact cooling –** Pump cool river or ground water in enclosed pipes that circulates in effluent or around conveyance pipe. Returns cooling water to source.
    - *Benefits:* Maintains in-stream flow; once constructed, low maintenance cost.
    - *Disadvantages:* Must have source of cool water; cooling water warms as effluent temperatures are reduced - that impact would need to be evaluated.

- **Stepped Discharges –** Structure that allows water to cascade over steps or riprap before entering receiving water. To be useful for temperature reduction, cascading water must be in shade.

- *Benefits:* More often used to increase dissolved oxygen; inexpensive and uncomplicated.
- *Disadvantages:* Unpredictable temperature reduction - effectiveness has not been studied.

2.C. Remove discharge from stream (either seasonally or permanently)

- **Store discharge in reservoir** (covered or uncovered) – store discharge during critical season; release water in cooler season. Storage area must be able to accommodate discharge volume and can be above or below grade.
    - *Benefits:* Once constructed, low operation and maintenance costs.
    - *Disadvantages:* Must have land to construct ponds. To avoid excessive algae growth should use aeration and control waterfowl usage

- **Constructed wetlands** – Although a fairly new methodology for temperature reductions, constructed wetlands are considered a potential treatment for reducing effluent temperatures. Deep, narrow channels with maximum tree canopy are the most effective for temperature reduction. Wetlands can have an outlet to a receiving water or infiltrate to groundwater. Evaporative cooling can also occur.

    In 2010, construction recently began on what is being considered the first constructed wetlands project in the United States designed to cool treated wastewater from municipal and industrial sources. The municipal wastewater will come from Albany-Millersburg Water Reclamation Facility, which serves the Oregon cities of Albany and Millersburg. The primary driver for the project was a temperature TMDL done by Oregon Department of Environmental Quality in 2006 for the Willamette River basin. For more details see publication in Civil Engineering, June 2010, *Environmental Engineering: Constructed Wetlands Will Cool Blend of Municipal, Industrial Wastewater.*

    Benefits and disadvantages of constructed wetlands include:

    - *Benefits:* Predictive models show cooling could be 2 to 5° F. Wetlands can be effective in heavy metal removal, also provides nutrient and sediment removal (from vegetative growth) and wildlife habitat. This option has no to minimal energy consumptive needs for operation. Effective when coupled with hyporheic infiltration.
    - *Disadvantages:* Must have land to construct an adequately sized wetland to handle the volume of discharge; this option may be most viable for small POTWs that own or have ‘inexpensive’ land available. Minimal empirical data on temperature reductions possible (see Table 6.7). If infiltration expected, effluent must meet groundwater standards; significant quantity of water may be lost to evaporation, in which case a water rights issue may be triggered.

TABLE 6.7
Reduction of Temperature through Free Water Surface Constructed Wetlands at Sacramento County, California, and Mt. Angel, Oregon

	Sacramento County, California			Mt. Angel, Oregon		
Month	In[a] (°F)	Out (°F)	Reduction (°F)	In[b] (°F)	Out (°F)	Reduction (°F)
January	57.7	48.0	9.7	45.3	44.2	1.1
February	62.4	51.3	11.1	50.2	50.4	–0.2
March	59.0	55.6	3.4	53.5	52.4	1.1
April	64.9	61.1	3.8	63.3	60.9	2.4
May	67.5	59.9	7.6	67.0	62.5	4.5
June	72.1	71.8	0.3	72.8	68.0	4.8
July	74.8	73.6	1.2	73.7	69.1	4.6
August	78.4	72.7	5.7	73.1	66.9	6.2
September	76.1	68.5	7.6	70.3	64.5	5.8
October	64.2	58.6	5.6	59.5	55.9	3.6
November	60.6	57.2	3.4	52.2	50.6	1.6
December	56.3	50.2	6.1	48.4	47.5	0.9
Average	—	—	5.5	—	—	3.0

[a] Five-year average 1994 to 1998 (Nolte Associates, 1999).
[b] Four-year average 1999 to 2002 (City of Mt. Angel, Oregon).

Above table from: Ronald W. Crites, Sherwood C. Reed, E. Joe Middlebrooks. "Natural Wastewater Treatment Systems", CRC Press. 2006 P 276

- **Reclamation and reuse** - Apply treated effluent to landscape or agricultural areas during growing season. When land is available, water could be stored in wet season to be applied in dry months. Reclaimed water sent to landscaping or agriculture use replaces surface or groundwater that would have been used.
  - *Benefits:* Once negotiated with partner(s) and conveyance constructed low operation and maintenance costs. Vegetation can update some nutrients in effluent.
  - *Disadvantages:* Must have partner(s) to receive water. Water must be treated to meet partner(s) needs. Will remove water from stream during growing season; not possible when there is an in-stream flow issue.

- **Infiltration ponds or trenches** – Treated discharge diverted to pond or lagoon in soils/substrate that is uniform, non saturated and porous. Groundwater table must be deep; sites not designed for wellhead protection zones or sole source aquifers. Ponds operate best if basin absorbs standing water and then ‘rests’ before reapplication of discharge.

- *Benefits*: Simple design, low construction and operational costs; recharges groundwater.
- *Disadvantages:* Must have land to construct ponds and appropriate soil type. Effluent must meet groundwater standards; not possible when there is an in-stream flow issue.

- **Hyporheic injection** - Inject treated effluent to hyporheic zone to cool then discharge to groundwater and stream. Works best in conjunction with stream bank and floodplain restoration. Hyporheic zone must have adequate storage capacity and cooling potential for effluent.
  - *Benefits:* Recharges groundwater and stream. Should not have conflict with in-stream flow.
  - *Disadvantages:* Would require detailed engineering reports and modeling to understand the site specific streambed morphology and surface/ground water interaction. Method probably not suitable for salmonid spawning areas. Must have land to construct injection ‘wells’; effluent must meet groundwater standards.

- **Move discharge location –** Discharge into adjoining water body that does not have temperature or flow issues and the temperature limit could be met.
  - *Benefits:* Would keep the water in the same stream system assuming the tributaries flowed to the same downstream water body.
  - *Disadvantages:* There are probably very limited circumstances where an adjacent water body would meet the criteria and the receiving water would not. Would require reconfiguring the discharge location so would involve expenses to reengineer.

2.D. Other considerations for effluent discharges

When controlling effluent temperature outputs, permit writers should not promote the mixing of the effluent with receiving water. Instead, they should advise the operator to try to maintain the temperature gradient within the receiving water by keeping the warmer water on the top and cooler water near the bottom, as well as the gradient between the air and water surface. Maintaining these gradients promotes higher rates of cooling, and lessens the impact on the flora/fauna of the receiving stream that are distributed, in part, by the temperature gradient of the receiving water.

It is understood that this BMP (i.e., not promoting mixing) is in conflict with how outfalls are generally designed; maximize mixing to reduce the toxicity of pollutants. Unfortunately, outfall design and construction has traditionally been done based on our efforts to lessen the impacts of the 'low hanging fruit' pollutants; chlorine, ammonia, BOD; 'stuff' that is within the water. Now that standards are requiring stringent controls on temperature, which is a property of water due to thermal energy, a different approach may be needed as it relates to how the effluent is discharged.

Appendix 3: Factors Affecting Temperature Control Options

Temperature Control Options identified in Appendix 2 are further rated for cost, relative effectiveness, and other key factors.

✓ cost, effectiveness and/or acceptance of treatment option increases with number of checks
⭘ requires land to construct and maintain cooling option
? unknown or uncertain

3.A. Cooling off-site (stream or effluent cooling)

Limitations for most/ all: Cooperation needed from off-site landowners or operators

Treatment Option	Relative Cost	Relative Effectiveness	Potential Water Right Issue	Need partner(s)	Examples in WA
Riparian Restoration	✓✓✓	✓✓✓✓✓	*NO*	*YES*	*Numerous; most commonly used method*
Pollutant Trading (Water Quality Offsets)	?	✓✓✓✓	*NO*	*YES*	*None in WA*
Water rights trading	✓✓✓✓?	✓✓✓✓?	*YES*	*YES*	*None in WA*
Flow Augmentation	?	✓✓✓✓	*YES*	*YES*	*None in WA*
Industrial Pretreatment	✓	✓✓✓✓✓	*NO*	*YES*	*None reported by Temperature Work Group*

3.B. Cool effluent on-site

Limitations for most/ all: Assess cost/benefit

Treatment Option	Relative Cost	Relative Effectiveness	Potential Water Right Issue	Need partner(s)	Examples in WA
Shade/cover for Clarifier	✓	✓✓✓	*NO*	*NO*	*None reported by Temperature Work Group*
Aeration/Spray cooling	✓✓	✓✓	*NO*	*NO*	*SEH America (Vancouver); Granite Falls POTW;* *Tree Top Plant (Cashmere)*
Chillers	✓✓✓✓✓✓	✓	*NO*	*NO*	*McCleary POTW;* *Kemira Chemical (Washougal)*

3.B. Cool effluent on-site cont'd

Cooling Towers	✓✓✓✓✓	✓✓	*NO*	*NO*	*Larch Correction Center; Cedar Creek Corrections Ctr.; ConAgra Foods (Prosser); West Far, Foods (Sunnyside); Quincy Industrial (Quincy)*
Multiple Port Diffusers	✓✓	?	*NO*	*NO*	*Centralia POTW; Cashmere POTW*
Effluent Blending	?	✓✓✓✓✓	*YES*	*YES*	*Darigold (Issaquah)*
Geothermal Loop ⭘	✓✓✓✓✓	✓✓✓✓✓	*NO*	*NO*	*Washington State Penitentiary*
Non-contact cooling	✓✓✓	?	*?*	*NO*	*ChemTrade (Kalama) Great Western Malting (Vancouver)*
Stepped Discharges ⭘	✓✓	✓	*NO*	*NO*	*Goldendale POTW; ConAgra Foods (Prosser)*

3.C. Remove discharge from stream *(Either seasonally or permanently)*

Limitations for most/ all: Must have property to construct structure, in-stream flow issues; must meet groundwater standards; Assess cost/benefit.

Treatment Option	Relative Cost	Relative Effectiveness	Potential Water Right Issue	Need partner(s)	Examples in WA
Store in covered or uncovered reservoir ⭘	✓✓✓✓	✓✓✓✓	*YES*	*NO*	*None reported by Temperature Work Group*
Constructed Wetlands (with outlet or infiltration) ⭘	✓✓✓✓	✓✓	*?*	*NO*	*Carnation WWTP; Freeman School District; Yelm POTW Cowiche POTW (no longer used), Albany-Millersburg Water Reclamation Facility (Oregon)*
Reclamation and Reuse	✓✓✓✓	✓✓✓✓✓✓	*YES*	*YES*	*Lake Wenatchee POTW; ConAgra (Richland); WA Correction Center (Shelton); Yelm POTW; Olympic Correction Center; Walla Walla POW; LOTT (Olympia); Connell POTW; Chehalis POTW; Conconully POTW; Medical Lake POTW*
Infiltration ponds or trenches⭘	✓✓✓✓	✓✓✓✓	*?*	*NO*	*None reported by Temperature Work Group*
Hyporheic Injection ⭘	✓✓✓✓	✓✓✓✓	*?*	*NO*	*** Arlington WWTP; Dallesport WWTP*
Bioswale	✓✓	✓	*YES*	*NO*	*Dickey Farms (Bingen)*
Move discharge location ⭘	✓✓✓✓✓✓	*??*	***?***	***?***	*BBA nonwovens (Washougal)*