NORTHWEST ENVIRONMENTAL ADVOCATES

July 26, 2013

Dan Opalski, Director
Christine Psyk, Associate Director
Office of Water and Watersheds
U.S. Environmental Protection Agency, Region X
1200 S.W. Sixth Ave. *Via e-mail only*: opalski.dan@epa.gov
Seattle, WA 98101 *Via e-mail only*: psyk.christine@epa.gov

Re: **Use of Hyporheic Flows for the Cooling of Thermal Discharges**

Dear Dan and Christine:

In the development of temperature standards in Oregon, dating back to the 1992-94 triennial review, one driving concern has always been that the standards not lead to "unintended consequences." This concern about unintended consequences pertained to the standards' impacts on permitted discharges and, specifically, sought to avoid dischargers' having to use energy-intensive chillers to cool effluent prior to discharge. Northwest Environmental Advocates (NWEA) has always agreed with both the basic principle that unintended consequences should be anticipated and avoided and that the temperature standards should be designed so as to obviate driving the use of chillers. This position is consistent with our belief that although point sources must take responsibility for their thermal discharges, they are even at their worst merely an insult to the injury caused primarily and extensively by widespread and uncontrolled nonpoint sources.

It is, however, becoming increasingly clear that as permitted sources seek alternatives to the use of chillers they are also at risk of causing their own host of unintended consequences to waters that EPA has specifically called out for special protective treatment. Namely, permitted sources are evaluating the prospect of discharging their effluent into hyporheic zones. As you know, hyporheic zones have been identified by EPA and others as critically important to moderating stream temperatures and providing thermal refugia, in stream nutrient cycling, and in creating unique habitats within streams. NWEA is therefore concerned that using these irreplaceable and important habitats as discharge zones will be harmful to the very designated uses and environment the water quality standards for temperature are intended to protect. Using these areas as discharge points will harm the biota living within the hyporheic zones and further push threatened and endangered cold-water species which depend upon naturally functioning stream ecology towards extinction.

Even so, some dischargers in Oregon, such as the Roseburg Urban Sanitary Authority (RUSA), are already using hyporheic zones for discharge and others are actively evaluating this option, including, for example, the City of Corvallis which is investigating the use of the Orleans Natural Area, having concluded that groundwater at the site is hydrologically connected to the

Willamette River.[1] We have heard of others contemplating this option as well, which is entirely logical considering that the Oregon Department of Environmental Quality (DEQ) is actively encouraging the approach, as discussed below. Understanding that the EPA Region is currently considering various matters related to temperature standards, we can think of no better time for EPA to evaluate the use of hyporheic zones as discharge points. If, as we believe, these sites are better used – indeed essential – as thermal refugia to support salmonid survival both now and in the future, and are deserving of protection for the ecological role they play, temperature standards and permitting policies in Oregon and other Northwest states should reflect that conclusion. If EPA believes instead that, in some circumstances, hyporheic zones can be disregarded in their role as thermal refugia and used alternatively as underground mixing zones, now would be an appropriate time for the agency to explain its rationale and provide guidance to the states on the limitations of that use. In doing so, we hope that EPA would consider the environmental benefits to alternative approaches for dischargers to take responsibility for their thermal loads, such as riparian restoration, flow augmentation, and reestablishing connectivity. In other words, the choice is never limited to hyporheic injection or chillers.

This letter discusses the physical, chemical, and biological role played by hyporheic zones. As an initial matter it is worth noting that many regulatory documents seem to focus on a single aspect, ignoring all others. For example, the DEQ guidance document discussed below is utterly silent on the biota inhabiting hyporheic zones as if, indeed, there were none. The EPA guidance on thermal refugia that heavily emphasizes hyporheic zones does not mention anywhere that some states are considering using them for the purpose of cooling effluent prior to its reaching the surface water. This rather disjointed view of hyporheic zones – including their identification, their ecological role, their restoration and/or protection – has set the stage for what NWEA and others consider some very poor decision making on the part of both dischargers and regulators.

For this reason, this letter begins in Section I by reviewing federal and state agency treatment of hyporheic flows in various regulatory and guidance documents. Section II discusses the physics of hyporheic flows. Section III discusses the role of hyporheic flows in supporting chemical attributes of streams and biota that depend upon them, including salmonids. Finally, Section IV discusses some of the regulatory challenges associated with permitting discharges into hyporheic flows.

I. <u>The Importance of Hyporheic Flows as Thermal Refugia in Protecting Cold-Water Species Under the Clean Water Act</u>

Protecting and restoring thermal refugia has been considered an essential part of Oregon's water quality standards and its approach to protecting water quality for threatened and endangered salmonids since the early 1990s. The refugia concept was included in the 1992-1994 triennial review of temperature standards, ultimately submitted to EPA in 1996, and was intended to result in documentation of the current baseline condition of "important cold-stream reaches" and their

---

[1] Kennedy/Jenks, Orleans Natural Area Subsurface Investigation Results City of Corvallis East Alternative TMDL, March 11, 2013 at 5 ("the underlying coarse sand and gravel of the Willamette River floodplain deposits at the site are highly conducive to large rates of infiltration and subsequent subsurface discharge to the Willamette River.").

subsequent designation as a "cold-water refuge segment."[2] Even so, it took EPA until 2012 – two decades from the early days of this discussion – to issue guidance on identifying thermal refugia, guidance that, while helpful, falls well short of providing a regulatory pathway to protecting these essential features. Yet, during this period, EPA has enthusiastically approved numerous Total Maximum Daily Loads (TMDLs) in which purportedly natural temperatures ranging up to 32.5°C (90°F) have been established for Oregon waters through the now-vacated Natural Conditions Criterion (NCC) with no requirement that cold water refugia be likewise established to ensure protection of cold-water species.

A. EPA Direction on the Importance of Protecting Thermal Refugia

EPA Region X has provided guidance to Northwest states in three major documents: its 2003 regional temperature guidance, its 2003 proposed federal promulgation of temperature standards for Oregon, and its 2012 guidance on the identification and protection of thermal refugia. All of these documents have emphasized the thermal refugia benefits of hyporheic zones for salmonids, putting aside their role in stream ecology and the non-salmonid beneficial uses that depend upon them. None of these documents, however, has contemplated eradicating the ecological benefits of hyporheic zones by virtue of their being used to receive heated effluent.

1. ***EPA Region 10 Guidance For Pacific Northwest State and Tribal Temperature Water Quality Standards***

EPA issued its *EPA Region 10 Guidance For Pacific Northwest State and Tribal Temperature Water Quality Standards* (hereinafter "Regional Guidance") in 2003.[3] The Regional Guidance notes that human activities can have an adverse effect on stream ecology by "eliminating or reducing the amount of groundwater flow which moderates temperatures and provides cold water refugia."[4] Specifically, EPA notes that dams and their reservoirs, along with channeling, straightening, and diking rivers, reduce or eliminate cool groundwater that moderates summer temperatures of rivers including hyporheic flow which is otherwise "plentiful in fully functioning alluvial rivers systems."[5] As a consequence, the Regional Guidance places an appreciable benefit on the presence of thermal refugia:

> Although some altered rivers, such as the Columbia and Snake, experience similar summer maximum temperatures today as they did historically, there is a big difference between the temperatures that fish experience today versus what they likely experienced historically. Unaltered rivers generally had a high degree of

---

[2] DEQ, Temperature: 1992-1994 Water Quality Standards Review, Final Issue Paper, June 1995 at 3-10.

[3] EPA Region 10 Guidance For Pacific Northwest State and Tribal Temperature Water Quality Standards, April 2003 available at http://www.epa.gov/region10/pdf/water/final_temperature_guidance_2003.pdf.

[4] *Id*. at 6.

[5] *Id*. at 6-7.

> spatial and temporal temperature diversity, with portions of the river or time periods that were colder than the maximum river temperatures. These cold portions or time periods in an otherwise warm river provide salmonids cold water refugia to tolerate such situations. The loss of this temperature diversity may be as significant to salmon and trout in the Columbia and Snake Rivers and their major tributaries as maximum temperatures. Therefore, *protection and restoration of temperature diversity is likely critical* in order for salmonids to migrate through these waters with minimal thermal stress.[6]

In its guidance, EPA singles out hyporheic flows as among the most important of these "critical" thermal refugia:

> The areas where relatively cold tributaries join the mainstem river and where groundwater exchanges with the river flow (hyporheic flow) are two critical areas that provide cold water refugia for salmonids to escape maximum temperatures. As described in Issue Paper 3 and the Return to the River report (2000), alluvial floodplains with a high level of groundwater exchange historically provided high quality habitat that served as cold water refugia during the summer for large rivers in the Columbia River basin (and other rivers of the Pacific Northwest). These alluvial reaches are interspersed between bedrock canyons and are like beads on a string along the river continuum. Today, most of the alluvial floodplains are either flooded by dams, altered through diking and channelization, or lack sufficient water to function as refugia. Efforts to restore these alluvial river functions and maintain or cool down tributary flows will probably be critical to protect this use.[7]

The Regional Guidance focuses solely on providing protection for, and potentially restoration of, thermal refugia, without discussing the use of thermal refugia as discharge injection zones:

> As noted above, EPA recommends that States and Tribes include a natural thermal regime narrative provision to accompany the 20°C numeric criterion. If a State or Tribe chooses to do so, TMDL allocations would reflect the protection, and where feasible, the restoration of the cold water refugia and other aspects of the natural thermal regime described above. If it is impracticable to quantify allocations to restore the natural thermal regime in the TMDL load allocations, then the TMDL assessment document should qualitatively address the human impacts that alter the thermal regime. Plans to implement the TMDL (e.g., watershed restoration plans) should include measures to restore the potential areas of cold water refugia and the natural daily and seasonal temperature patterns.[8]

Moreover, due to the importance of thermal refugia where states, such as Oregon, established standards allowing them to substitute superseding temperatures that purportedly model "natural

---

[6] *Id.* at 30 (emphasis added).

[7] *Id.*

[8] *Id.*

conditions" for otherwise applicable numeric criteria, EPA's Regional Guidance directed states to use TMDLs to assess thermal refugia:

> When using natural background maximum temperatures as TMDL targets and to set TMDL allocations, the TMDL assessment document should assess other aspects of the natural thermal regime including the spatial extent of cold water refugia . . . . Findings from this assessment should be integrated into the TMDL and its allocations to the extent possible. For example, if possible, TMDL allocations should incorporate restoration of the diurnal and seasonal temperature regime and cold water refugia that reflect the natural condition. If it is impracticable to address these impacts quantitatively through allocations, then the TMDL assessment document should qualitatively discuss the human activities that modify these aspects of the natural thermal regime. Plans to implement the TMDL should include measures to restore and protect these unique aspects of the natural condition.[9]

Despite recognizing the importance of hyporheic flow to achieving natural thermal regimes, EPA recognized as well that models, used in the development of TMDLs, purporting to identify natural thermal potential cannot capture the human impacts to reductions in hyporheic flow:

> When estimating natural background conditions, States and Tribes should use the best available scientific information and the techniques described[.] For TMDLs, this usually includes temperature models. Those human impacts that cannot be captured in a model (e.g., loss of cooling due to loss of hyporheic flow, which is water that moves between the stream and the underlying streambed gravels) should be identified in the TMDL assessment document (i.e., supporting material to the TMDL itself) along with rough or qualitative estimates of their contribution to elevated water temperatures. Estimates of natural conditions should also be revisited periodically as our understanding of the natural system and temperature modeling techniques advance.[10]
>
> EPA believes it is particularly important for the TMDL itself or the TMDL assessment document to address the above aspects of the natural thermal regime for waterbodies where the natural background maximum 7DADM temperature exceeds 18°C and where the river has significant hydrologic alterations (e.g., dams and reservoirs, water withdrawals, and/or significant river channelization) that have resulted in the loss of temperature diversity in the river or shifted the natural temperature pattern. For example, there may be situations where the natural background maximum temperatures exceed 18°C, but historically the exposure time to maximum temperatures was limited due to the comparatively few number of hours in a day that the water reached these temperatures, the comparatively few number of days that reached these temperatures, and plentiful

---

9 *Id.* at 38. It is worth noting that EPA's "shoulds" in this guidance have been widely ignored and Oregon TMDLs do not, in fact, address thermal refugia other than to point out their importance.

10 *Id.* at 37.

> cold water refugia from cold tributary flows and hyporheic flow in alluvial floodplains where salmonids could avoid the maximum water temperatures.[11]

Focused as it was on the difficulty of identifying and restoring natural thermal regimes including hyporheic flows, EPA's Regional Guidance never once addressed the issue of NPDES permittees' discharging into the very hyporheic flows that it had singled out for special protections in a world where current conditions and those in the foreseeable future would remain inhospitable to threatened and endangered cold-water species.

2. ***EPA Proposed Federal Water Quality Standards for Oregon***

In 2003, EPA issued proposed rules for Oregon's water quality standards for temperature. While not finalized, these rules demonstrate the central role EPA thought thermal refugia need to play in Northwest states' temperature standards.[12] In addition to requiring "well-distributed cold water refugia" for waters meeting the 20°C Salmon and Steelhead Migration criterion,[13] EPA's proposed rules also required well-distributed cold water refugia wherever the rule's proposed natural conditions criterion allowed estimated natural conditions to supersede otherwise applicable numeric criteria over 20°C in order to "allow salmon and steelhead to migrate through a river segment or rear without significant adverse effects from high water temperatures."[14] Likewise, the proposed federal rule prohibited thermal plumes from increasing the temperature of thermal refugia by more than 0.3°C.[15] In this proposed rule, EPA described cold water refugia as resulting from "cold tributaries and cooler groundwater flow entering into a warmer river." EPA noted that the narrative refugia requirement was likely essential to the protectiveness of the 20°C criterion because "information in the record indicates that many sublethal effects could occur without cooler nighttime temperatures or portions of the river that are cooler during the day, rendering the numeric criterion of 20°C/68°F alone unprotective of the designated use."[16] These sublethal effects included "increased disease and decreased swimming performance in adults, and increased disease, impaired smoltification, reduced growth, and increased predation for late emigrating juveniles."[17]

---

[11] *Id.* at 38. Whereas EPA's Regional Guidance states that thermal refugia should be included where purportedly natural thermal temperatures exceed 19° C, EPA approved Oregon's standards that do not include such a requirement. Accordingly, Oregon's TMDLs have not addressed the need for thermal refugia when numeric temperature criteria are superseded by the NCC, including temperatures ranging well over 20° C.

[12] 68 Fed. Reg. 58758 (October 10, 2003).

[13] Proposed C.F.R. § 131.39(d)(1), 68 Fed. Reg. 58788.

[14] Proposed 40 C.F.R. § 131.39(d)(1), 68 Fed. Reg. 58772, 58788.

[15] Proposed C.F.R. § 131.39(e)(2)(v), 68 Fed. Reg. 58788.

[16] 68 Fed. Reg. 58771.

[17] *Id.*

EPA concluded that, as a practical matter, the provision would be implemented during the establishment of a TMDL when

> the State or EPA would identify the existing cold water refugia and determine whether or not they were sufficient to protect the use. Existing cold water refugia would be identified in the TMDL and the existing temperatures of the cold water refugia would be the applicable numeric criteria for those water segments. Thus, the TMDL would be the document where the narrative cold water refugia criteria is translated into numeric terms. If the existing cold water refugia were insufficient to protect the use, then additional cold water refugia sufficient to protect the use would also be identified and expressed in numeric terms in the TMDL. Depending on how the TMDL is structured, the expression of cold water refugia in numeric terms might also occur during the development of watershed plans to implement the TMDL rather than in the TMDL itself. In addition, the watershed plans may contain measures to protect and restore the cold water refugia.[18]

EPA also included in its proposed rule that in the future, when the waterbody was assessed for attainment of the criteria, the status of thermal refugia would likewise require assessment.[19] Again, it must be pointed out that EPA has approved Oregon TMDLs and never held them to any such standard with regard to their treatment of existing or needed thermal refugia.

3. ***Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes***

Approximately a decade after opining on the importance of cold water refugia for any waters designated for temperatures over 19° C, Region X issued its guidance for cold water refugia, a *Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes* (hereinafter "Primer").[20] The Primer highlights the importance of refugia by noting that "[f]ish are capable of detecting differences in temperature of <0.1°C and respond to these fine-scale differences in both space and time by moving to areas that are more favorable."[21] Despite EPA's position set out in both the Regional Guidance and the proposed federal rule that natural conditions determinations exceeding 18-19° C require thermal refugia, the Primer limits its discussion to those rivers Oregon designated as migration corridors for salmon and trout, e.g., the lower 80 km of the Willamette River, with no mention of the superseding temperatures established by TMDLs' implementing the NCC.

---

[18] *Id.*

[19] *Id.* EPA also required that wasteload allocations to protect existing or new cold water refugia would be incorporated into NPDES permits. *Id.*

[20] EPA, Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes, February 2012.

[21] *Id*. at 6

The Primer describes identification of refugia at the basin, subbasin, segment, reach, channel unit, and microhabitat scale. It describes the role of hyporheic flow in the context of reaches:

> Floodplain connectivity in alluvial valleys with high sinuosity, multiple subsurface pathways, and alluvial fans with glacial meltwater can create thermal diversity at a reach scale, but studies that have investigated how these areas may be used as cold-water refuges are rare. Reach-scale studies of fish and groundwater, hyporheic and surface-water exchange primarily have focused on spawning site selection by salmonids where upwelling creates warm-water refuges for eggs and fry in the winter. [22]

Despite the long wait for this guidance and the importance placed by EPA on thermal refugia, the Primer's objectives apparently do not include identifying the regulatory methods for designating, protecting, and restoring refugia.[23] The Primer describes at length the various technical tools to identify refugia but fails to explain how a state will designate, protect, or restore them. Section 7 of the Primer is titled "Protection and restoration" but it does not say anything more than "a conceptual framework is needed," "restoration will require consideration of cold-water refuges within a broad context," advances in prediction capacity "will continue to make it easier for scientists to provide the kind of information that managers need to make informed decisions," and that the document "will lead to more discussions between scientists and mangers about the complexity of river systems."[24] In other words, the Primer does not advance the actual regulatory framework that might and should be associated with protecting and developing thermal refugia. Specifically, in a conceptual model set out in the Primer that outlines the steps for assessing, protecting, and restoring refugia, EPA offers nothing whatsoever by way of explaining how a state will meet the goal to "protect and maintain key structures and functions identified" or to "rehabilitate structure and function of refuges."[25] Despite EPA's desire to rely on thermal refugia in the regulatory context, after all these years EPA has yet to get beyond such platitudes.

Even so, in this section of the Primer, EPA stresses the importance of thermal refugia and, specifically of hyporheic flows, particularly in light of the pressures of climate change on stream temperatures:

> By reconnecting the river with the floodplain and restoring riparian vegetation, potential hydrologic processes that create thermal heterogeneity may be restored. This integrated approach certainly *will be required to address the challenges posed by climate change*, which will put additional constraints on the capacity of rivers to maintain the processes that create thermal diversity.[26]

---

[22] *Id*. at 17 (internal citation omitted).

[23] *Id*. at 4.

[24] *Id*. at 21-22.

[25] *Id*. at 57, Figure 7.1.1.

[26] *Id*. at 22 (emphasis added).

EPA emphasizes that the reestablishment of riparian vegetation – itself both essential to restoring "historic" river temperatures and unlikely to happen any time in the near future – is merely the beginning of attempting to restore hyporheic flows:

> To effectively restore the hydrologic processes that create thermal diversity, manipulation of entire riverine landscapes may be required, experimentation not just of distinct reaches or channel units. Hyporheic processes occur laterally, longitudinally, and vertically and do not have easily defined boundaries. Thus, active approaches to restoring these processes by installing instream structures and engineering new channels may be difficult to apply and test in the field. When passive restoration and reestablishment of riparian vegetation are not enough to reconnect the river with the floodplain, re-engineering may be used as an experiment, with monitoring in place to adapt the approach as needed.[27]

B. Thermal Refugia and Oregon's Water Quality Standards

As stated above, thermal refugia were identified as essential elements to protecting water quality in Oregon as early as the 1992-94 triennial review. The most recent Oregon temperature standards continue in this vein although, as shown below, not nearly as extensively as EPA believed at the time it approved them.

1. *Oregon's Current Water Quality Standards*

Oregon's water quality standards ostensibly protect existing cold water. This starts with the policy underlying the temperature standards:

> It is the policy of the [Environmental Quality] Commission to protect aquatic ecosystems from adverse warming and cooling caused by anthropogenic activities. The Commission intends to minimize the risk to cold-water aquatic ecosystems from anthropogenic warming, to encourage the restoration and protection of critical aquatic habitat, and to control extremes in temperature fluctuations due to anthropogenic activities. The Commission recognizes that some of the State's waters will, in their natural condition, not provide optimal thermal conditions at all places and at all times that salmonid use occurs. Therefore, it is especially important to minimize additional warming due to anthropogenic sources.[28]

For certain rivers intended only as salmonid migration corridors and which were deemed to have been historically warm, Oregon established a 20° C criterion. Understanding that this temperature is too high to be adequately protective of salmonid health, Oregon followed the Regional Guidance and included a narrative provision that "[i]n addition, these water bodies must have coldwater refugia that are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the

---

[27] *Id*. at 23.

[28] OAR 340-041-0028(2).

water body."[29]

Oddly, however, Oregon's NCC provision, now vacated by federal court order, that allowed the State to supersede otherwise applicable numeric criteria with temperatures well over 20° C does not include any requirement to provide thermal refugia in such extreme temperatures. EPA apparently was not aware that it had approved a provision with such a glaring omission.[30]

2. *Oregon's Disposal of Municipal Wastewater Treatment Plant Effluent by Indirect Discharge to Surface Water via Groundwater or Hyporheic Water Internal Management Directive September 2007*

In September 2007, DEQ issued guidance entitled *Disposal of Municipal Wastewater Treatment Plant Effluent by Indirect Discharge to Surface Water via Groundwater or Hyporheic Water Internal Management Directive* (hereinafter "IMD").[31] This guidance document purportedly addresses NPDES-permitted discharges to ground- or hyporheic water intended to reach surface waters. DEQ claims that under this circumstance it has complete discretion to establish the boundaries of a "waste management area" pursuant to its groundwater rules at OAR 340-040-0030(2)(e) and that concentrations of pollutants in this area "may exceed background groundwater quality and still satisfy the requirements of [its groundwater rules] OAR 340-040[.]"[32] The IMD repeats this principle no fewer than three times but it never explains why, other than for the convenience of pollution dischargers, its rules can and should be interpreted to allow a violation of the groundwater protection rules. Neither does the IMD explain why DEQ

---

[29] OAR 340-041-0028(4)(d).

[30] DEQ, Willamette Basin TMDL Response to Comments, September 2006 at 4-4 – 4-5, (Quoting EPA: "The TMDL states that the "cold water refugia" requirement only applies to the lower Willamette (where the migration corridor is the designated use). Although its (sic) true that the specific cold water refugia narrative criteria only applies to where the migration corridor use is designated, EPA views cold refugia as an integral part of the "natural conditions criteria" and "natural thermal potential" definition. That is, the natural conditions criteria is not just one number, but a profile, that takes into account the cold water refugia provided by the natural "geomorphology" of the river. EPA believes it is especially important to evaluate current and potential cold water refugia whenever modeling indicates maximum temperatures reach or exceed 20C and the model does not account for all the natural features that create cold water refugia (e.g., hyporheic flow). Thus, consistent with the Region 10 Temperature Guidance, where the "natural conditions criterion" applies and the "natural thermal potential" is estimated to be 20C or greater, cold water refugia assessment, protection, and restoration also applies because cold water refugia is part of the natural condition." DEQ disagrees: "[W]e disagree with the broader interpretation of narrative criteria that ODEQ must identify refugia whenever natural condition temperatures exceed 20°C.").

[31] DEQ, Disposal of Municipal Wastewater Treatment Plant Effluent by Indirect Discharge to Surface Water via Groundwater or Hyporheic Water Internal Management Directive, September 2007.

[32] *Id*. at 2, 6, 14.

finds that "the Department usually will be able to conclude that indirect discharge systems meet this policy [requiring a point source to choose the highest and best practicable treatment method pursuant to groundwater protection rules at OAR 340-040-0020(11)] due to the level of treatment of municipal wastewater, the potential environmental gain from removing a direct discharge from surface water, and the waste management area controls (such as land ownership) that will ensure that groundwater degradation is minimized."[33] The only apparent prohibition on the use of ground- and hyporheic water for the discharge of effluent is where this so-called indirect disposal method could affect drinking water.[34] While DEQ notes the potential for indirect discharges to be a less expensive option for treating thermal loads, while also allowing for so-called "polishing" – that is, the transfer of contamination from effluent to groundwater or hyporheic water[35] – it never considers the impacts of the effluent on the hyporheic zone itself. This is best demonstrated by the IMD's discussion of the interface between the hyporheic zone and surface water:

- The indirect discharge systems should be designed and a permit issued with conditions so that effluent leaving the treatment system and entering surface water indirectly will meet water quality standards at the edge of the surface water mixing zone;
- If for some reason, no surface water mixing zone is allowed, then the indirect discharge system should be designed and a permit issued with conditions so surface water quality standards are met prior to groundwater entering the surface water channel. This is analogous to the waste management area being the mixing (and treatment) zone, and surface water quality standards would be met at "end of pipe," but the "pipe" in this case would be a diffuse groundwater to surface water discharge area;
- When surface water is the downgradient edge of a waste management area, groundwater compliance points (and subsequent concentration limits or variances) may be established at side-gradient edges of the groundwater waste management area to ensure the size of the area does not grow larger than contemplated in the design phase; and
- Groundwater monitoring within the waste management area at or near the discharge point to surface water may be included to confirm design assumptions are true, permit effluent limits are adequate, or for other operational purposes (i.e., detection monitoring instead of compliance monitoring).[36]

In other words, DEQ's IMD is notable for what it does not discuss. There is no mention of the

---

[33] *Id* at 7.

[34] *Id*.

[35] *Id.* at 3. This is despite the IMD's reference to "[r]ecognition that groundwater, once polluted, is difficult and sometimes impossible to clean up and establishment of an anti-degradation policy to control discharges to groundwater so that the highest possible water quality is maintained [OAR 340-040-0020(2)];" *id*. at 5.

[36] *Id*. at 13.

impact of indirect discharges on thermal refugia, no discussion of the impact of such discharges to the biota of hyporheic zones, no discussion of whether the use of hyporheic flows for cooling will actually work (aside from whether the proposed area is large enough), or whether it will be possible for either the discharger or DEQ to monitor the impacts of the discharge to assure compliance with NPDES permit limits, including a prohibition on not causing or contributing to violations of water quality standards. There is really only concern expressed as to whether the are of this underground mixing zone contaminating groundwater will ever be used for groundwater drinking water wells in the future and a not particularly helpful statement that the underground discharge must meet the requirements of surface water mixing zones.[37] There is also a cryptic footnote stating that

> In 2005, DEQ contracted with Oregon State University to assess the cooling capability of hyporheic gravels. The final report for this modeling assessment indicates that hyporheic flow can indeed be a significant source of cooling.[38]

In this statement, DEQ is not clear whether it means to say hyporheic flows now are or could be a significant source of cooling to the Willamette River or that such flows have the potential to cool indirect discharges to hyporheic zones. The agency certainly does not make clear whether the use of hyporheic flows for the latter purpose would reduce their cooling effect on the Willamette and/or affect their role as thermal refugia in a river system with current and projected temperatures well above temperatures protective of salmonids. However, the OSU report summarizes its findings as follows:

> The goals of this project were to examine whether (1) injection of wastewater into the subsurface could mitigate excess thermal load due to a municipal wastewater plant and (2) restoration of floodplains could cool rivers during the critical summer/early fall months. . . . Of the two afore-mentioned mitigation options, subsurface injection is the more viable option for temperature mitigation due to the large heat storage capacity of the ground. Specifically, peak temperature effects of warm effluent could probably be reduced 100-fold (e.g., increasing river temperature by 10^{-3} °C rather than 10^{-1} °C). The cooling capability due to restoring rarely (e.g., once per year) inundated side channels on the floodplain is probably small without great surface area and therefore infeasible purely for reasons of enhancing hyporheic flow.[39]

The OSU report correctly sums up the whole extent of DEQ's concerns: "In general, for discharge to the groundwater/hyporheic zone to be an option, a source will have to demonstrate to DEQ's satisfaction that all the effluent discharged to the groundwater would discharge to the

---

[37] *Id.* at 18.

[38] *Id.* at 18, fn 9.

[39] Oregon State University, Stephen Lancaster, Roy Haggerty *et al., Investigation of the Temperature Impact of Hyporheic Flow: Using Groundwater and Heat Flow Modeling and GIS Analyses to Evaluate Temperature Mitigation Strategies on the Willamette River, Oregon*, *Final Report* (December 30, 2005) at 2.

river via the hyporheic zone."[40]

3. *DEQ-Commissioned Report on Use of Hyporheic Zones to Cool Discharges*

The OSU report relied upon by DEQ to supports its IMD describes the use of hyporheic zones for cooling discharges as

> a heat sink for the excess thermal energy from the waste water. The gravel/sand/silt of the hyporheic zone acts as a heat exchanger between the warm waste water and the river. In addition to mitigating the thermal effects on the river, the hyporheic zone may delay a pulse of warm waste water from entering the river until after the critical summer months have passed. The effluent pulse would also be attenuated by mixing (dispersion) with cooler subsurface water before entering the river. We will refer to this temporary storage of warm water in the hyporheic zone as "warm banking".[41]

While the report concludes that "depending on the integration method, only 1 – 10% of heat injected in the SED scenario eventually arrives in the river. For all modeling scenarios, the amount of heat entering the river was small,"[42] it also makes the point that

> heat "lost" to deeper flow paths in these simulations *would, in reality, probably find its way back into the river at some point further downstream*. Though the heat would not actually be lost, heat following longer flow paths would experience greater delay and dispersion before entering the stream than heat following shorter paths and would, therefore, still lessen the impact on stream temperatures during the critical months."[43]

In other words, it is unknown how much heat would enter surface water after its injection into hyporheic zones and it is likely impossible to determine. An additional caveat was the report's note that "[w]orthy of mention also is that this model represented an ideal case for hyporheic zone groundwater movement. The groundwater in the model moved perpendicular in the hyporheic zone to the river. In a real fluvial system, groundwater would move down the elevation gradient parallel to the river, as well as moving toward the river."[44] This further underscores the point that DEQ likely will be unable to determine whether a source is causing or contributing to violations of water quality standards, as the Clean Water Act requires, in the event it issues an NPDES permit authorizing indirect discharges to hyporheic zones.

---

[40] OSU, *supra* note 39 at 19.

[41] *Id.* at 18-19.

[42] *Id.* at 82.

[43] *Id.* (emphasis added).

[44] *Id*. at 84 (internal citation omitted).

The OSU report makes no reference whatsoever to thermal refugia.

4. ***EPA's Technical Support Document Approving Oregon's 2004 Temperature Standards***

EPA approved Oregon's 2004 temperature standards, commenting on provisions associated with the importance of protecting thermal refugia. As the federal agency said in its Technical Support Document ("TSD") supporting this approval, the thermal refugia component of the 20° C migration corridor will "ensure the presence of sufficient cold water refugia [to] protect migrating juveniles and adults from lethal temperatures, prevent migration blockage conditions, and protect this use."[45] EPA also discussed the role of narrative criteria providing for thermal refugia when temperatures naturally exceeded upper end optimum temperatures, established in Oregon's numeric criteria:

> [EPA] believes that even though natural maximum temperatures likely reached 20°C historically, temperature diversity in the rivers provided cold water refugia, which fish could use to avoid maximum temperatures. As such, EPA believes Oregon's added provision to provide sufficient cold water refugia is an important part of the overall criteria to protect this use. . . . Without extensive monitoring and modeling in the waterbodies where this use is designated, it is impossible to know at this time the specific locations and times in the waterbody where cold water refugia currently exist or may potentially exist. Thus, the use of supplemental narrative criteria in this situation is reasonable and appropriate.[46]

EPA went on to explain that because all of the waterbodies currently designated for the 20° C use were currently on Oregon's 303(d) list of impaired waters, they would all be subject to the development of a TMDL in which Oregon

> will conduct the monitoring and modeling to identify cold water refugia sufficient to meet this narrative requirement. . . . When applying this narrative criteria in the context of a TMDL, the existing cold water refugia will be identified and determined. Temperatures reflective of existing areas of cold water refugia will be identified and protected in the TMDL. *Thus, the TMDL would be the document where the narrative cold water refugia criterion is translated into numeric terms for specific locations and times. If the existing cold water refugia is insufficient to protect the use, then additional cold water refugia sufficient to protect the use would also be identified and expressed in numeric terms in the TMDL.* Depending on how the TMDL is structured, the expression of cold water refugia in numeric terms might also occur during the development of watershed plans to implement the TMDL rather than in the TMDL itself. In addition, the watershed

---

[45] EPA, Support Document for EPA's Action Reviewing New or Revised Water Quality Standards for the State of Oregon, March 2, 2004, at 52 (internal citations omitted).

[46] TSD at 53-54.

> plans may contain measures to protect and restore the cold water refugia.[47]

Moreover, EPA concluded it expected

> the cold water refugia provision to be primarily considered in NPDES permits after a TMDL is completed because that is best forum to evaluate the sufficiency of cold water refugia for a waterbody. Once the TMDL is completed, however, any wasteload allocations to protect either existing or new cold water refugia must be incorporated into NPDES permits during the next permit cycle.[48]

In response to a public comment that cold water refugia should be subject to an absolute prohibition on warming, EPA commented that

> EPA agrees it is important to protect cold water refugia. In the event that a new or existing point source discharges into a river reach that currently has summer maximum temperatures lower than the applicable criteria, the protecting cold water provision (OAR 340-041-0028(11)) would apply, thereby protecting the existing cold temperatures.[49]

EPA's express wishful thinking aside, Oregon has ignored the thermal refugia requirement in all of its TMDLs and NPDES permits. For example, the John Day Basin TMDL includes a 20° C criterion applicable to the John Day River yet the narrative requirement is not even mentioned in the TMDL.[50] Instead, DEQ makes a determination in the TMDL that the NCC applies to the entire basin and makes no reference to the need for refugia in evaluating natural thermal conditions for any water in that basin.[51]

Likewise, while the Willamette Basin TMDL mentions the narrative criterion for thermal refugia, it does not identify any refugia, require the protection of existing refugia, or require restoration of any refugia.[52] The Willamette TMDL does, however, acknowledge the legal importance of refugia:

> along the lower reaches of the Willamette, restoration and protection of natural vegetation is essential to the maintenance of riparian and floodplain processes that influence cold water refugia and provide other benefits to water quality and aquatic species. Such measures are necessary to attain water quality standards in

---

[47] *Id.* (emphasis added).

[48] *Id.*

[49] *Id.* at 65.

[50] DEQ, John Day River Basin Total Maximum Daily Load and Water Quality Management Plan, November 2010.

[51] *Id.* at 58.

[52] DEQ, Willamette Basin Total Maximum Daily Load, September 2006.

the lower river. (OAR 340-41-0028(4)(d)).[53]

And the Willamette TMDL does discuss the ecological importance of refugia:

> Less obvious factors of stream warming include deliberate or coincidental changes in watershed processes and channel morphology. Watershed management activities that interrupt groundwater flows and hyporheic exchange with surface waters reduce summer base flows and the availability of cool water refugia that are necessary when mainstem temperatures exceed biological criteria. Channel modification activities such as deepening, bank armoring, dike construction, aggregate mining, wetlands and floodplain reclamation often contribute to the loss of channel complexity. Such activities may affect cool water refugia and simplify fish habitats. Although the impacts of such watershed and channel modifications on stream temperature are not quantified in this TMDL, protection of diverse temperature environments and refugia is an important element of Oregon's temperature standards.[54]

In addition, NWEA is not aware of any NPDES permit issued by DEQ that addresses the protection or restoration of thermal refugia.

5. ***National Marine Fisheries Service Biological Opinion on Oregon's 2004 Temperature Standards***

The National Marine Fisheries Service (NMFS) prepared a Biological Opinion ("BiOp") for the EPA's approval of Oregon's 2004 temperature standards pursuant to the Endangered Species Act.[55] NMFS found that the potential adverse effects of the 20° C migration corridor criterion would not be of a magnitude, extent, or duration so as to pose significant risks to the long-term survival of salmonids by relying on the "cold water refugia provision that should provide areas of colder water," and "[c]onsideration of spatial and temporal aspects of water temperature cycles and cold water refugia."[56] But, as well as considering the role of thermal refugia to be of significant importance, NMFS recognized its reliance on this tenuous thread was questionable for which reason it included in the list of conservation measures the following requirement:

---

[53] *Id*. at 4-72.

[54] *Id*. at 4-30. *See also id.* at 4-60 (development has resulted in massive loss of channel complexity including loss of hyporheic exchange and availability of thermal refugia); 4-8 (hyporheic flow may provide thermal refugia which are a key element for implementation); and 4-21– 4-22 (channelization, bank armoring and other development likely contribute to the lack of thermal refugia).

[55] NMFS, Biological Opinion on EPA's Proposed Approval of Revised Oregon Water Quality Standards for Temperature, Intergravel Dissolved Oxygen, and Antidegradation Implementation Methods, February 23, 2004.

[56] *Id*. at 37. No TMDL in which the ODEQ should have identified thermal refugia consistent with the expectations of NMFS have, in fact, done so.

> Within two years of the date of EPA's approval of the Oregon rules, EPA will participate with ODEQ, NOAA Fisheries, the USFWS, and interested tribes in a review of the Oregon Division 41 Rules, including consideration of . . . (2) identification of cold water refugia under the migration corridor criterion[.][57]

To the best of our knowledge, this review has never taken place.

II. <u>The Physics of Using Hyporheic Flows to Cool Discharges</u>

Relatively little research exists on hyporheic flows in Oregon. However, DEQ cites OSU as having concluded hyporheic flows historically played an important role in the thermal profiles of at least some Oregon rivers:

> Recent studies of the Willamette River have revealed that a significant amount of the river's flow passes through gravels below and at the margins of the river – an area referred to as the hyporheic zone. When passing through hyporheic gravels, the water cools considerably and other favorable chemical changes take place. By one estimate, the river's historical access to hyporheic gravels may have been five times as great as under current conditions, due to factors such as the absence of bank/hardening structures and the presence of more islands, side channels, and alcoves.
>
> The potential exists to take advantage of the cooling function of the river's hyporheic gravels to "treat" the river's elevated water temperature problems. Additional gravels could be accessed by the river if it were allowed to flow more freely over adjacent lands that historically were subject to at least periodic inundation by the river. In other words, if the river were allowed to regain some of its channel width and complexity, its natural functions could have a greater mediating effect on water temperature.[58]

These statements are consistent with the DEQ findings in the Willamette TMDL, and support the position that salmonids using the Willamette River prior to widespread human activity had access to far more cool and cold water than they do now. If that is true, setting the temperature standards to reflect "natural conditions" would require mirroring that fact. Yet DEQ's TMDL for the Willamette River does not. Instead, the TMDL contains such vapid comments as "[a]lthough not well documented, thermal refugia likely occur throughout the mainstem Willamette" and "[h]yporheic flow and groundwater inflows may also provide local thermal refugia."[59] By way of identification, protection, and restoration of such flows, DEQ merely states

> Protection of riparian areas and floodplains along tributaries and the mainstem river itself is necessary for the maintenance and restoration of thermal refugia and the processes that create them. This will be a key element for TMDL

---

[57] *Id*. at 6. *See also* terms and conditions, *id*. at 57.

[58] Bowman 2003.

[59] Willamette TMDL, *supra* note 52, at 4-8.

> implementation not only in the lower 50 miles of the river, but also in other reaches where temperatures exceed the biologically-based numeric criteria.[60]

and

> Methods were not developed to assess the effects of channelization, bank armoring and other aspects of watershed development on stream temperature. Although difficult to quantify, these activities likely contribute to changes in tributary temperatures and the availability of thermal refugia. Implementation of the TMDL and attainment of narrative criteria in Oregon temperature standards will require the protection and restoration of diverse stream habitats and thermal regimes throughout the basin. This is especially true where temperatures exceed biologically-based criteria and refugia are necessary to sustain cold water species.[61]

In other words, DEQ has established in the Willamette TMDL, as supported by the federal agencies and scientists, that hyporheic flow was likely significant to the historical support of salmonids and that thermal refugia are key to protecting cold-water species. However, the agency has done nothing to identify a regulatory mechanism to protect and restore those refugia.

Even in light of their importance, and its failure to ensure their protection, DEQ proposes, through issuance of its IMD, to allow permittees to destroy thermal refugia for purposes of avoiding other more environmentally-beneficial methods of addressing their thermal discharges (e.g., planting trees to create shade). The agency does not even propose concurrently to gather or cause to have gathered more information on thermal refugia and the scientific justification for warming them with heated discharges.

What information does exist now demonstrates high variability from location to location and that while hyporheic flows may do relatively little to buffer overall stream temperatures, hyporheic discharges create cooler waters that are likely essential for the survival of salmonids and other aquatic organisms. These were the findings, for example, of a study done on 24 kilometers of the Clackamas River.[62] In this study, researchers found the overall cooling effect of 40 "temperature anomalies" to be small, at 0.012° C because of their relatively small flows, but that the "patches of cooler water can benefit coldwater species such as salmon, providing local habitat and refugia from warmer mainstem temperatures."[63] Moreover, and with relevance to the use of hyporheic zones for discharges, the study determined that of three Clackamas gravel bars studied,

---

[60] *Id*.

[61] *Id* at 4-21 – 4-22.

[62] Barbara K. Burkholder, *et al.*, *Influence of hyporheic flow and geomorphology on temperature of a large, gravel-bed river, Clackamas River, Oregon, USA,* Hydrol. Process. 22, 941–953 (2008).

[63] *Id*. at 952.

"residence times of hyporheic water can vary from hours to weeks and months."[64] The study also found that the exchange of heat between surface water and sediments is "fast – dimensional analysis for cobbles of typical properties indicate thermal equilibrium is achieved within 1 or 2 h."[65] Once equilibrium is achieved it is unclear how the hyporheic zone will provide cooling of discharged effluent.

The information that exists, including especially basic physics, raises questions about whether the use of hyporheic zones as thermal dumps will even work to reduce sources' kilocalorie discharges to Oregon waters. Namely, once the hyporheic gravels have been heated they no longer can act to transfer heat away from effluent. Equally it raises questions about such discharges' effects on maintaining and enhancing hyporheic flows as essential thermal refugia. Until these and other questions are answered, Oregon DEQ should cease dangling this option in front of dischargers as a viable way to offset or mitigate thermal discharges.

III. <u>The Role of Hyporheic Flows in the Support of Biota and Chemical Integrity</u>

Overlooked in the regulatory discussions of hyporheic zones in the Northwest are the chemical and biological roles played by these flows. In a 1990 paper on refugia, the late Jim Sedell explained the role of hyporheic flows in creating essential refugia at the section or reach scale:

> Refugia at the section scale are best illustrated by mosaic habitats in a wide floodplain and low-gradient reach. Sections function as refugia in more extensive and higher magnitude events than do channel units and subunits. They may function as refugia in all types of natural and anthropogenic disturbances. The hyporheic zone is one such refugium. The hyporheic zone is defined as the area of interstitial space permeated by riverine water (Orghidan 1959). It serves as impotant refugia for river channel organisms, particularly invertebrates (Williams and Hynes 1974) during environmental stress in large gravel-bed rivers. It is also an area of energy and nutrient transformation.[66]

Likewise, the U.S. Forest Service (USFS) Aquatic Ecology and Management Team has investigated the role of hyporheic zones in aquatic ecosystems including how those flows are driven, the effect of human activities on the zones, quantifying the exchange flow within stream networks, and evaluating the role of the hyporheic zones in stream nitrogen cycling.[67] Studying mountain streams that are not likely to be the subject of future point source discharges, these researchers have drawn conclusions that mirror those of downstream areas. For example, there are strong connections between stream channel morphology – such as floods, debris flows, large

---

[64] *Id*. at 941.

[65] *Id.* at 942.

[66] James R. Sedell *et al.*, *Role of Refugia in Recovery from Disturbances: Modern Fragmented and Disconnected River Systems*, 14 Environmental Management 5 (1990), 711-724 at 715.

[67] U.S. Forest Service Aquatic Ecology and Management Team, Hyporheic Zones and Mountain Streams, http://www.fs.fed.us/pnw/lwm/aem/projects/hyporheic.html

wood, removal of trees on gravel bars, elimination of secondary channels – and hyporheic exchange.[68] And the USFS has described the importance of hyporheic zones to biochemical cycles in streams:

> The hyporheic zone can provide unique habitats for aquatic organisms, and exchange of stream water through the hyporheic zone exposes transported solutes to unique biogeochemical environments with subsequent impacts on whole stream metabolism and nutrient cycling. Water temperatures in the hyporheic zone are also typically buffered and lagged, with respect to diel changes in stream temperature. As a consequence, upwelling environments are of special interest, because upwelling water has the potential to be thermally or chemically distinct from stream water.
>
> The effects of the hyporheic zone on both temperature and nitrogen cycling are a function of the residence time of stream water in the hyporheic zone. The influence of hyporheic processes on stream water temperatures or stream nitrogen loads is a function of amount of stream water cycled through the hyporheic zone, relative to stream discharge.[69]

Other Oregon scientists have similarly noted the importance of hyporheic zones to ecological functions:[70]

---

68 *Id*. at Channel Morphology and the Hyporheic Zone.

69 USFS, Stream Temperature and Nitrogen Cycling, at http://www.fs.fed.us/pnw/lwm/aem/projects/hyporheic.html ("Key processes in the nitrogen cycle are also a function residence time. Stream water entering the hyporheic zone is well oxygenated, supporting mineralization and nitrification as DOC is metabolized. As available oxygen is used up and the rate of DOC metabolism decreases, areas of the hyporheic zone farther from the stream show a net loss of nitrogen through denitrification[.]").

70 Researchers have also described the interactions of hyporheic flows with woody debris, which has been established as essential to developing the channel complexity that is needed to support ecological functions:

> Logs and other woody debris that fall into channels in forested basins create flow obstructions that have particularly strong controls on channel form and hydraulics (e.g. Buffington and Montgomery 1999a; Buffington et al. 2002; Keller and Swanson 1979; Marston 1982; Montgomery et al. 2003). Although the effects of wood debris on streambed pressure distributions and hyporheic exchange have not been widely studied, several recent investigations highlight its potential importance. Mutz et al. (2007) found that wood debris caused a significant increase in the depth and volume of hyporheic exchange in a laboratory study of sand-bed rivers, and Lautz et al. (2006) observed that debris dams in a sand-bed river produced exchange comparable to that caused by meander bends. Furthermore, in step-pool channels of the Oregon Coast Range, Wondzell (2006) found that large, infrequent steps created by log jams produced greater hyporheic exchange than smaller, more frequent steps caused by individual logs or boulder

> Streams with intact hyporheic zones provide more temporary storage space and residence time for water than streams without hyporheic zones. As a result, nutrients and other materials remain in the system longer before they are lost downstream. Bacteria, fungi, and protozoa that live on sediments convert nutrients into food, making the hyporheic zone an area of high productivity. Because hyporheic water has greater exposure, both in residence time and physical extent, to these sediments than surface water, biogeochemical process rates are increased. The inorganic nutrients that are transformed along hyporheic flowpaths are then redelivered to the stream water where they stimulate algal growth. Furthermore, the hyporheic zone supplements the nutrients that algae need to recover from floods and other disturbances. Marine-derived nutrients from dying and dead salmon can also be transported by hyporheic flows, which can result in higher growth rates for riparian vegetation.[71]

They have also concluded that hyporheic zones play an important role in water quality:

> As hyporheic water flows from the riparian zone to the stream, the riparian area may retain nutrients. In the case of a riparian zone with high rates of denitrification (conversion of dissolved nitrate to nitrogen gas), retention of nutrients may result in less nitrogen reaching the stream. The hyporheic zone can also trap heavy metals and other contaminants that absorb to sediments, thus improving surface water quality.[72]

Building on this understanding of the chemical attributes of hyporheic zones, the hyporheic zone as a biological entity has been described as an "interactive system" in which the microbial loop reintroduces dissolved organic carbon back into the food web:

> In the [hyporheic zone] biogeochemical cycling, microbial ecology and the ecology of higher animals should not be considered as discrete compartments but rather as an interactive system. This is often best described as the microbial loop showing flow of carbon from the microbial level and its release to higher trophic levels. Feris et al. (2003) describe the hyporheic zone as a spatially and temporally dynamic ecotone which provides connectivity between terrestrial, groundwater, and lotic habitats. It lies beneath the channel of a stream, often extending great distances laterally in the subsurface, and is an essential part of lotic ecosystems. The microbial transformations of dissolved and particulate

---

> clusters. The importance of wood debris in modifyinglocal head gradients and generating hyporheic exchange likely depends on its frequency, size, and orientation within the channel.

Tonina, *infra* note 74, at 2074.

[71] OSU Libraries, Oregon Explorer: Natural Resources Digital Library, Hyporheic Zone and Water Trading at http://oregonexplorer.info/willamette/WaterandAir/WaterFlow/HyporheicZone.

[72] *Id*.

> nutrients taking place in the hyporheic zone have been shown to influence both macro-invertebrate and algal assemblages and may play a role in the productivity of riparian vegetation. This zone supports an active microbial community involved in nutrient cycling and nutrient retention and this community constitute the majority of the biomass and activity in lotic ecosystems and may contribute up to 96% of the ecosystem respiration. Therefore, Feris *et al.* (2003) noted that the microbial transformations in the [hyporheic zone] of dissolved and particulate nutrients influence both the macro-invertebrate and algal communities and furthermore influence the productivity in lotic systems and beyond.[73]

In short, hyporheic zones are known to have significant influences on the chemical and biological attributes of waterbodies. In addition, hyporheic zones support a variety of aquatic life, including threatened and endangered salmonids. In a paper evaluating mountain hyperheic flows in Oregon, researchers concluded that life forms that live some portion of their lives within the hyporheic zones "include microorganisms such as bacteria, fungi, and protozoa that live on sediment surfaces, as well as macroinvertebrates, fish, and other organisms."[74] In 2010, Scottish researchers concluded this contribution to stream ecology is significant: "For many riverine habitats it has been shown that invertebrate production within the [hyporheic zone] can equal or even exceed that of the benthos[.]"[75]

A. Hyporheic Flows Support Macro- and Micro-Invertebrates

The earliest study on the role of hyporheic zones in supporting invertebrates dates to 1935 and found that hyporheic flows "yielded rich hauls of invertebrates of both surface benthos (e.g., mayflies, stoneflies, chironomid midges) and interstitial groundwater fauna, such as blind water mites, isopods, and amphipods."[76] Much later, studies in the 1990s concluded that

> Living space, dissolved O2, and food appear to be key resources influencing the distribution of the hyporheos, with the microscale supply of energy and O2 mediated by mesoscale factors of sediment matrix structure and direction and strength of hydrological exchange with the surface stream. The food base in the hyporheic zones of the Nyack Flood Plain (Middle Flathead River, Montana) is a complex microbial biofilm; recent determination of its composition has identified

---

[73] Environment Agency (United Kingdom), *The Hyporheic Handbook: A handbook on the groundwater-surface water interface and hyporheic zone for environment managers*, Science Report No. SC050070, October 2009 at 109 (internal citations omitted).

[74] Daniele Tonina, *et al.*, *Hyporheic Exchange in Mountain Rivers I: Mechanics and Environmental Effects*, Geography Compass 3/3 (2009): 1063–1086 at 1065-66.

[75] Pryce, D. *et al.*, An investigation into the hyporheic zone of gravel bed rivers in Scotland and its associated fauna, Scottish Natural Heritage Commissioned Report No. 397 (2010) at 3-4. (Citations omitted).

[76] Boulton, Andrew *et al.*, *Ecology and management of the hyporheic zone: stream-groundwater interactions of running waters and their floodplains*, J. N. Am. Benthol. Soc., 2010, 29(a):26-40 at 29.

> entire suites of previously undescribed microbes. Biological interactions, such as competition and predation, also are likely to govern the ecology of hyporheic invertebrates, but there seem to be no published studies of these interactions, despite the prevalence of hyporheic predators in many streams.[77]

Sedell *et al,* writing in 1990 came to similar conclusions about the role of hyporheic zones in supporting invertebrates, particularly as refuges:

> Hyporheic zones may contain a very specialized fauna. Portions of the hyporheic fauna may reside permanently within the interconnected aquifers, while other species, particularly aquatic insects, may spend their larval stages deep within these interstices but return to the main channel to emerge and complete their life cycles.
>
> The hyporheic zone may be extensively utilized by many stream invertebrates during intervals of disturbance. Floods and spates frequently result in bed load movement and the scouring of the stream channel, yet benthic organisms recolonize substrata quickly after flood subsidence. . . . Other investigators have found similar patterns of zoobenthos migration into the substratum to avoid scour and the increased silt loading of spates and floods. Hyporheic zones also may serve as important refuges from periodic drought or periods of unfavorable temperatures, which manifest as short-term disturbances to the stream ecosystem. Several studies have suggested that surface-dwelling macrozoobenthos may move into the substrata during severe drought in an attempt to remain within a wetted environment. Diapausing stonefly nymphs have been collected from as much as 25 cm below the substrate surface in a dry streambed.[78]

Scottish scientists, who sampled 25 survey sites in which a total of 10,257 invertebrates were collected with 44 microcrustacean species represented,[79] observed that

> The [hyporheic zone] has been shown to be a very important habitat for aquatic invertebrates. The hyporheos itself can be divided into three main groups – the obligate hyporheos that live within the zone through all of their life stages; the occasional hyporheos that spend a portion of their life within the zone; and the accidental hyporheos that enter it by chance. As a result of lack of sunlight detritivores dominate and the number of larger top predators is also reduced by the physical necessity for movement through the medium in order to locate prey, coupled with small pore sizes and periodic bed mobilisation. The resulting fauna has truncated functional biodiversity which will consequently react differently from the benthic fauna to environmental stressors. The [hyporheic zone] also acts as a refuge for some benthic macroinvertebrates during times of drought and flood. Most of the obligate hyporheos are poorly known in terms of their

---

[77] *Id.* (internal citations omitted).

[78] Sedell, *supra* note 66 at 716-7 (internal citations omitted).

[79] Boulton, *supra* note 76 at i-ii.

> distribution, life history and ecology and almost any information that can be recovered about these organisms will add significantly to the body of knowledge about them.[80]

The invertebrates in hyporheic zones are sensitive to human interference. Canadian scientists found that many macroinvertebrates use the streambed substrate in areas of discharging groundwater for critical development states and as refuge from stream conditions.[81] In particular, during egg and pupal stages, these insects are not mobile and must tolerate the temperature conditions in the streambed. Moreover, aquatic insects do not acclimate generally and some have critical temperature thresholds above which acute mortality occurs.[82] Likewise, the eggs and embryos of fish are not mobile and must survive the thermal regime in the hyporheic zone.[83] Similarly, the Scottish study found that in hyporheic zones "[a]mong the insects both [dissolved oxygen] and ammonia were the major drivers of spatial variation in ASPT [average score per taxon], as is the case in the benthos itself."[84] They also concluded that "[m]ajor threats to the hyporheos are similar to those that impact salmonid egg survival, namely siltation, excessive algal growth, gravel extraction, ground water abstraction, interbasin transfers and stream water temperature increases due to climate change."[85]

B. Hyporheic Zones Support Salmonids

Hyporheic zones support salmonids in at least two ways, by providing primary production that supports salmonid growth and by affording thermal refugia. In what is termed the "ecohydrological approach," researchers have identified the role of these zones in bacterial activity and production, looking at how the zones support the total metabolism of waterbodies. Findings of the functional significance of hyporheic mechanisms to whole stream ecosystems include that "numerous studies [have] confirmed that hyporheic metabolism can equal or far exceed metabolism at the stream bed[.]"[86] As explained above, the organic fuel for hyporheic metabolism can be dissolved organic carbon from surface stream water or ground water or from infiltration and burial of particulate organic matter from the surface stream.[87]

Oregon scientists agree that hyporheic zones are important to both invertebrates and to fish:

---

80 Pryce, *supra* note 75 at 3 (internal citations omitted).

81 Markle, Jeff, *Thermal plume transport from sand and gravel pits – Potential thermal impacts on cool water streams*, Journal of Hydrology (2007) 338, 174-195 at 175.

82 *Id*. (citing numerous studies).

83 *Id*. (citing numerous studies).

84 Pryce, *supra* note 75, at ii.

85 *Id*.

86 Boulton, *supra* note 76, at 33.

87 *Id*.

> Hyporheic zones harbor a diverse community of invertebrates including microcrustaceans, oligochaetes, water mites, and early larval forms of stoneflies and mayflies up to 80 invertebrate species have been recorded from a hyporheic zone in a single sampling location. In some systems, the emergence of aquatic insects from the hyporheic zone is an important food source for fish. The hyporheic zone is also prime habitat for spawning salmon, since oxygenated stream water downwelling through redds creates an environment ideal for egg development.[88]

Likewise, British scientists have not only evaluated the ecology of the hyporheic zone but have considered the role of the zone in supporting cold-water, deeper gravel spawning salmonids.[89] They concluded that

> While the survival of developing embryos can be directly affected by the hyporheic conditions, sub-lethal effects can also be apparent under conditions of reduced oxygen availability. These sub-lethal effects, which cause affected fish to be smaller and lighter, can influence the longer term survival after emergence from the gravel into the stream channel[.] [90]

The British scientists considered the relationship between hyporheic flows and intergravel dissolved oxygen, fine sediments, and redd survival,[91] concluding that "[w]here efforts are made to improve or create new spawning habitat, local hyporheic water quality and groundwater-surface water interactions should be examined. It is important to ensure that managers are not encouraging fish to spawn in superficially appealing locations that offer poor spawning success."[92] This warning seems pertinent to allowing or encouraging the discharge of wastewater into what would, or could with restoration, otherwise be high quality salmonid spawning grounds.

C. There is Relatively Little Understanding of Human Impacts on Hyporheic Zones, Their Biota, and Their Role in Stream Ecology

Despite the importance of hyporheic zones, "no quantititative framework yet exists that predicts where and when a hyporheic zone will play a major role in overall stream metabolism."[93] Even as the tools to assure appropriate identification and protection of such areas are developed, protocols for assessing the health of hyporheic areas do not yet exist and human activities have

---

88 http://oregonexplorer.info/willamette/WaterandAir/WaterFlow/HyporheicZone

89 Hyporheic Handbook, *supra* note 73, at 123.

90 *Id*. at 125 (citations omitted).

91 *Id*. at 126-133.

92 *Id*. at 136.

93 Boulton, *supra* note 76, at 34.

had many negative impacts,[94] as discussed in Oregon's Willamette TMDL.[95] And yet restoration activities often focus on methods of improving stream health that are aimed at hyporheic improvements:

> If an intact hyporheic zone underpins stream health in some streams, hyporheic restoration in reaches where the hyporheic zone is impacted by human activities is a logical direction for management applications. Instream habitat enhancement projects often modify stream channel morphology to improve habitat structure. These channel modifications increase bedform roughness, heterogeneity of hydraulic conductivity, near-bed turbulence, and channel sinuosity, all of which induce hyporheic exchange flow in natural streams. For example, logs across stream channels produce a stepped longitudinal channel profile that promotes hyporheic exchange. In a flume study, introduction of natural quantities of wood doubled vertical hyporheic exchange and increased the magnitude of the hyporheic zone, supporting the early proposition by Mutz and Rohde that restoring natural levels of instream wood could enhance hyporheic exchange in impacted streams.[96]

The Scottish scientists concluded much the same as to the importance of hyporheic zones to stream ecology, suggesting that stream restoration for purposes such as protection and restoration of threatened and endangered salmonids should take into account the role hyporheic flows play in overall ecological function:

> Interactions between water chemistry, bacterial primary production and invertebrates within the [hyporheic zone] have been shown to have major consequences for the overlying benthic community. In a study in the catchment of the Flathead River Wyatt et al. (2008) showed that upwelling hyporheic water enhances benthic algal production in comparison to downwelling or neutral zones. This enhancement is in response to nutrients being brought to the surface and can result in downstream nutrient spiralling; this varies both spatially and temporally. Downwelling water rich in dissolved oxygen has been shown to be of importance in the survival of salmonid eggs. Riparian land use and man-made stream discontinuities (e.g. dams) have been shown to have a considerable impact on the biota of the [hyporheic zone]. A large body of research on the [hyporheic zone] has focused on the processing of solutes and the effect of this on stream metabolism. Rates of nitrogen, phosphorus and carbon cycling have beenshown to be strongly influenced by processes occurring in the [hyporheic zone] and the residence time of water within it. Dissolved oxygen carried by downwelling water is one of the primary drivers of productivity within the [hyporheic zone], so any metabolism that reduces oxygen in the stream water above or within the zone itself will have a profound effect on the organisms within it. The cycling of nutrients within the [hyporheic zone] has also been shown to have an influence on

---

94 *Id*. at 35.

95 Willamette TMDL, *supra* note 52, at 4-61.

96 Boulton, *supra* note 76, at 35 (internal citations omitted).

> the development of riparian vegetation.[97]

As a consequence of all these (and many other) factors, the exchange of waters between the benthic and hyporheic zones can have a profound impact on the distribution and structure of the biotic community in streams and rivers, stream metabolism, the processing of nutrients and even the structure of riparian vegetation.

IV. Regulatory Implications of Permitting Discharges to Hyporheic Zones

The British Hyporheic Handbook puts the case bluntly: "Temperature is a master variable driving many hyporheic biogeochemical and hydroecological processes, which is controlled by heat and water flux between the water column and riverbed."[98] Despite the importance of hyporheic zones, their importance in supporting cold-water biota, their widespread loss in Oregon, and the fact that "temperature is a master variable," DEQ has endorsed their use as thermal discharge zones. This endorsement is not based on, for example, studies that have evaluated thermal impacts on hyporheic zones and found them inconsequential. In fact, DEQ has no such studies and has, instead, blindly attempted to accommodate dischargers' interest in this option with its existing groundwater rules, rules that have no relationship to the protection of aquatic life or surface waters. One Canadian study evaluated the potential impact of gravel mining on hyporheic flows, an activity which, of course, was not intended to add thermal loads to hyporheic zones. There, researchers found that in the aquifer studied, cool and warm thermal plumes persisted for up to 11 months after entering the aquifer. They concluded that had a stream been present within the 250 meter down-gradient zone in which these plumes persisted "and aquatic animals such as brook trout and cool-water macroinvertebrates were relying on the cool ground-water discharge, then thermal alterations may adversely affect these animals."[99] They further concluded that

> even small temperature changes may adversely impact the stream productivity especially if the stream temperatures are already near the upper or lower tolerable temperatures. . . . Given the potential for small changes in ground water temperature to negatively impact the benthic and fish community in this creek, quantification of the transport distance of the thermal disturbance from the aggregates pits is very important[.] This study demonstrated that aggregate extraction can impact stream temperatures if sufficient separation distances are not provided, and that these temperature changes may adversely affect the macroinvertebrate community and incumbent brook trout populations.[100]

The results of this Canadian study suggests that intentional insertion of thermal loads into hyporheic zones is a poor idea given already high heat loads in receiving streams, streams on which cold-water threatened and endangered species rely. There are, of course, other concerns

---

97 Pryce, *supra* note 75 at 4 (internal citations omitted).

98 *Id.* at 92.

99 *Id.* at 192.

100 *Id.* at 193.

with discharging partially treated wastewater to sensitive hyporheic zones, not the least of which is that Oregon simply does not know enough about what lives in the zones, how they function, and how they interact with surface waters which are badly impaired throughout the state. And there appears not to be a one-size-fits-all approach to understanding hyporheic zones' impacts on streams as British scientists have observing, noting that

> In contrast to observed attenuation of nutrients in the [hyporheic zone], some case studies also reported that transport and transformation of nutrients in hyporheic sediments with high metabolic rates resulted in the remineralisation of nutrients and net export into the surface water. Water returning to the channel may have such elevated levels of N and P that localised algal periphyton blooms occur.[101]

Regardless of the state of knowledge on hyporheic zones, we do know that pollution discharges affect microcrustaceans. In fact, in one study, scientists identified microcrustacean presence as a simple method for assessing biotic indicators and predicting biodiversity in the hyporheic zone of a river polluted with metals.[102] And, as some researchers have observed, relatively little is known about the biota in hyporheic zones, information that should be front and center to decisions about how to treat them in regulatory programs:

> Current inventories of the hyporheos of most streams are inadequate to identify rare or threatened species, but some assemblages of invertebrate taxa in the hyporheic zone are surprisingly diverse and should be considered in management decisions about water resource development in these areas. Even intermittent streams can contain a rich hyporheic biota. Intermittent reaches act as *temporal ecotones* between terrestrial and aquatic ecosystems and harbor a unique biota of aquatic, semiaquatic, and terrestrial taxa that contribute substantially to overall biodiversity. This biota, including the hyporheos, might be at risk from management practices that seek to increase flow permanence artificially, especially because the hyporheic zone can be a refuge from drying.[103]

A. Municipal Projects to Discharge Heated Effluent to a Hyporheic Zone Are Ill-Considered

The Roseburg Urban Sanitary Authority (RUSA) is currently discharging wastewater from its sewage treatment plant to the South Umpqua River pursuant to an NPDES permit. In addition, on January 28, 2008, RUSA and DEQ entered into a stipulated order and memorandum of agreement ("MOA") requiring and allowing RUSA to construct a new "natural treatment" facility that RUSA would operate in conjunction with its primary sewage treatment plant. This

---

[101] *Id.* at 98 (internal citations omitted).

[102] Oana Teodora Moldovana, *et al.*, *A Simple Method for Assessing Biotic Indicators and Predicting Biodiversity in the Hyporheic Zone of a River Polluted with Metals,* 24 Ecological Indicators 412–420 (2013)("For almost all dissolved metals and those partitioned into sediments in the hyporheic zone, microcrustaceans were good indicators of pollution, as they were absent in samples where concentrations of these elements were high.")

[103] Boulton, *supra* note 76 at 36 (internal citations omitted).

natural treatment facility includes, according to the MOA, discharges to the South Umpqua River and Sylman Creek from its uplands, irrigation pond, wetlands, and water table via the hyporheic zone. This discharge to hyporheic flows is not covered by an NPDES permit.

Similarly, the City of Corvallis has proposed a project at the Orleans Natural Area to discharge its effluent into a hyporheic zone. Citizens have raised numerous concerns including: the likelihood of flood damage to the area, the consequences of contaminating the hyperheic zone, potential adverse impacts to biota in the hyperheic zone, and no assurance that the project would actually work to reduce kilocalorie discharges to surface water. With regard to the latter, the specific concern is that the gravels, while providing some cooling in the initial hours or days, will soon reach equilibrium temperatures and provide no additional cooling to the discharged effluent. Instead, the result will be a warming of otherwise cooler hyperheic flows, with a negative impact on this area as a thermal refugia, and no significant impact on the temperature of the discharged effluent.

NWEA is aware there are yet other municipalities that are currently considering or have considered the option of discharge to hyporheic zones including, for example, Woodburn and Eugene Springfield MWMC. This is not surprising, considering the fact that not only does DEQ have guidance on the option but its staff make presentations endorsing it. These facts demonstrate that it is now past time for EPA to offer its views on the efficacy and acceptability of hyporheic injection.

B. A Possible Role for Hyporheic Zones in Mitigating Thermal Discharges

This letter does not intend to suggest that NWEA thinks there is no role for hyporheic zones in assisting NPDES permittees' coming into compliance with state water quality standards. As OSU's Willamette Basin Explorer website suggests,

> The potential exists to take advantage of the cooling function of the river's hyporheic gravels to "treat" the river's elevated water temperature problems. Additional gravels could be accessed by the river if it were allowed to flow more freely over adjacent lands that historically were subject to at least periodic inundation by the river. In other words, if the river were allowed to regain some of its channel width and complexity, its natural functions could have a greater mediating effect on water temperature.
>
> A mechanism could be created by which entities that discharge heated effluent into the river from point sources (such as municipal sewage treatment facilities) fund the removal of river blockages (such as revetments and levees), as well as secure agreements for the use of lands in the floodplain, to allow the river to spread onto those lands and access additional hyporheic gravels. Revegetation of riparian areas, newly created islands, etc., could also be undertaken to provide greater shade and an additional cooling effect.[104]

Clearly the efficacy and cost of restoring hyporheic zones is not well known but worthy of exploration. But note, the "treatment" discussed does not involve discharging wastewater

---

[104] http://oregonexplorer.info/willamette/WaterandAir/WaterFlow/HyporheicZone

effluent into hyporheic zones but, rather, using the restoration of such areas for purposes of trading credits to offset kilocalories contained in thermal discharges.

As OSU has simply stated,

> Allowing the river to meander and create new gravel bars and side channels is one of the best ways to maintain hyporheic flow. It is likely that the river used to be in contact with five times as much gravel bed as is today, given that it lost about 80% of its island area since 1850. When we reduce and simplify the way the river interacts with its riverbed, including the way it moves sediments, we limit the river's connection with its hyporheic zone and its ability to improve its own water quality"[105]

Conclusion

This letter conveys a mere sampling of the research on hyporheic zones which makes clear that they contribute to the physical, chemical, and biological processes of natural streams. That body of research demonstrates the importance of such waters for primary productivity and a strong connection between groundwater and surface waters flows in ecosystems. Human activities have already had a significant negative influence on hyporheic zones and the role they play as refugia in stream systems. Likewise, restoration efforts focused on hyporheic zones may improve the ecological health of systems both above and below ground. A primary conclusion of the material we have reviewed in this letter is that allowing injection of wastewater into an ecologically sensitive zone without first studying and understanding the impact of that injection contradicts the purpose and intent of the Clean Water Act. This central point was made by Sedell *et al.* in 1990 when they observed that

> The importance of the hyporheic zone in these rivers is just now being recognized and its role as a refuge should not be underestimated or overlooked. Hyporheic zones may be highly variable within and between stream systems, corresponding to the natural geomorphic variability. Thus, the size and localized importance of the hyporheic zone of any stream or river system expands and contracts laterally along the longitudinal gradient of the riverine corridor. This important added dimension in our understanding of the structure and function of stream ecosystems is merely in its infancy and needs considerable additional study to more fully realize its scope and interrelationship in stream ecology.[106]

Today, there is every basis for believing that hyporheic flows are one key to achieving the "natural conditions" upon which salmonids and the entire aquatic ecosystem rely. There is, however, no basis for believing that in a highly degraded environment – a description, unfortunately, of a great many of Oregon's waters – there is a rationale for doing further harm. Injecting wastewater into hyporheic zones may strike some as a form of "natural" pollution treatment (or at least putting it more out-of-sight) but doing so is incontrovertibly antithetical to the EPA's increasing focus on providing refugia for aquatic species. We hope EPA will take the

---

[105] http://oregonexplorer.info/willamette/WaterandAir/WaterFlow/HyporheicZone

[106] Sedell *et al., supra* note 66 at 717.

opportunity to reconcile its statements on the critical importance of thermal refugia, including hyporheic zones, with Oregon's ill-conceived notions of how to undercut the effort to protect and restore refugia by using such sensitive areas as effluent dumping grounds.

Sincerely,

Nina Bell
Executive Director

cc: Dru Keenan, EPA
Angela Chung, EPA