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WATER QUALITY TRADING ASSESSMENT HANDBOOK

Can Water Quality Trading Advance Your Watershed's Goals?

November 2004

Glossary

Best Management Practice (BMP): A method that has been determined to be the most effective, practical means of preventing or reducing pollutant loadings, typically from a nonpoint source.

Credit, or Pollutant Reduction Credit: A measured or estimated unit of pollutant reduction representing a level of control beyond that needed to meet a water quality based effluent limit (for an NPDES permittee) or a TMDL allocation (for a nonpoint source) which may be exchanged in a trading program. A buyer or user of credits compensates another party for creating this overcontrol and uses the resulting pollutant reductions, typically to meet a regulatory obligation. A seller or provider of credits has overcontrolled pollutant loadings and can receive compensation from a party wishing to use the surplus reductions.

Designated Uses: Water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act. Uses can include cold water fisheries, public water supply, irrigation, and others.

Discharge Monitoring Report (DMR): The form used by NPDES permittees to report self-monitoring results to delegated states or EPA.

Downstream Trade: A water quality trade in which one source compensates another source located downstream of its position within the watershed for producing pollutant reductions.

Effluent: Wastewater that flows out of a treatment plant, sewer, or industrial outfall.

Incremental cost: The average cost of control for the increment of pollutant reduction required for an individual source to meet a regulatory limit or achieve a specified level of pollutant reduction. Incremental cost is an alternative to average cost. For example, if a discharger needs a 5 lbs./day reduction to comply with requirements but that drives a $10 million technology investment that actually reduces 20 lbs./day, then the incremental cost would be $2 million, four times higher than the average cost of $500,000.

Indirect Discharge: A non-domestic discharge introducing pollutants to a publicly owned treatment works.

Load allocation: The portions of a TMDL that are allocated to nonpoint or diffuse sources of a pollutant.

National Pollutant Discharge Elimination System (NPDES): The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits for discharge of pollutants into waterways. An NPDES permit is issued to all point source dischargers.

Nonpoint source: Diffuse pollutant sources (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet). The pollutants are generally carried off the land by stormwater. Common nonpoint sources are agriculture, forestry, urban areas, and historical mining sites.

Overcontrol: Taking steps to reduce pollutant discharge below the water quality based effluent limit for individual point sources or below the TMDL-based load allocation, or other specified baseline, for nonpoint sources.

Point source: Any discernible confined and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged, excluding those exempted by CWA or regulation. A discharging point source must have an NPDES permit.

Publicly Owned Treatment Works (POTW): Wastewater treatment facilities owned by the State or any political subdivision thereof, such as a municipality, district, quasi-municipal corporation or other public entity, responsible for handling local water supplies and includes any devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. POTWs receive and treat sewage and/or wastewater from residences, commercial activities, and industries.

Total Maximum Daily Load (TMDL): A quantitative expression of the amount of a pollutant that can be present in a waterbody without causing an impairment of the applicable water quality standard for any portion of that water. A TMDL must include wasteload allocation(s) for point sources and load allocation(s) for nonpoint sources plus a margin of safety.

Upstream Trade: A water quality trade in which one source compensates another source upstream of its position within the watershed for surplus pollutant reductions.

Wasteload Allocation: The portions of a TMDL that are allocated to individual point sources of a pollutant.

Water Quality Equivalence: The establishment of the physical inter-changeability among pollutant reductions made at different points within a watershed, usually through application of a ratio, intended to ensure that the impact of pollutant reductions at a designated area of concern is equivalent. Water quality equivalence concentrates solely on water quality impacts of pollutant control actions and does not include non-water impacts such as habitat enhancement.

Water Quality Standards: State-developed standards that include the following components: a) designated uses for waters, such as water supply, recreation, fish propagation, etc. (b) numeric or narrative water quality criteria which define the amounts of pollutants the waters may contain without impairing their designated uses; and (c) antidegradation requirements, which protect existing uses and otherwise limit degradation of waters. TMDLs must be designed to meet water quality standards.

Appendix A

Water Quality Trading Suitability Profile for *Phosphorus*

Trading Suitability Overview

The EPA Water Quality Trading Policy supports nutrient trading, such as total nitrogen and total phosphorus. Sources of phosphorus include background sources such as natural springs, point sources such as municipal sewage treatment plants and food processors, and nonpoint sources such as agriculture. Water quality trading pilot projects have shown that total phosphorus can be successfully traded, i.e., that cost-effective trades can reduce overall pollutant loadings without creating locally high pollutant concentrations. These projects have found that phosphorus discharges and in-stream concentrations can be readily measured at points within a watershed, and that the pollutant is relatively stable as it travels through river systems. As a result, phosphorus dischargers will have a reasonable ability to establish water quality equivalence relationships among themselves and/or with an area of water quality concern.

TMDLs address phosphorus to control a number of water quality problems including aquatic plant growth, low dissolved oxygen, and high pH. To establish equivalence appropriately, trading parties will need to understand how their loadings connect to the specific problem. Excessive phosphorus contributes to exceeding the narrative or numeric water quality standards established by many states relating to nuisance aquatic plant growth, deleterious materials, floating, suspended, or submerged matter, and oxygen-demanding materials. Excessive phosphorus concentrations have both direct and indirect effects on water quality. Direct effects include nuisance algae and periphyton growth. Indirect effects include low dissolved oxygen, elevated pH, cyanotoxins from blue-green algae production, trihalomethane production in drinking water systems, and maintenance issues associated with public water supplies.

Many TMDLs are intended to address the correlation between phosphorus concentrations and these water quality concerns. Excess nutrient loading causes excess algal growth which in turn affects levels of dissolved oxygen and pH in aquatic systems. In some TMDLs, concentration levels are established for both chlorophyll a and total phosphorus to ensure that nutrient concentrations do not result in excessive algae or other aquatic growth, which may impede the attainment of water quality standards for dissolved oxygen and pH.

Key Trading Points

A. Phosphorus Pollutant Form(s)

Total phosphorus TMDLs—Most TMDLs establish allocations for total phosphorus, although levels of both total phosphorus and ortho-phosphorus are often monitored. Total phosphorus is comprised of two forms:

- Soluble—also known as dissolved ortho-phosphate or ortho-phosphorus—includes highly soluble, oxidized phosphorus. Because of its solubility, ortho-phosphorus is commonly more available for biological uptake and leads more rapidly to algal growth than non-soluble phosphorus.
- Non-Soluble—also known as sediment-bound or particulate-bound phosphorus—is mineral phosphorus incorporated in sediment and is not as likely to promote rapid algal growth, but has the potential to become biologically available over time.

The concentration of total phosphorus is calculated based on the sum of the soluble and non-soluble phosphorus. Due to phosphorus cycling in a waterbody (conversion between forms) TMDLs usually consider total phosphorus concentrations. Total phosphorus then represents the phosphorus that is currently available for growth as well as that which has the potential to become available over time.

Sources covered by a total phosphorus TMDL will be measuring discharges and reductions using a common metric. Use of this common metric for measuring phosphorus reductions in a TMDL should provide a high potential for matching phosphorus discharges from various sources in the watershed. It will be important, however, to understand the actual forms of phosphorus being discharged because some trades may not represent an equivalent impact on water quality. For example, if individual dischargers have substantially divergent load characteristics (e.g., one primarily discharges soluble phosphorus while another primarily discharges non-soluble phosphorus) then a trade between the two may not be environmentally equivalent. This determination will be site specific. Most nonpoint phosphorus from croplands is sediment-bound, non-soluble phosphorus. Most phosphorus loadings from grasslands and pastures are in soluble form. Phosphorus discharges from POTWs are comprised primarily of soluble phosphorus. If a high percentage of the total phosphorus is present as soluble ortho-phosphate, it is more likely that rapid algal growth will occur than if the majority of the total phosphorus is mineral phosphorus incorporated in sediment. Adjustments, using a trade ratio or other means of establishing an equivalence relationship, may be needed to account for such differences.

<u>Other Phosphorus-Related TMDLs</u>—To the extent that a TMDL establishes load allocations in terms of individual phosphorus forms, challenges to trading may exist. If a TMDL provides load allocations for different forms, participants in the watershed will be limited to trading within two, smaller, more constrained markets for each form. Alternatively, a reliable translation ratio may be generated to create broader trading opportunities.

There may be circumstances where some dischargers receive phosphorus allocations while others receive dissolved oxygen allocations. There is a well-characterized link between phosphorus concentrations and dissolved oxygen problems. This relationship provides an opportunity to establish a specific translation ratio between total phosphorus and dissolved oxygen, potentially enabling additional trading opportunities. For example, a power company might be given a load allocation for DO, while municipal, industrial, and agricultural sources have received total phosphorus allocations. The development of a total phosphorus/dissolved oxygen translation ratio is possible that would enable the power company to become a potential purchaser of surplus reductions from other sources.

B. Impact

Adjusting for Fate, Transport, and Watershed Considerations—In general, phosphorus fate and transport are sufficiently well understood, and the models used to develop phosphorus TMDLs are reasonably well suited, to support the development of water quality equivalence relationships among potential phosphorus trading parties. The phosphorus "retentiveness" of a water body describes the rates that nutrients are used relative to their rate of downstream transport. As ratios are set for trading opportunities, the factors that contribute to retentiveness should be considered. Areas of high retentiveness are usually associated with low flows, impoundments, dense aquatic plant beds, and heavy sedimentation. Trades that involve phosphorus loading through these areas will likely require higher ratios to achieve water quality equivalence between dischargers. In areas with swift flowing water and low biological activity, phosphorus is transported downstream faster than it is used by the biota, resulting in low levels of retentiveness and minimal aquatic growth. In areas of low retentiveness, where phosphorus is transported rapidly through the system, lower ratios may be appropriate.

Other factors, including substrate stability and light contribute to plant growth and factor into a segment's "retentiveness." Sedimentation is another condition that can affect how phosphorus will move through and be utilized in a system. Phosphorus is often found in sediments and will persist longer in them. As a result, the presence of these factors should be an explicit consideration in setting water quality equivalence ratios.

Examining Local Considerations—In a downstream trade, the upstream source will not directly reduce its discharge to the permit limit because it is purchasing reductions from another source downstream. Discharges from the upstream source may not be reduced and, if so, water quality will not be improved in the segment between the two sources. Overcontrol by the downstream source will result in improved water quality only further downstream. In general, these types of trades will only avoid unacceptable localized impacts if the segment between the two sources has not reached its assimilative capacity.

Additionally, a trade, irrespective of its direction (up or downstream), involving sources discharging substantially different phosphorus forms could be more likely to create localized impacts. In particular, a trade that involves offsetting a primarily soluble phosphorus discharge with a sediment-attached discharge will leave a greater quantity of readily available phosphorus in the water body than otherwise would have been the case. This readily available phosphorus has greater potential to contribute to short-term, local nuisance aquatic growth problems.

C. Timing

The key timing element to consider when examining phosphorus trading is the seasonal load variability among sources. Agricultural nonpoint source loadings will vary seasonally, with greater loadings likely during the growing season and during storm events associated with soil runoff. Point sources generally discharge all year round. The relative importance of this difference plays out in the context of how TMDL phosphorus allocations are set. Many TMDLs provide seasonal phosphorus load allocations that apply only during the months of the growing season. The potential for excessive algal growth occurs predominately in the summer when sufficient light and temperature conditions support plant growth. Under these circumstances, both point and nonpoint sources will likely receive a seasonal allocation, and their ability to match reduction needs with the timing of phosphorus reduction credits will overlap and readily support trading.

However, allocations to lakes or other large water bodies may be annual because of the relationship in these water bodies between annual phosphorus loadings and eutrophication. In such cases, sources receiving year-round allocations may be restricted from trading with sources that produce seasonal loads.

D. Supply of Surplus Reductions

Typically, phosphorus TMDLs establish WLAs and LAs in terms of concentration or mass based reductions. For the most part, these allocations provide a straightforward means to establish over control for purposes of identifying marketable reductions. For example, a WWTP with a permit limit established at 700 lbs./day that currently discharges 600 lbs./day, will have 100 lbs./day of potential marketable reductions. For some nonpoint sources, estimates may need to be utilized to establish the level of phosphorus reductions. This will likely be needed when sampling a discharge is complex, infeasible, and/or not cost effective. Pilot projects have used estimation methods based on the type and degree of BMP implementation to establish phosphorus reductions. Such estimates should be based on the type and extent of BMP implementation and local conditions. While less precise, if conservative assumptions are utilized, the degree of control that can be achieved with various BMPs can be estimated and utilized for trading purposes. Thus, in either case, reasonably well established methods exist for understanding the degree of over control achieved by phosphorus sources and enabling trading parties to clearly verify the existence of marketable reductions.

Appendix B

Water Quality Trading Suitability Profile for *Nitrogen*

Trading Suitability Overview

The 2003 EPA Water Quality Trading Policy supports nitrogen trading. Anthropogenic sources of nitrogen to receiving waters include point sources such as municipal sewage treatment plants and industrial discharge, nonpoint sources such as agriculture, and atmospheric deposition from nitrogen initially released by combustion sources. Human activity has had an important influence on nitrogen cycles causing a dramatic increase of mobilized nitrogen. In particular, nitrogen fertilizer use in the United States has increased nitrogen input to receiving waters between 4-fold and 8-fold since widespread use began in the 1950's. Furthermore, fossil-fuel combustion activities leading to atmospheric deposition, and more recently manure from animal feedlots, have also contributed significantly to anthropogenic conversion of nitrogen from inert forms to biologically available forms that may contribute to water quality impairment.[11] In addition, both natural and human-caused disturbances of natural ecosystems (e.g., forest fires, forest clearing) can also contribute significant quantities of biologically available nitrogen to receiving waters.

Pilot trading programs have demonstrated that total nitrogen from some of these sources can be successfully traded, i.e., that cost-effective trades can reduce overall pollutant loadings without creating locally high pollutant concentrations. These projects have found that nitrogen discharges can be effectively measured or calculated and tracked in their course through a watershed. As a result, watershed participants have reasonably reliable models to establish water quality equivalence relationships and can engage in trading.

Effects of excessive nitrogen include those related to eutrophication—such as habitat degradation, algal blooms, hypoxia, anoxia, fish kills as well as direct toxicity effects.[12] Most nitrogen-related TMDLs recognize the relationships between nitrogen concentrations and these water quality concerns. In considering a new nitrogen trading marketplace to address water quality concerns, participants will need to understand how their load connects to the specific problem. While nutrient and eutrophication impacts associated with excess phosphorus may be more commonly of concern in freshwater systems, nitrogen is generally the limiting nutrient in marine environments and thus has a greater impact in estuarine systems. The increasing prevalence of hypoxic "dead zones" in the world's coastal areas (such as the Gulf of Mexico and Chesapeake Bay) is notable evidence of nutrient enrichment problems.

[11] National Research Council, 2000
[12] Paerl, 2002

Key Trading Points

A. Nitrogen Pollutant Form(s)

Total Nitrogen TMDLs—Most TMDLs prepared to address water quality problems associated with nitrogen establish load allocations for total nitrogen. Total nitrogen is, however, comprised of several forms.

- **Organic nitrogen** refers to nitrogen contained in organic matter and organic compounds and may include both dissolved and particulate forms. Sources of organic nitrogen include decomposition of biological material, including plants and animals; animal manure, either from feedlots or from organic manure fertilizer; soil erosion; wastewater treatment plant discharges; and some industrial discharges. Organic nitrogen is not available to aquatic plant uptake, but eventually organic forms will mineralize and go through nitrification in conversion to inorganic, bio-available form. It is important to note, however, that some nitrogen-containing organic compounds, such as those found in soil humic material, may be extremely persistent, and the nitrogen may not become available for many years.
- **Inorganic nitrogen** includes nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3) and ammonium (NH_4^+). The primary sources of inorganic nitrogen are mineralized organic matter, nitrogenous fertilizers, point source discharge, and atmospheric deposition nitrogen. Inorganic nitrogen is available for aquatic plant life, including nuisance growth algae.

While many nutrient calculations focus on measures of concentration, total nitrogen is typically calculated based on the total load. When it is assumed that all of the organic nitrogen will become bio-available (i.e., mineralized) within a relevant time period, Total nitrogen may be used to represent the nitrogen that is currently available for growth as well as that which has the potential to become available for growth over time. Because the primary water quality concern is the nutrient availability for nuisance growth leading to eutrophic conditions, and because it is often assumed that most or all of the organic nitrogen present in the system will be mineralized to a bio-available form within a relevant time period, TMDLs are based on total nitrogen.

TMDLs' focus on total nitrogen will facilitate trading in a watershed by using a common unit of measure among all potential trading participants. However, there are some forms of nitrogen that may pose particular problems and warrant specific attention. High levels of ammonia can be toxic to the point where there may be a need for local limits (applying local permit limits for ammonia is common practice in total nitrogen trading). For instance, if there are a large number of animal feeding operations, there may be a high level of ammonia run-off from manure which has the potential to cause localized toxicity problems. In addition, high concentrations of nitrate in drinking water may raise concerns for human health.

Also, although the total nitrogen load is the most important measure, you should note if individual dischargers may have substantially different load characteristics. A variety of sources in a watershed that include both nonpoint sources and point sources may result in a markedly different load of nitrogen forms that have differing environmental impacts (e.g., one primarily discharges sediment containing organically-bound nitrogen while another primarily discharges soluble inorganic nitrogen). Adjustments, using a trade ratio or other means of establishing an equivalence relationship, may be needed to account for such differences.

Atmospheric deposition nitrogen (AD-N) originates from a number of sources including combustion activities and ammonia volatilized from agricultural areas. Although AD-N can be an important factor in impaired estuarine and coastal water bodies downwind of NO_x and NH_3 (ammonia) air emissions, such sources have not yet been incorporated into water quality trading markets. Nitrogen TMDL budgets can include AD-N in models and have shown AD-N accounting for 10%-40% of total nitrogen loads. Deposition occurs either in wet form, in which gaseous and particulate matter is removed from the atmosphere in snow or rain precipitation, or dry form, in which removal occurs by physical processes such as gravitational settling of particles or high-energy fixation caused by lightning. In the future, relatively advanced air dispersion modeling may help to include air sources of nitrogen in a watershed trading marketplace. For the time being, potential nitrogen trading marketplaces should be sure to consider AD-N in any nitrogen load modeling, especially in TMDL nutrient budgeting.

B. Impact

Adjusting for Fate, Transport, and Watershed Considerations—In general, tools are available to predict nitrogen fate and transport and to support the development of water quality equivalence relationships among potential nitrogen trading parties. A key consideration in determining any equivalence ratios will be to understand the nitrogen loss from the watershed system. In addition to exiting the watershed system to the land via irrigation diversions, marketplace participants should note conditions in the watershed conducive to nitrogen attenuation. For instance, vegetation, such as wetland grasses, can draw dissolved inorganic nitrogen (NO_3^- and NH_4^+) from the system. In fact, some management programs may utilize enhanced forested filter zones to remove surface water nitrogen. The associated attenuation will need to be accounted for. When nitrogen loads pass through areas of relatively high vegetation uptake, not all of the nitrogen will reach the zone of impact. This will need to be considered in establishing trading ratios. At the same time, watershed participants should be cognizant of the possibility that through the nitrogen cycle (i.e., decomposition and mineralization of vegetation in filter zones) the nutrients removed from the water column by plant uptake could eventually re-enter the receiving water.

Another form of attenuation involves the process of “denitrification” whereby nitrate is reduced to gaseous nitrogen mainly by microbiological activity. Particular forms of bacteria enable the denitrification process throughout the watershed, and areas of high denitrification are usually associated with low, shallow flows. For those nitrogen dischargers whose load passes through areas of high denitrification, if the nitrogen is mainly in the form of nitrate, a (potentially large) portion of their nitrogen may not reach the zone of water quality concern and may have higher equivalence ratios. Conversely, nitrogen loads that travel in swift, deep waters will have less opportunity for denitrification and may have lower equivalence ratios.

Another factor important to water quality impacts in estuarine environments is the degree of flushing activity, particularly from tides. For instance, some areas of a marine coastal water body may have a low level of tidal activity, mixing, and flushing. It is likely that these zones will retain the nitrogen for long periods of time (potentially up to a few years) and have significant water quality concerns. In fact, most estuarine areas with water quality impairment are likely to have limited tidal mixing influences. Discharges directly into such a zone will have a direct water quality impact. On the other hand, nitrogen discharges near the mouth of an estuary may be flushed out of the system, and therefore less nitrogen would be delivered to the zone of water quality concern.

Examining Local Considerations—In a downstream trade, the upstream source will not attain its TMDL wasteload allocation through direct onsite controls because it is purchasing reductions from another source downstream. Discharges from the upstream source will not be reduced by the full amount targeted by the TMDL, and water quality will not be fully improved in the segment between the two sources. Overcontrol by the downstream source will result in improved water quality further downstream. These types of trades will only avoid unacceptable localized impacts if the segment between the two sources has not reached its assimilative capacity or is not affected by the water quality impairment affecting downstream waters.

C. Timing

Nitrogen TMDLs in coastal areas and large water bodies often set allocations and associated permit limits in terms of annual loads. Nitrogen TMDLs take this approach because the residence time is often very long, the area of concern is far-field, and the long-term average Total nitrogen load over time, rather than a short-term maximum pollutant load, is of concern.[13] Unlike some other nutrients (e.g., phosphorus) that can have a more direct and immediate impact in a watershed, nitrogen is processed in several steps which have buffers and delays between the time the nutrient is discharged and the time the nutrient has its full effect. Of course, all local water quality standards must be met. Since nitrogen typically has the greatest water quality impact in estuarine areas, most nitrogen TMDLs will assign annual loads. However, in the event that freshwater watersheds develop nitrogen TMDLs, they may specify shorter time periods, such as monthly loads. Sources receiving annual allocations may be restricted from trading with sources that have seasonal or monthly allocations.

A key time element to consider when examining nitrogen trading is any seasonal load variability that may exist among dischargers. While point sources such as WWTPs are likely to have relatively consistent discharge timing, agricultural nonpoint sources will likely have variable loadings that change seasonally based on land management activities. In addition, precipitation variation can impact the nutrient loading in a system with increased nitrogen levels during periods of high rainfall. The relative importance of this difference plays out in the context of how TMDL nitrogen allocations are set. In the case where TMDLs set annual limitations, the seasonal load variability will have limited impacts. However, allocations in river systems and freshwater systems may have monthly allocations, in which case seasonal variability will complicate the trading marketplace.

D. Supply of Surplus Reductions

Typically, nitrogen TMDLs establish wasteload allocations and load allocations in terms of mass based reductions. For the most part, these allocations, when reflected in an NPDES permit limit, provide a straightforward means to establish overcontrol for purposes of identifying marketable reductions. For example, a WWTP with a total nitrogen permit limit of 700 lbs./day that currently discharges 600 lbs./day, will have 100 lbs./day of potential marketable reductions (before any ratios are applied).

Nonpoint sources may also be able to measure their load and their ability to create reductions; however, in many cases it will be necessary to estimate reductions. This will likely be needed

[13] *Chesapeake Bay Memorandum*, 2004

when sampling a discharge is complex, impractical, and/or not cost effective. Pilot projects have used estimation methods based on the type and degree of BMP implementation to establish nitrogen reductions. Such estimates should be based on the type and extent of BMP implementation and local conditions. While less precise than point source measurements, conservative assumptions about BMP performance and/or the use of uncertainty discounts can enable BMP performance estimates to be utilized for trading purposes. Thus, in general, methods exist for measuring or estimating the degree of overcontrol achieved by nitrogen sources and enabling trading parties to verify the existence of marketable reductions.

Appendix C

Water Quality Trading Suitability Profile for *Temperature*

Trading Suitability Overview

Unlike nutrient trading, which has been piloted in a number of areas around the country, there is very little experience trading to reduce water temperature. The EPA Water Quality Trading Policy does recognize that trading of pollutants other than nutrients and sediments has the potential to improve water quality and achieve ancillary environmental benefits if trades and trading programs are properly designed. Issues related to determining the tradeable commodity for temperature and establishing water quality equivalence have been considered in a couple of watersheds. These efforts indicate that temperature impacts, fate, and transport are sufficiently well understood to support at least some level of trading among sources of elevated water temperature. It is currently anticipated that water quality equivalence can be established through models used in TMDL development and other tools, supported by monitoring.

Temperature standards have been established to protect beneficial uses such as cold water biota, salmon spawning and rearing, and fish passage. Water temperature is also an important consideration because a number of salmon species listed as threatened or endangered under the Endangered Species Act (ESA) inhabit waters and require improved water quality to support survival and recovery. Water temperature has direct and indirect impacts on native salmonids, bull trout, and other species listed under the ESA. Water temperature affects all life stages of these fish including spawning, rearing, feeding, growth, and overall survivability. The incidence and intensity of some diseases are directly related to increased water temperatures. Indirect effects include changing food availability, increasing competition for feeding and rearing habitat, and enhancing the habitat for predatory fishes. Increased water temperature also indirectly affects water quality by increasing the toxicity of many chemicals, such as un-ionized ammonia. High water temperatures reduce DO concentrations by increasing plant respiration rates and decreasing the solubility of oxygen in water. For example, TMDLs in the Pacific Northwest address water temperature primarily to protect cold water fish (salmonids) as the most sensitive beneficial uses. In that region, water temperature has been addressed in at least 240 TMDLs.

Sources of elevated temperature usually include both natural loading (from high air temperatures and solar radiation) and anthropogenic loading (from point source discharges and nonpoint sources such as devegetation of riparian areas, agricultural and stormwater drains, and tributary inflows). Nonpoint sources contribute to solar radiation heat loading by removing near stream vegetation and decreasing stream surface shade. In urban areas, impervious surfaces reduce the cooling effect of natural infiltration of surface runoff and increase the temperature of stormwater inflows. EPA[14] identified the four largest sources of increased temperature in the Pacific Northwest to be 1) removal of streamside vegetation, 2) channel straightening or diking, 3) water withdrawals, and 4) dams and impoundments.

[14] *Pacific Northwest State and Tribal Water Quality Temperature Standards* (US EPA, April 2003, 901-B-03-002)

Key Trading Points

A. Temperature Pollutant Form(s)

Temperature TMDL allocations are designed to limit human-caused water temperature increases and to meet the applicable water quality standards. The standards are usually expressed as specific limitations on surface water temperatures, as expressed in degrees. For example, temperature load capacity in the Snake River-Hell's Canyon TMDL is defined (through Oregon state standards) as no measurable increase over natural background levels. The quantitative value used by Oregon Department of Environmental Quality as "no measurable increase" is 0.25°F (0.14° C).

Most TMDLs provide temperature wasteload allocations to point sources in degrees Centigrade, (°C), degrees Fahrenheit (°F), or as heat per unit time, such as BTU's or Kilocalories per day. In effect, allocations establish what volume of discharge at a given temperature may enter a water body over a given period of time.

For nonpoint sources, temperature load allocations are often expressed as "no anthropogenic increase" or no loading by human sources. For ease of implementation, these may also be expressed in terms of percent of stream area shade required, providing site-specific targets for land managers. In temperature impaired reaches, nonpoint sources could meet this target by allowing stream banks to revegetate naturally until it attains "system potential," or the near stream vegetation condition that would naturally grow and reproduce on a site, given elevation, soil properties, plant biology, and hydrologic processes.

Although point and nonpoint sources tend to receive different forms of temperature allocations, models have been developed to convert the effect of increased stream shade into degrees cooling. One model uses multiple data sources related to temperature, vegetation, and hydrology to predict stream temperature at 100-foot distances. Other models are used to simulate stream temperatures for various hypothetical riparian restoration strategies. These models provide a basis for converting between point and nonpoint source temperature reductions for purposes of trading allocations.

B. Impact

Adjusting for Fate, Transport, and Watershed Conditions—In general, temperature fate and transport are sufficiently well understood, and the models to develop temperature TMDLs are reasonably well suited to support the development of water quality equivalence relationships among potential temperature trading parties. Moreover, EPA temperature guidance currently supports the establishment of a mixing zone for temperature discharges.[15] If a similar provision is included in the state's water quality standards and utilized in the development of the WLAs in the TMDL, this provides for some mixing between the discharge water and receiving stream. If the receiving water is sufficiently cool as a result of upstream overcontrol, additional mixing may be allowed provided that the temperature standard is met at the edge of the mixing zone.

However, water temperature fluctuates in response to natural conditions, such as ambient air temperature, solar heating, and flows. Thus, the temperature effects of control options can

[15] *Pacific Northwest State and Tribal Water Quality Temperature Standards* (US EPA, April 2003, 901-B-03-002)

dissipate quickly as water bodies rapidly reach a new water temperature equilibrium with the atmospheric and hydrologic conditions. As a result, although models and sampling can be used to predict and track the impacts of water temperature reductions at locations in a watershed, major water temperature effects are not likely to be seen at distant locations. For trading purposes, this suggests that potential trading parties will likely need to be relatively close to each other for an environmentally equivalent trade to emerge.

A second aspect of assessing the water quality equivalence of temperature reductions relates to the potential importance of cold water refugia in streams which provide salmonid habitat. Although temperature load allocations are designed to meet the numeric criteria of applicable water quality standards, narrative standards also often address the need to protect ecologically sensitive cold-water refugia. Thus, it will be important to identify how sources of temperature impacts are connected to these refugia. If these connections can be modeled to determine how overcontrol options can benefit refugia, then trading opportunities that provide targeted temperature improvements to refugia can be explored. In this context, and as discussed under the Quantity section below, certain locations of temperature reductions will be of higher quality (more valuable to protection of the desired beneficial use) and therefore more desirable. To the extent a trading system can recognize this value and help to steer reductions to these areas it can substantially support the TMDL goals.

Examining Local Considerations—Certain forms of temperature trades hold the potential to create localized impacts. In some areas, high water temperatures can have harmful or even lethal impacts on fish populations. In other areas, fish may be able to avoid the hotspots with little effect on the species. Any established threshold temperature level will be site and condition specific, and watershed participants should expect that the presence of cold water refugia will almost certainly require limitations on the degree to which a source could exceed their temperature allocation and mitigate through trading. Caps on purchasing activity placed in NPDES permits can be used to avoid unacceptable local temperature impacts.

C. Timing

Exceedances of temperature-related water quality standards are more likely to occur in the summer months. As a result, temperature TMDLs have focused allocations seasonally, with required temperature reductions typically applying during the warmest times of the year. In response, many wasteload allocations provide (or are expected to provide) different allocations for various times of the year, with more stringent limits during summer months and salmonid spawning or other life cycle periods that are critical to fish survival. In general, this seasonal approach supports opportunities for point sources and nonpoint sources to consider temperature trading options. Irrespective of the temperature allocation cycle, nonpoint source temperature reduction efforts in the form of shade are seasonally dependent, as greater cooling effects are provided by the shade during the warmer seasons. Most nonpoint source temperature allocations are not seasonal—thus encouraging the vegetation to be in place year-round and indirectly support channel stability and other key channel characteristics. Under a seasonal temperature TMDL, point sources' need for reductions will coincide with the nonpoint sources' ability to influence stream temperature, thus establishing a strong match for trading from a timing standpoint.

D. Supply of Surplus Reductions

Based on the nature of temperature allocations and related control options, both point and nonpoint sources of temperature impacts have the ability to overcontrol their "discharge" and create temperature credits. For point sources, overcontrol would take the form of lowering discharge temperature below that identified in a TMDL. In instances where the point source is a significant contributor to elevated in-stream temperatures, the impact of overcontrol will likely be discernible for some distance. This situation would readily support upstream trading with other point or nonpoint sources. In the case that point sources of heat are relatively small and have limited thermal loads, it is anticipated that their overcontrol would quickly be offset by more dominant in-stream and riparian conditions, constraining trading opportunities to those sources in close proximity.

In order to attain nonpoint source allocations in many temperature TMDLs, land along streams would need to achieve site potential shade. Natural re-vegetation varies with species, climate, and local conditions, requiring a minimum of 20 years to achieve site potential shade. If there are no state or local measures in place requiring landowners to plant and restore riparian areas, nonpoint sources can overcontrol by influencing stream area shade in three ways: 1) earlier shade creation through tree planting; 2) more effective shade creation through selection of planted vegetation with a denser canopy; and 3) increasing the total shaded area of the stream.

In some areas, tree planting programs that substantially advance the creation of shade as compared to natural re-vegetation have emerged as strong candidates for creating overcontrol. Current thinking indicates that generating temperature benefits sooner than would be present under either natural or required stream bank re-vegetation could be used, at least temporarily, as reduction credits available for trading. The value of these credits may be quite high, as they are potentially available for at least five and possibly up to fifteen years, allowing other sources to delay what might otherwise be very substantial capital expenditures to reduce discharge temperatures.

Other means of nonpoint source overcontrol are more theoretical at this time. Although it remains an untested concept, certain trees that create a denser and/or higher canopy than natural vegetation may produce greater shading and thus reduce the warming effects of sunlight. Under such an approach, tree planting would not only produce temperature benefits earlier than natural re-vegetation, it would create a more consistent and/or greater area of shade than described in the TMDL. If utilized, tree selection should take into consideration a diversity of native species and the ability of the re-vegetated community to sustain other functions of the riparian area.

Additionally, in instances where TMDL allocations do not call for site potential shade throughout a watershed, expanding the area of stream bank vegetation beyond TMDL allocations could represent overcontrol. However, temperature TMDL experience to date indicates that a typical approach would be to call for natural re-vegetation throughout the TMDL area, substantially reducing the likelihood of this option.

Both point and nonpoint sources may have two additional options for creating temperature reduction credits for either their own use or for sale to others. First, modifications to channel complexity that return streams to more natural width-to-depth ratios may result in temperature reductions. Moreover, reestablishing tree-covered islands in mid stream is another channel modification that can create additional shading effects to reduce water temperature.

Second, water volume and flow are critical factors affecting water temperature. Creative solutions to water temperature problems often involve changes in flow regimes. Water temperature improvement measures relating to flow include changes in location of discharges, increases in irrigation efficiencies, and water right purchases or leases. Any such changes in flow regimes that result in improved temperature conditions could likely be accounted for with models used in the development of the TMDL.

Irrespective of the means by which nonpoint sources achieve overcontrol, these actions hold the potential to be more attractive than point source temperature reductions from the standpoint of overall watershed health. Nonpoint source overcontrol options that accelerate the return of vegetation in riparian areas provides important benefits to water quality and fish and wildlife habitat. Increased vegetation along stream banks helps to maintain temperature improvements from other sources. Increased vegetation in riparian areas supports other water quality objectives by reducing erosion and sediment loads and providing natural filtration of water entering the stream. Vegetated stream banks improve the health of riparian areas, which provide important habitat for many types of wildlife and aquatic species. As a result, a trade in which a point source opts to pay for nonpoint source overcontrol may prove highly desirable for overall watershed health.

Appendix D

Water Quality Trading Suitability Profile for *Sediments*

Trading Suitability Overview

The 2003 EPA Water Quality Trading Policy Statement specifically supports trading to reduce sediment loads. Sediment is defined as fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water. The erosion, transport, and deposition of sediment is an essential natural process in the right amount, but sediment becomes a problem and a pollutant when significant increases in sediment supply exceed the water body's ability to move it. Most sediment problems involve the presence of excess fine sediment such as silt and clay particles that increase turbidity when suspended and form muddy bottom deposits when they settle. Excessive fine suspended and bedload sediments both cause numerous kinds of impairments of aquatic life.

Two major sources account for nearly all sediment discharge: soil erosion carried by surface runoff; and within-channel erosion of banks and bedload sediments. Natural and anthropogenic influences can strongly affect the amount and timing of sediment discharge from these sources. In minimally impacted areas, runoff and in-channel erosion during average flows and rainfall patterns transport sediment in moderate quantities at fairly consistent rates. Erosion from extreme flow events can generate a greater sediment load than occurs all year from average flows. Because these events are infrequent, aquatic systems adjust over time and return to a healthy condition.

In watersheds where human activity has markedly increased overland and in-channel erosion and sediment load, excess sediment may be a common rather than infrequent event with impairment resulting. Nonpoint sources of excess sediment include: streambank destabilization due to mowing and riparian tree removal; cropping without buffer zones; livestock hoof shear; channel flow redirection; urban/suburban sources including construction; stormwater runoff and irrigation; agricultural sources such as unmanaged runoff from croplands; forestry sources such as unmanaged runoff from logging operations and unmaintained access roads; gravel mining; roadside ditch maintenance; and other sources. It is also possible to have impairments from too little sediment supply, such as when dams reduce the downstream replenishment of bedload gravels to the point that salmonid spawning habitat is reduced. Point sources can also contribute to sediment problems.

Water quality standards are developed to protect the most sensitive designated use and have generally been established for sediments to protect designated uses associated with aquatic life. They are often based on both a numeric standard related to turbidity and a narrative standard that protects designated uses. Narrative standards are translated into a wide range of numeric criteria depending on the conditions in the watershed, the fish species present, and the interpretation of the agencies and stakeholders in the area. State standards for sediment vary widely. EPA is currently developing updated national guidance for sediment water quality criteria.

TMDLs address sediments to meet water quality standards and control a number of water quality problems. To establish appropriate water quality equivalence, trading parties will need to understand how their sediment loads connect to the specific problem. High concentrations of sediment can have both direct and indirect effects on water quality. Excessive amounts of sediment can directly impact aquatic life and fisheries. Excessive sediment deposition can choke spawning gravels, impair fish food sources, and reduce habitat complexity in stream channels. Excessive suspended sediments can make it more difficult for fish to find prey and at high levels can cause direct physical harm, such as scale erosion, sight impairment, and gill clogging. Stream scour can lead to destruction of habitat structure. Sediments can cause taste and odor problems for drinking water, block water supply intakes, foul treatment systems, and fill reservoirs. High levels of sediment can impair swimming and boating by altering channel form, creating hazards due to reductions in water clarity, and adversely affecting aesthetics.

Indirect effects associated with sediment include low dissolved oxygen levels due to the decomposition of organic sediment materials, and water column enrichment by attached pollutant loads, such as nutrients. Elevated stream bank erosion rates also lead to wider channels which can contribute to increased temperatures. Sediment targets and monitored trends often function as indicators of reductions in transport and delivery of these attached pollutants. These additional pollutants would likely be addressed in other types of remediation tools other than sediment trading. Sedimentation can also be an important consideration because a number of species listed as threatened or endangered under the Endangered Species Act (ESA) inhabit impaired waters and require cold, clear, well oxygenated water and spawning gravels unchoked by fine sediments to support spawning, survival, and recovery.

Key Trading Points

A. Sediment Pollutant Form(s)

<u>Sediment TMDLs</u>—Sediment is discharged by sources in a wide range of particle sizes and weights. TMDLs generally provide separate load allocations for sediments based on two different forms.

- Suspended or "water column" sediments are particles that are small and light enough to remain suspended in the water column, generally less than 1 mm. Sources discharge two different types of these suspended sediments: geological particles, which are derived from rock and soil, and biological particles such as planktons and other microscopic organisms. These different forms of suspended sediments may have different impacts on water quality. As discussed below, TMDLs often establish different allocation forms for point and nonpoint sources to control water column sediments.
- Bedload sediments are generally larger particles that are too heavy to be suspended in the water column. They are generally discharged by nonpoint sources and are transported by sliding, rolling, or bouncing along the bed of the stream. Bedload sediments can range in size from fine clay particles to large boulders. TMDLs often establish mass-based allocations for bedload sediments such as pounds per day or tons/square mile/year of sediment loading, or use a percentage of fines deposited in stream bottoms.

TMDLs often establish different allocation forms for point and nonpoint sources. Wasteload allocations for point sources often use concentration-based limits, such as an average weekly limit of 45 mg/L of Total Suspended Solids (TSS). Load allocations for nonpoint sources are often expressed in mass-based allocations, such as tons/square miles/year of sediment loading. Point source dischargers with similar sediment discharge forms and wasteload allocation metrics may have trading opportunities. For example, two WWTPs from neighboring jurisdictions in Virginia have entered into a cooperative agreement whereby one WWTP has agreed to a reduction in its permit limit for discharging total dissolved solids so the other facilities can have an increased limit. The allocations are both expressed in terms of kg/day of total dissolved solids. The two plants discharge into the same stream segment, and the Virginia DEQ has determined that the agreement would not result in a decrease in water quality.

B. Impact

Adjusting for Fate and Transport Characteristics and Watershed Considerations—As dischargers consider trading opportunities, it will be important to understand the specific water quality impacts of each potential trading partner. Sediment load reductions by sources may be measured directly by sampling, with the models used to develop sediment TMDLs, or using surrogate measures, such as percentage of fines in stream bottoms. Other site specific watershed conditions, such as velocity, slope, channel conditions, and type of sediment, are important considerations for understanding water quality impacts and matching potential trading partners. For example, assessing channel measurements and bedload composition can verify whether a stream is relatively stable, or unstable and undergoing channel evolution. Potential trades can then be evaluated in the context of these dynamics. For example, a trade involving establishment of riparian vegetation in a stream segment that is or can be readily stabilized would be more likely to produce positive results than the same effort undertaken on a portion of stream channel that is actively cutting and likely to continue doing so until the channel is reestablished.

For suspended sediments, models are available to determine the impacts of reductions. However, depending on the watershed conditions, and the water quality problem that is being addressed, geological and biological forms of suspended sediments may have different impacts. It is more likely that trading between similar forms (e.g., geological to geological, and biological to biological) will support water quality improvements.

Watershed flow patterns are also likely to define market areas for trading. Sediment movement in a stream varies as a function of flow. Suspended sediments discharged into high flow areas will travel longer distances and may define a large market area. The boundaries of markets may be defined by lower flow areas. The areas usually occur in the lower sections of watersheds where flows decrease and the lighter, smaller suspended sediments fall out. Upper sections of watersheds with higher flows often transport more bedload sediment. Impoundments create significant barriers that restrict sediment transport and create areas of sediment deposition. These distinct areas, based on flow patterns, are likely to delineate defined trading market areas, with trading limited to within each defined area.

Examining Local Considerations—Because watershed conditions relating to velocity, slope, and channel conditions will directly affect the impact of sediment reductions, each trade will have to be assessed to determine the potential for localized impacts. As with other pollutants, downstream trades will only avoid unacceptable localized impacts if the segment between the two sources has not reached its assimilative capacity. Additionally, a trade, irrespective of its direction (up or downstream), involving sources discharging substantially different sediment forms may be vulnerable to creating localized impacts. For example, a trade that involves offsetting a biological form of suspended sediment discharge with a geological form of suspended sediment discharge will leave a greater quantity of biological sediments in the water column. This form of sediment may have a greater impact on dissolved oxygen levels and may lead to unacceptable dissolved oxygen-related water quality problems.

C. Timing

Although sediment delivery to streams from nonpoint sources is usually episodic and sometimes seasonal, sediment allocations are generally applied year round. TMDL allocations are often expressed as an average amount of sediment per year. To account for variability between years (i.e., years with high snow melt or other extreme weather events will have higher sediment delivery), some TMDL load allocations are expressed as ten year rolling averages. Because sediment load allocations are generally applied on an average basis year round, participants will likely be able to align reductions between potential buyers and sellers.

D. Supply of Surplus Reductions

There are a number of ways that sources can apply control options to reduce sediment loads. These controls can be sampled and/or modeled to estimate the amount of sediment reduction beyond TMDL expectations.

Point sources can apply technological control options that result in a measurable change in sediment concentration and associated loads. Sediment limits for point sources are usually based on a technology-based limit which may be sufficient to meet the TMDL target. Under the Clean Water Act, point sources are required to comply with their technology-based limits without trading unless trading is explicitly incorporated in the effluent guidelines. Under such circumstances, there is no incentive for such sources to become purchasers of sediment reductions. However, in circumstances where the technology-based limit is not sufficient to meet water quality standards, incentives for trading may exist.

In many watersheds, point sources may be relatively minor contributors to excessive sediment loads. Therefore, they may have a limited capacity to overcontrol in a meaningful way to improve water quality. As discussed above, point sources also discharge a different form of suspended sediment. Point sources may be limited to trading with other sources discharging similar sediment forms. Nonpoint sources have the ability to overcontrol using more aggressive controls than required to meet load allocations, using controls that cover broader areas, or using controls that target more valuable areas for sediment reduction.

Nonpoint sources can overcontrol using Best Management Practices (BMPs). Aggressive BMPs, such as conversion to drip irrigation on agricultural lands, have the ability to reduce sediment loads below TMDL allocations. BMPs can also be applied to cover broader areas than specified in a TMDL. Another potential overcontrol option is for nonpoint sources to select higher value areas to implement BMPs, thus achieving greater pollutant reductions in the waterbody of concern. Marketable reductions may be generated by applying control options that focus on areas with highly erodible soils, or areas that have a direct impact on the designated use, such as salmonid spawning areas, and may create a greater improvement in water quality than specified under the TMDL allocation.

Appendix E

Capital Cost Annualization Factors

	Interest Rate							
Year	0.50%	1.00%	1.50%	2.00%	2.50%	3.00%	3.50%	4.00%
1	1.005	1.01	1.015	1.02	1.025	1.03	1.035	1.04
2	0.5038	0.5075	0.5113	0.515	0.5188	0.5226	0.5264	0.5302
3	0.3367	0.34	0.3434	0.3468	0.3501	0.3535	0.3569	0.3603
4	0.2531	0.2563	0.2594	0.2626	0.2658	0.269	0.2723	0.2755
5	0.203	0.206	0.2091	0.2122	0.2152	0.2184	0.2215	0.2246
6	0.1696	0.1725	0.1755	0.1785	0.1815	0.1846	0.1877	0.1908
7	0.1457	0.1486	0.1516	0.1545	0.1575	0.1605	0.1635	0.1666
8	0.1278	0.1307	0.1336	0.1365	0.1395	0.1425	0.1455	0.1485
9	0.1139	0.1167	0.1196	0.1225	0.1255	0.1284	0.1314	0.1345
10	0.1028	0.1056	0.1084	0.1113	0.1143	0.1172	0.1202	0.1233
11	0.0937	0.0965	0.0993	0.1022	0.1051	0.1081	0.1111	0.1141
12	0.0861	0.0888	0.0917	0.0946	0.0975	0.1005	0.1035	0.1066
13	0.0796	0.0824	0.0852	0.0881	0.091	0.094	0.0971	0.1001
14	0.0741	0.0769	0.0797	0.0826	0.0855	0.0885	0.0916	0.0947
15	0.0694	0.0721	0.0749	0.0778	0.0808	0.0838	0.0868	0.0899
16	0.0652	0.0679	0.0708	0.0737	0.0766	0.0796	0.0827	0.0858
17	0.0615	0.0643	0.0671	0.07	0.0729	0.076	0.079	0.0822
18	0.0582	0.061	0.0638	0.0667	0.0697	0.0727	0.0758	0.079
19	0.0553	0.0581	0.0609	0.0638	0.0668	0.0698	0.0729	0.0761
20	0.0527	0.0554	0.0582	0.0612	0.0641	0.0672	0.0704	0.0736

	Interest Rate							
Year	4.50%	5.00%	5.50%	6.00%	6.50%	7.00%	7.50%	8.00%
1	1.045	1.05	1.055	1.06	1.065	1.07	1.075	1.08
2	0.534	0.5378	0.5416	0.5454	0.5493	0.5531	0.5569	0.5608
3	0.3638	0.3672	0.3707	0.3741	0.3776	0.3811	0.3845	0.388
4	0.2787	0.282	0.2853	0.2886	0.2919	0.2952	0.2986	0.3019
5	0.2278	0.231	0.2342	0.2374	0.2406	0.2439	0.2472	0.2505
6	0.1939	0.197	0.2002	0.2034	0.2066	0.2098	0.213	0.2163
7	0.1697	0.1728	0.176	0.1791	0.1823	0.1856	0.1888	0.1921
8	0.1516	0.1547	0.1579	0.161	0.1642	0.1675	0.1707	0.174
9	0.1376	0.1407	0.1438	0.147	0.1502	0.1535	0.1568	0.1601
10	0.1264	0.1295	0.1327	0.1359	0.1391	0.1424	0.1457	0.149
11	0.1172	0.1204	0.1236	0.1268	0.1301	0.1334	0.1367	0.1401
12	0.1097	0.1128	0.116	0.1193	0.1226	0.1259	0.1293	0.1327
13	0.1033	0.1065	0.1097	0.113	0.1163	0.1197	0.1231	0.1265
14	0.0978	0.101	0.1043	0.1076	0.1109	0.1143	0.1178	0.1213
15	0.0931	0.0963	0.0996	0.103	0.1064	0.1098	0.1133	0.1168
16	0.089	0.0923	0.0956	0.099	0.1024	0.1059	0.1094	0.113
17	0.0854	0.0887	0.092	0.0954	0.0989	0.1024	0.106	0.1096
18	0.0822	0.0855	0.0889	0.0924	0.0959	0.0994	0.103	0.1067
19	0.0794	0.0827	0.0862	0.0896	0.0932	0.0968	0.1004	0.1041
20	0.0769	0.0802	0.0837	0.0872	0.0908	0.0944	0.0981	0.1019

	Interest Rate							
Year	8.50%	9.00%	9.50%	10.00%	10.50%	11.00%	11.50%	12.00%
1	1.085	1.09	1.095	1.1	1.105	1.11	1.115	1.12
2	0.5646	0.5685	0.5723	0.5762	0.5801	0.5839	0.5878	0.5917
3	0.3915	0.3951	0.3986	0.4021	0.4057	0.4092	0.4128	0.4163
4	0.3053	0.3087	0.3121	0.3155	0.3189	0.3223	0.3258	0.3292
5	0.2538	0.2571	0.2604	0.2638	0.2672	0.2706	0.274	0.2774
6	0.2196	0.2229	0.2263	0.2296	0.233	0.2364	0.2398	0.2432
7	0.1954	0.1987	0.202	0.2054	0.2088	0.2122	0.2157	0.2191
8	0.1773	0.1807	0.184	0.1874	0.1909	0.1943	0.1978	0.2013
9	0.1634	0.1668	0.1702	0.1736	0.1771	0.1806	0.1841	0.1877
10	0.1524	0.1558	0.1593	0.1627	0.1663	0.1698	0.1734	0.177
11	0.1435	0.1469	0.1504	0.154	0.1575	0.1611	0.1648	0.1684
12	0.1362	0.1397	0.1432	0.1468	0.1504	0.154	0.1577	0.1614
13	0.13	0.1336	0.1372	0.1408	0.1444	0.1482	0.1519	0.1557
14	0.1248	0.1284	0.1321	0.1357	0.1395	0.1432	0.147	0.1509
15	0.1204	0.1241	0.1277	0.1315	0.1352	0.1391	0.1429	0.1468
16	0.1166	0.1203	0.124	0.1278	0.1316	0.1355	0.1394	0.1434
17	0.1133	0.117	0.1208	0.1247	0.1285	0.1325	0.1364	0.1405
18	0.1104	0.1142	0.118	0.1219	0.1259	0.1298	0.1339	0.1379
19	0.1079	0.1117	0.1156	0.1195	0.1235	0.1276	0.1316	0.1358
20	0.1057	0.1095	0.1135	0.1175	0.1215	0.1256	0.1297	0.1339

Appendix F

Participant Pollutant Management Options Characterization

1. Background Information
   a. Model Trade Participant Organization Name:
   b. Organization Representative Contact Information:
      i. Name:
      ii. Address:
      iii. Phone Number:
      iv. E-mail:
2. Pollutant Load Source(s) for Consideration:
   a. Source A: (provide name of load source e.g., Trout Growers, Inc. at Bhule)
   b. Source B:
   c. Source C:
3. Individual Source Characterization (Source A)
   a. Source Description:
   b. Source Location (river mile):
   c. Source Discharge Location (river mile):
   d. Source Type(s):
   e. Source Discharge Quantity (from TMDL):
   f. Source TMDL Target Load (from TMDL):
   g. Source Current Load (by type if possible):
   h. Source Expected Future Load (annual growth/decline rate and time horizon):
   i. Seasonal or Other Cyclic Load Considerations:
4. Source Control Option(s):
   a. Option A:
   b. Option B:
   c. Option C:
5. Source Control Option Description (Option A):
   a. Description: (include technology/management practice, ability to scale/size to specific control levels, seasonal variability of control, and design, construction, shakedown periods along with overall lifespan)
   b. Currently in Place: (yes or no, and provide date of completion and expected lifespan)
   c. Capital Cost:
   d. Annual O&M Cost:
   e. Control Achieved/Expected (in lbs./day)

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