LAKE TAHOE TMDL SYNTHESIS OF FINDINGS AND PROGRAM ADJUSTMENT RECOMMENDATION MEMO

2010 – 2013

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Contact

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INTRODUCTION

Each year Lake Tahoe TMDL Program Managers and stakeholders take time to consider and evaluate TMDL Program operations, achievements, and challenges and to highlight new relevant scientific findings. This process of synthesizing findings enables TMDL Program Managers to identify implementation and policy issues, opportunities for program adjustment, and emerging information needs. Each year TMDL Program Managers compile and synthesize these findings into the *Synthesis of Findings Report*, paired with a memo describing recommended program adjustments. The combined document, the annual *Synthesis of Findings and Program Adjustment Recommendation Memo*, allows interested stakeholders and Lahontan and NDEP TMDL Executives to have an informed discussion about the need for proposed program adjustments.

The *2010 to 2013 TMDL Synthesis of Findings and Program Adjustment Recommendation Memo* is the inaugural document capturing findings and TMDL Program adjustment recommendations. It provides an overview of relevant science and information generated primarily from within the Lake Tahoe Basin since the release of the Lake Tahoe TMDL. Subsequent annual memos will build upon this inaugural document by synthesizing and integrating new information from the past year.

The *TMDL Synthesis of Findings and Program Adjustment Recommendation Memo* is organized as follows:

Section I: Findings and Implications:
Findings are derived from new science and technical information and from the observations and experiences of those implementing TMDL tools and management strategies. The process of synthesizing findings and drafting implications enables TMDL Program Managers to identify: 1) implementation and policy issues; 2) opportunities for program adjustment; and 3) emerging information needs.

Section II: Recommendations:
This section is a distillation of actionable recommendations to adjust the TMDL Program, including both management strategies and policies. TMDL Program Managers create the recommendations based on their review of new science, stakeholder feedback, and direct learning over the past year. The recommendations are used to guide and inform discussions at the TMDL *Program Review Meeting*, an annual executive meeting between the Lahontan Water Board and NDEP.

References Cited
References cited in this memo are placed in categories that disclose to readers the amount and type of peer review associated with each reference.

Appendices
The Appendices to this document includes documents that capture stakeholder input:

- 2013 List of Information Needs
- 2013 Program Adjustments List
- TMDL Stormwater Tools Improvement Project description and action plan of prioritized improvements

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PART I: FINDINGS AND IMPLICATIONS

Introduction

For this inaugural document, findings are categorized among nine subject areas. Individual findings and associated implications are presented for each subject area.

- Individual findings are statements synthesized from existing documents or drawn from observations or stakeholder comments or feedback. All findings statements contain a citation to the reference from which the finding was derived.

- Implications provide the TMDL Program Managers' assessment of how the findings in each subject area may affect the TMDL Program – including program implementation, and TMDL-related science investment, or other associated policy.

Areas for Future Build-Out

TMDL Program Managers are aware that the *2010 to 2013 TMDL Synthesis of Findings and Program Adjustment Recommendation Memo* may contain information gaps. The intention of circulating this document for stakeholder review is to provide TMDL stakeholders with the opportunity to flag new research and findings that may have been overlooked. New information will be considered in the production of the *2014 TMDL Synthesis of Findings and Program Adjustment Recommendation Memo,* planned to be circulated in August 2014. This next iteration will be the version used as a reference for Lahontan and NDEP TMDL Executives at their September *Program Review* Meeting.

1. URBAN ROADS

Overarching Finding:

Urban roads are the primary source of fine sediment particles from the urban source area.

Findings

A. Paved urban roads are the greatest source of fine sediment particles < 16μm (FSP) in the Tahoe Basin. The vast majority of this FSP occurs as a result of chronic winter road abrasive applications and subsequent pulverization by vehicle traffic (2NDNATURE et al. 2010a; Kuhns et al. 2010).

B. An average of 12,000 metric tons of abrasives has been applied to Tahoe basin roads each winter over the last decade. (2NDNATURE et al. 2010a).

C. On average, nearly 300 metric tons of FSP <10μm (PM_{10}) are contributed annually to the atmosphere by vehicles traveling on paved roads in Tahoe Basin. (Kuhns et al. 2010; Zhu et al. 2009).

D. Seasonal interpretations from water quality measurements and road dust emission studies agree that roads contribute a significantly greater amount of FSP to stormwater and to the atmosphere in the winter compared to the summer. The seasonal increase in FSP is due to the application, pulverization, and subsequent mobilization of traction abrasives applied to road surfaces in the winter. (2NDNATURE et al. 2010a, 2012a; Kuhns et al. 2010; Zhu et al. 2009).

E. FSP from roads can be transported to Lake Tahoe in a variety of ways: 1) by entering the stormwater system either by proximal deposition from road dust emissions and/or wash off during snowmelt and rain events; or 2) by direct atmospheric deposition onto Lake Tahoe's surface (2NDNATURE et al. 2010a, 2012a; Kuhns et al. 2010; Zhu et al. 2009).

Implications

A. Findings from recent investigations continue to support the 2008 TMDL Technical Report's (Lahontan Water Board and NDEP 2008) finding that paved roads in the Urban Uplands source category are the primary source of FSP loading to Lake Tahoe. Thus, implementation of the TMDL Program will continue to emphasize measures to reduce and control the production and transport of road-borne FSP.

B. From a mass balance perspective, the greatest opportunity to reduce annual loading of road-borne FSP is to target the period and locations of greatest input. Given limited resources, the top priority

management strategy is to implement pollutant source control best management practices (PSC BMPs) during the winter and early spring on those paved urban roads that receive the most frequent abrasive application.

2. POLLUTANT SOURCE CONTROL BMPS

Overarching Finding:

Pollutant source control best management practices (PSC BMPs) are more cost effective than stormwater treatment (SWT) BMPS in reducing fine sediment particles from urban roads.

Findings

A. A contemporary cost benefit analysis of potential strategies to meet TMDL load reduction targets indicates pollutant source control best management practices (PSC BMPs) are up to an order of magnitude more cost effective than increased implementation of stormwater treatment best management practices (SWT BMPS; 2NDNATURE et al. 2011a).

B. A study to evaluate roadway sweeping effectiveness determined that using a high efficiency vacuum assisted sweeper corresponds with a statistically significant reduction in the FSP mass accumulated on the road surface. The study results also support the hypothesis that more frequent sweeping reduces the amount of pulverized FSP that accumulates on the roadway (2NDNATURE 2012, NTCD 2011).

C. Frequent wintertime street sweeping and/or the use of anti-icing pretreatment is estimated to be three orders of magnitude more cost effective than other options evaluated to reduce the annual mass of FSP <10µm (PM_{10}) emissions from urban roads in the Tahoe basin. Estimates of more than sixty percent reduction in regional PM_{10} emissions are expected when annual road abrasive applications are significantly reduced, and all urban roads are frequently and effectively swept during winter months to recover as much of the applied material as possible (Kuhns et al. 2010).

D. FSP deposited onto and generated from urban road surfaces can be reduced by:

   a. Reducing the frequency when abrasives are applied (2NDNATURE et al. 2010a).

   b. Employing advanced control technology abrasive spreading equipment to target and minimize the mass of abrasives applied and reduce cast-off through pre-wetting of materials (2NDNATURE et al. 2010a; TRPA, BMP Handbook, 2012).

   c. Pre-washing abrasives to remove FSP prior to application on Tahoe roads, and/or selecting abrasives to minimize the initial proportion of FSP (Caltrans 2012).

   d. Applying brine, other anti-icing treatments, or biodegradable polymers as traction abrasive alternatives.

e. Selecting abrasives that are more resistant to pulverization, and therefore potentially remain as coarse material on the road surface for longer durations (Caltrans 2012).

f. Using road sweepers that include regenerative air and/or vacuum assist technologies that increase the removal of FSP from road surfaces over mechanical broom models (NHC et al 2009; Sutherland and Jelen 1996, Center for Watershed Protection 2008).

g. Reducing the residence time of abrasives and the mass available for pulverization by vehicle traffic. Abrasive residence time can be reduced by sweeping roadways shortly after abrasive application events, and targeting sweeping practices to those locations where the most abrasives were applied. Pulverized material on a road may be effectively dispersed throughout the road network by vehicle traffic. (2NDNATURE et al. 2010a, 2012a; 2NDNATURE, 2012; NTCD and DRI 2011; Kuhns et al. 2010).

h. Maintaining the integrity of the road surface such that pavement conditions are free of cracks and crevices. Cracks and crevices in pavement can accumulate FSP that most sweepers cannot remove, but that is effectively mobilized and transported by stormwater runoff events (2NDNATURE et al. 2010a, NTCD and DRI 2011).

Implications

A. A number of viable and cost-effective strategies exist to control road-FSP derived loads. Substantial urban load reductions are expected when jurisdictions minimize abrasive application and increase the frequency and improve the effectiveness of street sweeping. This is especially true in the winter and spring when the most abrasives are applied to roads. Further investigation of real world applications of such controls would help determine which practices provide the greatest cost-benefit.

B. The performance of SWT BMPs that rely on infiltration rapidly declines when accepting runoff that contains high volumes of FSP because the FSP entrained in the runoff clogs the SWT BMPs. Prioritizing implementation of PSC BMPs could help reduce maintenance intervals and maximize the lifespans of infiltration SWT BMPs.

C. Further reduction or outright elimination of typical road abrasives requires investigating the efficacy of other traffic safety measures not frequently used in the Tahoe basin. These investigations would need to quantify the resulting road condition, as well as the type and levels of potential adverse impacts any of these alternatives could have on the human and natural environments.

D. There are a number of traffic safety measures that are each expected to provide incremental reductions in the application of traction abrasives. These include: 1) using best advanced control technology bulk spreading equipment for road abrasive and deicer application to target application and reduce overall application amounts, 2) increasing public transit ridership, 3) reducing and enforcing speed limits during storms, or 4) using radiant-heating to melt ice from high trafficked winter roads. Radiant heating technology is currently used on some roads in parts of Japan and Germany. Pilot-scale implementation of any of these measures could occur immediately, with the aim of verifying the preservation of traffic safety, quantifying the incremental reduction in traction abrasive use, and quantifying the resulting road condition.

3. DESIGN, INSPECTION AND MAINTENANCE OF STORMWATER TREATMENT BMPS

Overarching Finding:

Regular inspection and maintenance of stormwater treatment best management practices (SWT BMPs) are needed to sustain intended fine sediment particle load reductions.

Findings

A. There is a consistent and ubiquitous lack of appropriate maintenance conducted on SWT BMPs in the Tahoe basin. All SWT BMPs have been installed with the intention of reducing downslope pollutant loads though volume control, pollutant reductions, or both. The lack of maintenance has been observed for private (residential, commercial) and public (roadways, facilities) SWT BMPs and includes all types of SWT BMPs, including vegetated swales, sediment traps, dry basins, wet basins, cartridge filters, treatment vaults, etc. (2NDNATURE 2006, 2NDNATURE et al. 2012a).

B. Observations suggest problems associated with existing SWT BMPs are primarily due to a lack of proper conveyance and/or accumulation of excessive sediment, debris or vegetation, both of which may be a result of flawed design, poor construction, or lack of regular maintenance (2NDNATURE et al. 2012a, 2013).

C. The performance of SWT BMPs that rely on infiltration, and that accept runoff from FSP sources, rapidly declines due to effective clogging.

    a. FSP loading rates estimated for untreated driveway and parking lot runoff substantially affected the infiltration capacity of SWT BMPs within a few years, resulting in a failure to meet the 20 year/1 hour storm infiltration typical design standard (2NDNATURE 2006, 2010; 2NDNATURE et al. 2012a, 2013).

    b. Infiltration BMP configurations with more lateral (side) infiltration surface area experienced a somewhat slower decline in measured infiltration capacity because less FSP accumulated at the sides of the BMP relative to the base (2NDNATURE et al. 2013).

D. SWT BMPs (including Treatment Vaults, Sediment Traps and Drop Inlets) that rely upon particle settling are not effective at removing FSP entrained in stormwater. This is due to the low settling velocities of very small particles and their tendency to be easily re-suspended (2NDNATURE et al 2009, 2NDNATURE et al. 2012a; Dennett and Ridenoure, 2007).

Implications

A. Without regular inspection and maintenance, the actual average annual load reduction achieved by SWT BMPs will remain far below load reduction expectations. Maintenance actions need to include both frequent and simple actions (e.g.,vactoring, debris removal, verifying appropriate conveyance) as well as infrequent but more complicated actions (e.g., regrading to maintain hydrologic function, or restoring infiltration capacity).

   a. Properly constructed SWT BMPs have finite lifespans. Regular inspections would help to maximize this lifespan by identifying when maintenance is required.

   b. A substantial number of existing SWT BMPs need to be maintained to restore intended functionality and demonstrate accountability for expenditures of public funds on these water quality improvements.

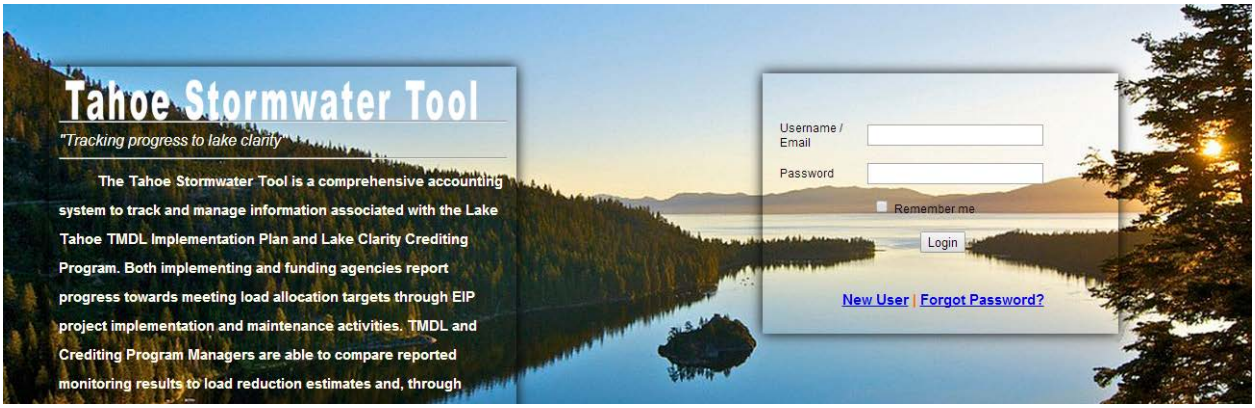
   c. Clear technical guidance to objectively define inspection and maintenance intervals for implemented SWT BMPs to prioritize maintenance needs and minimize subsequent maintenance costs can improve SWT BMP performance.

B. The long-term effectiveness of infiltration SWT BMPs would likely be improved if infiltration performance was sustained over time through one or more of the following strategies: i) regular maintenance; ii) installation and regular maintenance of effective pre-treatment devices to ensure the desired treatment volume is achieved long-term, and iii) controlling and reducing the sources of FSP from paved surfaces (see Pollutant Source Control BMP subject area above). Effective and spatially distributed FSP source control actions on roads would extend the lifespan of SWT BMP performance and reduce the required maintenance frequencies for those SWT BMPs that accept roadway, driveway or parking lot runoff.

C. Sediment traps and drop inlets are relatively ineffective at FSP removal, and these facilities should remain ineligible for load reduction assessment within the Lake Clarity Crediting Program.

D. The benefit of treatment vault effectiveness is likely overestimated in the current version of the Pollutant Load Reduction Model (PLRM).

4. TMDL STORMWATER TOOLS



Overarching Finding

Improvements to the suite of TMDL stormwater tools can provide more effective implementation, adaptive management, and progress tracking.

Background

The Lake Tahoe TMDL and supporting Lake Clarity Crediting Program rely upon a suite of stormwater tools to provide pollutant load reduction estimates and verify relative condition of critical landscape features, namely SWT BMPs and urban roadways. The current suite of tools includes the **Pollutant Load Reduction Model** (PLRM) and two assessment tools: **Road Rapid Assessment Methodology** and **Best Management Practices Rapid Assessment Methodology** (ROAD RAM and BMP RAM respectively). The **Tahoe Integrated Stormwater Tool** (TIST) is the online TMDL registration and accounting platform that provides for the management of relevant data and sharing of information between the jurisdictions and regulators.

Findings

A. Each stormwater tool was developed independently and under different timelines as stand-alone tools to address individual stormwater planning and reporting needs. Consequently, the tools are not well integrated.
B. Due to limited available development funds, only limited testing of the tools was accomplished at the time of development. Therefore, the initial tools are more akin to beta-version tools.
C. Research projects funded specifically to collect and analyze datasets to compare and assess tool performance that are now complete with recommendations on technical improvements to the tools.
D. Application and testing of the initial versions of the tools since their release has resulted in user identification of a number of technical, efficiency and integration improvements for the tools.
E. The *Stormwater Tools Improvement Project* was initiated to refine and improve the current suite of stormwater tools by addressing the priority operational improvement needs identified by researchers, tool users and tool developers. A feedback and prioritization process carried out through the project has resulted in the prioritization of tool functionality and efficiency over technical accuracy and other improvements. Specific improvements to be carried out through the project are identified in Appendix C.

Implications

A. Improving stormwater tools will improve implementation efficiency by increasing the ability of Urban Jurisdictions to prioritize and target implementation of the most cost-effective water quality improvement actions. More efficient progress reporting and assessment will provide better accountability for the expenditure of public monies on water quality improvement actions.

B. The list of potential improvements and associated costs far exceed the available funding for improvements. Approximately half or less of all identified improvements will be able to be carried out through the project. No funding is available or projected for user improvements in the future.

5. MONITORING

Overarching Finding:

Targeted long-term water quality monitoring is critically important for assessing TMDL progress over time.

Findings

A. Data collected as part of the long-term tributary monitoring effort known as the Lake Tahoe Interagency Monitoring Program (LTIMP) was instrumental in supporting Lake Tahoe TMDL development. Funding for LTIMP continues to decline, threatening data continuity and the ability to detect changes in pollutant loading at the watershed scale over time.

B. The Water Board and partner agencies provide funding to support in-lake monitoring. Annual average Secchi disk depths from 2010 – 2013 range from 64.4 (2010) to 75.3 (2012) feet. The highest annual average Secchi disk reading during this period occurred in 2012. While the 2013 reading represents a 5 foot decrease from the previous year, clarity levels continued a decade-long trend of stabilization (TERC 2014). The five-year running average over the same time period (2010-2013) displayed an increasing trend from 68.0 to 69.4 feet.

C. Urban storm water monitoring at the catchment scale is needed to assess status and trends over time, and additional work is needed to evaluate the efficacy of various SWT BMPs. The Implementers Monitoring Plan (IMP) will monitor outfall runoff from five urban catchment sites and four SWT BMP effectiveness projects covering two different treatment approaches. Runoff monitoring conducted under the IMP will facilitate a better understanding of how storm water management practices are affecting runoff water quality. The IMP is an important step in implementing a more comprehensive basin-wide catchment scale monitoring network under the Regional Stormwater Monitoring Program (TRCD 2013a, 2013b).

D. California Proposition 84 funding has been secured to establish a centralized structure responsible for organizing and administering the Lake Tahoe RSWMP. In addition to programmatic development tasks, the project will build on the IMP and establish additional storm water monitoring sites to assess urban storm water runoff pollutant load status and trends at a catchment scale (TRCD, 2013b).

E. Comparative analyses were conducted on various data collection and analysis techniques for FSP measurements in the Tahoe Basin (Heyvaert et al. 2011). Results included:

    a. Holding times longer than one day can affect the particle size distribution (PSD) results for stormwater samples, with a tendency towards increases in larger particles with increased holding time. Sonication was shown to restore the samples to the original PSD profiles, while dispersants did not.

b. The LiQuilaz (laser optical) particle counting instrument is more appropriate for low concentrations typical of streams and Lake Tahoe, while laser diffraction instruments (e.g., Beckman Coulter LS-13320 and Micrometrics Saturn DigiSizer) are more appropriate for the higher concentrations in urban stormwater.

F. Continued instrument quality assessment and quality control is critical to ensure data integrity for automated equipment. The freeze and thaw weather cycles in Tahoe can wreak havoc on continuous flow and water quality monitoring equipment (2NDNATURE 2006; 2NDNATURE et al. 2010a, 2012a, 2012b). Manual measurements to calibrate the instrument readings are imperative to ensure high confidence in the observed data.

G. Various Lake Tahoe basin research efforts have found strong correlations between field turbidity measurements and FSP (both mass and number of particles) in stormwater, streams, and land use data, however the slope of the relationship can vary depending on the FSP source (2NDNATURE 2011, 2013; 2NDNATURE et al. 2010a, 2012a, 2012b; Heyvaert et al. 2011).

Implications

A. Funding must be secured to support the consistent, long-term status-and-trend monitoring required to detect the effects of management actions on water quality at various scales. Urban runoff monitoring at the catchment scale is needed to evaluate the integrated effect of storm water management practices. Tributary monitoring of both impacted and reference streams are important to track landscape-level pollutant loading trends over time. In-lake monitoring must be maintained to assess the ultimate receiving water response.

B. Standardized data collection, management and analysis techniques that constrain sampling and natural hydrologic variability would improve the power of water quality monitoring data to detect load reduction changes resulting from management actions, as opposed to other sources of variability.

C. Field turbidity measurement is the most promising and cost-effective proxy for FSP concentrations. Although careful attention to sampling methods and quality control are required, field turbidity measurements allow more data to be collected over a wider spatial area and with increased frequency given available resources.

6. STREAM RESTORATION

Overarching Finding

Restoring floodplain connectivity and geomorphic function in riverine systems can provide significant FSP load reductions.

Findings

A. The Stream Load Reduction Tool (SLRT) is a recently developed model that provides load reduction estimates that can potentially be used to support the tracking of pollutant load reductions in conjunction with the implementation of the Lake Tahoe TMDL (2NDNATURE 2013). The SLRT provides estimates of average annual FSP load reductions as a result of changing the frequency and extent of floodplain connectivity.

B. Targeted floodplain sampling during eight independent overbank events on two floodplains consistently measured FSP load reductions as a result of floodplain interactions (2NDNATURE 2011, 2013). Reach scale water quality monitoring efforts during water year 2010 and water year 2011 overbank events on the restored reach of Trout Creek measured FSP load reductions. Mass balance estimates of the event scale FSP retention on the floodplain exceeded FSP contributions from channel erosion in systems where the channel capacity and morphology approximates natural conditions (2NDNATURE 2013).

C. Laboratory simulations demonstrated FSP accumulation and microfilm creation on vertical structures perpendicular to flows, suggesting FSP retention on floodplain vegetation could be substantial (Andrews et al. 2011). Modeling of suspended sediment on the Trout Creek restored floodplain indicated that flocculation (i.e., the aggregation of smaller particles) is the most important physical mechanism influencing FSP removal on floodplains, followed by sediment stranding due to infiltration and gravitational settling (Andrews et al. 2011).

D. In simulations using a calibrated BreZo model, inducing overbank flow via weir installation had a greater effect on the total FSP load reduction due to overbank flow than increasing floodplain vegetation or backwater depressions (Andrews et al. 2011).

E. Observations immediately following in-channel restoration of Blackwood Creek Reach 6 showed an increase in the extent of flooding, particularly in the small magnitude, high recurrence flows. A decrease in average shear stress for all floods was modeled, showing a 39 percent decrease for the 1.5-year recurrence flow and a 48 percent decrease for a 20-year recurrence flow (Immeker 2012). A decrease in shear stress is expected to reduce erosion of the streambank, reducing the overall input of sediment to the lake due to channel erosion.

F. A multitude of research studies have been conducted over the last few years to improve the technical understanding of physical streambank processes. These studies have led to direct improvements to

the BSTEM Dynamic and CONCEPTS models and their ability to assess the potential impacts of various mitigation measures and restoration actions. Improvements include modeling floodplain soil heterogeneity, incorporating the effects of riparian vegetation (RipRoot), and quantifying meander migration rates (Bankhead et al. 2013; Garcia et al. 2010; Langendoen 2011, 2013; Motta et al. 2010, 2011, 2012; Simon et al. 2011).

G. While toe erosion is responsible for only a small proportion of the total erosion predicted within a stream, hydraulic erosion of the bank toe is the precursor to geotechnical failure of the stream bank as a result of bank oversteepening (Simon et al. 2011; Bankhead et al. 2013).

Implications

A. The 2010 TMDL analysis of pollutant control opportunities focused on strategies to reduce FSP loads associated with channel erosion (bank and bed). However, functional floodplain areas can also contribute to reductions in FSP loads from contributing catchments. These findings further support the TMDL Implementation Plan assumption that planned and anticipated restoration activities will result in attainment of load reduction milestones for the stream channel erosion source category, and additional benefits associated with floodplain function provide a margin of safety to basin-wide TMDL load reduction expectations.

B. Effective morphologic stream restoration projects that increase the frequency, duration and extent of floodplain flows can result in substantial and sustained FSP load reduction opportunities.

C. When overbank conditions exist, functioning floodplain areas can reduce FSP loads prior to runoff entering Lake Tahoe without the frequent and intensive maintenance required by SWT BMPs that rely upon retention and infiltration to achieve sustained FSP load reductions. Routing urban runoff through functioning floodplain area should remain a viable opportunity for load reduction potential within the Lake Clarity Crediting Program.

7. FOREST MANAGEMENT AND EROSION CONTROL

Overarching Finding:

Forest management with appropriate mitigation techniques can reduce sediment generation from forested lands and residential properties.

Findings

A. Active unpaved roads are estimated to produce sediment yields that are 20-2000 times (1-3 orders of magnitude) higher than inactive unpaved roads and provide higher contributions of FSP (42-52 percent compared to 12-43 percent, respectively) (Drake et al. 2012). Various BMP strategies have been shown to reduce sediment yields on unpaved roads and ski runs (Drake et al. 2012). Specifically:

   a. Mulch (2-3 inch depth of wood chips or pine needles) applied to inactive dirt roads reduced sediment yields by 72 to 86 percent (measured with rainfall simulation). Similar sediment reductions of 60-90 percent were achieved with the same mulch applications on ski runs.

   b. For large disturbed slopes, such as ski runs, mulch filter berms have been shown to reduce sediment yields in surface runoff by 45 percent.

   c. Grading active unpaved roads was shown to increase sediment yield by 3,300 percent (33 times) compared to ungraded conditions. Applying gravel as a hardening agent to active unpaved roads (graded and ungraded) was shown to reduce sediment by up to two orders of magnitude and reduce ongoing maintenance costs including grading.

B. Short-term vegetation establishment on eroding slopes has been shown to be an insufficient (and sometimes misleading) predictor of long-term restoration success (Herrick et al. 2006) and erosion resistance (Grismer et al. 2009).

C. Pile burning provides a cost-effective alternative when prescribed underburning and/or biomass harvesting are restricted. Pile burning can alter soil properties, including reducing porosity and infiltration rates, and result in increased erosion rates for several years post burn (Hubbert et al. 2013). Impacts of pile burning can be greatly reduced by being cognizant of the content of each pile and treating the burn site following burning (Busse et al. 2013). Piles of large-sized wood (logs) burn much hotter and longer than piles containing small sized material. Soil damage can be greatly mitigated by "mopping up" (i.e., quenching the fire with water after the bulk of the biomass is consumed, and thereby avoiding lengthy lingering beds of hot coals).

D. Prescribed burn treatments that create spatial patchiness and burning during higher moisture conditions can effectively reduce fire risk without increasing erosion potential. Erosion rates are twice as high when mastication of fuels results in bare soil compared to leaving patches of masticated material that cover 25-50 percent of the soil surface (Stubblefield et al. 2012).

E. "Light on the land" equipment and treatment techniques used for mechanical vegetation treatments have not resulted in ecologically significant adverse effects on the Tahoe Basin soils evaluated (Norman et al. 2012). On the other hand, modeled estimates of different mechanical treatment techniques such as whole tree skidding as compared with cut-to-length indicate substantial differences in event mean concentrations (EMCs) in forest runoff by factors of 5-50 times, depending on land use and soil type. Volcanic soils with high erosion potential are especially prone to experience high EMC in forest runoff (Tetra Tech 2012).

F. Eight landscape treatments were tested for reducing erosion risk and maintaining low fire risk using rainfall simulation and burn tests (IERS 2012). Results showed:

   a. Soil loosening, incorporation of woody material and surface mulching can reduce sediment yield and improve erosion resistance compared to compacted, partially vegetated areas with no mulch cover.

   b. Mulch cover is highly effective at preventing erosion, but some mulch (pine needles, landscape bark) pose high fire risk.

   c. Roto-tilled woodchips and duff mulch have the lowest erosion risk/fire risk combination.

Implications

A. Disturbed soils in non-urban areas (such as ski runs or forest roads) function similarly to disturbed soils in more urbanized areas (such as road cut/fill slopes). Most sediment source control treatments developed and demonstrated in non-urban areas (described in above findings) may be directly transferable to erosion control projects in urban areas.

B. Short-term vegetation establishment, which is a common permit requirement and criteria of success for Tahoe Basin erosion control projects, is on its own, an inappropriate and sometimes misleading indicator of upland erosion control effectiveness. Rather, soil density/infiltration, total surface cover (including mulch) and soil organic matter have proven to be more relevant and readily-measurable indicators of long-term erosion resistance. Optimizing these factors also helps to create the soil conditions that support robust, self-sustaining, native plant communities.

C. Mitigation measures to reduce the likelihood of wildfire occurrence, including prescribed burns and vegetation management, could reduce erosion risk and associated sediment generation potential from forested uplands when fires do occur.

D. Certain vegetation management measures, including mechanical treatment techniques, can cause elevated sediment erosion rates if not controlled with proper BMPs, particularly on volcanic soils with high erosion potential.

8. CLIMATE CHANGE

Overarching Finding

The levels of potential water quality impacts attributable to climate change are mixed: sediment loads are not projected to increase substantially, but nutrient availability from within the lake could increase substantially.

Findings

A. The Tahoe Environmental Research Center recently released a report highlighting and summarizing some of the key findings from the 50-years of scientific studies and monitoring in the Lake Tahoe basin, and the first extensive modeling investigation of future climate change impacts on the Tahoe basin (TERC 2013a). Projected 21st Century trends of direct relevance to the Lake Tahoe TMDL Program include:

   a. Sediment and nutrient loading to Lake Tahoe from streams should not increase substantially.

   b. Overall fine sediment load reductions should still be achievable, if stormwater treatment BMPs are properly sized.

   c. Lake Tahoe could cease to mix to the bottom for extended periods, resulting in complete oxygen depletion in the deep waters with an increase in nutrients released from bottom sediments. An increase in lake nutrients released from bottom sediments under chronic conditions of oxygen depletion could further enhance levels of phytoplankton productivity, which is an important component in the long-term decline of summer lake clarity levels (TERC 2013b).

B. Forecasted precipitation and temperature data based on a low carbon emissions scenario (B1) and medium-high carbon emissions scenario (A2) were input into the Storm Water Management Model (SWMM), and simulations were run for 1) a baseline condition (i.e., current land use conditions) and 2) an improved condition (i.e., implementation of a hypothetical WQIP). Simulated results indicated a modest decline in performance for FSP load reductions as a result of climate change; however, the WQIP continued to provide more than an 80 percent FSP reduction relative to the baseline condition (Coats et al. 2010).

Implications

A. Climate change has the clear potential to impact lake clarity due to a variety of factors beyond the control of the TMDL Program – increasing lake temperature among them. However, climate change is not going to change the effectiveness of urban pollutant control reduction treatments. While

climate change is anticipated to affect the type, timing and amounts of precipitation and associated runoff in the Tahoe Basin, these impacts on annual pollutant loading of fine sediment particles to Lake Tahoe will likely be negligible in comparison to potential load reductions that are anticipated to be achieved by the implementation of effective PSC and SWT BMPs.

B. Wildfire frequencies and intensities are expected to increase in the coming decades due to climate change (less annual precipitation, warmer air temperatures, shift to earlier snowmelt), which could affect progress toward achieving load reductions milestones for the forest upland source categories.

9. NEARSHORE QUALITY

Overarching Finding:

Nearshore conditions will improve in response to Lake Tahoe TMDL implementation.

Findings

A. Changes in nearshore conditions at Lake Tahoe have become evident to visitors, residents and resource managers. Of particular concern are the changes in nearshore clarity, increasing periphyton growth, spread of invasive species, and a decline of native species in the nearshore biological communities (DRI et al., 2013).

B. All contributing factors and the observed nearshore response characteristics are inter-related and directly connected to conditions in Lake Tahoe's open-water. The pollutant sources affecting nearshore conditions are generally the same as those identified in the Lake Tahoe TMDL. Therefore, the control measures to reduce nutrient and fine sediment loading implemented to improve mid-lake clarity will also provide benefits for related characteristics in nearshore condition, primarily those metrics associated with clarity and trophic status (DRI et al., 2013).

C. Nearshore water quality is strongly influenced by localized pollutant input, so a load reduction action that may improve the open-water may or may not have a directly comparable effect on all nearshore areas. For example, while load reductions along the south shore will contribute to an eventual improvement of open water clarity and a more immediate effect on that region's nearshore, its direct effect on the nearshore zone in the north lake may be delayed or attenuated (DRI et al., 2013).

D. Asian Clams (*Corbicula fluminea*) can affect nearshore lake clarity by concentrating nutrient excretion in discrete locations and causing benthic algal blooms. Nearshore populations of the invasive clam have been increasing over the last decade, from 2-20 individuals per square meter in 2002 to more than 5,000 per square meter in 2009. (Wittman et al. 2013a, b).

Implications

A. While the TMDL focuses on the deep water transparency of the lake, impairment of the nearshore environment is most visible to the Tahoe community and therefore can have an impact on people's perception of the effectiveness of the TMDL Program. Focusing TMDL implementation actions in localities where nearshore conditions are degraded will act to improve nearshore condition in addition to open water clarity.

B. Implementation of a nearshore status-and-trend monitoring program would assist in verifying if nearshore condition is improving in response to TMDL implementation as expected.

PART II: RECOMMENDATIONS

Introduction

Creating, adopting, and implementing well-supported recommendations for TMDL Program adjustments in response to new information is key to the TMDL Program's adaptive management process. Annual adjustments ensure procedures and tools are practical and encourage effective actions to meet TMDL Policy objectives.

This section is a distillation of actionable recommendations proposed by TMDL Program Managers to adjust the TMDL Program, including its management strategies or its guiding policies. Recommendations contained within this document will be presented by TMDL Program Managers to TMDL Executives at the Annual *Program Review* meeting in September 2014. Recommendations are specifically targeted at actions TMDL Program Managers may take, as they are the main implementers of any desired changes to the TMDL Program. TMDL Program Managers are currently enacting some of the recommendations described here. Other recommendations are proposed but have not been approved for action by TMDL Executives.

TMDL Program Managers compiled recommendations based on the findings and implications described in Part I, and based on TMDL stakeholder feedback regarding: 1) scientific findings since 2010 that would likely inform TMDL implementation; and 2) information needed in order to achieve TMDL clarity goals. Note that stakeholder feedback for which no action is recommended to be taken is also captured in the *Program Adjustments List* (see Appendix B).

Recommendations contained within this memo fall into one of three subject areas: 1) Urban Stormwater Management (SW); 2) Non-Urban Source Category Management (NU) and Overall (O). Each recommendation within each subject area includes:

- Summary of the recommendation;
- Response Categories: I, II or III;
- Alignment with Findings and with Stakeholder Input;
- Rationale for the Recommendation;
- Identified Concerns;
- Status.

RESPONSE CATEGORIES

To establish a relative level of effort associated with each suggested recommendation, adjustment recommendations are placed into one of the following three response categories:

- **Response Category I** – Minor TMDL Program Adjustments. Generally, Category I adjustments may be executed by TMDL Program Managers at any time with consultation only from TMDL Executives. Little or no additional funding is required to implement Category I recommendations.
- **Response Category II**– Adjustments to TMDL Program technical tools or models. Category II adjustments always require formal approval from Lahontan and NDEP TMDL Executives, and may also require formal approval from the Lahontan Regional Water Board and NDEP Administrator. Additional funding is usually required to implement Category II recommendations.
- **Response Category III** – Adjustments that would require amending the EPA-Approved Lake Tahoe TMDL Report. Category III recommendations may be warranted in the case of new scientific findings or substantial changes to environmental or economic conditions. Category III recommendations are first reviewed and approved or rejected by Lahontan and NDEP TMDL Executives. They are implemented through the appropriate policy change process for each agency. Additional funding is usually required to implement Category III recommendations.

URBAN STORMWATER MANAGEMENT

SW.1 Support opportunities to fund pollutant source control (PSC) BMPs on paved roads and reinforce their importance in communication materials and BMP implementation schedules.

Response Category I: This recommendation is consistent with the current focus of the TMDL implementation plan and the Lake Clarity Crediting Program.

Alignment with Findings and Stakeholder Input: This recommendation is supported by findings in subject areas #1, #2 and #3, and addresses Information Needs #1 and #2 in the *List of Information Needs*.

Rationale: As implicated by findings in subject areas #1 and #2, road FSP derived loads are controllable, and significant urban load reductions can be expected, when jurisdictions minimize traction abrasive application and increase the frequency and improve the effectiveness of street sweeping – especially in the winter and spring, the seasons when the most abrasives are applied to roads. Efforts to minimize the accumulation of FSP on high trafficked roads should be a high priority in the winter, when winter management of icy roads results in excessive FSP accumulation. Efforts to recover FSP from roads should be a priority anytime road conditions change to melt-off or run-off conditions. Reducing the annual mass of urban road-derived FSP during the winter is one of the most cost-effective, long-term and sustainable approach to reduce FSP loads from urban roads, the primary sources of this pollutant. As implicated by findings in subject area #3, reducing the annual mass of urban road-derived FSP also will substantially reduce maintenance needs and extend the water quality performance of SWT BMPs throughout the Tahoe Basin. Once entrained in stormwater, FSP rapidly clogs SWT BMPs that rely upon infiltration, and is extremely challenging to capture and retain by SWT BMPs that rely upon particle settling.

Identified Concerns: While significant load reduction opportunities reside with implementation of advanced and innovative roadway operations and maintenance, traditional funding sources (including federal and state grant programs) consider these practices ineligible for grant funding. Urban Jurisdictions continue to struggle to find funding for staff and equipment needed to perform and verify cost-effective roadway operation and maintenance work that result in sustained pollutant load reductions.

Status: Urban Jurisdictions are working to increase the efficacy of street sweeping and other abrasive recovery practices and are exploring opportunities to reduce traction abrasive application rates. Urban Jurisdictions are also evaluating different mechanisms to reduce the amount of FSP applied to roadways. Road condition assessment via Road RAM is part of the Lake Clarity Crediting Program to provide consistent inspection protocols to verify practices are having the desired effect. Road RAM is being updated through the Tahoe Urban Stormwater Tools Improvement Project and some Urban Jurisdictions may explore alternative road condition assessment methods. In addition, NDEP is working in collaboration with Urban Jurisdictions to test and refine road maintenance operations to effectively reduce FSP loading from urban roads through the Road Operations Testing Effectiveness Study. This study is partially funded by NDEP and was initiated in October 2013. Additional required funding for the study has been requested from the United States Army Corps of Engineers, and a Nevada License Plate Grant 2014.

SW.2 Emphasize the importance of using the BMP RAM to prioritize inspection and maintenance of stormwater treatment (SWT) BMPs to ensure water quality benefits from this infrastructure are realized over the long-term.

Response Category I: TMDL Program Managers continue to stress the importance of infrastructure inspection and maintenance and will assess the need for more formal encouragement once catchment registration begins in late 2014.

Alignment with Findings and Stakeholder Input: This recommendation is supported by findings in subject area #3, and addresses Information Need #6 in the *List of Information Needs*.

Rationale: As described in subject area #3, there is a ubiquitous and consistent lack of maintenance conducted on SWT BMPs in the Tahoe Basin. This lack of maintenance impairs the ability of SWT BMPs to infiltrate water and to capture and retain FSP and nutrients. The continued and reliable performance of SWT BMPs is critical to achieve and sustain desired reductions in stormwater pollutant loading to Lake Tahoe. Further, a critical incremental step toward full implementation of the Lake Clarity Crediting Program is for Urban Jurisdictions to inspect SWT BMPs and report the results using BMP RAM.

The Lake Clarity Crediting Program requires annual inspections of SWT BMPs that are anticipated to result in substantial load reductions using BMP RAM. Encouraging Urban Jurisdictions to begin SWT BMP inspections will ensure that Urban Jurisdictions: 1) increase their awareness of the extent of need to maintain neglected SWT BMPs; 2) learn how to incorporate the use of BMP RAM into routine maintenance practices; and 3) prioritize limited maintenance funding to increase the effectiveness of treatment BMPs in greatest need.

Identified Concerns: Adoption of new practices and procedures requires staff training and possibly reallocating available resources. Urban Jurisdictions have expressed concerns related to adopting new inspection and maintenance practices given staffing and budget constraints.

Status: Initial direction from TMDL Program Managers has occurred. The Tahoe Urban Stormwater Tools Improvement Project is evaluating the need for Lake Clarity Crediting Program changes to re-define which BMPs will require annual condition assessment to ease the inspection burden.

SW.3 Work with the Tahoe Regional Planning Agency, Resource Conservation Districts and Urban Jurisdictions to develop a private property BMP inspection and maintenance program, including a verification component that can be integrated into the Lake Clarity Crediting Program.

Response Category II: Implementing this recommendation would require that TMDL Program Managers commit substantial time to program development and alignment with TRPA. Implementation also may require updating several BMP design and selection tools.

Alignment with Findings and Stakeholder Input: This recommendation is in response to findings in subject area #3, and addresses Information Need #6 in the *List of Information Needs*.

Rationale: There is a need to create clear technical guidance to objectively define inspection and maintenance protocols and intervals for private parcel BMPs. Potential reasons for the shortage of inspections and maintenance on private parcels, include: 1) lack of awareness that inspections and maintenance are critical to preserve SWT BMP infiltration performance; 2) lack of understanding of how or when to conduct informative inspections; and 3) disconnect between information gathered from an inspection and the implementation of specific maintenance actions.

In addition, the Lake Clarity Crediting Program currently does not include requirements for regular private parcel BMP condition assessments to verify acceptable condition. Incorporating annual condition verification requirements of private parcel SWT BMPs into the Lake Clarity Crediting Program would help ensure credit awarded for private parcel BMP implementations is appropriate.

Identified Concerns: Maintenance costs may be substantial barriers for landowners to maintain parcel BMPs. The scale of private parcel BMP implementations and agencies' staffing limitations may mean that

field-based verification of maintenance activities is impractical. Moreover, field-based verification is complicated by private property trespass restrictions.

Status: TMDL Program Managers are participating in a comprehensive stakeholder process evaluating TRPA's private parcel BMP policies and implementation efforts (including inspection and maintenance). Aligning TRPA's Stormwater Management Program with the Lake Clarity Crediting Program would require extensive coordination with TRPA – and may generate recommendations to modify aspects of TRPA's Stormwater Management Program.

SW.4 Integrate, improve and align the four tools supporting the Lake Clarity Crediting Program: PLRM, Road RAM, BMP RAM and TIST.

Response Category I: This recommendation requires updating TMDL Program technical tools and models.

Alignment with Findings and Stakeholder Input: This recommendation is supported by findings in subject area #4 and responds to Information Need #3, #4 and #5 in the *List of Information Needs*.

Rationale: TMDL Implementers, consultants and scientists have expressed concerns regarding the function and alignment of the current suite of TMDL Program tools. Common priority improvements include: user functionality and workflow, stability improvements, and the need for improvement in the integration and alignment of each tool.

Making improvements to this suite of tools is expected to increase the ability of the TMDL Program to prioritize which water quality improvement actions to undertake depending on circumstances and locations, reduce administrative costs, and improve understanding of the link between water quality improvement actions and the resulting expected FSP load reduction. Improving the alignment between BMP RAM and PLRM, as well as enacting improvements to the current vegetation and infiltration field protocols would assist with greater functionality and implementer acceptance of these stormwater tools.

Identified Concerns: None.

Status: This recommendation is being implemented by the TMDL Program with TMDL Executive approval. This recommendation is currently being funded and implemented through the Tahoe Urban Stormwater Tools Improvement Project. The Tahoe Urban Stormwater Tools Improvement Project was initiated through NDEP in June 2013 with an expected end date of 2015. Expected deliverables include revised and tested versions of PRLM, Road RAM, BMP RAM and TIST.

NON-URBAN SOURCE CATEGORY MANAGEMENT

NU.1 Continue to support efforts to restore and enhance degraded stream and floodplain systems as a means to reduce FSP loading to Lake Tahoe. Establish a new TMDL non-urban Performance Measure (TMDL PM) to track and report floodplain restoration activities in a manner consistent with TRPA EIP Program reporting efforts.

Category I: Implementing this recommendation may require adding a new non-urban source category TMDL PM.

Alignment with Findings and Stakeholder Input: This recommendation is supported by findings in subject area #6, responds to Information Need #7, 8, and 9, and relates to Information Need #13 in the *List of Information Needs.* It is also aligned with recommendation #11 and 13 and relates to recommendation #12 in the *Program Adjustments List*.

Rationale: As described by findings in subject area #6, the Stream Load Reduction Tool (SLRT) is a recently developed model that provides an estimate of average annual FSP load reductions associated with overbank flow event. As implicated by findings in subject area #6, effective stream and floodplain

restoration projects that increase the frequency, duration and extent of floodplain flows can result in significant and sustained FSP load reduction opportunities. Given that SLRT has been validated as a tool for estimating annual FSP load reductions, and given information about the potential significance of stream restoration projects in reducing FSP loads, some TMDL stakeholders believe active stream and floodplain restoration should be incentivized through the Lake Clarity Crediting Program (see recommendation #12 in the *Program Adjustments List)*.

Identified Concerns: A process for linking fine sediment load reduction estimates associated with stream restoration project implementation to TMDL baseline load estimates has not been developed. Because the SLRT load estimates cannot be directly compared to TMDL or jurisdiction-specific baseline load estimates, TMDL Program Managers have no mechanism to relate the expected water quality benefit associated with a given stream or floodplain project to an Urban Jurisdiction's load reduction expectation.

Status: Accounting for urban load reduction implementation activities is the current focus of the Lake Clarity Crediting Program. TMDL Program Managers will consider crediting for non-urban activities once all urban jurisdictions have demonstrated familiarity with Crediting Program protocols through application of the associated tools and registration of catchments and actions.

In the interim, TMDL Program Managers continue to support implementation stream restoration efforts throughout the basin. In lieu of incentivizing stream restoration through the Lake Clarity Crediting Program, TMDL Program Managers suggest elevating the importance of restoring and enhancing streams and associated floodplain areas as a means of reducing FSP loads to Lake Tahoe by adding it as a TMDL Performance Measure.

Adding "Acres of Floodplain Restored or Enhanced" or a similar metric as a TMDL PM would mean this activity would be reported in the *TMDL Annual Performance Report* and be available to the public to view and query on the *TMDL Online Interface*.

OVERALL TMDL

O.1 Continue to actively support development and implementation of the Regional Stormwater Monitoring Program (RSWMP).

Category I: The TMDL Program is currently engaged with, and supports implementation of, the Regional Stormwater Monitoring Program (RSWMP).

Alignment with Findings and Stakeholder Input: This recommendation is supported by subject area #5.

Rationale: As described in the implication section of subject area #5, consistent, long-term monitoring is required to detect the effects of management actions on water quality at the catchment scale. Prioritization of long-term data collection at the urban catchment scale would ensure that the data obtained could be used to assess the effectiveness of TMDL management actions and inform adaptive management of the TMDL. RSWMP is intended to fulfill the urban stormwater-related monitoring information needs of the TMDL including: monitoring urban catchments, verifying model parameters used to estimate load reductions, informing adaptive management, and tracking progress towards meeting the TMDL clarity challenge targets for the Urban Uplands source category.

Identified Concerns: Current RSWMP activities, including catchment monitoring and program development work, are funded through one-time grant funds. Dedicated, ongoing resources to fund RSMWP monitoring in the future have not been identified.

Status: The TMDL Program is engaged with aligning the RSWMP Program to inform priority TMDL research objectives, such as effectiveness of management actions, improvement of TMDL management tools and models, and tracking of catchment pollutant loads over time. The RSWMP was funded by SNPLMA in 2012 and the California State Water Quality Control Board in 2013. The Program has funding to continue monitoring into water year 2017. Expected deliverables from RSWMP include: program

technical guidance documents – including a document outlining a flexible and collaborative organization and management structure, annual and final reports, successful instrumentation and maintenance of selected monitoring sites, a regionally effective stormwater database, and a short- and long- term monitoring funding strategy.

O.2 Continue to support the development and implementation of a nearshore quality status and trend monitoring program to help assess whether nearshore conditions are improving in response to TMDL implementation. The most relevant indicators to TMDL implementation are clarity and trophic status metrics.

Category I: The TMDL Program agencies are currently engaged with, and support implementation of, the nearshore quality monitoring program.

Alignment with Findings and Stakeholder Input: This recommendation is supported by subject area #9.

Rationale: Lake Tahoe's nearshore condition is an issue of primary public and resource management agency concern because it is the area that most residents and visitors see and recreate in. As described above, the pollutant sources affecting nearshore conditions are mostly the same as those identified by the Lake Tahoe TMDL. Implemented control measures to reduce nutrient and fine sediment loading to improve mid-lake clarity will also provide benefits for related characteristics in nearshore condition; primarily those metrics associated with clarity and trophic status. Implementation of a nearshore status-and-trend monitoring program would assist in verifying if nearshore condition is improving in response to TMDL implementation as expected.

Identified Concerns: Dedicated resources to support the needed nearshore monitoring program have not been identified.

Status: Trophic metric monitoring is currently funded through 2015 by the Lahontan Water Board. The University of California at Davis conducts bi-monthly to quarterly sampling of periphyton, phytoplankton and chlorophyll at nine sites and a one-time spring synoptic at 40 sites. Funding to pilot monitor the clarity metrics has been secured through the Nevada Division of State Land's 2014 Lake Tahoe License Plate Grant. The Desert Research Institute is expected to commence monitoring activities in the summer of 2014. Turbidity, transmissivity and relative chlorophyll will be measured instantaneously around the entire perimeter of the lake on a seasonal basis for one year.

REFERENCES CITED

Categorizing References in the Synthesis of Findings

Credibility of the findings in this memo is based in large part on the source information for the finding, particularly the level of independent peer review. References cited in this memo are placed in categories that disclose to readers the amount and type of peer review associated with each reference. The intention of these categories is to prevent the dissemination of irrelevant findings, unwarranted claims, inaccurate interpretations and opinions. Generally, both the type (independent vs. colleague or internal review) and amount (number of thorough reviews) can affect the credibility of a document, and the findings distilled from that document.

The following categories define four different levels of references, based on the 'strength' of the peer review. The categories are organized in order of strongest peer review (scholarly independent peer review) to weakest peer review (draft document and stakeholder comments).

1. Scholarly independent peer review
   Publications in academic journals that adhere to scholarly review processes (e.g., single blind and double blind peer review) resulting in a minimum of three independent peer reviews. Further, the authors must explicitly show how they have addressed the review comments.

2. Formal stakeholder or internal colleague review
   Publications that have been authored or primarily funded by an officially recognized bipartisan organization, public agency or research institution; that are distributed and available for public consumption; and that have received multiple reviews from colleagues familiar with the subject area of the publication. This category includes publication for which the primary author or authors have relied on a technical review committee, advisory committee, or other body of engaged stakeholders for input and review during creation. This category also includes publications for which the primary author or authors have informally requested input and review from colleagues in their field during the creation of the publication. Generally there is an applied assumption that the authors have revised the document to address review comments, but there is rarely an explicit requirement to show how the comments were addressed.

3. Final publications with unknown peer review
   Publications that have been authored by an officially recognized bipartisan organization, public agency or research institution; and that are distributed and available for public consumption; but for which there is no clear indication that any peer review process took place during document creation.

4. Draft documents and stakeholder comments
   Draft documents are documents that have been authored by an officially recognized bipartisan organization, public agency or research institution, but that have not yet been distributed for public consumption. Draft documents may or may not have received formal or internal colleague review. Draft documents include white papers, memos and reports distributed for specific stakeholders, but not for public review.

   Draft documents include documents distributed and available for public consumption that are not authored or funded by an officially recognized bipartisan organization, public agency or research institution. Stakeholder comments also include thoughts, ideas, concerns or questions expressed to TMDL Program Managers via phone, through in-person comments or by email. Findings developed as a result of stakeholder comments should cite, as a reference, the individuals (name and affiliation) who provided the feedback, and the date it was received. Reviewers of the *Synthesis of Findings Report* should clearly be able to tell whether findings were

developed from an individual stakeholder comment, or from a collection of similar comments received from a variety of agencies, organizations and individuals.

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APPENDIX A – LIST OF INFORMATION NEEDS

The *List of Information Needs* is a tool to help 1) communicate and track research and applied science needs, and 2) coordinate participants' efforts to secure funding to address priority needs. This list is an important reference for writing the *Synthesis of Findings-Program Adjustment Recommendation Memo.* Stakeholders can add content to the *List of Information Needs* throughout the year. In March of each year TMDL Program Managers review and organize the list according to the source category the information need would affect. They also describe their interpretation of the information need and whether any action has been or is being planned to address the stated need.

The *List of Information Needs* will be included in the circulation of the *2010-2013 Synthesis of Findings & program Adjustment Recommendation Memo* is also available upon request from TMDL Program Managers. In the future, the *List of Information Needs* will be made available on the TMDL Online Interface.

APPENDIX B – PROGRAM ADJUSTMENTS LIST

The *Program Adjustments List* contains recommended adjustments to operational protocols or technical tools related to TMDL implementation. TMDL Program Managers use the list to track, organize, prioritize and make recommendations for program adjustments. Adjustment suggestions must be added to the list between October 1 and May 31 in order to be included in the annual program adjustment discussions for that calendar year.

The *Program Adjustments List* will be included in the circulation of the *2010-2013 Synthesis of Findings & program Adjustment Recommendation Memo* is also available upon request from TMDL Program Managers. In the future, the *Program Adjustment List* will be made available on the TMDL Online Interface.

APPENDIX C – STORMWATER TOOLS PRIORITIZED ACTION PLAN AND IMPROVEMENTS DESCRIPTIONS

Developed through the Stormwater Tools Improvement Project, the *Stormwater Tools Prioritized Action Plan and improvements Descriptions* identifies and describes a list of stormwater tool improvement recommendations and ranks them based on: 1) implementer and regulator feedback, and 2) available funding. This action plan informs the efforts for the Stormwater Tools Improvement Project and is helping to direct funding for this project through 2015.

The *Stormwater Tools Prioritized Action Plan and Improvement Descriptions* has been circulated with the *2010-2013 Synthesis of Findings & Program Adjustment Recommendation Memo* and is available upon request from TMDL Program Managers.