Public Comment
Lake Tahoe TMDL
Deadline: 3/18/11 by 12 noon

KEEP TAHOE BLUE.
League to Save Lake Tahoe

Tahoe Area Sierra Club Group

March 18, 2011

Via E-mail

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Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
P.O. Box 100, Sacramento, CA 95812-2000
commentletters@waterboards.ca.gov

Re: Comment Letter – Lake Tahoe TMDL.

Dear Ms. Townsend and Members of the State Water Resources Control Board,

These comments are submitted on behalf of the League to Save Lake Tahoe ("League") and the Tahoe Area Sierra Club Group ("TASC"). On September 13, 2010, the League and TASC previously submitted extensive comments on the Regional Board's proposed TMDL and Basin Plan amendment. On November 10, 2010, the League and TASC filed additional comments replying to staff's responses to the League's earlier comments and explaining why many of those responses were inadequate. Although the League and TASC sent a copy of the reply to the State Board, a true and correct copy is attached and incorporated by reference. In addition, the following comments provide further explanation as to why the Regional Board's staff's responses to the League's and TASC's original comments are inadequate. A true and correct copy of the League's and TASC September 13, 2010 comment letters without the accompanying attachments also is attached for the State Board's convenience.

In general, the Regional Board's responses and refusal to amend the TMDL proposal do not adequately address almost all of the League's and TASC's concerns regarding the deep water transparency standard TMDL and its implementation. The groups' concerns are numerous:

- The proposed clarity TMDL does not factor in discharges from all of the point sources and nonpoint sources affecting the Lake, including pollution from future development, pollution from increases in vehicle miles traveled in the Tahoe Basin, and pollution resulting from the consequences of global warming. The TMDL and its allocations do not adequately factor in future growth within the Lake Tahoe Basin, instead rely on calculations that underestimate parcel sizes and the degree of development allowable under TRPA's current regulations. The waste load allocations for Caltrans and the municipalities are inadequate because they fail to account for increases in vehicle miles traveled. Despite an acknowledged increase in the rate of fuel reduction projects in the Tahoe Basin since the Angora Fire, the TMDL fails to account for increased road construction associated with aggressive fuel reduction activities currently underway and planned for the Basin. The TMDL must factor in now the uncertainty created by global warming either as part of the propose load allocations or the margin of safety. The Boards have no authority to reduce the margin of safety or avoid allocations now based on future "adaptive management."

- The Regional Board has no authority under the CWA to establish a schedule of compliance deferring achievement of water quality standards for 65 years. The implementation plan and Basin Plan amendment's proposed 65-year schedule amounts to a change to the underlying water quality standards that must be submitted to, reviewed, and approved or disapproved by EPA under Section 303(c) of the CWA. The agencies' proposal to continue violations of the deep water transparency standard for the next 65 years also is in violation of the federal antidegradation policy.

- Relatedly, the Regional Board's proposal that NPDES Permit dischargers be allowed to meet permit limits ~~consistent only~~ with interim targets for up to 65 years rather than the final TMDL and standards is inconsistent with the CWA 303(d)(4).

- The Regional Board's proposal to establish total annual loads, without any mechanism to apply those loads on a daily basis, is contrary to the CWA.

- The Regional Board's proposed lake clarity crediting program must be refined to assure it reflects actual pollution reductions and complies with the antidegradation policy. Load Reduction Estimates and Catchment Credit Schedules must be reviewed and approved by the Regional Board and included in the NPDES discharger's permits. Load Reduction Estimates and Catchment Credit Schedules must be subject to public review and comment. The validation of conditions and awarding of credits must include storm water effluent monitoring. The apparent absence of direct monitoring of stormwater from various management measures and dischargers' storm drains precludes the Boards from determining the effectiveness of those measures, whether or not the measures qualify as best practicable treatment controls under the State of California's high quality waters policy or whether the actual discharges from various contributors comply with the state and federal antidegradation policies, especially as they apply to Outstanding National Resource Waters.

- The League and TASC are very concerned that the TMDL and its accompanying functionally equivalent document under CEQA did not include worsening water quality conditions in the Lake's near shore. By shifting the pollution control emphasis to addressing fine sediments and the Lake's deep water transparency problem, the TMDL will focus management measures and treatment options on that pollutant type and less on the nutrients. However, it is nutrient discharges that are causing nuisance levels of algae and invasive species along the Lake's shorelines. The League and TASC are concerned that the TMDL will be used as a rationale for only focusing proposed measures on complying with the measures addressing fine sediments and not adequately address the nutrients contributing to the mounting shorezone degradation. The League and TASC are very concerned that the TMDL is relying upon the Tahoe Regional Planning Agency to only accomplish a 1% reduction in nitrogen and 2% in 65 years to protect deep water clarity. This is far less than needed to restore historic near shore conditions.

- Lastly, the Regional Board's functionally equivalent document does not comply with CEQA for several other reasons. The FED fails to acknowledge the significant environmental impact of allowing impairing discharges for upwards of 65 years. The FED fails to acknowledge the significant growth-inducing impacts it may have by its express reliance on leveraging new development to implement many of its anticipated management measures. And, the range of alternatives included in the FED is insufficient, basically reviewing the same 65-year long implementation three times and not considering any faster implementation scenarios.

In addition to the League's and TASC's letter of November 10, 2010 responding in detail to many of the Regional Board staff's responses and the above general concerns about the inadequacy of the Regional Board's response, the League and TASC also offer the following summary of the inadequacy of the Regional Board's responses to the groups' concerns:

LTSLT-4: *See* League's November 10, 2010 reply to Regional Board responses.

LTSLT-5: *See* League's November 10, 2010 reply to Regional Board responses.

LTSLT-6: As explained in the League's comment letter, the referenced study does not apply a worst case scenario. The study and TMDL instead underestimate the average size of parcels in the Tahoe Basin; do not account for TRPA's Land Capability Challenge procedure which will allow additional development beyond the amount allowed by the Bailey's map and; do not account for increased development based on the updated NRCS soil maps.

LTSLT-7: New development should be subject to a specific allocation in the TMDL that institutes staff's perceived zero allocation or, as staff's response suggests, a negative allocation. Only by establishing an enforceable allocation will the Boards and EPA assure that new loadings from new development be addressed prior to construction and those project's contribute to reducing overall loads to meet the TMDL. Leaving it to a municipalities catchment-wide estimate will obscure whether or not such new development was in fact more than fully mitigated and contributed to the catchments overall reduction in fine sediment consistent with the TMDL. EPA's recent TMDL guidance, issued a few days prior to the Regional Board's meeting, emphasizes the importance of specifying as narrowly as possible specific categories of dischargers contributing pollutants addressed by a TMDL. "[S]ince 2002, EPA has noted the difficulty of establishing clear, effective, and enforceable NPDES permit limitations for sources covered by WLAs that are expressed as single categorical or aggregated wasteload allocations." Revisions to the November 22, 2002 Memorandum "Establishing Total Maximum Daily Load (TMDL) Waste Load Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs," p. 4 (Nov. 12, 2010) ("TMDL Guidance"). *See also id.*, p. 5 ("disaggregated WLAs should be defined as narrowly as available information allows"). Given the obvious importance of limiting coverage and restricting development in the Lake Tahoe basin to the protection of water quality in the Lake, the TMDL should address new development with specific WLAs.

LTSLT-9: According to the TMDL Report, the referenced Basin-wide parcel information was a claimed average parcel size which in the League's experience does not reflect the actual sizes of parcels throughout the Basin, especially those along the Lake or larger parcels where development is more likely to occur than a residential parcel. *See* LTSLT-6 above.

TASC-17: Staff's response to to TASC's comments regarding the inaccuracy of the estimated parcel sizes also demonstrates how the Regional Board underestimated the development projection. Staff states "that there will be an additional 200,000 square feet of commercial development" when in fact the TRPA has allocated an additional 400,000 sq ft.

LTSLT-12: *See* League's November 10, 2010 reply to Regional Board responses.

LTSLT-13: Staff concedes that the estimate of future growth potential did not factor in likely Land Capability Challenges. Staff responds that "[t]he future growth analysis used the land capability maps that were in effect as of the 2004 baseline evaluation and did not speculate as to how those land capability maps may or may not change in the future." The TMDL's margin of safety is precisely the mechanism staff is required to use to address uncertainty about the future. Staff's discussion of the effect of Land Capability Challenges is confused. Although the formulas do remain the same, a successful land capability challenge will allow increased coverage, *i.e.* new development, on a parcel. Staff acknowledges that the Bailey's maps are not accurate on a parcel level. Land capability challenges thus almost always change the allowed coverage on a parcel. Because staff's estimate of future development assumed that the Bailey's map accurately predicts the scope of future development in the Basin without factoring in likely increases based on land capability challenges, the future development estimates are inaccurate. In addition, the future development scenario does not factor in automatic coverage overrides in the TRPA codes for new roads and paved trails, new public facilities and recreation development. TRPA Code, Chapter 20.

LTSLT-14: The League is not referring to future TRPA Ordinances but to the existing ordinances, including the Land Capability Challenge process which must be taken into account in order to accurately estimate future development.

LTSLT-16 and -17: *See* League's November 10, 2010 reply to Regional Board responses. Staff does not respond to most of the studies referenced by the League in its comments relating to vehicular traffic and fine sediments. Staff's response does not address Kuhn's plain reference to urban roads with "high traffic volumes" as emitting the largest volume of fine sediments. In addition, a more recent road dust report has been released that further corroborates the significant contribution by vehicle traffic on pollutants to Lake Tahoe. *See* Kuhns, Hampden, et al., Draft Final Report, "Examination of Dust and Air-Borne Sediment Control Demonstration Projects" (Sept. 15, 2010) (attached as Exhibit C).

LTSLT-21: Similar to new development, road emission should be subject to a specific allocation that mandates specific percentage reductions of fines for all roads consistent with the TMDL.

LTSLT-22: Staff's response that additional, new forest roads meet existing BMP-type requirements does not acknowledge that such BMPs will not eliminate all fine sediment discharges from these new roads nor reduce fine sediments in any catchment consistent with the TMDL.

LTSLT-23: *See* League's November 10, 2010 reply to Regional Board responses. Potential fine sediment discharges from new forest roads need to be factored into the TMDL's allocations and margin of safety now. Once EPA completes its ongoing study, the TMDL can be adjusted to reflect that new information.

LTSLT-24 through -27: *See* League's November 10, 2010 reply to Regional Board responses.

LTSLT-28 through -32: *See* League's November 10, 2010 reply to Regional Board responses.

LTSLT-34: The lengthy compliance schedule adopted by the Regional Board is a change to the underlying deep water transparency standard that must be reviewed by EPA pursuant to Section 303(c) of the Clean Water Act. The Regional Board failed to distinguish the cases cited by the League in its comments. Whether or not some interim progress is made does not change the fact that the Regional Board's adoption of the TMDL effectively suspends the deep water transparency standard for 65-years. And BMPs and interim targets for some farms were required by the State of Florida in the *Miccosukee* case. *Miccosukee Tribe of Indians v. United States*, 1998 U.S. Dist. LEXIS 15838*44, 45 n. 8 (S.D. Fla. Sept. 11, 1998).

LTSLT-35: *See* League's November 10, 2010 reply to Regional Board responses.

LTSLT-36: *See* League's November 10, 2010 reply to Regional Board responses.

LTSLT-38: Staff does not say a rolling annual average would not work but simply admits that such loading framework would be more readily enforceable. The League believes that allowing the Regional Board to respond by enforcing daily violations where a municipality or other entity has not achieved TMDL loading reductions is required by the Act. Given the high stakes to the Lake at issue and the ineffectiveness of the Regional Board's efforts historically to address degradation to the Lake's transparency, a more enforceable TMDL that implements the Act's ***daily*** load requirement should be adopted.

A rolling annual average also would be consistent with EPA's recent TMDL Guidance. As EPA now emphasizes, "[n]umeric WQBELs in stormwater permits can clarify permit requirements and improve accountability and enforceability." TMDL Guidance, p. 2. "EPA now recognizes that where the NPDES authority determines that MS4 discharges and/or small construction stormwater discharges have the reasonable potential) to cause or contribute to water quality standards excursions, permits for MS4s and/or small construction stormwater discharges should contain numeric effluent limitations where feasible to do so." *Id.*, p. 3. "EPA recommends that NPDES permitting authorities use numeric effluent limitations where feasible as these types of effluent limitations create objective and accountable means for controlling stormwater discharges." *Id.* The Lake Tahoe implementation plan should incorporate a rolling annual average in order to achieve EPA's prescribed goal of creating objective and accountable means for controlling storm water discharges, or as staff would paraphrase that goal, "magnif[y] possible enforcement penalties." LTSLT-38.

And even where WQBELs are expressed as BMPs, EPA provides that "the permit should contain objective and measurable elements (*e.g.*, schedule for BMP installation or level of BMP performance). "The objective and measurable elements should be included in permits as enforceable provisions. Permitting authorities should consider including numeric benchmarks for BMPs and associated monitoring protocols or specific protocols for estimating BMP effectiveness in stormwater permits." TMDL Guidance, p. 3. Likewise, "[w]here WQBELs are expressed as BMPs, the permit must require adequate monitoring to determine if the BMPs are performing as necessary. When developing monitoring requirements, the NPDES authority should consider the variable nature of stormwater as well the availability of reliable and applicable field data describing the treatment efficiencies of the BMPs required and supporting modeling analysis." *Id.*, p. 4. The implementation plan should include specific provisions describing how the dischargers will directly monitor BMPs to verify their effectiveness at reducing fine sediments and other pollutants.

LTSLT-43 through -46: To date, the Regional Board has failed to require monitoring of the Basin Plan's existing numeric storm water effluent limitations by any municipality or Caltrans. The Regional Board now extends this de facto exemption to the near shore standards to its implementation of the TMDL for the deep water transparency standard, providing for no site specific BMP monitoring to determine if the pollution credits the Board intends to hand out reflect any fine sediment and other pollution reductions actually being achieved by installed BMPs. Likewise, baseline calculations by municipalities without corroborating monitoring would appear to be an exercise in guessing, not calculating.

LTSLT-53: Staff failed to address the League's comment that "the FED fails to address the significant environmental impact to the Lake's water quality of institutionalizing violations of the deep water transparency standard for a period of 65-years . . . ." By allowing sediment and other pollution discharges for the next 65 years that will fail to comply with Lake Tahoe's deep water transparency standard, the proposed TMDL and implementation plan authorize numerous pollution sources around the Lake to discharge pollutants that cause or contribute to that violation. Where a local or regional policy of general applicability, such as an ordinance or in this case a water quality objective, is adopted in order to avoid or mitigate environmental effects, a conflict with that policy in itself indicates a potentially significant impact on the environment. *Pocket Protectors v. Sacramento* (2005) 124 Cal.App.4th 903. Indeed, any inconsistencies between a proposed project and applicable plans must be discussed in an EIR or FED. 14 CCR § 15125(d); *City of Long Beach v. Los Angeles Unif. School Dist.* (2009) 176 Cal. App. 4th 889, 918; *Friends of the Eel River v. Sonoma County Water Agency* (2003) 108 Cal. App. 4th 859, 874 (EIR inadequate when Lead Agency failed to identify relationship of project to relevant local plans). A Project's inconsistencies with local plans and policies constitute significant impacts under CEQA. *Endangered Habitats League, Inc. v. County of Orange* (2005) 131 Cal.App.4th 777, 783-4, 32 Cal.Rptr.3d 177.

LTSLT-58 through -60: By limiting its review to three alternatives, all of which suspend compliance with a final TMDL and the deep water transparency standard for 65 years, the Board did not consider a reasonable range of alternatives consistent with CEQA. Staff does not respond to the League's comments that any schedules to comply should be addressed at the permitting stage for each discharger. Different dischargers will have different capabilities and different levels of activity in the past that must be factored in to determining whether a schedule for them to comply with the TMDL should be allowed and for how long. Thus, for example, it may be that Caltrans could implement all of its necessary measures (many of which should already have been installed) in a much shorter period, perhaps 10 years or less. Each municipality's circumstances also would differ. The TMDL should not prejudge that every discharger, regardless of their past recalcitrance or access to adequate resources, should plan on 65 years to fully implement actions necessary to comply with the deep water standard. And it is the Board's responsibility, not the League's, to analyze a reasonable range of alternatives rather than the essentially one alternative presented by the FED.

LTSLT-61: Staff does not address the League's comments about the growth-inducing impact of a TMDL that depends in part upon future growth to leverage additional water quality controls. TMDL Report, p. 11-2. Staff's response discusses how they claim the TMDL program addresses future development but it does not refute that the TMDL would act as an inducement by TRPA and other local agencies to approve new development to fund pollution control measures.

Lastly, staff does not comment on the League's reference to the recent Ninth Circuit decision in *Northwest Environmental Defense Center v. Brown*, __ F.3d __, 2010 U.S. App. LEXIS 17129 (9th Cir., Aug. 17, 2010). *See* League Comment, p. 12 n. 5. EPA's TMDL Guidance compliments that citation by encouraging state's to designate pollution sources contributing to violations of water quality standards addressed by a TMDL. "Since 2002, EPA has become concerned that NPDES authorities have generally not adequately considered exercising these authorities to designate for NPDES permitting stormwater discharges that are currently not required to obtain permit coverage but that are significant enough to be identified in the load allocation component of a TMDL. Accordingly, EPA encourages permitting authorities to consider designation of stormwater sources in situations where coverage under NPDES permits would afford a more effective mechanism to reduce pollutants in stormwater discharges than available nonpoint source control methods." TMDL Guidance, p. 6. Consistent with that Guidance, the State Board should designate discharges from all forest roads in the Tahoe Basin for regulation under the NPDES program and assign WLAs to those sources.

Thank you for this opportunity to provide further comments on the proposed Lake Tahoe TMDL. The League and TASC respectfully request that the State Board not let what should be an opportunity to cure Lake Tahoe's pollution problems become an excuse to prolong that long-standing violation for several generations.

Sincerely,

Carl Young
Program Director
League to Save Lake Tahoe
2608 Lake Tahoe Blvd
South Lake Tahoe, CA 96150

Laurel Ames
Conservation Co-Chair
Tahoe Area Sierra Club
P.O. Box 16936
South Lake Tahoe, CA 96150

cc via e-mail:

Rochelle Nason, Executive Director, League to Save Lake Tahoe
Michael R. Lozeau, Lozeau Drury LLP
Alexis Strauss, Director, Water Division, EPA Region 9
Peter Kozelka, EPA Region 9
Janet Hashimoto, EPA Region 9
Jacques Landy, EPA Region 9

KEEP TAHOE BLUE.
League to Save Lake Tahoe

Tahoe Area Sierra Club Group

November 10, 2010

Via E-Mail Transmission

Douglas F. Smith
TMDL/Basin Planning Unit Chief
California Regional Water Quality Control Board, Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, CA 96150
DFSmith@waterboards.ca.gov

Jason Kuchnicki
Lake Tahoe Watershed Program Manager
Nevada Division of Environmental Protection
901 S. Stewart Street, Suite 4001
Carson City, Nevada 89701-5249
jkuchnic@ndep.nv.gov

Re: Comments on Lake Tahoe TMDL Technical Report, Lake Tahoe TMDL Report and Basin Plan Amendments and Related Documents – Reply to Responses

Dear Messrs. Smith and Kuchnicki,

Thank you for posting the revised TMDL documents and the Regional Board's responses to our comment letters of September 13, 2010. The League to Save Lake Tahoe ("League") and Tahoe Area Sierra Club Group ("TASC") appreciate several of the clarifications and changes made by staff to the TMDL Report and proposed Basin Plan amendment. The League and TASC nevertheless continue to have a number of substantive concerns regarding the proposed TMDL and Basin Plan amendment. The League and TASC have had a brief opportunity to review the responses and have prepared the following reply regarding several of the key issues that were raised. We respectfully request that you include this brief reply in the packet of documents being circulated to the members of the Regional Board in advance of next week's Board meeting.

1. STAFF'S CONCEPT THAT THE REQUIRED MARGIN OF SAFETY DOES NOT APPLY TO FUTURE EVENTS AND THEIR ACCOMPANYING POLLUTION LOADING UNCERTAINTIES IS INCORRECT.

In striving to exclude from the TMDL and its component waste load allocations the uncertainty posed by future water pollution effects of global warming, future development, fire management activities and potential increases in vehicle miles travelled in the Lake Tahoe basin, staff demonstrates a misunderstanding of Section 303(d)'s margin of safety requirement. Where uncertainty about the future correctness or efficacy of the waste load allocations exists because of events that are certain to occur in the future, the Board has no authority to exclude those uncertainties from the margin of safety. Nor is the Board authorized to deal with those future events solely through adaptive management. Even where adaptive management will apply, the Board must nevertheless quantify the uncertainty posed by these future events in the margin of safety included in the current TMDL.

Staff attempts to justify excluding these critical future events from the margin of safety based on two inappropriate rationales. First, staff states that "The MOS does not address speculative events in the future that may or may not happen, even if a scientific study concludes that the future event could occur." Response to Comment LTSLT-12. The problem with this assertion is that each of the future events discussed in the League's comment is definitely going to occur. There will be aggressive fire management activities within the Basin, discharges from which are not factored into the proposed margin of safety. The fact that EPA has commissioned a study of this pollution source confirms that it is not speculative but in fact already occurring. *See* LTSLT-23. New development will be allowed in the Basin and, based on any development proposal considered to date, will attract additional vehicles and more miles traveled within the Basin. Global warming is a scientific certainty. And, again, the Board acknowledges that global warming will have some effect on the sufficiency of the proposed allocations. LTSLT-25 ("To achieve net load allocations, project implementers may have to adjust some practices or project designs to account for the potential effects from global climate change"). So, there is no speculation by the League that these types of activities will occur in the future. What is uncertain is the amount of pollutant loading that may result from these sources. Hence, the proposed allocations included in the TMDL must reflect the possibility that significant loadings will result from these sources. This is done by including those potential loadings in the mandated margin of safety. The TMDL must conservatively incorporate all present day uncertainty about future loadings. If, in the future, adaptive management demonstrates that portion of the margin of safety established for these categories of potential loadings were greater than actually occurred, the waste load allocations could then be adjusted accordingly.

Staff also errs in attempting to carve future events out of the required margin of safety. Staff states that "[t]he adaptive management is the portion of the implementation plan that sets forth a process to address future events. The adaptive management process is completely different and separate from the MOS." Response to Comment LTSLT-12. Staff's response conflicts with the basic definitions of waste load allocations ("WLAs") and margin of safety as well as EPA guidance. EPA's TMDL regulations expressly require future loadings to be included in a TMDL. As EPA's guidelines for reviewing TMDLs states, "EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to individual existing and future point source(s)." EPA Guidelines for Reviewing TMDLs Under Existing Regulations Issued in 1992, § 5 (citing 40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)).[1] The guideline makes clear that any lack of knowledge about how the waste load or load allocations will affect water quality must be included in a margin of safety. "The statute and regulations require that a TMDL include a margin of safety (MOS) to account for <u>any</u> lack of knowledge concerning the relationship between load and wasteload allocations and water quality. EPA Guidelines, § 6 (citing CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)) (emphasis added). Any lack of knowledge includes lack of knowledge about the pollution conditions resulting from

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[1] *See* 40 C.F.R. § 130.2(g) (defining "Load allocation" as "The portion of a receiving water's loading capacity that is attributed either to one of its existing or <u>future</u> nonpoint sources of pollution or to natural background sources") (emphasis added); 40 C.F.R. § 130.2(h) (defining "Wasteload allocation" as "The portion of a receiving water's loading capacity that is allocated to one of its existing or <u>future</u> point sources of pollution") (emphasis added).

future activities that the agency knows are occurring or will occur. "Any model uncertainty and future conditions should be built into a margin of safety for the TMDL. A final TMDL should not be assigned until all of these factors are considered carefully." EPA Technical Guidance Manual for Developing Total Maximum Daily Loads, Book II: Streams and Rivers, Part 1: Biochemical Oxygen Demand/Dissolved Oxygen and Nutrients/Eutrophication (EPA 823-B-95-007) (Sept. 1995), p. B-30.

Indeed, the Board's entire modeling effort is predicting future loadings. In effect, the entire TMDL is about the future and staff's notion that future events are only addressed by adaptive management is not a meaningful distinction. Because new development, additional vehicle miles travelled, additional fire management and global warming are expected or guaranteed to occur within the Lake Tahoe Basin, and because the Regional Board lacks knowledge about the potential increases in loading that my result from these events, a reasonable, conservative estimate of their possible increase in pollution loadings must be factored into the proposed margin of safety now.

Staff's general reliance on conservative assumptions in the modeling effort cannot cure the omission of the above uncertainties from the margin of safety because none of the above categories were included in the modeling effort. According to Region 9's TMDL development guidance, "Where an implicit margin of safety is provided, the submittal should include a <u>specific discussion of sources of uncertainty</u> in the analysis and how individual analytical assumptions or other provisions adequately account for <u>these specific sources of uncertainty</u>. Guidance for Developing TMDLs in California, EPA Region 9, p. 7 (Jan. 7, 2000) (http://www.epa.gov/region9/water/tmdl/303d-pdf/caguidefinal.pdf). The above sources of uncertainty are not specifically addressed anywhere in the proposed TMDL, including the assumptions included in the modeling effort.

2. THE CWA DOES NOT AUTHORIZE A 65 YEAR COMPLIANCE SCHEDULE TO ACHIEVE EXISTING STANDARDS.

Staff's response claims that "[n]othing in the Clean Water Act prohibits a 65-year implementation plan. There is nothing in the Clean Water Act that states how quickly a TMDL must be implemented. . ." LTSLT-28. Staff simply ignores Section 303(d)(4), discussed in the League's earlier comment, which requires NPDES permits to include effluent limitations based on the TMDL and its waste load allocation. The interim reductions and clarity challenge proposed by staff are not the TMDL or an applicable waste load allocation. Section 303(d)(4) precludes the Regional Board from issuing NPDES permits as it proposes to do in the implementation plan by allowing them to discharge at levels well above the applicable TMDL and waste load allocations, at least for many decades. That alone precludes any notion that a 65-year compliance schedule is authorized.

Likewise, Section 301(a) of the Clean Water Act provides the deadlines for complying with water quality standards. As EPA has made clear, any schedules of compliance purporting to extend those firm deadlines established by Congress are not authorized. In the case of water quality-based effluent limitations, the clear deadline was July 1, 1977. 33 U.S.C. § 1311(b)(1)(C). *See* EPA Memo, Feb. 3, 1975, Revision of Water Quality Standards and Implementation Plans (http://water.epa.gov/scitech/swguidance/waterquality/standards/upload/1999_11_03_standards_revisions.pdf) ("Under § 303 of the Federal Water Pollution Control Act, the reason §303(c) did away with the requirement for implementation plans is that they are not needed under the 1972 Amendments. Section 301 establishes the compliance dates for water quality standards"). The deep water transparency standard was adopted in the mid-1970s. Any notion the Regional Board has of authorizing through the implementation plan the issuance of NPDES permits that include schedules of compliance extending out as long as 65-years plainly violates the express deadline established by Congress. *See id*. ("there shall be achieved— (C) not later than July 1, 1977, any more stringent limitation, including those necessary to meet water quality standards . . . or required to implement any applicable water quality standard established pursuant to this chapter"); *See also In the Natter of Star-Kist Caribe, Inc.*, 3 E.A.D. 172, 175, 177 (1990).

Staff lists various TMDLs for which it suggests EPA has approved similar schedules. First, it is worth noting that Lake Tahoe – one of the two Outstanding Natural Resource Waters for the State of California – is proposed to demolish the previous record of delayed implementation of a TMDL by 25 years! More importantly, it is the League's and TASC's understanding that EPA limited its review of the listed TMDLs to the TMDL and Waste Load Allocations, and did not review or approve the implementation schedules. Likewise, EPA's approval of the State Board's 2008 compliance schedule policy regarding NPDES permitting compliance schedules did not specifically address the issue raised here – whether there is any authority at all to defer compliance with an existing standard through a TMDL. In any event, Congress' deadline controls as well as the plain language of Section 303(d)(4) which precludes the Board from adopting a plan that calls for issuing an effluent limitation implementing anything less than the final waste load allocation.

Likewise, EPA's regulations prohibit the 65-year long implementation scheme proposed by the Regional Board. 40 C.F.R. § 122.44(d)(1) states unequivocally that:

> each NPDES permit shall include conditions meeting the following requirements when applicable . . .
>
> (d) Water quality standards and State requirements: any requirements in addition to or more stringent than promulgated effluent limitations guidelines or standards under sections 301, 304, 306, 307, 318 and 405 of CWA necessary to:
>
> (1) Achieve water quality standards established under section 303 of the CWA, including State narrative criteria for water quality.

> (i) Limitations must control all pollutants or pollutant parameters (either conventional, nonconventional, or toxic pollutants) which the Director determines are or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to an excursion above any State water quality standard, including State narrative criteria for water quality.

40 C.F.R. § 122.44(d)(1). And those mandated limitations must be consistent with any applicable TMDL: "the permitting authority shall ensure that . . . : (B) Effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, are consistent with the assumptions and requirements of any available wasteload allocation for the discharge prepared by the State and approved by EPA pursuant to 40 CFR 130.7." 40 C.F.R. § 122.44(d)(1)(vii)(A). Hence, the permits have to be consistent with the waste load allocations – not some interim step which is not a waste load allocation and is not reviewed and approved by EPA pursuant to 40 C.F.R. § 130.7. The implementation plan calls for the Regional Board to issue NPDES permits that by definition will violate 40 C.F.R. § 122.44(d)(1) because they will not achieve water quality standards and will not control all pollutants causing or contributing to excursions above the deep water transparency standard.

Staff also claims that the regulation's mandate that any effluent limitations in the relevant NPDES permits be consistent with a TMDL and waste load allocation is not the same as implementing the TMDL. The League and TASC do not discern any meaningful distinction in staff's assertion. Both state and federal courts have had no difficulty in underscoring the clear mandate that any NPDES permit issued to point sources subject to a TMDL and its waste load allocations must be consistent with the terms of the TMDL and waste load allocation – barring any claim of authority to issue NPDES permits that only implement half a TMDL or only interim load reductions. "When a TMDL and specific wasteload allocations for point sources have been established, any NPDES permits issued to a point source must be consistent with the terms of the TMDL and WLA. *Dioxin/Organochlorine Ctr. v. Clarke*, 57 F.3d 1517, 1520 (9th Cir. 1995) (citing 40 C.F.R. § 130.2) (emphasis added). *See also City of Arcadia v. United States EPA*, 265 F. Supp. 2d 1142, 1145 (N.D. Cal. 2003); *Pronsolino v. Marcus*, 91 F. Supp. 2d 1337, 1349 (N.D. Cal. 2000); *Communities for a Better Environment v. State Water Resources Control Bd.* (2003) 109 Cal.App.4th 1089, 1095–1096 ("[o]nce a TMDL is developed, effluent limitations in NPDES permits must be consistent with the [waste load allocations] in the TMDL"); *City of Arcadia v. State Water Resources Control Bd.* (2006) 135 Cal.App.4th 1392, 1404. As EPA's Water Quality Standard Handbook states:

> Waste load allocations establish the level of effluent quality necessary to protect water quality in the receiving water and to ensure attainment of water quality standards. Once allowable loadings have been developed through WLAs for specific pollution sources, limits are incorporated into NPDES permits. . . . The WLA and permit limit should be calculated to prevent water quality standards impairment at all times.

Water Quality Standards Handbook, p. 7-9 (emphasis added). Contrary to staff's response, there is nothing in the plain language of the Act that suggests a TMDL can be legally implemented by issuing NPDES permits with effluent limitations that are consistent with anything but a waste load allocation and final TMDL. The Board has no authority to defer compliance with the final WLAs and TMDL and calling for the issuance of NPDES permits consistent with only interim loadings that exceed and are inconsistent with the final waste load allocation.

Staff also asserts that the lengthy timeline proposed in the TMDL Report is not a schedule of compliance. *See* LTSLT-31 ("The 65-year timeframe is the proposed staged implementation plan to achieve the numeric target of the TMDL and is not a compliance schedule pursuant to section 303(c) of the federal Clean Water Act"). Technically, the League agrees that it is not a schedule of compliance because, by definition, a schedule of compliance can only be adopted as part of a NPDES permit (there are no compliance schedules for existing standards pursuant to section 303(c)). *See* 40 C.F.R. §§ 122.2; 122.47. However, the implementation plan is proposing to authorize, pursuant to the proposed Basin Plan amendment as well as the State Board's compliance schedule policy, the issuance of schedules of compliance in the relevant NPDES permits consistent with the 65 year schedule. Just changing the label does not make the plan's proposal to authorize compliance schedules that are forbidden by the Act and regulations any more palatable. In addition, by delaying any need for dischargers to comply with the existing standard for many decades, the proposed Basin Plan amendment also is a de facto change to the long-standing deep water transparency standard which must be reviewed by EPA pursuant to Section 303(c). *See* Sept. 13, 2010 League Comment.

As written, the proposed implementation plan predetermines the issuance of extremely long compliance schedules for all of the NPDES dischargers around the Lake (the vast majority of discharges to the Lake). The League and TASC believe that plan conflicts with the Clean Water Act and the Board must refrain from authorizing any schedules of compliance in the Basin Plan for the proposed TMDL and waste load allocations. Instead, any such schedules should be considered on a permit-by-permit basis and must be bound by the limitations on compliance schedules applicable to all water quality-based effluent limitations.

3. STAFF MISCONSTRUES THE ANTIDEGRADATION REQUIREMENT AS REQUIRING COMPARISON OF DISCHARGES ALLOWED BY THE TMDL TO CURRENT CONDITIONS RATHER THAN CONDITIONS IN 1975, THE FEDERAL ANTIDEGRADATION BASELINE.

Staff's handling of the League's antidegradation concerns is especially troubling. Staff claims that the antidegradation policy is not triggered by the proposed TMDL. See LTSLT-35. Staff is wrong for two basic reasons. First, staff misconstrues the antidegradation policy as requiring a comparison of the proposed action and the authorized pollution loadings to water quality as it exists today rather than the quality of water in Lake Tahoe in 1975, the date the policy was enacted. *Id*. The federal antidegradation policy states in pertinent part that "[e]xisting instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected." 40 C.F.R. § 131.12(a)(1). The policy was enacted on November 28, 1975. Accordingly, "[e]xisting uses are those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards." 40 C.F.R. § 131.3(e). The policy has forbidden degradation of the Lake's deep water transparency standard as of November 1975. *See* Memorandum of William Attwater, SWRCB, to Regional Board Executive Officers, pp. 5-7 (Oct. 7, 1987). Staff would have one believe that, as soon as the transparency levels degrade further, the antidegradation policy resets. That is not the case. To the extent the proposed TMDL Report and Basin plan amendment proposes to allow loadings from all sources that exceed the loading levels and water quality levels present in 1975, the proposed actions trigger and, given the Outstanding Natural Resource Waters status of Lake Tahoe, by definition, violate the antidegradation policy. 40 C.F.R. § 131.12(a)(3).

Likewise, just because the Regional Board is attempting to improve the current water quality situation in the Lake, does not allow the Board to amend the Basin Plan to allow discharges for upwards of 60 years that will grossly exceed the levels of pollution and water quality that existed in November 1975. It is clear from various EPA memoranda and guidance that the antidegradation policy must be vigorously applied in the development of TMDLs and waste load allocations. EPA Memorandum, "Antidegradation, Wasteloads, and Permits" (http://water.epa.gov/scitech/swguidance/waterquality/standards/upload/2006_12_01_standards_antidegpermits.pdf) ("All Agency staff involved in water quality standards, wasteload allocations, and permitting should be reminded that in developing wasteload allocations and permits and in reviewing state allocations and State permits, consideration must, of course, be given to the State's applicable water quality standards, including the antidegradation provisions"). As EPA has emphasized:

> Wasteload allocations must reflect applicable State water quality standards including the antidegradation policy. No wasteload allocation can be developed or NPDES permit issued that would result in standard being violated, or, in the case of waters whose quality exceeds that necessary for the Section 101(a)(2) goals of the Act, can result in a lowering of water quality unless the applicable public participation, intergovernmental review and baseline control requirements of the antidegradation policy have been met.

EPA, Questions and Answers on Antidegradation, p. 8 (http://water.epa.gov/scitech/swguidance/waterquality/standards/upload/2006_12_01_standards_antidegqa.pdf). Because Lake Tahoe is an Outstanding Natural Resource Water, no lowering of water quality below that of November 1975 is allowed. *See id.* (Question 5) ("In addition to actions on permits, any wasteload allocations and total maximum daily loads violating the antidegradation policy are subject to EPA disapproval and EPA promulgation of a new wasteload allocation/total maximum daily load under Section 303(d) of the Act"). The proposed implementation plan and its proposed interim waste load allocations will continue to degrade Lake Tahoe's water quality for decades to come and cannot be approved consistent with the antidegradation policy.

The League and TASC appreciate staff's considerable effort to prepare the proposed TMDL Report and Basin Plan packet, including staff's effort to address our numerous comments. Unfortunately, the League and TASC believe the extremely long implementation schedule and insufficient margin of safety overshadow the benefits of the proposed TMDL and final waste load and load allocations. The League and TASC again request that the Regional Board adjust the margin of safety to assure that the TMDL and its accompanying allocations will assure compliance with the deep water transparency standard and propose a TMDL implementation plan that assures that dischargers will comply with their waste load allocations as soon as possible. Rather than prejudging the need for 65 years for every discharger to comply, the Regional Board should address any need for compliance schedules when the individual permits are taken up as well as any accompanying enforcement orders.

Sincerely,

Carl Young
Program Director
2608 Lake Tahoe Blvd
South Lake Tahoe, CA 96150

Laurel Ames
Conservation Co-Chair
P.O. Box 16936
South Lake Tahoe, CA 96150

cc via e-mail:

Rochelle Nason, Executive Director, League to Save Lake Tahoe
Michael R. Lozeau, Lozeau Drury LLP
Harold Singer, Executive Officer, Lahontan Regional Board
Alexis Strauss, Director, Water Division, EPA Region 9
Peter Kozelka, EPA Region 9
Janet Hashimoto, EPA Region 9
Jacques Landy, EPA Region 9
Rik Rasmussen, Manager, TMDL Section, State Water Resources Control Board

LOZEAU DRURY LLP
T 510.836.4200
F 510.836.4205
410 12th Street, Suite 250
Oakland, Ca 94607
www.lozeaudrury.com
michael@lozeaudrury.com

September 13, 2010 Via E-Mail Transmission

Douglas F. Smith
TMDL/Basin Planning Unit Chief
California Regional Water Quality
Control Board, Lahontan Region
2501 Lake Tahoe Boulevard
South Lake Tahoe, CA 96150
DFSmith@waterboards.ca.gov

Jason Kuchnicki
Lake Tahoe Watershed Program Manager
Nevada Division of Environmental
Protection
901 S. Stewart Street, Suite 4001
Carson City, Nevada 89701-5249
jkuchnic@ndep.nv.gov

Re: Comments on Behalf of the League to Save Lake Tahoe Regarding Draft Lake Tahoe TMDL Technical Report, Draft Lake Tahoe TMDL Report and Draft Basin Plan Amendments and Related Documents

Dear Messrs. Smith and Kuchnicki,

Thank you for this opportunity to provide input into the process for developing a total maximum daily load ("TMDL") addressing the agencies' and dischargers' ongoing failure to comply with Lake Tahoe's deep water transparency standard. Formed in 1957, the League advocates for strong protection of the Tahoe Basin's natural resources and the restoration of Lake Tahoe's famed clarity. The League is dedicated to protecting, restoring, and advocating for the ecosystem health and scenic beauty of the Lake Tahoe Basin, with a particular focus on the Lake's water quality and clarity.

As the agencies are aware, the TMDL being developed for Lake Tahoe's deep water transparency standard is perhaps the key opportunity for the Tahoe community and the water quality agencies to acknowledge the inadequacies of past water quality planning and implementation efforts in the Basin and to supplement or replace those efforts with enforceable pollution controls. For example, existing National Pollution Discharge Elimination System ("NPDES") permits issued to all of the urban upland areas and Caltrans highways on the California portions of the Lake have for years required Caltrans and the cities to drastically reduce their loadings in order to comply with the Basin Plan's storm water effluent limitations. Those permits already should have resulted in significant reductions in loadings to the Lake that would have given the region a running start at achieving the much larger loading reductions necessary to achieve the deep water transparency standard. However, although acknowledging the storm water effluent standards, the Regional Board has consistently skirted requiring the cities, counties, and Caltrans to monitor for compliance with the Basin Plan standards and enforcing compliance with the Basin Plan requirements.

The proposed TMDL suffers from similar efforts to avoid the tough problems by not factoring new development into the proposed waste load allocations and by attempting to establish an incomprehensibly long 65-year schedule for compliance with the deep water transparency standard. Rather than assuring compliance with the standard as quickly as possible, the TMDL institutionalizes – for our lifetimes and many of our children's lifetimes – the degradation that the agencies and dischargers have allowed to occur over the last four decades. No such lifetime extensions to comply with water quality standards are authorized by the Clean Water Act, especially for an Outstanding National Resource Water ("ONRW") like Lake Tahoe. Although some excellent science has gone into evaluating the health of the Lake and the steps necessary to achieve the deep water transparency standard, gaps remain in several important sources of pollution, including for example, the additional fine sediments that will be generated by additional traffic resulting from the Regional Board's acquiescence in the Tahoe Regional Planning Agency's current efforts to expand development in the Basin. Before the agencies approve the TMDL, the League requests that the agencies address the following concerns and accelerate the implementation measures in order to bring Lake Tahoe back into compliance with the deep water transparency standard much sooner than 65 years.[1]

A. BECAUSE THE REGIONAL BOARD'S ALLOCATIONS FAIL TO TAKE INTO ACCOUNT LOADINGS FROM NEW DEVELOPMENT, ADDITIONAL VEHICLE MILES THAT WILL RESULT FROM SUCH NEW DEVELOPMENT AND GLOBAL WARMING EFFECTS, THE PROPOSED ALLOCATIONS ARE NOT SUPPORTED BY THE WEIGHT OF THE EVIDENCE.

EPA defines a total maximum daily load as "[t]he sum of the individual WLAs [waste load allocations] for point sources and LAs [load allocations] for nonpoint sources and natural background." 40 C.F.R. § 130.2(i). Unfortunately, the proposed clarity TMDL does not factor in discharges from all of the point sources and nonpoint sources affecting the Lake, including pollution from future development, pollution from increases in vehicle miles travelled in the Tahoe Basin, and pollution resulting from the consequences of global warming.

1. The Agencies Must Either Establish WLAs and LAs for New Development or, at a Minimum, Reserve Such Allocations for the Future – Not Ignore New Development as Proposed.

"The Lake Tahoe TMDL does not specify a pollutant allocation for future growth." TMDL Report, p. 14-7. Nor are future discharges of fine sediment from new development factored into the TMDL's baseline loading estimates from 2004 and the load reductions from that baseline proposed in the TMDL. The only allocations proposed are percentage reductions from the 2004 baseline loading. The Regional Board's and NDEP's decision to ignore future development in the TMDL's allocations is contrary to law, arbitrary, and unsupported by the weight of the evidence.

The only way for the TMDL to ignore allocating any pollutant loading to future development is if future development could be shown to discharge no pollution. The agencies'

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[1] The League also joins in the Tahoe Area Sierra Club's comments on the proposed TMDL and the implementation plan.

own modeling effort demonstrates the opposite. According to the agencies' modeling effort, new development's percentage of fine sediment loading and the Lake's water quality problems is comparable in significance to stream bank erosion. The TMDL estimates that, circa 2004, stream bank erosion contributed 3% of the fine sediment loading to the Lake. TMDL Report, p. 10-4 (Table 10-1). The same modeling effort predicts that future development will result "in estimated fine particle sediment load up to about two percent greater than the total load modeled for 2004 conditions." TMDL Report, p. 14-6. *See also* Integrated Strategies Report, pp. 55-56 ("Fine sediment particle loads are estimated to increase by just over 2 percent at full build out [of future development]"); Basin Plan Amendment, p. 8. Two percent of the total 2004 fine sediment load amounts to a contribution of 9.6×10^{18} fine sediment particles discharged to the Lake every year from future development or roughly 4900 tons of fine sediment per year.[2] The RWQCB and NDEP must include this significant contribution of fine sediment in the overall loading estimate and allocations.

The agencies attempt to justify not including future development in the loading estimate or allocations by asserting that it is a small percentage of the total and that the loading estimate for future development is conservative. As for the claim that two percent additional loading over and above the 2004 baseline loading is not significant is belied by the TMDL's inclusion of streambed erosion as a source that needs to be controlled. Even by the agencies' own rationale, there is no significant difference between a 3 percent contribution of fine sediment and other pollutants and a greater than 2 percent contribution.

The agencies compare the 2 percent loading increase from future development to the 32 percent reduction in fine sediment necessary to meet the Clarity Challenge. TMDL Report, p. 4-7. The report then asserts that "[g]iven the uncertainty involved in the land-use change and watershed models, an increase up to two percent of the total fine sediment particle load is considered within the range of uncertainty in the modeling analysis and, therefore, is not considered a significant increase." *Id*. This kind of de minimus discharge reasoning is entirely inconsistent with the 1 percent and 2 percent loading reductions the TMDL assigns to forest uplands and stream channel erosion, respectively. TMDL Report, p. 9-2 (Table 9-1). If the Regional Board and NDEP choose to ignore the possible 2 percent increase in fine sediment loadings that are projected to result from new development, the loading reductions called for streambed erosion and forest uplands would be negated.

The agencies' excuse to ignore future development based on the alleged conservativeness of its modeling is inappropriate because it entirely undermines and erases the margin of safety for this category of discharges. A TMDL must include a margin of safety. 33 U.S.C. § 1313(d).

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2 According to the TMDL Report, Regional Board and NDEP staff converted 550 metric tons of silt and clay from shoreline erosion to equal a total load of 1.08×10^{18} particles per year. Applying the same ratio to two percent of the total annual fine sediment particle loading to the Lake, *i.e.* 9.6×10^{18} particles per year (two percent of 4.8×10^{20} particles/year), amounts to a proportionate estimate of 4889.9 tons of fine sediment per year.

Nothing in that requirement suggests that an agency can erase or overlook a margin of safety in order not to address a category of pollution sources. The agencies' claim they have applied an implicit margin of safety in preparing the TMDL. TMDL Report, p. 14-1. The TMDL Report cites to three "independent approaches" to including an implied margin of safety, though the report goes on only to discuss the first two. The three approaches were, stated generally, a comprehensive science program, conservative assumptions, and adaptive management program. Only the science program and several assumptions are discussed.[3] In regard to future development, the applicable margin of safety largely depends upon the use of conservative assumptions, no historic "comprehensive science" being available for future projects. By using any conservative assumptions as a rationale for ignoring future development in the allocations, the Regional Board and NDEP are erasing the margin of safety for this category of pollutant loadings.

In addition, the agencies' alleged conservativeness of the projection of future development also is not supported by substantial evidence. The assumptions underestimate parcel sizes that may be developed in the Basin. They underestimate the potential level and scale of development that will be allowed by TRPA in the future as reflected in the current Regional Planning process, with potential for greater capacity for residents and visitors, designation of new urban areas, higher and denser structures, more development based upon the new NRCS land capability maps, and transfers of soft coverage into impervious hard coverage.[4] And the assumptions do not appear to factor in increased vehicle traffic that will contribute additional fines from roadways servicing the new development.

The Regional Board and NDEP rely upon estimates of coverage associated with future new development which assume without any basis that all developable parcels are on average only 0.25 acres in size. Projects currently pending before TRPA indicate that this acreage estimate is potentially drastically underestimated. For example, the proposed expansion of the Homewood Ski Resort involves parcels ranging in size from 5.67 acres to 270.11 acres, with an average size of 62.66 acres. The Homewood project by itself proposes new hard coverage of 12.6 or more acres of currently uncovered land. If a single pending proposal eats up 3 percent of the 373 acres of new coverage projected by the agencies for the next 65 years, the TMDL's future development projection plainly underestimates what is likely to occur over that time period. The 0.25 estimate also is inconsistent with other agency reports. For example, the average size of the approximately 5600 parcels bordering the shores of Lake Tahoe is 0.7 acres. http://www.nltra.org/docs/

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[3] Section 303(d) of the CWA mandates the inclusion of a margin of safety. The League does not believe a future adaptive management program can ever qualify or contribute to the inclusion of a margin of safety in an adopted TMDL. Such adaptive management is plainly part of an implementation plan which is not part of the TMDL itself. To allow for agencies to replace Congress' directive to include margins of safety in TMDLs with future, unknown management adaptions would effectively nullify the margin of safety requirement.

[4] TRPA Land Use sub element, TRPA fact sheet 3 Follow up, 2006 Land Capability maps.

Invasive%20Species.pdf (at p. A-15). Of course, development of these lakeside parcels bears extra consideration when evaluating fine sediment loading to the Lake.

The agencies also assume without any basis that the Bailey's map is a static document. The Boards' estimate of future development fails to take into account changes to the Bailey's map based on land capability challenges ("LCCs") that are certain to occur because of the lack of precision in the Bailey's map. Under TRPA's Code of Ordinances, a landowner has the right to challenge the accuracy of the Bailey's Map through a Land Capability. TRPA Code §§ 22.2.D. Invariably, such challenges result in increased coverage allowances. For example, a land capability challenge completed last year for several Homewood Ski Resort parcels increased the acres of coverage allowed by the Bailey's map significantly after the challenge. *See* TRPA Staff Memorandum (July 2, 2009). The agencies' future development assumptions fail to acknowledge the certain increase in coverage land capability challenges will allow over the existing Bailey's map.

The 2006 NRCS soil capability maps, referenced in the TMDL, significantly alter the 1974 Bailey soil and capability report. Two maps make that clear – the Percent of Allowable Land Coverage by Bailey 1974 map, NRCS 2006, compared to Percent of Allowable Coverage by First Named Component 2006. The "First Named Component" designation effectively removes the second component, that of percent of slope. Steeper slopes have more restrictive land coverage rules, reducing land coverage controls and allow additional erosion. The TMDL has determined that fine sediments are the new pollutant that impacts the deep-lake clarity and that phosphorus is a key element that must be reduced to control primary productivity, while the new NRCS Conservation maps would permit greater development on steeper slopes, thus permitting more erosion, and allowing more phosphorus to enter the system and the lake. The coverage study and assumptions for the TMDL thus underestimate the total coverage increase expected due to the NRCS new maps.

The agencies' two percent loading estimate also is arbitrary because it is based on a presumption that existing development rules will be in place for the 65-year life of the TMDL. That presumption is demonstrably false because it fails to account for the scale of development as proposed in TRPA's new draft Regional Plan. The three different alternatives (other than the "no action") currently under review by TRPA each would dramatically increase the density of development along the shores of Lake Tahoe. Any "conservative" projection of future development must at a minimum consider the likely scenario that TRPA will adopt one of the Regional Plan alternatives currently before it that will allow more development than the current regulations.

The pending proposals allowing increased development density along the Lake's shores also underscore the fact that such future development not only will impact the Lake's water quality by increasing coverage but will also adversely affect water quality by attracting more and more vehicles to the shores of Lake Tahoe. The Regional Board's and NDEP's failure to include in this estimate additional pollutants from additional VMTs from this new development is not conservative. Instead, the agencies are ignoring potential future pollution that likely will cancel out significant portions of the TMDL's projected pollution reductions.

Although in general the Board and EPA may not have to establish WLAs and LAs for all sources at the adoption of the TMDL, they at least have to reserve allocations for those sources as part of their TMDL. If no allocation is established or, at least, reserved, then no discharges from new development may be authorized pursuant to the existing NPDES permits issued to the counties, municipalities and CalTrans. 33 U.S.C. § 1313(d)(4); 40 C.F.R. § 122.44(d)(1)(vii) (NPDES permits must implement and be consistent with TMDL allocations). The TMDL and proposed Basin Plan's language concluding that future growth potential will result in loadings that need not be addressed in the TMDL through proposed allocations or a reservation of future allocations is inconsistent with law and not supported by the weight of the evidence.

2. **The waste load allocations for Caltrans and the municipalities are inadequate because they fail to account for increases in vehicle miles travelled (VMT).**

The TMDL's oversight of increased vehicle miles travelled is not limited to new development but extends to any increases in vehicle miles travelled projected for the Tahoe Basin. Increase in VMTs in the Basin over time will be a significant source of fine sediments through the grinding up of traction materials, road dust emissions, and conveyance of any fine particles through the air or water to any tributaries or other conduits to the Lake.

Numerous peer reviewed reports document the significant loadings of fine sediments attributable to vehicle traffic. According to Zhu and Kuhns et al. (2009), "Atmospheric deposition of fugitive dust from roadways has increased fine sediment loadings into Lake Tahoe, which has reduced water clarity." They also state, "principle factors influencing road dust emissions in the basin are season, vehicle speed (or road type), road condition, road grade, and proximity to other high emitting roads." Roadways with the most vehicular traffic are of significant contribution: "An analysis of the total emissions from the road sections surveyed indicated that urban areas (in particular South Lake Tahoe) with high traffic volume contain the largest emitting roads in the basin."

TRPA is in the midst of updating the Regional Plan. TRPA's proposed preferred alternative Regional Plan amendment (Alternative 2) is to substantially increase the resident population in the Tahoe basin, increase the capacity for visitors, facilitate the construction of denser high-rise structures in areas that are currently urban (South Stateline) and areas that are not currently urban (Tahoma, Homewood, Meyers, etc.), more parking structures, and greater potential of soft coverage transfer into hard coverage across hydrologic zones. Given this proposed scenario by TRPA – the agency that the Regional Board is counting on "to incentivize TMDL implementation" – the Regional Board and NDEP have overlooked the future potential increases in traffic volume and traffic on all of the basin's roadways along with the associated fine sediment production and transport to the Lake. TMDL Report, p. 11-2. The TRPA's proposed Regional Plan has the strong potential to result in substantial increases in traffic volumes in and out of the basin on its various high speed highways, which are primarily steep. Steeper roadways have much greater emission factors of particulate matter than flatter roadways. Furthermore, as the wintertime visitor capacity will be increased, the potential for greater emission factors and fine sediment production during this season will be especially of concern, as "road dust emissions increased by a factor of 5 in the winter, on average, and about a factor of 10 when traction control material was applied to the roads after snow events." ." Increases of vehicles and congestion during the winter season will be especially impactful, by around an order of magnitude or more. Additionally, traffic jams and other forms of congestion will slow vehicles to less than the posted speed limits, especially during weekends, holidays, and storm events. Slower speeds will increase emission factors exponentially.

The TMDL may have also overlooked the current and future contributions of on and off road vehicles through fleet mix of conventional light duty spark ignition vehicles vs. heavy duty vehicles. Abu-Allaban et al. (2003) found that PM_{10} and $PM_{2.5}$ emission rates due to road dust, tailpipe, and break wear were approximately an order of magnitude greater for heavy duty vehicles, to the extent that road dust emission rates from a conventional vehicle were potentially equivalent to the brake wear emission from a heavy duty vehicle. Thus, even the cumulative impacts due solely to heavy duty vehicles are significant, even with respect to brake wear, especially in congested or urban zones.

The narrative and study on the "Impacts of Vehicle Activity on Airborne Particle Deposition to Lake Tahoe", Kuhns et al. (2010), references other factors that affect deposition potential of fine sediments to the Lake, such as proximity to the Lake itself, winds, and landscape features. Roadways that are upwind and are in close proximity to the Lake will have greater deposition potential. Therefore, any roadway in any class (primary, secondary, tertiary, or non-paved road) must be evaluated by a variety of variables (seasonality, vehicle type, speed, local BMP, proximity to the lake, and wind direction) that may result in orders of magnitude difference in emission factors.

The increase in the construction and utilization of dirt roads in the Tahoe basin for fuel reduction activities (especially on USFS lands) will also be a significant contributor to production and re-suspension of road dust. According to Kuhns et al. (2007), a reference to a dust emission study from military wheeled vehicles operating on unpaved roads, concluded that "measurements of emissions from a range of vehicles showed road dust emission factors increase with both vehicle weight and speed." The study also adds that during the summer or fall "perturbations of steady state emissions are most frequent due to track out of material by vehicle from unpaved roads or construction sites." Thus, travel of heavy vehicles on dirt roads around the basin will be significant contributors of road dust. Contributions of road construction repair and housing or building construction are also of significance with emission factors of 30 noted in this study (3.8 g/vgt on Sugarpine Road in Incline Village during construction phase vs. .12 g/vkt after construction was complete). *See* Thomas Holson peer review, p. 4 ("Loadings from fugitive dust from vehicular traffic on both paved and unpaved roads may be important. Although this source is discussed in other sections there is limited or no discussion of this source in the atmospheric deposition section").

By not including these loadings in the TMDL and the allocations, the Regional Board and NDEP cannot know whether the TMDL can ever be achieved.

3. The load allocation for upland forests is inadequate because it fails to account for increases in fuel reduction activities, which intensify the use, building, or re-commissioning of forest roads.

It is common knowledge that the rate of fuel reduction projects in the Tahoe Basin has drastically increased in the last three years, largely in reaction to the Angora Fire. *See* http://www.sierrasun.com/article/20100816/NEWS/100819911 ("The reduction of forest fuels in the Lake Tahoe Basin has reached unprecedented levels since 2007's Angora fire." The TMDL Report's discussion of forest management pollution relies on the Lake Tahoe TMDL Pollution Reduction Opportunity Report v. 2, dated March 2008 ("Pollution Reduction Report"). TMDL Report, p. 9-4 ("The Forest Upland load reduction analysis determined that maintenance activities (including fuel reduction projects) in the forest uplands have the potential to reduce or avoid increases in fine sediment and nutrient loads (Lahontan and NDEP 2008a)." The TMDL Report overstates the conclusion of the Pollution Reduction Report and does not address that Report's failure to consider new road construction associated with aggressive fuel reduction activities currently underway and planned for the Basin.

The Pollution Reduction Report notes that "[t]hinning and fuels reduction treatments are planned for forests throughout the Tahoe Basin over the next ~20 years, focused primarily within the wildland- urban interface during the next ~5 years." Pollution Reduction Report, p. 183. The Pollution Reduction Report also notes that "[u]nfortunately, there is still very limited directly measured data available on the effects of different fuels reduction treatments on runoff, sediment and nutrient yield, particularly in the Tahoe Basin." *Id*. at 197. *See also id*., p. 183 ("[t]hinning and fuels reduction treatments can range widely in cost, intensity, and potential impacts on soil erosion"); *id*. at p. 184 ("From a sediment or nutrient-loading analysis standpoint, forest management is wrought with uncertainty"). Nevertheless, the Pollution Reduction Report concludes that "given the types of low-impact treatments being employed and planned in Tahoe Basin fuels management efforts (primarily hand treatment and CTLsystems) and regulatory limitations on mechanical treatment on steep slopes and SEZs, fuels treatments are unlikely to increase sediment and nutrient loading at the subwatershed scale (the scale of this analysis)." Pollution Reduction Report, p. 184.

Although the Pollution Reduction Report evaluates the various fuel management techniques employed in the Tahoe Basin, the Report does not consider or even mention associated road building or reactivation of roads throughout the Tahoe Basin. The Report does emphasize, however, the large pollution reductions one might expect from the decommissioning of legacy roads in conjunction with fuel management activities. Pollution Reduction Report, p. 183. Although the construction of new roads coupled with removal of old roads and habitat restoration may logically claim some form of net benefit to sediment loadings in a particular fuel management area, the new roads will nevertheless introduce new pollution sources in the Tahoe Basin. These planned pollution sources need to be factored into the Forested Uplands' pollution sources if the TMDL and its allocations are to be reasonably accurate.

Although the absence in the "Lake Tahoe Basin Multi-Jurisdictional Fuel Reduction and Wildfire Prevention Strategy 10 Year Plan" of any discussion of new roads that will accompany fuel management projects is remarkable, it appears that new roads will be part of numerous fuel management projects proposed for the Basin. For example, the Forest Service's plan in response to the Angora Fire itself includes no less than 9.5 miles of new roads and 10.4 miles of new trails. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5180837.pdf. The new roads and trails are offset in part by the project's inclusion of "Decommissioning/restoring 1.9 miles of road and 16.7 miles of trail. *Id*. Depending on whether any decommissioning rather than restoration occurs, there would appear to be a net increase in road surface for the Angora Fire area. The League does not believe the Angora Fire Restoration Project is unique in its handling of new road construction. Our research indicates that the Pollution Reduction Report and now the TMDL report continue a practice of the agencies deemphasizing the road construction necessary to implement the more aggressive fire treatment plans being proposed. Indeed, our research indicates no effort appears to have been made by the Regional Board, NDEP, or other affected agencies to consider the expected miles of new roads that likely may be built as a result of the "unprecedented levels" of fuel management now underway in the Region.

Given the 65-years that the agencies hope to have to actually implement the TMDL, these new fuel treatment roads will be legacy roads before the TMDL is fully implemented. Just because they are newly constructed does not mean they will not contribute significant pollution to the Lake. Even when management practices are applied similar to the Tier 2 measures defined by the Pollution Reduction Report, it appears that significant pollution still remains from even well-maintained unpaved roads. For example, a report prepared for roads within the Glenbrook Creek watershed on the Nevada side of the Lake, concluded that for the segments of the existing roads where BMPs could be implemented, the "best solution," although reducing the loadings significantly from a scenario including no BMPs, still left 11.5 tons of sediment being discharged over a twenty year planning period. http://etd.lib.umt.edu/theses/available/etd-09012009-091937/unrestricted/Efta_James_Thesis_final.pdf, p. 65. And this was in a watershed that, according to the study's author, already had "outstanding BMP infrastructure." *Id*. at 72.

Recent EPA comments also confirm that fuel management activities are not the panacea for water quality anticipated by the TMDL Report, emphasizing the uncertainty of fuel management activities' impacts to water quality. http://yosemite.epa.gov/oeca/webeis.nsf/(PDFView)/20090101/$file/20090101.PDF?OpenElement. At a minimum, the one known source of pollution associated with fuel management in the Tahoe Basin – new unpaved roads and trails – must be taken into account in any valid TMDL for the Lake's transparency standard. By not including these loadings in the allocations, the agencies cannot show that reductions of upland forest pollutant loadings will be sufficient to achieve the TMDL.

4. **Global warming needs to be factored into the TMDL now as part of the load calculation and perhaps more importantly as part of the margin of safety.**

The TMDL "does not assign pollutant load or waste load allocations to address potential effects of climate change." TMDL Report, p. 12-6. Nor is global warming factored into the TMDL's proposed margin of safety. Instead, the Regional Board and NDEP propose to address the uncertainty posed by global warming solely through the adaptive management process described in the accompanying implementation plan: "Since the impacts of climate change on pollutant loading are uncertain and cannot be conclusively determined at this time, the climate change effects will be addressed through the continual improvement and active adaptive management processes of the Management System." TMDL Report, p. 12-6. Indeed, the discussion of climate change is included in the TMDL Report's section on adaptive management.

The uncertainty posed by global warming must be included in the TMDL itself, either through an allocation or the margin of safety. "For pollutants other than heat, TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical WQS with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." 40 CFR § 130.7(c)(1). There is no authority for the Regional Board and NDEP to replace the margin of safety requirement with an adaptive management requirement.

In addition, by replacing a margin of safety that squarely addresses the uncertainties of global warming's effect on Lake Tahoe's pollution loadings, the proposal undermines EPA's review of the TMDL by attempting to address that uncertainty solely through the state implementation plans, which generally are not reviewed by EPA. According to the TMDL, adjustments based on global warming impacts would be carried out solely through the implementation plan. TMDL Report, p. 12-6 ("Potential measures for adapting to significant climate change effects may include adjustments in the Lake Clarity Crediting Program or adjustments to the implementation strategy to emphasize or de-emphasize different approaches to water quality improvement projects"). The agencies' attempt to move the federal margin of safety requirement into the implementation process is contrary to Section 303(d), 33 U.S.C. § 1313(d).

Coats and Reuter et al. (2010) suggest:

1. A continuing shift from snowfall to rain, toward earlier snowmelt and runoff during the water year, for both scenarios;
2. Dramatic increases in flood magnitude in the middle third of the century, especially in the B1 scenario;

3. That by the middle of 21st Century (after about 2050) Lake Tahoe could cease to mix to the bottom. This will in turn result in complete oxygen depletion in the deep waters and increase in sediment release of nitrogen and phosphorus;
4. That annual loading of soluble reactive phosphorus under sustained conditions of lake stratification (no deep mixing) and anoxic sediments could be twice the current load from all other sources. Loading of ammonium under these conditions could increase the amount of biological available nitrogen that enters the lake by 25%. Tahoe's nutrient budgets could have a dramatic and long-lasting impact on the food web and tropic status of Lake Tahoe, and;
5. That the annual Secchi depth in the later portion of the 21st Century could be in the range of 15-20 m as compared measured values of 21-22 m since 2000.

The agencies' effort to defer adjusting the TMDL to address global warming does not mean that the process has not gathered information and analyzed the issue. Indeed, the analysis to date indicates that global warming likely will exacerbate the long-standing violations of the deep water transparency standard by increasing erosion, stunt mixing in the Lake, and accompanying adverse impacts to water quality. TMDL Report, pp. 12-7 – 12-9. By not including a margin of safety in the allocations being adopted now, the agencies risk seriously underestimating the additional pollution loadings that will result from global warming, rendering the proposed allocations insufficient to meet the standard.

B. THE REGIONAL BOARD'S PROPOSED 65-YEAR COMPLIANCE SCHEDULE IS INCONSISTENT WITH LAW BECAUSE IT IS NOT AUTHORIZED BY THE CWA AND MUST BE REVIEWED BY EPA AS A CHANGE TO THE STATE'S WATER QUALITY STANDARDS UNDER 33 U.S.C. § 1313(c).

The League is very concerned with the Regional Board's and NDEP's proposed schedule for dischargers to achieve their allocations and come into compliance with the transparency standard. The standard has been violated for at least forty years already. The agencies now propose to extend that violation for another 65 years, breaking the century mark for the duration of the violation. Rather than enforce compliance, the Regional Board and NDEP are instead proposing to institutionalize the violation for well beyond the lifetime of any of the decision makers.

"Based on the best professional judgment of Water Board and NDEP staff, reducing fine sediment, nitrogen, and phosphorus loads to meet the deep water transparency standard will take approximately 65 years." TMDL Report, p. 10-1. As far as the League can tell from its review of the TMDL Report and the Integrated Water Quality Management Strategy Progress Report, v.1.0 (March 2008) and its participation in various stakeholder meetings, the proposed 65-year timeline appears to be based on the staffs' projection of BMP efforts and available funding at the tail end of the first 15-year period. Staff estimates that about $1.5 billion dollars will likely be available during the initial 15-year period and that sum will buy sufficient planning and project implementations to achieve the Clarity Challenge within 20-years. The Clarity Challenge represents the dischargers' achievement of about 50 percent of the final fine sediment TMDL and the transparency standard. TMDL Report, p. 10-4. As for the TMDL and the deep water transparency standard, the remaining 45-years is based simply on staff's conception that a linear progression from the tail end of the initial 15 year period funding levels justifies an additional 45 years for compliance.

Whether or not staff's patience with dischargers' slow progress amounts to best professional judgment is beside the point because the proposed schedule is illegal for several reasons. The 65-year schedule of compliance to achieve an existing water quality standard is without authority under the Clean Water Act; amounts to a change to the transparency standard that must be reviewed by EPA pursuant to Section 303(c) of the CWA, 33 U.S.C. § 1313(c), and; violates the federal and state antidegradation policies as they apply to Outstanding National Resource Waters.

The League believes that most of the existing NPDES dischargers (Caltrans, the counties and South Lake Tahoe)[5] – whose permits already have governed the vast majority of fine sediment discharges for the past 15 years – have not fully complied with their NPDES permits and should have been implementing much more aggressive BMPs over the last several decades. Those dischargers must now accelerate BMP implementation faster than the proposed TMDL schedule anticipates. Although the Regional Board should consider costs, it has no authority to defer compliance with its now forty-year old Basin Plan standards. Rather than embody a 65-year schedule into the Basin Plan, which grants in advance 65 year schedules of compliance for each NPDES permit holder and other dischargers, the Regional Board and NDEP should project a much quicker timeline to achieve the TMDL. Whether or not any particular discharge should receive that schedule to comply or any schedule at all should be left to the individual permit decisions or accompanying enforcement orders.

1. **The Regional Board has no authority under the CWA to establish a schedule of compliance deferring achievement of water quality standards for 65 years.**

Neither the Regional Board nor NDEP can authorize a schedule of compliance for dischargers to achieve the now three decades old deep water transparency standard. However, the TMDL and proposed Basin Plan amendment include a 65-year schedule of compliance to achieve the deep water transparency standard. TMDL Report, p. 10-1; Basin Plan Amendment, p. 11. The proposed waste load allocations are also keyed into achieving the TMDL and transparency standard in 65 years. TMDL Report p. 10-2. The deep water transparency standard was adopted by the Regional Board and State Water Resources Control Board in 1975 and approved by EPA. By adopting the TMDL as part of the Basin Plan including a 65-year schedule of compliance, the

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[5] The Ninth Circuit Court of Appeals also recently clarified that all logging roads also are industrial discharges subject to the NPDES permitting program. *Northwest Environmental Defense Center v. Brown*, __ F.3d __, 2010 U.S. App. LEXIS 17129 (9th Cir., Aug. 17, 2010).

Regional Board is adopting a schedule of compliance to delay achievement of that now decades old water quality standard.[6]

Nothing in the Clean Water Act authorizes states to adopt schedules of compliance to achieve already existing water quality standards. Section 303(e)(3)(F), 33 U.S.C. § 1313(e)(3)(F), contemplates authority for states to authorize schedules of compliance for new or revised water quality standards. Similarly, states also may include in their water quality standards schedules of compliance for effluent limitations that are implementing new or revised water quality standards. 303(e)(3)(A), 33 U.S.C. § 1313(e)(3)(A). *See* 40 C.F.R. § 122.2 ("Schedule of compliance means a schedule of remedial measures included in a 'permit'"). Nor are any schedules of compliance referenced in Section 303(d), 33 U.S.C. § 1313(d), and its TMDL requirements or its implementing regulations. *See* 40 C.F.R. §§ 130.7, 130.2. Because the deep water transparency standard is anything but new, nothing in the Clean Water Act authorizes the schedule of compliance proposed in the TMDL.

Indeed, Section 303(d)(4) plainly requires that all effluent limitations must be based on and consistent with the TMDL, not an interim goal associated with a time schedule or a "Clarity Challenge" amounting to half the TMDL. See 33 USC § 1313(d)(4). That provision also makes clear that effluent limitations issued pursuant to a TMDL "must assure the attainment of" the water quality standard at issue. *Id*. Hence, any effort by the Regional Board or NDEP to implement the 65-year compliance schedule in any of the existing NPDES permits (Caltrans, South Lake Tahoe and California counties) or legally required NPDES permits (all logging roads) by allowing allocations that only meet interim reductions would be plainly illegal for failing to "assure the attainment of [the] water quality standard." *See also* 40 CFR § 122.44(d)(1)(vii) (effluent limits must be "consistent with the assumptions and requirements of any available wasteload allocation for the discharge prepared by the State and approved by EPA pursuant to 40 CFR 130.7[,]" not an interim or partial allocation).

For these reasons, the agencies should delete the proposed 65-year compliance schedule and prepare a TMDL and implementation plan that leaves any scheduling questions to the respective permitting decisions and enforcement orders.

2. **<u>The implementation plan and Basin Plan amendment's proposed 65-year schedule amounts to a change to the underlying water quality standards that</u>**

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[6] The State Board's Resolution No. 2008-0025, "Policy For Compliance Schedules in National Pollutant Discharge Elimination System Permits" confirms that TMDL schedules are schedules of compliance implemented in relevant NPDES permits. Resolution No. 2008-0025, ¶ 6(c) (April 15, 2008) ("A Water Board may establish a compliance schedule that exceeds ten years in a permit that . . . (2) has a permit limitation that implements or is consistent with the waste load allocations specified in a TMDL that is established through a Basin Plan amendment, provided that the TMDL implementation plan contains a compliance schedule or implementation schedule").

must be submitted to, reviewed, and approved or disapproved by EPA under Section 303(c) of the CWA.

It is not clear from the proposed Basin Plan amendment whether the 65-year schedule of compliance will be submitted to EPA for review and approval under either Section 303(d) or 303(c) of the CWA, 33 U.S.C. § 1313(d), 1313(c). Because the schedule is not part of the TMDL or its component waste load allocations, it does not appear that EPA is authorized to review the schedule pursuant to Section 303(d), 33 U.S.C. § 1313(d). However, the schedule of compliance must be reviewed by EPA pursuant to Section 303(c) § 1313(c). *See* 40 C.F.R. § 131.13 ("States may, at their discretion, include in their State standards, policies generally affecting their application and implementation, such as mixing zones, low flows and variances. Such policies are subject to EPA review and approval"); 40 C.F.R. § 131.20(c) (EPA review under 303(c) includes "any general policies applicable to water quality standards").

Where a state proposes to extend compliance with an applicable standard, allowing dischargers to continue to violate the standard into the future, the compliance schedule is a change in the water quality standard that must be reviewed by EPA. *See Miccosukee Tribe of Indians v. United States*, 1998 U.S. Dist. LEXIS 15838 (S.D. Fla. Sept. 11, 1998). In *Miccosukee*, the Court addressed a state implementation plan addressing ongoing phosphorous pollution in the Florida Everglades. Florida's plan included a 12-year schedule of compliance to achieve the phosphorous standard. "By not requiring farmers to implement additional water quality measures until 2006, the EFA allows those discharges of phosphorous that violate Florida's narrative standard for nutrients to continue until 2006. This is not a compliance schedule; it is a de facto suspension of; and therefore a change in, water quality standards." *Id.* at 15838*45. The *Miccosukee* case is indistinguishable from the implementation plan proposed for Lake Tahoe's deep water transparency standard. Indeed, the Regional Board's and NDEP's proposal takes the concept of a schedule of compliance to an entirely new level, suspending the deep water standard for 65-years. As a result, the proposed 65-year schedule for achieving the deep water transparency standard cannot go into effect until it is reviewed by EPA pursuant to Section 303(c), 33 U.S.C. § 1313(c).

3. **The agencies' proposal to continue violations of the deep water transparency standard for the next 65 years is in violation of the federal antidegradation policy.**

Neither the proposed TMDL nor the Regional Board's proposed Basin Plan amendment provides any analysis of the proposed action's compliance with the federal and state antidegradation requirements. This is especially troublesome given the proposed TMDL's and amendments' blatant violation of the federal antidegradation policy's protections for Outstanding National Resource Waters.

As the agencies are well aware, California and EPA designated Lake Tahoe's California waters as Outstanding National Resource Waters in 1980. By prolonging degradation in Lake Tahoe's transparency that has occurred since the early 1970s, the proposed TMDL and the

Regional Board's accompanying Basin Plan amendment violate the federal antidegradation policy. The antidegradation policy provides, that "[e]xisting instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected." 40 C.F.R. § 131.12(a)(1). The policy establishes strict protections for waters designated as outstanding National resources: "Where high quality waters constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected." 40 C.F.R. § 131.12(a)(3). The antidegradation policy made its first appearance in the Clean Water Act when EPA adopted the policy as part of EPA's first Water Quality Standards Regulation on November 28, 1975. 40 F.R. 55340-41; EPA Water Quality Handbook, Chapter 4, Section 4.1. Degradation prohibited or otherwise regulated by the policy is based on water quality that existed as of November 28, 1975. *See, e.g.* Memorandum from Bill Attwater, Chief Counsel, State Water Resources Control Board, to Regional Boards, re: Federal Antidegradation Policy, p. 5 (Oct. 7, 1987) ("Attwater Memo").

As EPA's Water Quality Handbook ("EPA Handbook") emphasizes, "Outstanding National Resource Waters (ONRWs) are provided the highest level of protection under the antidegradation policy." EPA Handbook, § 4.7 (http://water.epa.gov/scitech/swguidance /waterquality/standards/handbook/chapter04.cfm#content). Any lowering of water quality as it existed in 1975 is prohibited by the regulation. 40 C.F.R. § 131.12(a)(3). "EPA interprets this provision to mean no new or increased discharges to ONRWs and no new or increased discharge to tributaries to ONRWs that would result in lower water quality in the ONRWs." EPA Handbook, § 4.7. The one exception to this prohibition recognized by EPA "permits States to allow some limited activities that result in temporary and short-term changes in the water quality of ONRW." *Id*. "Such activities must not permanently degrade water quality or result in water quality lower than that necessary to protect the existing uses in the ONRW." *Id*. "EPA's view of temporary is weeks and months. not years." *Id*. "The intent of EPA's provision clearly is to limit water quality degradation to the shortest possible time." *Id*. *See also* Water Quality Control Plan for Lahontan Region, p. 5.1-13 ("No permanent or long- term reduction in water quality is allowable in areas given special protection as Outstanding National Resource Waters (48 Fed. Reg. 51402).").

By allowing for standards to be violated for another 65 years, the Regional Board and NDEP propose to memorialize increases in discharges above and beyond the discharges and water quality that was present in the Lake in 1975. That result directly conflicts with the antidegradation policy's prohibition on expanding any discharges beyond those present in 1975. The agencies already have failed to prevent degradation of the Lake for the last 30 years. All told, the current TMDL proposal would institutionalize and prolong the Lake's illegal degradation for a total of almost 100 years. That is not a temporary or short-term change in the Lake's 1975 water quality and does not correlate at all to the "shortest possible time" for the agencies to limit impairing fine sediment and nutrient discharges. The TMDL instead should require immediate compliance with the TMDL and consider any compliance schedules for individual dischargers during the permit reissuance proceedings or through appropriate enforcement orders.

C. THE REGIONAL BOARD'S PROPOSAL THAT NPDES PERMIT DISCHARGERS BE ALLOWED TO MEET ONLY INTERIM TARGETS FOR UP TO 65 YEARS RATHER THAN THE FINAL TMDL AND STANDARDS IS INCONSISTENT WITH THE CWA.

The implementation plan proposes that NPDES permits be issued applying interim allocations assigned for the first 15 years of the proposed 65 year compliance schedule in the TMDL. TMDL Report, p. 16-3 ("The implementation plan allocates pollutant loads to the four source categories <u>for the first 15 years</u>"); Basin Plan Amendment, p. 7 (Tables 15-18-2 through -4). The interim allocations are to be included in NPDES permits for the municipalities and CalTrans, at least in California. Basin Plan Amendment, p. 9. However, all but the last NPDES permits issued in presumably in the Year 2071 will include waste load allocations consistent with the final TMDL and waste load allocations. The presumably 11 rounds of NPDES permits issued for each point source discharger will not implement the TMDL or its final waste load allocation, instead only requiring pollution reductions consistent with a small percentage of each discharger's allocation. Each of those 11 rounds of NPDES permits will fail to meet the requirements of Section 303(d)(4) and EPA's permitting regulation.

As noted above, Section 303(d)(4) requires that all effluent limitations must be based on and consistent with the TMDL, not an interim goal associated with a time schedule or a "Clarity Challenge." *See* 33 U.S.C. § 1313(d)(4). "Once a TMDL is developed, effluent limitations in NPDES permits must be consistent with the [waste load allocations] in the TMDL." *City of Arcadia v. State Water Resources Control Bd.* (2006) 135 Cal.App.4th 1392, 1404. Section 303(d)(4) also makes clear that effluent limitations issued pursuant to a TMDL "must assure the attainment of" the water quality standard at issue. *Id.* Hence, any effort by the Regional Board or NDEP to implement the 65-year compliance schedule in any of the existing NPDES permits (Caltrans, South Lake Tahoe and California counties) or legally required NPDES permits (all logging roads) by allowing allocations that only meet interim reductions is plainly illegal for failing to "assure the attainment of [the] water quality standard." *See also* 40 CFR § 122.44(d)(1)(vii) (effluent limits must be "consistent with the assumptions and requirements of any available wasteload allocation for the discharge prepared by the State and approved by EPA pursuant to 40 C.F.R. 130.7[,]" not an interim or partial allocation).

Any permits issued to South Lake Tahoe, the other municipal dischargers, CalTrans and logging roads (as well as any other point source discharges requiring an NPDES permit) in the Basin must establish effluent limitations consistent with the final waste load allocation and TMDL. The implementation plan should require all NPDES permittees, including logging roads, to immediately comply with the TMDL. To the extent some sources believe they may obtain a schedule of compliance, that request should be taken up during the initial permit proceedings following the issuance of the TMDL or addressed thorough the agencies' enforcement authorities.

D. THE REGIONAL BOARD'S PROPOSAL TO ESTABLISH TOTAL ANNUAL LOADS, WITHOUT ANY MECHANISM TO APPLY THOSE LOADS ON A DAILY BASIS, IS CONTRARY TO THE CWA.

The proposed action is not in fact a "Total Maximum Daily Load" but is instead a "Total Maximum Annual Load." Nor does the proposed TMDL attempt to translate or otherwise apply the annual average loading on a daily basis as, for example, a running annual average. As a result, the proposed annual maximum unload is not a TMDL and is inconsistent with the requirements of Section 303(d), 33 U.S.C. § 1313(d).

The D.C. Circuit Court of Appeals already has struck down a TMDL based solely on an annual average loading. In *Friends of the Earth v. EPA*, 446 F.3d 140 (D.C.Cir. 2006), the Court of Appeal considered the question of "whether the word 'daily,' as used in the Clean Water Act, is sufficiently pliant to mean a measure of time other than daily." 446 F.3d at 142. The Court rejected EPA's position that "Congress, in requiring the establishment of 'total maximum daily loads' to cap effluent discharges of 'suitable' pollutants into highly polluted waters, left room for EPA to establish seasonal or annual loads for those same pollutants." *Id*. As the Court bluntly concluded, "Daily means daily, nothing else." *Id*. "If Congress wanted seasonal or annual loads, it could easily have authorized them by calling for 'total maximum daily, seasonal, or annual loads.' Or by providing for the establishment of 'total maximum loads,' Congress could have left a gap for EPA to fill. Instead, Congress specified 'total maximum daily loads.' We cannot imagine a clearer expression of intent." *Id.* at 144. *Cf. Natural Resources Defense Council v. Muszynski*, 268 F.3d 91 (2nd Cir. 2001) (affirming use of total annual load but remanding to EPA for failure to explain how an annual load takes seasonal variation into account). The issue has not been addressed by the Ninth Circuit Court of Appeals.

A recent California Court of Appeal case addressed whether the Central Valley Regional Board's TMDL for salt/boron in the Lower San Joaquin River based on a "30-day running average" was a total maximum <u>daily</u> load. *San Joaquin River Exchange Contractors Water Authority v. State Water Resources Control Bd.* (2010) 183 Cal. App. 4th 1110, 1124. The decision is not clear which federal Court of Appeal ruling it applied, the salt/boron TMDL having effectively applied both. The TMDL set forth a monthly load though it applied it daily as a 30-day running average. *Id*. The Court of Appeal did agree with the Second Circuit that the TMDL was required to "clearly indicate . . . that this "Total Maximum Monthly Load" (TMML) was as effective as a TMDL (in achieving the Vernalis Salinity WQO). . . ." *Id.*

The League believes that the transparency standard TMDL can reflect the science supporting an annual average load as well as articulate that annual load on a meaningful daily basis by issuing the annual load as a rolling or running annual average so daily requirements kick in after the first year – not five or 15 years out. Where, at the end of the first year (and each subsequent year thereafter), a specific discharger exceeds the average annual load, every subsequent day of such exceedance would be in excess of that dischargers waste load allocation until the running average came down below the annual average. Such a daily component to the average annual loading will be important when translating the TMDL into the individual dischargers' permits and attempting to establish enforceable effluent limitations.

E. THE REGIONAL BOARD'S PROPOSED LAKE CLARITY CREDITING PROGRAM MUST BE REFINED TO ASSURE IT REFLECTS ACTUAL POLLUTION REDUCTIONS AND COMPLIES WITH THE ANTIDEGRADATION POLICY.

A key part of the TMDL's proposed implementation plan is the Clarity Crediting Program. TMDL Report, p. 15-5. According to the Basin Plan Amendment, "[t]he Lake Clarity Crediting Program, which is intended to be incorporated into the NPDES permits, provides a system of tools and methods to allow urban jurisdictions to link projects, programs, and operations and maintenance activities to estimated pollutant load reductions." Basin Plan Amendment, p. 8. The amendment states that the Crediting Program provides "a consistent method to track compliance with stormwater regulatory measures. . . ." *Id*. *See* TMDL Report, pp. 11-1 – -2 (The Water Board and NDEP will each conduct the following tasks to ensure progressive implementation towards meeting the Clarity Challenge and the numeric target: • Administer and apply the Lake Clarity Crediting Program to each of its urban stormwater programs, NPDES permits in California and Memoranda of Implementation in Nevada"). Indeed, the Clarity Crediting Program is the proposed mechanism by which, at least in the near term, the NPDES dischargers including South Lake Tahoe, CalTrans and the California counties will formulate their pollution control plans and BMP commitments and the proposed mechanism by which the Regional Board will determine dischargers' pollution reductions and compliance with their waste load allocations. Thus, the Crediting Program encompasses at least two of the requisite components of the implementation plan required by Water Code § 13242: (a) A description of the nature of actions which are necessary to achieve the objectives, including recommendations for appropriate action by any entity, public or private" and "(c) A description of surveillance to be undertaken to determine compliance with objectives." In terms of implementation, the Crediting Program is without a doubt where the rubber hits the road. Unfortunately, as proposed, the League believes there are several serious flaws in the Crediting Program as discussed in the Lake Clarity Crediting Handbook (2009) and as referenced in the TMDL and Basin Plan amendment. These concerns should be addressed up front because the TMDL's implementation plan, including the proposed Clarity Crediting Program, must comply with Section 13242 now. Correcting the following flaws also may alter the Regional Board's estimate of the amount of staff time that may be necessary to implement the TMDL.

1. Load Reduction Estimates and Catchment Credit Schedules must be reviewed and approved by the Regional Board and included in the NPDES discharger's permits.

The TMDL's implementation plan should direct that the pollution reduction plans to be developed by the dischargers for specific catchments must be reviewed and approved by the Regional Board and not just the agency's staff. As proposed, the review and approval of Load

Reduction Estimates and Catchment Credit Schedules is conducted exclusively by dischargers and Regional Board staff. Handbook, Ch. 1. Although the Basin Plan Amendment suggests the Crediting Program as a whole will somehow be incorporated into the dischargers NPDES permits, review of the Handbook indicates that the actual pollution control measures and plans will not be subject to public notice, review and comment or approval by the Regional Board itself. *Id.* Given that the staff's approval of the Load Reduction Estimates and Catchment Credit Schedules will presuppose the loading reductions credited to each discharger – as long as they install or implement the agreed upon BMPs – this point in the regulatory process is the point where the Regional Board will apply and attempt to assure compliance with the waste load allocations.

Recent Court of Appeals rulings hold that effluent limitations, such as those prescribed by the Load Reduction Estimates and Catchment Credit Schedules, must be reviewed and approved by the permitting authority. *Waterkeeper Alliance, Inc. v. United States EPA*, 399 F.3d 486, 498-502 (2d Cir. 2005). In California, the only NPDES permitting authorities are the Regional Boards and not their staffs. The Water Code expressly prohibits the Regional Board from delegating issuance of WDRs to its staff or, of course, any discharger. Water Code § 13223.

The ruling in *Waterkeeper Alliance* involved challenges to EPA's NPDES permitting of confined animal feed operations ("CAFOs"). Petitioners challenged the process by which EPA directed CAFOs to develop and implement nutrient management plans which set forth specific best management practices. As proposed, the permit did not require that EPA review and approve the plans prior to their implementation. The Court of Appeals ruled that the CAFO rule was inconsistent with the Clean Water Act because (1) the rule "does not require that NPDES permitting authorities review the nutrient management plans to ensure that the nutrient management plans designed by the Large CAFOs will in fact reduce land application discharges" and otherwise comply with the permit requirements and Clean Water Act and (2) "the CAFO Rule does not adequately prevent Large CAFOs 'from misunderstanding or misrepresenting' their specific situation and adopting improper or inappropriate nutrient management plans." 399 F.3d at 500 (emphasis added). As the Court explained, "[u]nder the Act, permits authorizing the discharge of pollutants may issue only where such permits ensure that every discharge of pollutants will comply with all applicable effluent limitations and standards." *Id.* at 498 (citing 33 U.S.C. § 1342(a)(1) ("EPA may issue a permit for the discharge of any pollutant or combination of pollutants 'upon condition that such discharge will meet … all applicable requirements [including the effluent limitations statutorily required by 33 U.S.C. § 1311]'"); 1342(a)(2) ("EPA 'shall prescribe conditions for such permits to assure compliance with [all applicable requirements, including effluent limitations].'" *Id.* As the Court explained:

> As presently constituted, the CAFO Rule does nothing to *ensure* that each Large CAFO has, in fact, developed a nutrient management plan that satisfies the above requirements. The CAFO Rule does nothing to ensure, in other words, that each Large CAFO will comply with all applicable effluent limitations and standards. This is because, most glaringly, the CAFO Rule fails to require that permitting

> authorities review the nutrient management plans developed by Large CAFOs before issuing a permit that authorizes land application discharges.

399 F.3d at 499. The Ninth Circuit Court of Appeals has applied the same rule to municipal storm water plans, similar to the municipal BMP plans that will be generated by the Credited Program. *Environmental Defense Center, Inc. v. EPA*, 344 F.3d 832, 856 (9th Cir. 2003) ("programs that are designed by regulated parties must, in every instance, be subject to meaningful review by an appropriate regulating entity to ensure that each such program reduces the discharge of pollutants to the maximum extent practicable [*i.e*., the relevant statutory standard]").

The proposed BMP planning process included in the TMDL implementation plan suffers from the same defect. As described in the Lake Clarity Crediting Handbook, the permitting authority in California – the Regional Board itself – is not included in the review and approval loop for the decisions that select BMPs to be installed and loading reductions to be assigned to those BMPs. Like in *Waterkeeper Alliance,* those plans and BMPs are effluent limitations. *Waterkeeper Alliance*, 399 F.3d at 501 (both the requirement to develop and implement a nutrient management plan and the terms of the nutrient management plans are effluent limitations). By failing to provide for the permit issuing authority to ensure that the BMPs developed under the Crediting Program are consistent with the TMDL, waste load allocations and the deep water transparency standard, the implementation plan runs afoul of the Clean Water Act.

The Regional Board must be involved also because both the Load Reduction Estimates and Catchment Credit Schedules included in the Crediting Program are "effluent limitations' under the Clean Water Act. The Clean Water Act defines effluent limitation to mean "any *restriction* established by a State or the Administrator on quantities, rates, and concentrations of chemical, physical, biological, and other constituents which are discharged from point sources..." 33 U.S.C. § 1362(11). Like the nutrient management plans addressed in *Waterkeeper Alliance*, there is no doubt that the only restrictions actually imposed on discharges are those restrictions imposed by the various terms of the dischargers' BMP plans, their Load Reduction Estimates and the resulting Credit Catchment Schedules. *See* 399 F.3d at 502. Because they are themselves effluent limitations, the Load Reduction Estimates and Catchment Credit Schedules must be included in the dischargers' respective NPDES permits. *Id*. at 502-503 (because "the terms of the nutrient management plans constitute effluent limitations, we hold that the CAFO Rule - by failing to require that the terms of the nutrient management plans be included in NPDES permits - violates the Clean Water Act and is otherwise arbitrary and capricious in violation of the Administrative Procedure Act").

2. **<u>Load Reduction Estimates and Catchment Credit Schedules must be subject to public review and comment</u>.**

The Lake Clarity Crediting Handbook fails to mention any role by the interested public in reviewing the dischargers' proposed BMPs and Load Reduction Estimates or the Regional Board staff's approval of Catchment Credit Schedules. Handbook, Ch. 1. Again as the *Waterkeeper Alliance* decision explains, "the [Clean Water] Act unequivocally and broadly declares that '[p]ublic participation in the development, revision, and enforcement of any regulation, standard, effluent limitation, plan, or program established by the Administrator or any State under this Act shall be provided for, encouraged, and assisted by the Administrator and the States.'" 399 F.3d at 503 (citing 33 U.S.C. § 1251(e)). There is no meaningful legal difference between the BMPs and measures formulated by a CAFO in a nutrient management plan and the BMPs proposed pursuant to the Crediting Program's Load Reduction Estimates and Catchment Credit Schedules. The resulting plans and pollution control measures are both effluent limitations or, at a minimum, a "regulation, standard, plan, or program" established under the CWA to regulate discharges that must be subject to public review and comment and an opportunity for a hearing before their adoption. 399 F.3d at 504.

3. The Validation of Conditions and Awarding of Credits Must Include Storm Water Effluent Monitoring.

The other major flaw in the Crediting Program is the lack of field monitoring of BMPs to assist in validating any estimates of dischargers' pollutant loadings as well as to assure that any pollution reductions assigned to those BMPs in the Crediting Program are reasonably accurate. Water Code § 13242(c) requires the implementation plan to include "[a] description of surveillance to be undertaken to determine compliance with objectives." Currently, the Crediting Program relies exclusively on visual monitoring to confirm that BMPs have been installed and noting conditions. *See* Handbook, p. 2-6 – 2-7. No storm water quality monitoring is required that is designed to confirm that the installed BMPs actually reduced any loading or are as effective as the discharger and Regional Board staff person believed. *Id*. Based on the League's review of BMP studies performed by Caltrans and others, there has never been a comprehensive study or analysis monitoring the effectiveness in the field of most of the Tier 1 and Tier 2 BMPs relied upon by the TMDL. There is no evidence that pre-installation estimates of a BMP's effectiveness coupled with visual monitoring of BMPs can determine compliance with the deep water transparency standard or any other standard applicable to Lake Tahoe, including in particular the numeric effluent limitations that apply to all storm water discharges to the Lake in California. The only monitoring associated with BMPs contemplated in the future by the implementation plan is mentioned in the Regional Stormwater Monitoring Program that has yet to be developed by the agencies. TMDL Report, p. 12-5 (Regional Stormwater Monitoring Program "currently under development"). The absence of any information about the form and substance of any stormwater and BMP monitoring in this future plan is plainly inconsistent with Water Code § 13242(c)'s requirement to describe the plan that assures monitoring of compliance with the relevant objectives.

The TMDL reveals the contributions to load for listed and to-be-listed pollutants, but does not propose to monitor for the numeric effluent limits, as is currently done by LTIMP for nutrients, phosphorus, iron, TSS, and turbidity. The implementation plan suggests that ski areas, marinas, golf courses and other sources of pollutants are controlling their pollutants and are not in need of additional monitoring. Such confidence in potential pollution controls may not prove to protect the Lake, as there are many factors that contribute to increased pollutants, not all of which will be recognized nor acted upon by such entities. Unfortunately, other sources, on public lands, such as logging, campgrounds, large paved parking lots, unpaved parking areas, unpaved roads, and other soil disturbances will continue, but will not be monitored. All public agencies must be required to undertake adequate and approved monitoring for all such disturbances and uses in order to have a complete record of discharges that eventually reach the Lake, through tributaries and overland flow. Table 5-18-3 in the TMDL summary reveals that 18% of nitrogen loads to the lake are generated in the forested uplands. Now that the lake is co-limited (State of the Lake Report, 2008 and 2009) to both phosphorus and nitrogen, it is extremely important that sediment and nitrogen discharges are monitored, tracked, considered in the regulatory structure, and reported annually.

The only way to establish a picture of the effectiveness of BMPs actually installed and implemented is to require water quality monitoring of BMP effluent with agency verification monitoring. One of the main reasons that Lake Tahoe's clarity is degraded is the absence of any BMP or discharge monitoring that holds the dischargers accountable to the Basin Plan's clear, numeric storm water standards or any other standard. The Regional Board has consistently failed to include any water quality monitoring of storm water discharges by the current NPDES permit holders – Caltrans and the municipalities – to evaluate compliance with the Basin Plan's numeric water quality standards for storm water. Staff now again proposes to avoid collecting the storm water effluent data from implemented BMPs that would enable them, the dischargers and the public to corroborate loading reductions claimed by the pre-installment Credit Schedules. This should be rectified in the implementation plan now.

4. **<u>Crediting Program's proposed credit trading scheme does not comply with NPDES permitting procedures and the antidegradation policy, particularly in near shore waters not addressed by the TMDL</u>.**

"The Crediting Program encourages cooperation among urban jurisdictions by enabling credits to be distributed. Credits generated in a catchment in one urban jurisdiction can be distributed to <u>any urban jurisdiction</u> in the Lake Tahoe Basin <u>as determined appropriate by the urban jurisdictions</u>. This enables urban jurisdictions to share equipment and expertise to reach the common goals of regulatory compliance and improved lake clarity." Crediting Handbook, p. viii (emphasis added); *id*. at 0-2; 0-9 ("The Crediting Program encourages cooperation among urban jurisdictions by enabling credits to be distributed. Credits generated in any one catchment in a year can be distributed to any urban jurisdiction in the Lake Tahoe Basin as determined appropriate by the urban jurisdictions").

As far as a reader can tell, it appears that the dischargers will unilaterally decide where to transfer credits without any input or approval from the Regional Board or NDEP. Nor does there appear to be any geographic restriction on where credits can be transferred. As presented, the credit trading scheme is problematic for several important reasons.

First, transferring credits would in effect change a particular discharger's BMPs and, hence, as described above, effluent limitations. For the NPDES permittees, this cannot of course be done without an action by the Regional Board as well as public review and comment. *See supra*. The absence of the agencies also frustrates the mandate of Section 303(d)(4) that the agencies implement the waste load allocation as effluent limitations and that any revision to a discharger's effluent limitation based on a waste load allocation only occur where the agency can determine that "the cumulative effect of all such revised effluent limitations based on such total maximum daily load or waste load allocation will assure the attainment of such water quality standard." 33 U.S.C. § 1313(d)(4). Allowing dischargers to revise their specific allocations in advance of a permit modification omits the critical agency role intended by Section 303(d)(4).

Third, the proposed credit trading scheme is destined to create pollution hotspots, especially in near shore areas unaddressed by TMDL. As proposed and currently incorporated into the implementation plan, dischargers' decisions to aggregate their credits in one location would result in potentially increased discharges in other parts of the Lake. Given the stringent (though generally unenforced) numeric storm water effluent limitations and near-shore standards that apply at the edge of the Lake (especially the antidegradation policy), it is almost inevitable that avoiding BMPs in some portions of the Lake will result in violations of the near-shore standards. Certainly, this aspect of the implementation plan does not demonstrate any actions necessary to achieve such water quality objectives. Indeed, it appears to be quite the opposite at least in the near-shore zone.

F. THE REGIONAL BOARD'S FUNCTIONALLY EQUIVALENT DOCUMENT DOES NOT COMPLY WITH CEQA.

Although the Regional Board's Basin Plan process is a certified program under the California Environmental Quality Act, the Regional Board nevertheless must prepare a functionally equivalent document that complies with the substantive requirements of CEQA. *See San Joaquin River Exchange Contractors*, 183 Cal.App.4th at 1125-1126. "[T]he documentation required of a certified program essentially duplicates that required for an EIR or negative declaration." *City of Arcadia v. State Water Resources Control Bd.* (2006) 135 Cal.App.4th 1392, 1422 (quoting 2 Kostka & Zischke, Practice Under the Cal. Environmental Quality Act, supra, § 21.10, p. 1086). "In a certified program, an environmental document used as a substitute for an EIR must include '[a]lternatives to the activity and mitigation measures to avoid or reduce any significant or potentially significant effects that the project might have on the environment. . . .'" *City of Arcadia*, 135 Cal.App.4th at 1422. Where CEQA would otherwise require a negative declaration, a functionally equivalent document "must include a 'statement that the agency's review of the project showed that the project would not have any significant or potentially significant effects on the environment and therefore no alternatives or mitigation measures are proposed to avoid or reduce any significant effects on the environment. This statement shall be supported by a checklist or other documentation to show the possible effects that the agency examined in reaching this conclusion.'" *Id*.

The FED prepared for the TMDL is the equivalent of a negative declaration under CEQA. The checklist provided indicates that the Regional Board determined that the Basin Plan amendment and TMDL would have no significant effects on the environment. As is discussed below, the Regional Board's conclusion is not defensible.

CEQA requires that an agency analyze the potential environmental impacts of its proposed actions in an environmental impact report ("EIR") except in certain limited circumstances. *See, e.g.*, Pub. Res. Code § 21100. The EIR is the very heart of CEQA. *Dunn-Edwards v. BAAQMD* (1992) 9 Cal.App.4th 644, 652. "The 'foremost principle' in interpreting CEQA is that the Legislature intended the act to be read so as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language." *Communities for a Better Environment v. Calif. Resources Agency* (2002) 103 Cal. App. 4th 98, 109.

CEQA has two primary purposes. First, CEQA is designed to inform decision makers and the public about the potential, significant environmental effects of a project. 14 Cal. Code Regs. ("CEQA Guidelines") § 15002(a)(1). "Its purpose is to inform the public and its responsible officials of the environmental consequences of their decisions before they are made. Thus, the EIR 'protects not only the environment but also informed self-government.'" *Citizens of Goleta Valley v. Board of Supervisors* (1990) 52 Cal. 3d 553, 564. The EIR has been described as "an environmental 'alarm bell' whose purpose it is to alert the public and its responsible officials to environmental changes before they have reached ecological points of no return." *Berkeley Keep Jets Over the Bay v. Bd. of Port Comm'rs* (2001) 91 Cal. App. 4th 1344, 1354 ("Berkeley Jets"); *County of Inyo v. Yorty* (1973) 32 Cal.App.3d 795, 810.

Second, CEQA requires public agencies to avoid or reduce environmental damage when "feasible" by requiring "environmentally superior" alternatives and mitigation measures. CEQA Guidelines § 15002(a)(2) and (3); *See also*, *Berkeley Jets*, 91 Cal. App. 4th 1344, 1354; *Citizens of Goleta Valley*, 52 Cal.3d at 564. The EIR serves to provide agencies and the public with information about the environmental impacts of a proposed project and to "identify ways that environmental damage can be avoided or significantly reduced." Guidelines §15002(a)(2). If the project will have a significant effect on the environment, the agency may approve the project only if it finds that it has "eliminated or substantially lessened all significant effects on the environment where feasible" and that any unavoidable significant effects on the environment are "acceptable due to overriding concerns." Pub. Res. Code § 21081; 14 Cal. Code Regs. § 15092(b)(2)(A) & (B); *City of Arcadia*, 135 Cal. App. 4th at 1420-1421.

In certain limited circumstances, a negative declaration may be prepared instead of an EIR. A negative declaration is permitted when, based upon the initial study (or in this case the environmental checklist), a lead agency determines that a project "would not have a significant effect on the environment." *Bakersfield Citizens for Local Control v. City of Bakersfield* (2004) 124 Cal.App.4th 1184, 1220; Pub. Res. Code § 21080(c). However, such a determination may be made only if "[t]here is no substantial evidence in light of the whole record before the lead agency" that such an impact may occur. *Id.*

When determining if an EIR must be prepared, the fair argument standard applies. The fair argument standard is a "low threshold" test for requiring the preparation of an EIR. *The Pocket*

Protectors v. City of Sacramento (2004) 124 Cal.App.4th 903, 928. A public agency must prepare an EIR whenever substantial evidence supports a fair argument that a proposed project "may have a significant effect on the environment." 124 Cal.App.4th at 927; Pub. Res. Code §§ 21100, 21151, 21080. Significant effect on the environment "means a substantial, or potentially substantial, adverse change in the environment." Pub. Res. Code § 21068; *Pocket Protectors*, 124 Cal.App.4th at 927.

If the record contains substantial evidence supporting a fair argument that a project may have a significant effect on the environment, the lead agency shall prepare an EIR, or in the case of a certified program a document fundamentally equivalent to an EIR, even though the agency may be presented with other contrary evidence that the project will not have a significant effect. Pub. Res. Code § 21151; *Pocket Protectors*, 124 Cal.App.4th at 927. CEQA places the burden of environmental investigation on government agencies and project proponents rather than the public. *Id.* As a result, an agency is not "allowed to hide behind its own failure to gather relevant data." *Gentry v. City of Murieta* (1995) 36 Cal.App.4th 1359, 1378-1379, *citing Sundstrom v. County of Mendocino* (1988) 202 Cal.App.3d 296, 311. "If the lead agency has failed to study an area of possible environmental impact, a fair argument may be based on the limited facts in the record. Deficiencies in the record may actually enlarge the scope of fair argument by lending a logical plausibility to a wider range of inferences. *Id*.

The fundamentally equivalent document prepared by the Regional Board in support of the TMDL is an abuse of discretion for at least three reasons. First, the FED fails to address the significant environmental impact to the Lake's water quality of institutionalizing violations of the deep water transparency standard for a period of 65-years and likely impacts of pollution allowed by the TMDL to the Lake's near-shore zone. As a result, the FED had to be the equivalent of an EIR rather than a negative declaration. Second, the FED fails to evaluate a reasonable range of alternatives, instead focusing on three alternatives all of which only consider a 65-year compliance timeline. Third, by omitting new development from the TMDL and not restricting pollution loadings from future development, the TMDL as proposed will have growth-inducing effects within the Basin which are not acknowledged or analyzed in the FED.

1. **The FED arbitrarily claims the TMDL and implementation plan will have no impact on water quality standards despite extending violations of the transparency standard for 65-years and overlooking likely impacts to near-shore standards.**

The FED boldly claims that the TMDL and its implementation will have no significant impact on water quality or applicable standards. TMDL Report, pp. 16-26 – 16-27. However, the FED completely ignores the near-shore zone of the Lake. The discharges allowed by the proposed TMDL and the implementation plan could concentrate pollution loadings from runoff and aerial deposition in certain areas of the Lake to a degree that degrade beneficial uses in the near-shore zone and violate applicable near shore standards and/or the storm water effluent limitations contained in the Basin Plan. Of particular note, the implementation plan includes a credit trading scheme that, according to the documents, is within the discretion of the dischargers. The implementation plan thus contemplates that the main dischargers to the Lake will decide where to assign credits, with the option of allowing increased discharges in some locations. On August 23, 2010, the League took part in a telephone conference call with staff of the Regional Board. In response to the League's question of whether the credits could allow a discharger to increase its pollution loadings in a specific drainage area of the Lake, even while a discharger may be reducing loading from other areas consistent with their waste load allocation, several staff responded that, yes, specific areas could end up with higher loadings. These localized increases in sediment, nitrogen and phosphorous discharges could result in degradation to the near-shore zones beneficial uses and violations of the Lake's near-shore water quality standards (including especially the federal antidegradation policy) and numeric storm water effluent limitations. The Basin Plan includes an express reminder to staff that CEQA environmental documents for shorezone projects should address compliance with all of TRPA's water quality related shorezone development standards. . . ." Basin Plan, p. 5.7 -9. Despite that admonition and the clear likelihood of a significant environmental harm to the shore zone, the FED prepared for the TMDL does not consider at all the effects the TMDL's discharge proposals and exceedingly long schedule will have on the Lake's near-shore zone.

As the Regional Board and Tahoe Regional Planning Agency already have recognized for several years, the near-shore zone of Lake Tahoe is currently not protecting beneficial uses. *See, e.g.* Taylor, K., *Investigation of Near Shore Turbidity At Lake Tahoe* (March 2002) (http://www.swrcb.ca.gov/water_issues/programs/swamp/docs/laketahoe_turbidity_ mar2002.pdf); SNPLMA Proposal for Theme 2c (Near-Shore Water Quality) (2007) (http://www.fs.fed.us/psw/partnerships/tahoescience/documents/SchladowNearShoreProposal.pdf) ; McConnell, Joe; Kendrick Taylor, Spatial Variability of Near Shore Turbidity at Lake Tahoe (2001) (synopsis) (http://www.agu.org/meetings/fm01/fm01-pdf/fm01_H42G.pdf). *See also* Basin Plan, pp. 5.7-8 Human activities in and near the littoral zone can physically alter fish habitat and contribute nutrients leading to eutrophication and the alteration of food webs . . . ; erosion and sedimentation can degrade habitat quality"); *Id.* ("Increased growth of attached algae and rooted plants in the shorezone is the most visible sign of eutrophication to human recreational users of lakes"). Readily available evidence indicates that "[t]here is a strong correlation between elevated turbidity near the shore and development on the shore." Taylor 2002. *See also* McConnell & Taylor (2004) ("Perimeter surveys (Taylor et al., 2004) quantified turbidity on a basin-wide scale, finding a distinct association between elevated near-shore turbidity and several developed areas"). "The near shore zone is the portion of the lake first impacted by disturbances on shore because the material causing the adverse impact will have the greatest concentration near the source on shore." *Id.* As Geoffrey Schladow of the Tahoe Environmental Research Center explains:

> Conditions in the near-shore zone have degraded over time. Elements of this degradation include elevated turbidity (Taylor et al. 2004)…and increasing concentrations of periphyton (attached algae) on rocks, piers and other hard substrate (Hackley et al. 2004, 2005, 2006).

http://www.fs.fed.us/psw/partnerships/tahoescience/documents/SchladowNearShoreProposal.pdf. Dr. Schladow also emphasizes that, even assuming any benefits accrue from pollution control measures attempting to address clarity issues in the deep waters of the Lake, those measures cannot be assumed to benefit the near-shore:

> Recent optical modeling (Swift et al. 2006) suggests that mid-lake clarity is predominantly controlled by the concentration and size distribution of fine, inorganic particles (< 20 microns). The near-shore zone, by contrast, is more biologically productive suggesting that nutrient fluxes and other factors may play a much larger role in that zone. It therefore cannot be assumed that the same management strategies will work for both the near-shore and mid-lake.

Id. Kendrick Taylor, in her 2002 study, linked degradation of the near-shore from turbidity to development:

> The highest turbidity values were in the lake adjacent to Tahoe Keys and exceeded the TRPA littoral zone turbidity threshold. Areas with persistently high turbidity occurred off South Lake Tahoe and Tahoe City. Areas with occasional high turbidity occurred off Incline Village and Kings Beach.

http://www.swrcb.ca.gov/water_issues/programs/swamp/docs/laketahoe_turbidity_mar2002.pdf. *See also* http://www.agu.org/meetings/fm01/fm01-pdf/fm01_H42G.pdf. Thus, where the implementation plan allows for a concentration of new development or allows a discharger to exclude BMP maintenance resources from some portions of the Lake's watershed, the near shore zone would be the portion of the Lake that realizes pollution increases, including potentially excessive discharges of sediment, turbidity, and nutrients that could impair and further degrade recreational uses and other beneficial uses as well as exceed the applicable standards.[7] Given the expected increases in near-shore activity, the cumulative impacts of concentrated discharges caused by the TMDL's implementation plan could have serious cumulative impacts to the near-shore zone as well.

Because the TMDL and its implementation plan may lead to pollution hot spots in portions of the near-shore zone of the Lake, the TMDL and plan, as proposed, cannot be adopted, and the FED's negative declaration cannot be certified. "Any potential significant environmental effect triggers the EIR requirement (§ 21080, subds. (c) and

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7 Nor does the mere compliance with the Tahoe Regional Planning Agency's current threshold's resolve these potential significant impacts. As explained in Taylor (2001) p. 21, "The TRPA littoral zone turbidity threshold (WQ-1) does not provide a level of environmental protection that is consistent with the other TRPA thresholds and may not be consistent with the community's expectations."

(d)), even if the plan revisions together provide a "net" or overall positive for the environment." *Lighthouse Field Beach Rescue v. City of Santa Cruz* (2005) 131 Cal.App.4th 1170, 1197. "If the agency determines that there is substantial evidence that any aspect of the project, either individually or cumulatively, may cause a significant effect on the environment, regardless of whether the overall effect of the project is adverse or beneficial, the lead agency shall do one of the following: (A) Prepare an EIR[,] [or rely on a EIR covering the proposed project]." *Id*. (citing CEQA Guidelines).

The above references are more than sufficient to establish a fair argument that the TMDL and implementation plan may have a significant impact on Lake Tahoe's near-shore environment. "[A]n agency that has failed to conduct an adequate initial study cannot 'hide behind its own failure to gather relevant data.... CEQA places the burden of environmental investigation on government ... [i]f the local agency has failed to study an area of possible environmental impact, a fair argument may be based on the limited facts in the record ... In the absence of any further information, the record thus permits the reasonable inference that sludge disposal presents a material environmental impact.'" *Azusa Land Reclamation Co., Inc. v. Main San Gabriel Basin Watermaster* (1997) 52 Cal.App.4th 1165, 1199, quoting *Sundstrom v. County of Mendocino* (1988) 202 Cal.App.3d 296, 311. Here, more than a reasonable inference exists that the TMDL's discharge proposals will adversely affect the Lake's near-shore zone.

2. **By focusing on only three alternatives all of which propose to allow violations of the deep water transparency standard for 65-years, the FED includes an insufficient range of alternatives.**

An EIR must describe a range of reasonable alternatives to the Project, or to the location of the Project, which would feasibly attain most of the basic objectives of the project but would avoid or substantially lessen any of the significant effects of the project, and evaluate the comparative merits of the alternatives. "An EIR's discussion of alternatives must contain analysis sufficient to allow informed decision making." *Laurel Heights I*, 47 Cal.3d at 404. An EIR must also include "detail sufficient to enable those who did not participate in its preparation to understand and to consider meaningfully the issues raised by the proposed project." *Id*. at 405.

One of CEQA's fundamental requirements is that the DEIR must identify the "environmentally superior alternative," and require implementation of that alternative unless it is infeasible. 14 Cal.Code Regs. §1526.6(e)(2); Kostka & Zischke, *Practice Under the California Environmental Quality Act* §15.37 (Cont. Educ. Of the Bar, 2008). Typically, a DEIR identifies the environmentally superior alternative, which is analyzed in detail, while other project alternatives receive more cursory review.

The analysis of project alternatives must contain an accurate quantitative assessment of the impacts of the alternatives. In *Kings County Farm Bureau v. City of Hanford* (1990) 221 Cal.App.3d 692, 733-735, the court found the EIR's discussion of a natural gas alternative to a coal-fired power plant project to be inadequate because it lacked necessary "quantitative, comparative analysis" of air emissions and water use.

A "feasible" alternative is one that is capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social and technological factors. Pub. Res. Code § 21061.1; 14 Cal. Code Regs. § 15364. California courts provide guidance on how to apply these factors in determining whether an alternative or mitigation measure is economically feasible.

The lead agency is required to select the environmentally preferable alternative unless it is infeasible. As explained by the Supreme Court, an environmentally superior alternative may not be rejected simply because it is more expensive or less profitable:

> The fact that an alternative may be more expensive or less profitable is not sufficient to show that the alternative is financially infeasible. What is required is evidence that the additional costs or lost profitability are sufficiently severe as to render it impractical to proceed with the project.

Citizens of Goleta Valley v. Bd. of Supervisors (1988) 197 Cal.App.3d 1167, 1180-81; *see also*, *Burger v. County of Mendocino* (1975) 45 Cal.App.3d 322 (county's approval of 80 unit hotel over smaller 64 unit alternative was not supported by substantial evidence). As discussed below, the EIR fails to meet the legal standards for an adequate CEQA alternatives analysis.

In addition to a no project alternative, the FED considers three "alternatives" all of which only consider a 65 year schedule to implement the TMDL. FED, p. 16-36 ("a) Alternative 1: No Action/No Basin Plan amendment (No Project). b) Alternative 2: 20 years to Clarity Challenge, 65 years to restore transparency. Alternative 3: 40 years to Clarity Challenge, 65 years to restore transparency"). This is not a reasonable range of alternatives. At a minimum, the FED needs to consider a number of alternatives with faster implementation as well as timelines restricted to permits or enforcement orders for the NPDES permit dischargers. The following alternatives should be incorporated into the FED's analysis:

- An alternative requiring immediate compliance with the TMDL and any timelines for dischargers to comply with their allocations are included in enforcement orders;

- An alternative requiring compliance with the TMDL within 20-years of adoption and any timelines for dischargers to comply with their allocations are included in permits/WDRs (if authorized) or enforcement orders; and

- An alternative requiring compliance with the TMDL within 40-years of adoption and any timelines for dischargers to comply with their allocations are included in permits/WDRs (if authorized) or enforcement orders.

Currently, all NPDES permit and WDR holders, at least in California, have permits with a requirement prohibiting them from violating water quality standards. *See* CalTrans Permit, p. 3; Municipal NPDES Permit, § B.2. None of them have a schedule of compliance to meet that prohibition. *Id*. It makes little sense that, now that everyone recognizes how impaired Lake Tahoe's deep waters are, the dischargers should be granted a 65-year compliance schedule to comply with reductions they already need to do to comply with in their current permits. At a minimum, given that the agencies' authority to adopt a 65-year schedule of compliance is not found in the Clean Water Act, the Regional Board must at least lay out the above alternatives that consider much shorter or no schedule of compliance.

3. <u>The FED fails to address the TMDL's growth-inducing impacts</u>.

An EIR must discuss "the ways in which the proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment." CEQA Guidelines § 15126.2(d). As discussed above, in establishing the waste load allocations for the TMDL, the agencies opted not to include future development or provide any allocations for pollution resulting from such future development. *Supra*. In addition, the TMDL Report highlights as a "crucial role" the leverage TRPA's approval of future development may have on implementing BMPs in furtherance of the TMDL. TMDL Report, p. 11-2 ("The TRPA will play a crucial role in TMDL implementation because the TRPA has the ability to incentivize TMDL implementation. As the agency responsible for zoning and permitting a wide variety of land uses and construction projects throughout the basin, TRPA has the ability to release or restrict building allocations, additional building height, and commercial floor area"). In effect, by keeping its hands off of future development in the allocation decision – and hence, deciding not to restrict pollution from those future sources through the TMDL – and noting that only by approving new development can TRPA incentivize TMDL implementation, the Regional Board is implicitly acknowledging the proposed TMDL and implementation plan's likely growth-inducing impacts. These potential impacts must be addressed in the FED.

G. <u>THE REGIONAL BOARD SHOULD WITHDRAW THE PROPOSALS TO ELIMINATE STORM WATER EFFLUENT LIMITATIONS FOR OIL AND GREASE AND IRON BECAUSE THE PROPOSALS ARE INCONSISTENT WITH THE 208 PLAN, HAVE NOT BEEN ANALYZED IN THE FED, AND WILL CREATE UNCERTAINTY REGARDING DISCHARGER'S COMPLIANCE WITH STANDARDS</u>.

It is the League's understanding that staff is planning on withdrawing the proposal to include amendments to the Basin Plan that would eliminate the existing numeric effluent limitations for oil and grease and iron in storm water discharges. Basin Plan Amendment, pp. 2-3; 22-25. The League believes that withdrawal of these proposals is prudent. The Regional Board should either maintain or lower the Basin Plan limit of 2 mg/L for oil and grease. If it is true that 2 mg/L does not meet the Basin Plan's sheen standard, the Board should establish a lower effluent limitation rather than eliminate the existing effluent limitation. Likewise, the Regional Board should not remove the existing iron limit but, if anything, replace it with a limit consistent with the primary MCL of 0.3 mg/L. By eliminating the effluent limitations – even the existing limits – the Board would create difficulties in enforcing any discharges of oil and grease especially where no visual observations of sheen are accurately documented. In the case of iron, not even visual observations will assist the Board in enforcing the iron standard. Also eliminating the limits is inconsistent with the EPA-approved 208 Plan. *See* 208 Plan, p. 188. Lastly, the FED does not address these project proposals and they cannot proceed until the Regional Board has considered them pursuant to CEQA.

CONCLUSION

The League appreciates the opportunity to submit these detailed comments regarding the proposed TMDL and implementation plan. The League requests that the Regional Board instruct staff to address each of the above concerns and propose a TMDL implementation plan that assures that dischargers will comply with their waste load allocations as soon as possible and, rather than prejudging the need for 65 years for every discharger, that the Regional Board address any need for compliance schedules when the individual permits are taken up as well as any accompanying enforcement orders.

Sincerely,

Michael Lozeau
Lozeau Drury LLP
Attorney for the League to Save Lake Tahoe

Encls.

cc: w/out encls, via e-mail:

Rochelle Nason, Executive Director, League to Save Lake Tahoe
Carl Young, Program Director, League to Save Lake Tahoe
Alexis Strauss, Director, Water Division, EPA Region 9
Jason Brush, EPA Region 9
Rik Rasmussen, Manager, TMDL Section, State Water Resources Control Board

Tahoe Area Sierra Club Group

September 13, 2010

Harold Singer, Acting Executive Director
Lahontan Regional Water Quality Control Board
2501 Lake Tahoe Blvd.
S. Lake Tahoe, CA 96150

By e-mail to DFSmith@waterboards.ca.gov

Dear Mr. Singer,

The attached comments are submitted in response to your "Notice of filing of draft environmental documents concerning Proposed Amendments to the Water Quality Control Plan for the Lahontan Region including the draft Lake Tahoe Total Maximum Daily Load for Sediment and Nutrients." We thank Lahontan Regional Water Quality Control Board (Lahontan) staff for meeting with us on numerous occasions to explain the development of the TMDL "package," some of the assumptions that were made, and some of the implementation concepts

TASC feels the Tahoe TMDL is a major work product that provides a good starting point to support a change in direction regarding regulation of discharges to Lake Tahoe's once-clear waters consistent with the non-degradation standard of the Outstanding Natural Resource Waters designation for the lake. Lahontan can and should use innovative methods, as long as Lahontan maintains its core duty—to protect and regulate for attainment of water quality. The key to knowing if a new method works is results—actual monitored and measured reduction in pollutants that improve lake clarity.

Accordingly, because the proposed TMDL is a promising but an untested approach, our support for it depends on the following conditions being met:

- An implementation plan is adopted. Chapter 11 of the TMDL (Implementation Plan) needs to have deadlines, reporting requirements, accountability measures, and mechanisms to assure the public that work is being done as predicted and that results are attained.
- A comprehensive monitoring network, including a fully funded RSWMP and LTIMP, is developed, implemented and in operation as a requirement of the NPDES permits.
- Effective and timely adaptive management, enforcement and reporting are in place.
- Credits are not awarded until expected annual load reductions have been confirmed through monitoring, either specific to a project and/or through field measurements of a BMP with similar attributes. This is especially important given the need to understand the actual results on a timely basis to justify the expenditures for the federal, state, and local residents who are supporting the work to restore the lake's clarity.

- All new projects undertaken in the Basin prior to the issuance of the NPDES permits in California install stormwater runoff controls to contain 100% of runoff on-site.
- Mechanisms are in place that will ensure timely adjustments to the model to reflect impacts from climate change, scientific findings regarding lake clarity response, near-shore issues and processes, and impacts from other sources, such as forest runoff, golf courses, ski areas, campgrounds, parking lots on public property, and unpaved roads.
- Near-shore clarity issues are addressed quickly, including the process and timeline for adopting, implementing and enforcing water quality standards to attain and maintain a clear view of the lake bottom while standing near the lake's edge.
- The Lahontan Board is identified as the official body to conduct oversight of the program and holds annual public meetings to review the progress of the TMDL.

Please review the following pages for detailed comments. We look forward to working with Lahontan to improve and implement the TMDL so that the mid-lake transparency ("clarity") standard is attained sooner than the current 65-year schedule.

Thank you for caring about Lake Tahoe and affording us this opportunity to share our views.

Sincerely,

Roger Rosenberger
Tahoe Area Sierra Club

Laurel Ames
TASC Conservation Committee

Detailed Comments

The following includes detailed questions and comments on the proposed Basin Plan Amendments (BPA) for the Tahoe TMDL.[1] Comments regarding changes to the summary document must also be reflected in the Basin Plan Amendments and TMDL chapters, as appropriate.

Overall Approach of the TMDL.

The body of work generated through this project provides an improved understanding of the pollutants affecting lake clarity loss, their sources, and the new annual water transparency standard (hereafter referred to as 'clarity') of 97.4 feet (29.7 meters).

While we understand the agency's desire to record clarity as an annual average, the TASC recommends that the winter four-month mean Secchi readings continue to be reported, in order to validate the assertion that changing from a winter average to an annual average is equivalent over time.

As noted by regulatory entities and the research community, the TMDL was developed on the best information available in 2004. Because of the six-year-old cutoff date, many research and monitoring gaps remain or are not included. Therefore a robust, ongoing monitoring, research and adaptive management structure must be clearly stated and adhered to through an implementation management plan for the public to be assured that anticipated load reduction targets are to be met and the clarity standard achieved.

Lake Tahoe TMDL Summary.

The summary (page 1) should include the following information and answer the questions and issues raised prior to the November Board hearing:

- The implementation management plan should be described. The plan should include a description of what success is and how the agency will know it has been attained, a timeline of decision points and protocols for those decision points, how the expected $1.5 billion will be spent, how it will be awarded (e.g., cheapest project, most effective, highest priority, off-the shelf technology or innovation, etc.).
- Why the cutoff point for "fine" particles is 16 microns and below instead of 2.5 microns and below. Peer reviewers noted that it is believed the largest impacts are actually from fines roughly 2-5 microns and smaller. This discussion is missing from the document and should be provided.
- The estimated loading addresses only atmospheric deposition onto the Lake's surface. Loading from deposition onto land has been included in the other land-based sources (e.g. urban runoff), but not reported. The document should report the estimated land-based deposition. In addition, further research is needed to better refine atmospheric estimates and amend the model to add those quantities of particulates and nutrients. This information

[1] Unless otherwise stated, references to information and page numbers are based on the July 9, 2010, Proposed Amendments document.

may result in a need to increase the load reductions required of atmospheric sources to attain the clarity standard.

- The quantity of fine sediment that enters the lake via stream channels because adjacent flood plains are no longer functioning properly as a result of development and other human disturbances. Because this value is unknown, this factor should be noted under the Stream Channel source category and a factor for fine sediment transported in the stream amended into the model.
- The text, especially the introduction (page 3), should insert "mid-lake" before transparency to clarify the TMDL is only focused on the mid-lake standard.
- The text should note the deteriorating conditions of the near-shore and that the agency long-ago concluded that the current turbidity standard is not adequate for protecting near-shore clarity; that it doesn't reflect the worsening water quality conditions; and that research is underway to better understand near-shore processes. The document should also explain how and when, once sufficient scientific information is available, the Board will develop and adopt a regulatory process to protect the new near-shore standard.

Although page 8 summarizes the results of assumed 'buildout,' what this actually represents has been a point of contention and confusion for quite some time. The text should include a clear description of what the assumptions actually are as described in the U.S. Geological Survey 2006 document cited in the models' references.[2]

Eliminate Numeric Effluent Limits for nutrients in Stormwater Discharges to Infiltration Systems (p. 2).

Nutrients:

- The TASC has serious concerns with the proposal to eliminate the effluent limits for nitrogen in stormwater discharges to infiltration systems due to the magical qualities of soil to remove the nitrogen before it enters the water. The summary and substitute environmental document (SED) should explain how the soils can absorb enough nitrogen to help attain the nitrogen loading proposed in the model.
- Now that the lake is co-limited in a number of months of the year (see State of the Lake Report 2008 and 2009), the input of nitrogen to the groundwater, the streams and the lake is of very serious concern. There is no information provided to assure that a large percentage of nitrogen will be treated in the soil through infiltration, because soil saturation during stormwater events will result in no soil treatment volume, as well as an increase in nitrogen discharge. The CWA 303(d) list for nitrogen sources should be re-examined and additional specific nitrogen reduction measures added to the crediting program.

[2] Tahoe Land-Use Change Model Summary Report and Climate Change Literature Review and Tahoe Basin Projections, U.S. Geological Survey, March 31, 2006

The effluent limit for nitrogen entering stormwater infiltration systems should be maintained as an integral part of all associated monitoring programs and as a standard requirement of the TMDL unless and until such time adequate scientific information shows that infiltration can sufficiently remove nitrogen as required by the TMDL load reductions. Without such controls and a monitoring program, it will be difficult or impossible to determine the amount of nitrogen added to the lake's load.

Nutrients and Near-shore Clarity

The TASC understands that more information is needed to fully understand the complex near-shore processes affecting the lake's shoreline, and that although research is already underway, we do not yet have enough information to develop an appropriate near-shore clarity standard, nor assess what control mechanisms will be necessary to restore the lake's once-clear shoreline. Further, although the mid-lake clarity TMDL addresses all three clarity-reducing constituents (fine particles, nitrogen and phosphorous) it prioritizes a reduction in fine particles – as expected given that the pollutants with the greatest impact on *mid-lake* clarity are fine particles and the TMDL is based on a requirement to achieve the *mid-lake* clarity standard.

However, in the interim, the problem remains that the tributaries still deliver nutrients to the lake every day, primary productivity is still increasing exponentially, and Tahoe's once-clear near-shore continues to degrade. It may be that nutrients have little or nothing to do with the phenomenal growth of invasive plants and aquatic animals in the near shore, but the likelihood is that nutrients are one potential element that cannot be dismissed until studies prove those nutrients are not a part of the disturbing amount of near-shore growths.

Therefore, the TMDL must maintain regular application of effluent limits for nitrogen and phosphorus and include these nutrients in all monitoring programs. Further, Lahontan must react swiftly and appropriately to restore Tahoe's near-shore areas once the needed scientific information is available to support the development of a standard and indicator that protects clarity in the shoreline areas, and necessary pollutant control measures can be determined, adopted and enforced.

Infiltration and Groundwater:

The summary on page 2 regarding the elimination of numeric effluent limits for stormwater discharges to infiltration systems explains: *"In the event there isn't sufficient separation between infiltration systems and groundwater levels, the Basin Plan ensures water quality protection by stating that when the separation between infiltration systems and groundwater is less than five (5) feet, discharges may be required to meet effluent limits for discharges to surface waters*."

Although the current BP language includes this reference to the five-foot distance, the proposed deletions to the BP include the removal of the following language (page 23): "*Therefore, discharges to infiltration systems located in areas where the separation between the highest anticipated ground water level and the bottom of the infiltration system is less than five (5) feet may be required to meet the effluent limits for stormwater discharges to surface waters."* Yet the proposed replacement language for this section does not include this specific protection, but rather addresses the issue in vague terms (as proposed on page 25): *"Infiltrating runoff volumes generated by* *the 20 year, 1-hour storm may not be possible in some locations due to shallow depth to seasonal groundwater levels, unfavorable soil conditions, or other site constraints such as existing infrastructure or rock outcroppings."*

- Either the summary is inaccurate or the BPA language fails to include the five-foot distance.
- The agency responsible for determining when infiltration is not possible due to groundwater level(s) shall be designated and specific criteria provided.
- Multiple alternative locations in an area should be evaluated for potential to design treatment that infiltrates stormwater. A project proponent or implementing entity cannot simply look at one location in a project (as individual parcels and/or a combined area) and state infiltration is not feasible.
- The document should state the potential for higher seasonal water table as the climate changes and provide criteria for determining when infiltration capacities are lost.
- Reducing the five-foot standard is unlikely to protect groundwater. Rather, it could provide that nitrogen has an easier path to the lake.

Eliminate Numeric Effluent Limits for Total Iron and Oil and Grease for Discharges to Surface Water (p. 3).

Although staff stated at the 9/8/2010 public hearing that due to an inadequate project description, the proposal to amend the requirements for Iron, Oil and Grease for discharges to surface water will be removed from the currently-proposed BPA, we presume the agency will eventually propose these amendments in the next iteration. Therefore, we maintain the following comments for future consideration:

The future environmental documents should describe the regulatory and legal differences, if any, between the requirements for meeting a stormwater effluent limit versus Maximum Contaminant Level (MCL). Also the documents should describe the difference between the monitoring programs for each in the same way, listing the different parameters. If both are comparable in almost every way, then the proposal to retain the more stringent MCL for iron would be an advantage. This information should be provided in the next draft of the SED.

Iron:

Researchers still lack a full understanding of the near-shore lake processes that are contributing to the loss of clarity, vulnerability to and impacts of invasive species, and exponential growth of algae in our near-shore environments. As such research is currently underway, the future environmental document should evaluate the best available science regarding the role of iron in near-shore processes, and whether this warrants tighter standards for iron.

Oil and Grease:

The future document should describe at what concentration(s) visual sheens are typically seen. The document currently states only "much lower than 2.0 mg/l." Will the deletion of the stormwater effluent limit affect the extent (e.g. frequency, location, etc.) of monitoring for these constituents? Are there conditions that could prevent a visual sheen from being observed at levels below 2.0 mg/l? If it's possible for the visual sheen 'measurement' to be subjective, where the reading is different between different observers, then how many observations are necessary to validate the standard? Are there other uses for the data pertaining to measuring the concentrations?

Describe Stormwater Treatment Requirements.

On page 3 this section states: "*…and the need to prioritize load reduction actions to make the best use of limited public resources to control roadway runoff*."

There has been extensive discussion regarding the cost of TMDL implementation and resources that are available to assist with these costs. The proposed BPA language seems to weigh in on this issue of contention, stating that public resources are "limited." However, in response to recent concerns expressed by local jurisdictions that the TMDL is an "unfunded local mandate," TRPA and Lahontan staff have responded by explaining that on the contrary, adoption of the TMDL will provide eligibility to the local jurisdictions for additional federal and state grant programs based on implementation of the mandated TMDL. Further, although not required to, the TRPA is proposing to provide "incentives" and allocations in conjunction with the award of credits by Lahontan, thus possibly providing additional financial means to help achieve the load reductions.

While the issue of funding is a valid discussion point, the TASC recommends the word "*limited*" be removed from this proposed BPA language. The intent will remain the same - that the idea is to make the best use of public resources to control roadway runoff. As much contention and question remains regarding public funding, it is not appropriate to state such funding is "limited" in the Basin Plan. This is an implementation issue (and is addressed later in this letter).

On page 25, the proposed language includes: "*Where conditions permit, project proponents should consider designing infiltration facilities to accommodate runoff volumes in excess of the 20 year, 1-hour storm to provide additional stormwater treatment.*"

- What conditions would either permit or not permit this design?
- Will Lahontan give additional 'credit' for implementers who design to accommodate larger runoff volumes? If not, then how will Lahontan encourage or require such designs?
- Lahontan agrees there are water quality benefits from accommodating larger runoff volumes, so why not require them now? Why does this language only suggest that jurisdictions and project implementers "should consider" such a design?

The science regarding expected impacts of climate change in the Lake Tahoe Basin may still be under development and ongoing. However, evidence today supports the expectation that we will see less snow, more rain, shorter winters and more intense flooding events. In other words, science already supports the need to design infiltration facilities to accommodate greater than the 20-year, 1-hour storm.

As the SED states: "*Existing concentration-based numeric effluent limits for stormwater runoff would be retained as the primary compliance objective. Those limits, which apply to all stormwater runoff at all times, do not account for storm event variability and do not recognize any correlation between pollutant loads into the Lake and transparency.*" (pages 16-37 and 16-38). As Lahontan therefore recognizes, these stormwater discharge effluent limits (included in Table 5.6-1, page 25) are not supported by current science with regards to lake clarity and pollutant loading.

Because the use of effluent limits would be retained as an option in certain circumstances, the SED should evaluate alternative effluent limits (e.g. lower limits).

Eliminate Reference to Alternative Deicer Studies.

The paragraph proposed for removal (shown on page 15 of the 7/9/2010 document) is outdated and should be removed. Further, the TMDL documents must explain how, when implemented properly, the TMDL will incentivize the consideration of alternative deicer and traction abrasive materials. However, although the focus of the TMDL is on those constituents which impact water clarity (fine PM, N and P), the amendments to the Basin Plan shall not negate or reduce the responsibility to consider the salt impacts from deicing materials. According to the discussion in Chapter 4.8 of the BP, it appears Lahontan recognizes that vegetation impacts occur from these materials. However, the BP suggests it is TRPA's responsibility to regulate such impacts. We disagree, because the listed beneficial uses for Lake Tahoe include both aquatic and terrestrial habitat (near the shore), which can be negatively affected by salt compounds. Therefore, with regards to the proposed BPA, it shall be clear that the only impacts of the amendments are to remove the outdated references and that no changes will affect regulation of deicing materials with regards to other pollutants.

Climate Change.

The Basin is already experiencing the impacts of climate change.[3] This includes more precipitation falling as rain and less as snow, more rain-on-snow events, flooding events, lake warming, warmer nighttime temperatures (especially during the winter months, further affecting snow levels), etc. Although the model was based on actual historical weather and climate data, we have long advocated that the model incorporate climate change impacts in some way, rather than wait for future adjustments. We note that information regarding climate change impacts and associated land use scenarios was gathered with the intention the information would be used for the TMDL, as summarized by David Halsing (USGS 2006):

> "The second part [of the report] summarizes and explains a detailed review of the most recent and relevant scientific literature on climate changes – specifically temperature and precipitation – expected to occur under various greenhouse gas emissions scenarios. From these projections of climate changes, a central estimate of temperature and precipitation changes, as well as ranges of variability around it, is developed for the Sierra Nevada mountain range in the region of Lake Tahoe. The result of the land use/land cover modeling and the changes expected to occur in regional climate both provide ways for users and decision-

[3] 2010 State of the Lake Report, TERC

makers to generate new inputs for the Total Maximum Daily Load (TMDL) Watershed model, which estimates sediment- and nutrient-loading to Lake Tahoe."

However, it does not appear that the climate change information provided by the USGS modeling efforts was incorporated into the current TMDL. If this is correct,

- Why did Lahontan decide not to use the climate change information that was gathered specifically for the TMDL?
- What are the loading implications of waiting 1, 2, 5, 10 or more years to adjust the model to reflect impacts of climate change (which generally result in increased loading to the Lake coupled with lake processes that themselves can further reduce mid-lake transparency as well)?

We understand any adjustments based on climate change impacts have been delayed until the implementation of the TMDL (via adaptive management), there will potentially be a lag time of years between the impacts occurring on the ground and updates to the model. Therefore, we will fall further behind with regards to pollutant load reduction. Also, as local jurisdictions are awarded credits for achieving modeled/estimated load reductions, TRPA intends to tie additional development allocations to these credits. Thus, additional development will occur *before* the adaptive management process can account for climate change impacts. How does the TMDL address this?

Considerations for TMDL Implementation.

TASC notes the following concerns regarding the successful *implementation* of the new direction of the BPA:

1. Coverage Removal.

Although Lahontan staff members have explained that it may be possible to get credit for coverage removal and eventually, improvements and restoration to naturally-functioning "stormwater treatment systems" such as flood plains, the current suite of tools provided to implementers for estimating load reductions are more heavily focused on non-natural systems for stormwater treatment (e.g. constructed facilities to capture and infiltrate and/or treat stormwater). According to Lahontan, in general, the removal of 10% coverage may generate an 8% decrease in loading (Project Report: Integrated Water Quality Management Strategy, March 2008, p.55-56). Removing coverage and restoring land, e.g. sensitive lands like SEZs which promote flood plain connectivity and provide for overbanking, will help reduce pollutant loading to the lake. Coverage removal and restoration of land must therefore be heavily incentivized as one of the most efficient options implementers can use for meeting load reductions, especially from an operations and maintenance perspective.

2. Monitoring.

Adequate monitoring is necessary to successfully reduce the pollutant loads entering Lake Tahoe. The Regional Stormwater Monitoring Plan (RSWMP) must provide for adequate monitoring in conjunction with the crediting program and other implementation activities. In addition, the LTIMP stream monitoring program must be fully funded, and partner agencies must be held accountable for their contributions to LTIMP monitoring. For example, will the Forest

Service be responsible for ongoing monitoring in the uplands and contribute to LTIMP status and trend data? Without consistent stream monitoring, it will be difficult if not impossible to track pollutant concentrations from public property, including land disturbance, and unpaved roads.

For the urban areas, monitoring must be performed for all projects of different BMP designs, different geomorphic states, including soil types, infiltration rates, slope, size and other significant differences.

Actual, on-the-ground measurements are needed to assure the actions being taken by the local jurisdictions are achieving the required load reductions and to justify the expenditure of public and local funds. Models such as those associated with the Crediting Program can provide useful planning tools for estimating the benefits of a given project. However, without confirmation through adequate monitoring, the models provide limited value. The RSWMP monitoring network must be fully developed to collect the information necessary to measure baseline loads and confirm load reductions post-project construction and in the long term. Cost should not affect the development of the scientific monitoring network. Instead, once the network is developed, Lahontan should identify how the costs will be covered through implementation activities (e.g. included in NDPES permits). Credits should only be awarded when monitoring is completed to confirm load reductions.

However, page 12 states: "*The Regional Board expects the monitoring plan components to be fully developed by agency stakeholders within the first two years following TMDL adoption by USEPA, and full monitoring program operation is expected by the third year*."

- It appears that the monitoring plan will not be fully developed before NPDES permits are issued. Is this correct?
- If so, how will Lahontan know what to put in the NPDES permits in order to adequate cover monitoring needs? How will baseline loads be measured prior to implementation of projects for which entities will receive credits upon project completion?
- Why will two more years be required for development of the monitoring plan?

Entities should not be awarded credit, especially where TRPA will correlate credits with approval of additional development allocations, prior to completion and operation of the monitoring network.

Page 12 further states that: "*Once fully developed, the monitoring program will assess progress of TMDL implementation and provide a basis for reviewing, evaluating, and revising TMDL elements and associated implementation actions. The monitoring program will cover each of the four major pollutant sources and will monitor the in-lake responses to the pollutant loading. The source monitoring will focus on the largest pollutant source, urban uplands. The in-lake monitoring has been established and operating for about 40 years and is expected to continue*."

- What is the difference between the "monitoring program that will cover each of the four major pollutant sources" and the "source monitoring?"

Will the monitoring network proposed also monitor the three other sources?

- This also implies the monitoring program will continuously monitor the in-lake responses to the pollutant loading. Because clarity measurements will be taken on a regular schedule, why wait 15 years to assess load reductions versus clarity response?[4] We understand that due to environmental factors, conclusions about clarity response cannot be made on just a year or two of readings. Lahontan staff has stated that it is assumed that a five-year time period is probably sufficient to reflect trends. Therefore, if clarity continues to decline for five+ years, yet jurisdictions are being awarded credits for estimated load reductions, will Lahontan really wait another 10 years to assess why clarity is declining as pollutant loads are supposedly being reduced (see next paragraph)?

3. Adaptive Management.

The term "adaptive management" has been used for years by numerous Lake Tahoe Basin entities. The application, however, has not been very successful. According to Lahontan staff, the intent of the TMDL program will be to incorporate new findings (e.g. measurement data, new technology, etc.) into the program and implementation tools (the Crediting Program) in a timely manner. For example, future monitoring may show that more or less fine particulate matter was removed by a given BMP than currently estimated. In such a situation, the TMDL model(s) will be adjusted to reflect this different load reduction, and jurisdictions' Stormwater Management Plans will also be adjusted. In concept, this type of adaptive system can be beneficial, especially when the program is beginning with recognition of research and monitoring gaps (including an expanded monitoring network). However, because thus far adaptive management has been extremely slow, at best, we are concerned that a lag time in "adapting" TMDL tools could lead to the award of more credits than should actually be received.

Page 12 states that: "*As part of the TMDL Management System, the Regional Board will annually assess relevant research and monitoring findings and may adjust annual load reduction targets and/or the TMDL implementation approach as needed.*"

- What mechanism assures that the Board will annually review the entire program, including the success of the implementation management plan?
- What specific mechanisms will ensure that TMDL tools will be adapted in a timely manner?
- What are the criteria the Board will use to assess whether to make adjustments annually?
- What is considered "as needed" and who will make this determination?

In other words, when new information is found that necessitates a model/crediting program update, what mechanisms will ensure this will be done

[4] Page 12 states: "Following the first fifteen year implementation period of this TMDL, the Regional Board will evaluate the status and trend of the lake transparency relative to the load reductions achieved."

immediately, and in a way that another year of crediting does not occur based on outdated information?

Will the scientific community, especially researchers from TERC, UCD and other institutions that helped develop the TMDL, be included in the adaptive management process? If so, how? If not, who will assess the new science and determine whether a change to the TMDL implementation (or TMDL itself) is warranted?

4. Funding

The issue of funding has been one of large debate and contention. Although Lahontan and TRPA have explained that additional funding opportunities will result once the TMDL is adopted (i.e. through federal and state grant programs aimed at TMDL implementation), and TRPA also intends to provide financial "incentives" to entities who achieve their load reductions (or "credits"), the issue of cost continues to be one of the largest concerns expressed by all parties. Therefore, the final TMDL documents should discuss in greater detail the additional funds that will actually be available to assist in implementation once the TMDL package is adopted.

5. Enforcement.

Regulations are only effective if adequately enforced. While we realize staff cannot inspect every project or assumption used by implementers to estimate their load reductions (e.g. through the clarity crediting model), there must be sufficient enforcement to deter inadvertent or direct manipulation of model inputs so that anticipated load reductions occur and credit is not received for load reductions that do not occur.

6. Baseline Estimates.

In the current TMDL package a baseline pollutant loading to the lake has been estimated for 2004 as one basin-wide value. However, the baseline values for each jurisdiction's 2004 contribution have not yet been estimated. According to Table 5.18-5, local jurisdictions will be required to calculate their 2004 baseline load values within two years of TMDL adoption using the specified tools.

> "To ensure comparability between the basin-wide baseline load estimates and the jurisdiction-scale baseline load estimates for urban runoff, municipalities and the state highway department must use a set of standardized baseline condition values that are consistent with those used to estimate the 2003/2004 basin-wide pollutant loads. Specifically, baseline load estimate calculations shall reflect infrastructure and typical basin-wide conditions and management practices as of October 2004." (p. 9)

We understand the tools they will use to determine their individual 2004 baseline values will be based on a different model than the one that provided the 2004 basin-wide baseline loading. Thus some minor differences will be expected when all individual values are summed together. However, what will Lahontan do if the sum of the individual jurisdictions' baseline levels fall far short of the basin-wide loading estimate? How will such a discrepancy be resolved? If not resolved, we may see local jurisdictions estimating lower baseline values than exist and thus setting the stage for not having to reduce as much loading. Lahontan needs a solid plan to address the individual jurisdictions' baseline values to ensure that when totaled together, they are within 5% of the basin-wide 2004 baseline value that has already been estimated.

In conclusion, we look forward to working with Lahontan staff on the upcoming "implementation phase" of TMDL development. A serious, rigorous and detailed implementation management plan can provide for success of the TMDL, especially if accompanied by a strong commitment by the Board to on-the-ground monitoring, timely adaptive management and a very clear plan for accountability, transparency, responsibility, timelines, and deadlines.

DRAFT FINAL REPORT

Examination of Dust and Air-Borne Sediment Control Demonstration Projects

September 15, 2010

PREPARED BY:

Dr. Hampden Kuhns (Principal Investigator)
Dr. Dongzi (Davis) Zhu
Dr. John Gillies (Co-Investigator)
Dr. Alan Gertler (Co-Investigator)

hkuhns@dri.edu 775 674 7111
Division of Atmospheric Sciences
Desert Research Institute
2215 Raggio Parkway, Reno, NV 89512

Dr. Steven Cliff (Co-Investigator)
Dr. Yongjing Zhao
Department of Applied Science
University of California Davis
3001 Engineering III, One Shields Ave, Davis, CA 95616

Mr. Scott Brown
Ms. Domi Feller
Mr. Michael Pook
Nevada Tahoe Conservation District
400 Dorla Court
Zephyr Cove, NV 89448

PREPARED FOR:

Jonathan W. Long
Tahoe Research Program Manager
USDA Forest Service
Pacific Southwest Research Station
Tahoe Environmental Research Center

Executive Summary

Lake Tahoe's water clarity has decreased from ~100 feet in the 1970 to ~70 feet in the last few years. Fine inorganic particles are causing about 58% of light attenuation in Secchi disk measurements of water clarity. The 2010 draft of the Total Maximum Daily Load (TMDL) report indicate that the sources of sediment include Urban Upland Loading (i.e. storm water runoff 72%), Non-urban Upland Loading (9%), Atmospheric Deposition (both dry and wet 15%), Stream Channel Erosion (4%). This report describes measurements and results collected in the Tahoe Basin that investigate the transport, deposition, chemistry, and emission control strategies of road dust that is a primary component of both the upland loading and atmospheric deposition sources.

Road side experiments were conducted at three sites around the lake. Instruments measured the composition of the near-roadway aerosol emissions and how they were depleted as they passed through landscapes ranging from open fields to dense Aspen and Willow stands. The UC Dave Rotating Drum Impactor was used to measure size distributions and chemistry next to the roadway source. Data from the 2007 DRI TRAKER study (SNPLMA round 5) were revisited to estimate the cost effectiveness of airborne particulate matter less than 10 microns (PM_{10}) emission control strategies including: street sweeping, summer construction, road resurfacing, road shoulder paving, anti-icing, and abrasive type.

Funding for the project by provided by the Southern Nevada Public Lands Management Act and administered by the U.S. Forest Service.

The major results from this study are summarized here.

- Within 5 m downwind of the road, PM_{lrg} (Total suspendable material - PM_{10}) accounts for ~half of the airborne mass emissions, PM_{crs} (PM_{10} - $PM_{2.5}$) account for the other half with PM2.5 representing less than 0.5%.
- Using the conservative Stokes deposition velocities, 99% of PM_{lrg}, PM_{crs}, and $PM_{2.5}$ deposit within 300 m, 5.2 km and 40 km of the ground level emission point with wind speeds of 2 m/s. Using more realistic deposition velocities (relevant for forested areas) the 99% deposition points reduce to 70 m, 400 m, and 19 km, respectively. As a result the bulk of airborne emissions will deposit within a few km of the road.
- Airborne phosphorous (a nutrient for algal growth in the lake) concentrations in near-roadway aerosols were greatest in the fine particle mode. Phosphorus did not appear to be associated with most of the road dust mass since 85% of roadside phosphorus was in $PM_{2.5}$ size fraction compared to only 20% of the crustal species.
- Fine PM phosphorus concentrations are greatest during peak travel times. A potential (although unproven) source of road side phosphorus is the burning of motor oil that contain the oil additive Zinc dialkyldithiophosphates (ZDDP).
- Winter street sweeping when roads are dry after storms (ASAP sweeping) was the strongest predictor of Emissions Equilibrium (EE, a traffic speed independent measure of road emission strength). Many secondary and tertiary roads are only swept seasonally and serve as a reservoir of material that is suspended into the air when abrasives are tracked onto higher speed roads.

- On an annual cost effectiveness basis, street sweeping costs \$0.6 per kg PM_{10} emissions reduced. This is less than 0.5% when compared with roads resurfacing of fair conditions roads (\$300 per kg PM_{10} emission reduction) or resurfacing of poor condition roads (\$700 per kg PM_{10} emission reduction).
- Road segments that employed anti-icing pretreatment on roadways had lower EE values by a factor of two. While being correlated with cleaner roads, anti-icing provides other benefits including reduced salt application, reduced abrasive application, and better utilization of resources since brine can be applied during routine shifts up to three days in advance of a storm. Although not quantitative, cost benefits are estimated to be on the same order as sweeping (~\$0.6 per kg PM_{10} emissions reduced)
- Roads with paved shoulders or barriers that prevented entrainment of material from the sides of roads had 50% lower EE than did roads with narrow (less than 3 feet) or unpaved shoulders. Shoulder improvement costs 10%-20% of road resurfacing and may prove to reduce airborne emissions. In comparison, ASAP Sweeping and anti-icing are substantially less expensive and more likely to provide significant emission reduction benefits.
- Potential basin wide emission reductions of 2/3 may be achievable if the emission equilibrium reservoir can be reduced through regional street sweeping and anti-icing practices. To be most effective, emission control strategies should require that not only primary roads, but *all roads*, be swept after snow storms to recover applied abrasive material.

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1 Introduction

Lake Tahoe is a unique environmental asset that has been designated an "Outstanding National Water Resource" by the US Environmental Protection Agency (EPA) to protect its water quality and its scenic characteristics. Lake Tahoe is located in a basin surrounded by the Sierra Nevada mountains to the west and the Carson mountain range to the east. Of particular concern to resource management agencies in the basin is that optical clarity in Lake Tahoe has been steadily decreasing during the last four decades. This is the result of increased algal growth from excess nutrient inputs and from the scattering of light by fine sediment particles in the lake due to watershed runoff and atmospheric deposition (Byron and Goldman, 1986; Goldman et al., 1993; Jassby et al., 1999).

Recent work by Swift et al. (2006) has shown that fine inorganic particles are causing about 58% of light attenuation in Secchi disk measurements of water clarity. That study noted that particle sizes from 0.5–10 microns are of particular concern due to their light scattering characteristics and relative abundance.

Through the Lake Tahoe Total Maximum Daily Load (TMDL) Program, these particles have been attributed to four main sources in the Tahoe Basin: Upland Loading (i.e. storm water runoff), Atmospheric Deposition (both dry and wet), Stream Channel Erosion, and Ground Water Infiltration. At the time the empirical Lake Tahoe Clarity Model was assembled, the confidence in the Atmospheric Deposition source component for fine sediment was determined to be "low" whereas all other sources were rated as "medium" (Smith and Kuchnicki, 2010). Improving the confidence in this source of waterborne sediment has been the objective of numerous studies in the last several years.

Emissions studies conducted by Kuhns et al. (2004) and Zhu et al. (2009) indicate that nearly 300 metric tons of particulates (less than 10 microns) are contributed annually to the atmosphere by vehicles traveling on paved roads in the Tahoe Basin. Emission factors of road dust during winter when traction control material was applied was found to be ~4 times higher than during the summer. Other sources of particulate emissions in the basin include wind blown dust, unpaved road dust, and fires. These results were compiled into a basin wide gridded emission inventory by Gertler et al. (2008) showing that the greatest density of PM emissions exist in South Lake Tahoe coincident with the highest wintertime traffic density.

Using receptor modeling, airborne concentrations of $PM_{2.5}$ (i.e. particle less than 2.5 µm aerodynamic diameter), PM_{10} (i.e. particle less than 10 µm aerodynamic diameter), and total suspended particulate (TSP operationally defined particles less than ~25 µm aerodynamic diameter) measured during the 2002-2004 Lake Tahoe Atmospheric Deposition Study (LTADS; CARB 2006) were attributed to a variety of local sources (Englebrecht et al., 2009). Although wood smoke was a major component of ambient PM, it was primarily associated with the smallest sized particles that have very small dry deposition velocities. Mobile source particles and geologic material were major contributors of PM_{10} and TSP particles especially at the urban sites near South Lake Tahoe. These larger particles have much higher deposition velocities but don't travel as far from their sources. Concentrations of geologic PM_{10} at the remote Thunderbird Lodge on the northeastern shore of the lake were only 20% of those measured at urban sites.

These prior studies have shown how road dust plays a substantial role in the airborne coarse particle concentrations around the lake and how the source strength changes with season.

The original LTADS draft report also formulated an estimate of air pollutant deposition to the lake based on a simple calculation of flux (defined as the shoreline concentration times a deposition velocity) multiplied by the lake area. During the report's peer review process, a reviewer commented that the estimates of deposition might be too high since large particles may deposit near their sources and become depleted from the air column. In response to this comment, LTADS authors noted that the original estimates were conservative upper bounds of the flux to the lake, but revised their central annual estimates of particle deposition down by 13%, 18%, and 25% for $PM_{2.5}$, PM_{crs} (PM_{10} - $PM_{2.5}$), and PM_{lrg} (TSP - PM_{10}), respectively to account for large particle depletion. These revisions were based on reducing the estimated mid lake concentrations from the shoreline concentrations measured at Lake Forest (north west lake) and Sandy Way (south lake) by 25% of the difference between these concentrations and those measured at Thunderbird Lodge (remote east lake).

The LTADS report also described a short term targeted study to quantify the near field deposition of particles using optical particle counters to measure changes in size distribution with increasing distance from roadways. With samplers located at 6 m, 16 m, and 100 m downwind of the road, regressions of the size resolved concentrations were used to infer dispersion coefficients (based only on particle concentrations between 1 µm and 2.5 µm) and deposition coefficients (based on the attenuation of larger particle concentrations). The analysis was based on the assumption that the influence of ambient background concentrations upwind of the road were negligible at all sites downwind of the road. This assumption has the potential to positively bias the estimate of the deposition coefficient by underestimating the fraction of particles that are vertically dispersed.

An additional component of the LTADS study employed limited shipboard sampling of aerosols in the vicinity of the northern and southern lake shores. When coupled with GPS measurements, the data showed strong gradients of particle concentrations along the shore, with highest concentrations of coarse and large particles measured near urban shorelines.

The present study focuses on how far road dust particles travel before depositing to the ground or the lake and also examines how road management practices (i.e., paving, sweeping, brining, and sanding) and other factors (i.e., vegetation) can affect particle emissions.

The principal goals of this study were to:

- Measure PM deposition at several points downwind of a road in areas representing a variety of fetch and land types (e.g., forest, urban, open) common to the Tahoe basin.
- Calculate fraction of emissions deposited to the ground in the first 100 m of fetch near the road.
- Measure particle emission factors and chemical/physical properties from roads employing a variety of emission control strategies.
- Calculate the emission control effectiveness
- Use calculated values along with emission control costs to determine cost effectiveness of various emission control strategies.
- Prioritize emission control strategies based on cost effectiveness to prevent PM from dry depositing to the lake surface.

The report is divided into 9 sections including the current section 1. Sections 2 and 3 describe the study sites and instrumentation used. Section 4 and 5 describe the road side aerosol chemical and size analysis from the RDI sampling and associated measurements. Section 6 describes the results of deposition experiments and integrates these data into a near field (~1 km) model downwind of a road. Section 7 employs results from an earlier road dust study to quantify benefits of emission control practices. Section 8 evaluates our original hypotheses based on our measurements. Section 9 lists the references cited in the report. Appendices A and B describe our original size selection list and optimization measurements from a pilot test with the deposition boxes.

2 Study Locations and Timeline

In February 2008, a survey of potential deposition sampling sites was conducted in the Tahoe Basin to identify a range of landscapes with potentially different depositional environments suitable for our experiment. Thirteen candidates sites were visited and a map of these sites along with a table of relevant metadata are shown in Appendix A.

The final three sampling sites were selected to represent a range of common landscapes found in the basin. Rabe Meadow represented sparse pine stands common around the lake. At Bourne Meadow, offshore winds transported emissions from the road across an open grass field. During off-shore conditions, roadway emissions passed through a dense stand of aspen trees. The willow forest at the Rocky Ridge site had the most dense vegetation. An urban experiment was also conducted in Incline Village however wind conditions were unsuitable for transport and deposition calculations (Figure 1).

The first year of the project field study began in November 2008 and lasted to early May of 2009 to study near source road dust deposition process. DRI Deposition Boxes and the UCD Rotating Drum Impactor (RDI) sampler were placed in Bourne Meadow and Rabe Meadow (southeast of Lake Tahoe) in March and April of 2009. The DRI Flux Tower was deployed twice and DRI TRAKER was operated around the lake once in 2009. The Deposition Boxes were also set up in Incline Village in June, 2009 to support a collocated street sweeper study (conducted by Nevada Tahoe Conservation District and later canceled). Meteorological data were acquired with each installation of the Deposition boxes. In 2010, the Deposition Boxes were set up at the Rocky Ridge site near Tahoe City (Table 1).

Table 1. Instruments used in this study and sampling locations and periods.

Location	DRI Flux Tower	DRI TRAKER	DRI Deposition Boxes	UCD RDI Sampler
Rabe Meadow 1	11/15/2008		11/14/2008-11/16/2008	
Bourne Meadow	3/13/2009		3/13/2009-4/2/2009	3/13/2009-3/30/2009
Rabe Meadow 2	4/21/2009	4/23/2009	4/2/2009-4/30/2009	4/3/2009-4/22/2009
Incline Village			6/23/2009-6/27/2009	
Rocky Ridge			4/23/2010-6/13/2010	

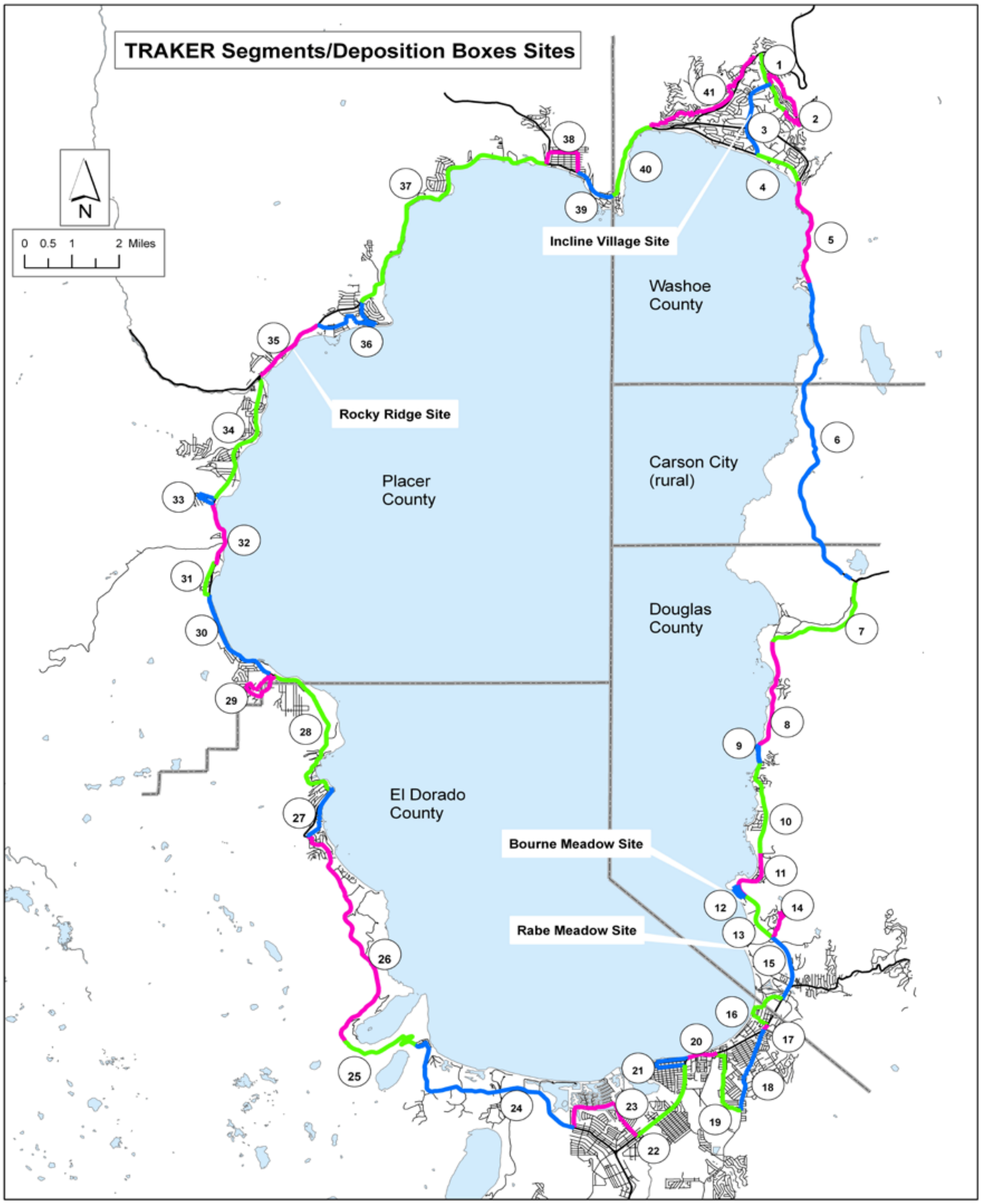

Figure 1. Deposition studies sites in Lake Tahoe Basin and 2006-2007 TRAKER study routes.

3 Instrumentation

This section describes the instrumentation used to measure the physical and chemical properties of the aerosol in the vicinity of highways around Lake Tahoe.

3.1 Deposition Box Description

Instruments for this experiment were enclosed in a weatherproof enclosure (0.69 m × 0.49 m × 0.95 m) (Figure 2). Instrumentation in each enclosure consisted of: two TSI (St Paul, MN) 8520 DustTraks (equipped with PM_{10} and $PM_{2.5}$ inlets), one Met One (Grants Pass, OR) Aerosol Profiler Model 212-2, one Met One model 014A anemometer with an 024A wind vane, one Airmetric MiniVol sampler collecting the PM_{10} on a 47 mm Teflon filter for gravimetric and chemical analysis, one Campbell Scientific CR1000 data logger, and 2 deep cycle gel cell batteries. Particle size cut points for Met One instrument were programmed at 0.3 µm, 0.5 µm, 0.7 µm, 1 µm, 2.5 µm, 5 µm, 10 µm, and 15 µm. Each deposition box is capable of operating for ≈100 hours on a battery charge and all the data were recorded by the data logger. Met One sampler rain caps covered the inlets for each of the four aerosol samplers. When the enclosure is mounted to stakes, the wind sensors and aerosol inlets were between 2.0 and 2.8 m above ground level (agl). Some sample inlets were (~6 m agl) at Rocky Ridge.

3.1.1 Instrument collocation tests

To better understand the instrument inter-comparison on target site, four Met One Aerosol Profilers Model 212-2 enclosed in the Deposition Boxes were collocated in the Bourne Meadow of Lake Tahoe (daytime upwind side) to evaluate their precision (Figure 3). The instruments sampled ambient air over a 4 day period from 1/29/2009 to 2/2/2009. During this period, ambient concentrations of PM_{10} and $PM_{2.5}$ were less than 20 µg/m^3 as measured by TSI DustTraks. The regression coefficients (Table 2) were applied when reducing data sampled at following sites.

Table 2. Regression coefficients for inter-instrument comparison of aerosol profilers. Uncertainties of the slopes and intercepts are the standard errors of regression. The term Average SE Y (counts L^{-1}) is the average standard error of the regressions for each particle size.

		X = H3206 Y = H3210		Box 1 vs Box 2	X = H3208 Y = H3210		Box 3 vs Box 2	X = H3209 Y = H3210		Box 4 vs Box 2	Concentration Range	Avg SE Y (counts/liter)
0.3-0.5 um	Slope	1.28	±	0.02	1.19	±	0.01	1.25	±	0.01	64795 to 3118023	478
	Intercept (counts/liter)	-9392	±	16389	-4707	±	5946	11304	±	6051		
	R^2	0.996			0.999			0.999				
0.5-0.7 um	Slope	1.20	±	0.01	1.21	±	0.01	1.23	±	0.01	10966 to 191128	35
	Intercept (counts/liter)	166	±	597	-2719	±	854	1025	±	899		
	R^2	0.999			0.998			0.997				
0.7-1 um	Slope	0.95	±	0.01	1.16	±	0.02	1.26	±	0.01	4962 to 48049	12
	Intercept (counts/liter)	345	±	240	-365	±	418	400	±	276		
	R^2	0.997			0.992			0.996				
1-2.5 um	Slope	0.89	±	0.01	0.93	±	0.03	1.81	±	0.02	2475 to 28265	8
	Intercept (counts/liter)	-228	±	155	693	±	437	215	±	132		
	R^2	0.997			0.970			0.997				
2.5 -5 um	Slope	1.41	±	0.02	1.28	±	0.02	1.30	±	0.04	2513 to 35874	12
	Intercept (counts/liter)	201	±	168	812	±	210	-1705	±	407		
	R^2	0.996			0.993			0.980				
5-10 um	Slope	1.27	±	0.03	1.51	±	0.03	0.83	±	0.01	142 to 10141	2.9
	Intercept (counts/liter)	-246	±	61	-187	±	47	-141	±	39		
	R^2	0.986			0.992			0.994				
10-15 um	Slope	0.60	±	0.01	2.86	±	0.09	0.67	±	0.01	5 to 991	0.3
	Intercept (counts/liter)	-17	±	4	-3	±	6	-3	±	4		
	R^2	0.988			0.971			0.987				
>15 um	Slope	0.72	±	0.02	1.47	±	0.06	0.44	±	0.01	5 to 1571	0.4
	Intercept (counts/liter)	3	±	6	15	±	8	17	±	5		
	R^2	0.981			0.960			0.984				

Figure 2. Deposition boxes and sampling equipments.

Figure 3. Collocation test of 4 deposition boxes in Bourne Meadow site in Feb, 2009.

3.2 Rotating Drum Impactor (RDI) Sampler

Under California Air Resources Board (CARB) and National Oceanic and Atmospheric Administration (NOAA) funding, UC Davis developed and constructed a novel aerosol impaction sampler. The current (4th) generation 8-Stage Rotating DRUM Impactor Sampler (8-RDI) is a cascade impactor based on the basic design of Lundgren (1967), and evolved significantly from the original DRUM impactor as described by Raabe et al. (1988). The RDI sampler used in this study operates at 16.7 liters per minute and was coupled to a 10 µm cut-point ("PM10") inlet. The 8-RDI samples are a continuous particulate record for 8 size bins (i.e., 10-5, 5-2.5, 2.5-1.15, 1.15-0.75, 0.75-0.56, 0.56-0.34, 0.34-0.26, and 0.26-0.09 µm aerodynamic diameter), which were analyzed in 3-hr time steps.

The RDI sampler size-separated stages were engineered based on theoretical calculation of aerodynamic collection efficiency. Modest size bias between real and theoretical particles is expected due to differences in particle type and ambient meteorological conditions. While bias is a consideration for every sampling device, the RDI minimizes these issues by allowing measurement of fundamental aerodynamic parameters. The pressure differential between stages is one measurable quantity used to verify compliance with theory. Numerous studies comparing results from the current RDI sampler to EPA approved $PM_{2.5}$ and PM_{10} samplers have been published revealing less than 10% bias for PM_{10} and $PM_{2.5}$ composite samples. Additionally, the predecessor sampler to the current RDI (with similar physical parameters) has been fully calibrated and published (Raabe et al., 1988) and the uniformity of the sample deposit, which relates to analytical quality assurance, is established (Bench et al., 2002).

The RDI sampler incorporates a stepper motor control, diagnostic testing for temperature, humidity, flow rate and pressure, Campbell data-logger, and battery backup. These diagnostics are recorded and used to verify sampler operation for quality assurance. The most important feature of the RDI sampler is the sample cassette which houses the sampling substrates. The drive mechanism remains with the mounted sampler enclosure with a removable cassette isolating the samples. This feature is especially important as the substrates are not exposed in the field, and thus sample and data retrievals approached 100%. Modest data loss is associated with periods when the generator power supply was stopped to refuel. Also, because the sampling is continuous and preprogrammed for sampling duration, the sampler operates autonomously with little or no operator interaction for the sampling duration. The sampler consists of a self-contained package of sampling cassette, drive system, diagnostics and electronics and an externally located pump. No supplemental enclosure or temperature-controlled environment was required. Thus, the 8-RDI was particularly well suited to deployment in this study. Continuous sampling during the intensive studies allowed measurement of both road-derived and background ambient air as described in the results section without deploying multiple samplers. One RDI was collocated with the DRI deposition boxes at the Bourne and Rabe Meadow sites (near box 1 in Figure 4C and between box 2 and box 1 in Figure 4d).

At the Bourne Meadow site, line power was available approximately 75 m north of the site; however, no line power was available at the Rabe Meadow site. Thus, an alternate power supply was necessary that would allow nearly continuous sampling for the experiment duration with minimal operator interaction. In preparation for the experiment several sources of power including deep cycle batteries with DC powered vacuum pumps and efficient AC powered pumps running from a 1000 watt DC to AC inverter powered by 12vDC batteries were evaluated for performance. Ultimately, we determined that the battery-supplied power would be insufficient for reliable sample collection and presented other problems such as transport weight and the need to recharge the batteries. We opted for a generator power supply as we were assured it would provide sufficient power when running and is more portable than deep cycle batteries. In order to provide continuous power for extended periods, we converted a Honda EU2000i gasoline generator to propane power using a conversion kit from US Carburetion (http://www.propane-generators.com/) and coupled the generator to a 100 pound (approximately 20 standard gallons at 80% capacity) portable propane tank. This system resulted in more than 168 hours (i.e., 7 days) continuous operation without refilling the propane tank. Propane is readily available and has other advantage over gasoline for this purpose including much lower particulate emissions and less hazardous handling (e.g. no spill concerns and fewer ambient vapor hazards). We have since used similar generator systems for other projects where line power was unavailable including at the Dulles International Airport (DIA) for a airport emissions study sponsored by the National Academies Transportation Research Board.

3.3 Sampling location Descriptions

3.3.1 Bourne Meadow February, 2009 test

Bourne Meadow is on Lake Tahoe's southeast shore at Marla Bay, approximately 3 km south of Zephyr Cover along Nevada Highway 50 (Figure 4). The site was chosen since there were no significant point sources of particulates nearby. Local vegetation consists of dense aspen trees of 5-6 m height (Figure 5). The four deposition boxes were deployed at positions as shown in Figure 4b for the period from 18th February to 21st February, 2009. Box 1 was set at 5 m from the highway on the eastern side of the road curb along the SW-NE direction, perpendicular to the road. Boxes 3 and 4 were 30 m and 100 m away from the Highway 50, respectively. Box 2 was 15 m west of the road and ≈400 m to the Lake. The sampling period commenced following a 130 mm (5") snow storm at lake level around 11th February, 2009. The ground surface nearby the road was still covered with snow but the road was dry and we expected there to be more suspendable road dust at this time than during the November sampling period, based on previous seasonal trends (Zhu et al., 2009). For this period, the daytime onshore (upslope) wind was southwesterly (225°) and nighttime offshore (downslope) wind was northeasterly (45°). In both cases, the winds were perpendicular to the highway. In another study the deposition boxes were sampling at Incline Village (North of Lake Tahoe) from June 23 to June 29, 2009, the wind switched from daytime onshore South wind to nighttime offshore North wind regularly. This diurnal wind oscillation was also reported by CARB (2006) at the South and Northwest sampling sites of Lake Tahoe, indicating this might be a basin wide pattern in the absence of strong synoptic systems.

To measure the nighttime dust deposition from March 26 to April 2, 2009 at the Bourne Meadow site, Box 2, 3, and 4 on placed at 15, 50, and 100 m downwind (offshore wind) side of Highway 50. Box 1 was set 5 m upwind of the road (Figure 4c). Figure 5 shows additional images of the instrumentation deployed at both Bourne and Rabe Meadows.

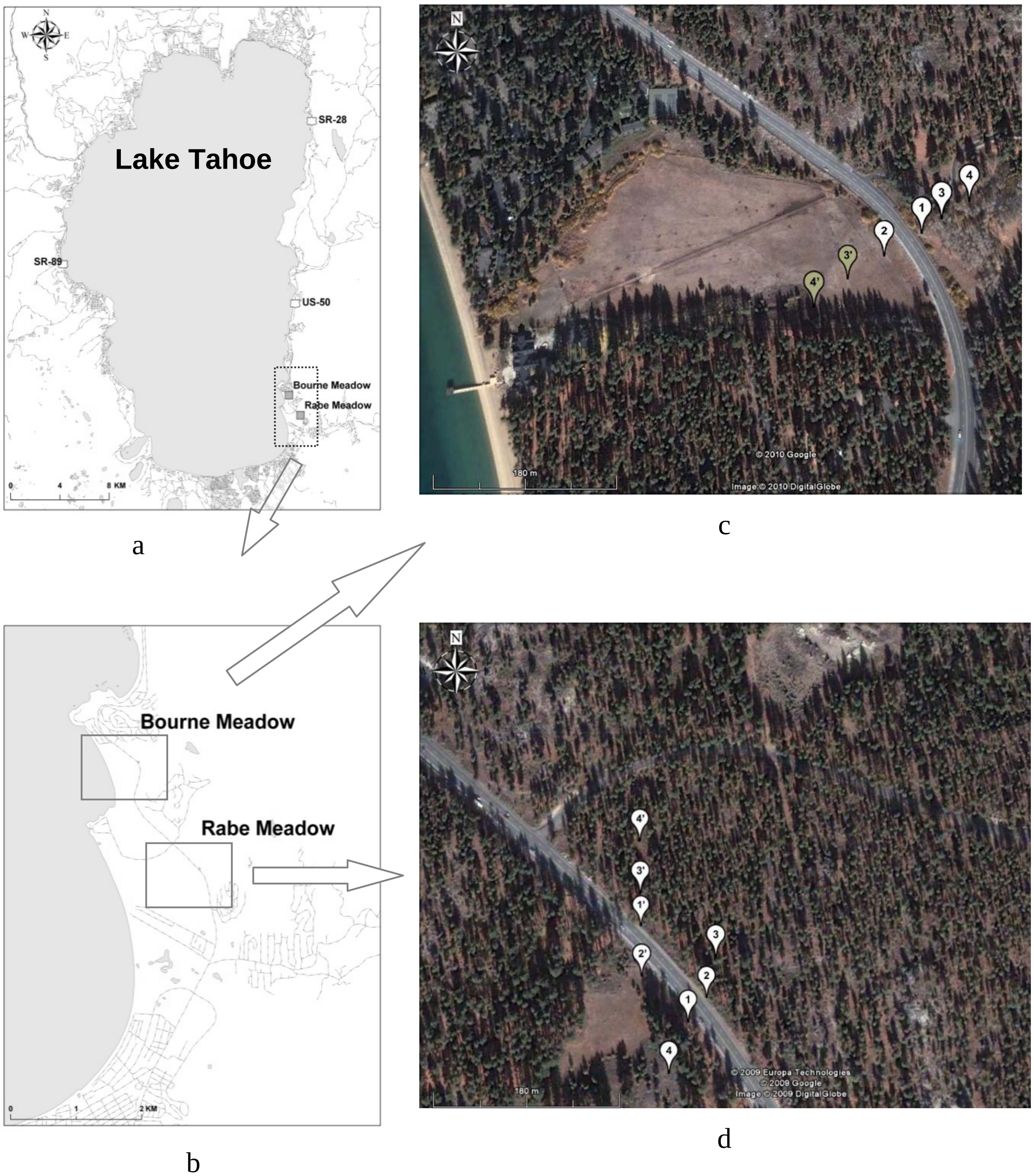

Figure 4. a) Bourne Meadow and Rabe Meadow sites on the Lake Tahoe; b)Detailed position of Bourne Meadow and Rabe Meadow in Southeast of Lake Tahoe; c) Aerial photograph showing the location of four deposition boxes with respect to a 4 line highway in Bourne Meadow, Lake Tahoe. Box 1-4 in February 2009, Box 1, 2, 3' and 4' in March, 2009. d) Aerial photograph showing the location of four deposition boxes with respect to Highway 50 in Rabe Meadow in November, 2008 with box number 1-4 and April 2009 with box number 1'-4' in Lake Tahoe.

Figure 5. Four Deposition Boxes and UCD DRUM sampler at the Bourne Meadow site. Top left: daytime upwind sampler 2; Top right: daytime downwind sampler 1 at 5 m away from road, and RDI sampler; Bottom left: daytime downwind Sampler 3 at 30 m away from the road; Bottom right: daytime downwind sampler 4 at 100 m away from road.

3.3.2 Rabe Meadow April 2009 test

In the spring sampling period of April, 2009, four sampling boxes were deployed at the Rabe Meadow site (Figure 2d), which is ≈1.5 km south of Bourne Meadow along Highway 50, and ~800 m from the lake shore. The nearby vegetation consists of tall (>15 m) pine trees spaced ~5 m apart and was less densely vegetated than the Bourne Meadow site. Since the daytime wind direction was south and the nighttime wind was north in the 2008 November test period, to align with the dominant wind directions, Boxes 1, 3, and 4 were deployed along the north-south orientation at 10, 38.5 and 100 m (daytime) downwind of the road. Highway 50 is oriented along a northwest-southeast direction at the measurement site thus the sampling boxes transected an angle of ~45 degrees with respect to the road. Box 2 was set 10 m upwind of the road during the daytime and experienced onshore winds.

3.3.3 Rocky Ridge (Tahoe City) May, 2010 test

To characterize the vertical dust profile near the road source and validate our assumption that vertical diffusion velocity [K(dC/dz)/C] is invariant with particle size, a modified version of the deposition box system was assembled to measures particle size and number concentrations at 2.2 m and 6.1 m agl. The Rocky Ridge Road in Tahoe City, CA is located along the Highway 28 of California. This system was deployed from April to June, 2010. On each position (10 m and 110 m) downwind of Highway 28, one box was equipped with a sampling inlet at 2.2 m height, the other box was equipped with a sampling inlet at 6.1 m height. A four-box collocation test was also done in this site after the instruments were sent back to the factory for calibration.

4 RDI Sample Analysis

RDI samples were analyzed by synchrotron X-ray Fluorescence (s-XRF) (Knochel, 1989) using a broad-spectrum X-ray beam generated on beamline 10.3.1 at the Advanced Light Source (ALS) Lawrence Berkeley National Laboratory. The ALS s-XRF system is capable of high sensitivity detection of elements ranging from sodium to uranium (Perry et al., 2004). The s-XRF analysis provides quantitative elemental data for approximately 28 elements in 8 size modes with 3-hour time resolution. Of the 28 elements analyzed, approximately 18 were well quantified due to low ambient atmospheric concentration. Light from the XRF beamline is collimated prior to entry into the sample chamber and is plane polarized thereby greatly reducing the background signal and dramatically improving the signal-to-noise ratio. We perform quantitative analysis by calibrating with a comprehensive set of 40 single- (Micromatter, Inc.) and multi-element National Institute of Standards and Technology (NIST)-traceable standards. An inter-laboratory comparison between Desert Research Institute and UC Davis shows no significant bias for major elements (i.e., those significantly above minimum detectable limit) in samples provided by CARB from Lake Tahoe during the LTADS experiment previously described (Cliff, 2005). Tests have shown that the sample deposit from the RDI sampler is extremely uniform along the non-time axis (Bench et al., 2002). De-convolution of the raw X-ray spectra is performed using WinAXIL (Canberra). Data reduction involves calibration, peak fitting, matrix, particle size, and loading corrections using accepted protocols.

5 PM Chemical Composition

As the LTADS study demonstrated, PM_{10} mass is dominated by coarse particle soil, while wood smoke is most abundant in fine PM. Windblown soil is composed mainly of the oxides of Mg, Al, Si, Ca, Ti and Fe with obviously many other trace elements. Summation of the 5 major oxides of Al, Si, Ca, Ti, and Fe typically accounts for more than 90% of the total soil composition (Malm et al., 1994). The major soil components excluded from this calculation are MgO, Na_2O, K_2O and water. That is:

$$\text{Fine 'Soil'} = 2.20*\text{Al} + 2.49*\text{Si} + 1.63*\text{Ca} + 1.94*\text{Ti} + 2.42*\text{Fe}$$

This equation also assumes that the two common oxides of iron Fe_2O_3 and FeO occur in equal proportions. The factor of 2.42 for iron also includes the estimate for K_2O in soil through the (K/Fe)=0.6 ratio for sedimentary soils.

Figure 6 shows a time series of soil concentration for stage 2 (i.e., 5 µm>d_p>2.5 µm) at both the Bourne and Rabe Meadow sites. Average PM_{10} soil concentration during March and April, 2009 was 7.3 µg/m^3 and 5.3 µg/m^3 at Bourne Meadow and Rabe Meadow, respectively. Diurnal cycling in soil concentration (Figure 6) indicates expected upslope/downslope flow with concentration minima each night and maxima each day when there were no synoptic weather events.

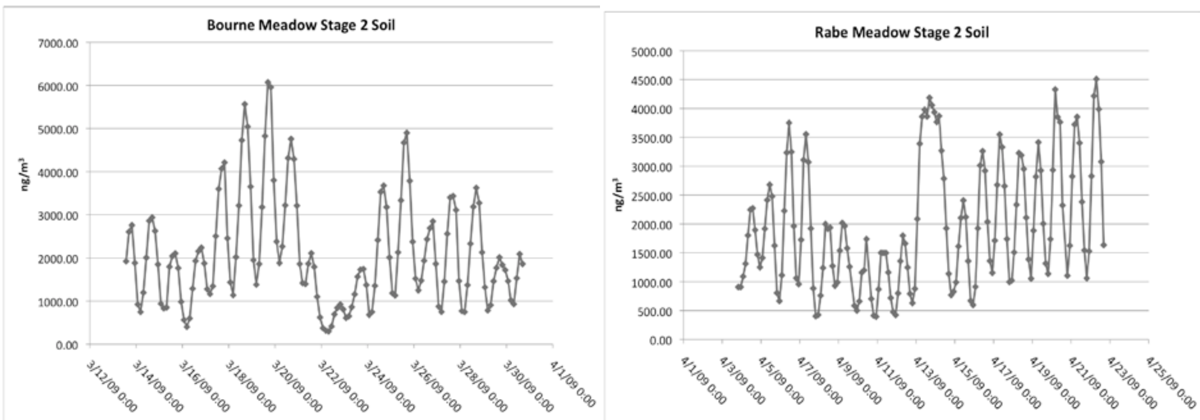

Figure 6. Time series of RDI stage 2 (5>d_p>2.5) soil concentration (µg/m^3) for Bourne Meadow (left) and Rabe Meadow (right) samples. Minima occur near midnight for most samples.

As part of the Lake Tahoe Atmospheric Deposition Study (LTADS), we analyzed 71 ambient filter samples and 21 source filter samples from various collection sites throughout the Lake Tahoe basin using the same synchrotron source x-ray fluorescence analysis (s-XRF) as employed for the present work. Since the s-XRF analytical technique enhances quantitative elemental sensitivity by use of a more intense, "white" (i.e., poly-chromatic) light source, the goal of the LTADS work was to obtain a statistically valid phosphorous concentration in air in the Lake Tahoe Basin. We also compared results for all data returned from analysis via the s-XRF technique and the results from XRF analysis technique employed by the Desert Research Institute that was the primary source of LTADS data. The s-XRF lower quantifiable limit (LQL) for phosphorous (P) from LTADS TSP filters was 15 ng/m^3 approximately half the LQL of traditional tube-source x-ray fluorescence analysis for the same samples.

Analysis of TSP phosphorous during LTADS resulted in an ambient air concentration range from non-detectable amounts (< approximately 15 ng/m^3) to almost 40 ng/m^3 P. With its greater sensitivity, the ALS method reported many more P detects in the matched sample set (24 vs. 3 for [P]>0.015 µg/m^3) than did the standard XRF method. Although our analysis of LTADS samples was limited to a subset of the total samples, we determined that average ambient TSP phosphorous concentrations in the Tahoe basin are extremely unlikely to be greater than 40 ng/m^3 (Cliff, 2005).

During the present work, average PM_{10} phosphorous concentration measured by s-XRF was 17 ± 2 ng/m^3 at Bourne Meadow and 21 ± 2 ng/m^3 at Rabe Meadow (1σ uncertainty). Peak [P] is approximately 60 ± 2 ng/m^3 at both sites. Since average total PM_{10} concentration (Figure 10) is approximately 10 µg/m^3, the measured [P] is approximately 0.2% of PM_{10} mass. Our results are in general agreement with previous [P] data from re-suspended road dust samples measured using inductively coupled plasma mass spectrometry by DRI in SNPLMA round 6 research (Gillies et al., 2010). However, ~2/3 [P] in the present work was measured in fine particles (< 2.5 μm) which are unlikely to represent a large fraction of the atmospheric PM deposition to Lake Tahoe. These results are in strong contrast to Silica (the primary component of road dust) that has only 20% of its PM_{10} mass in fine particles. This distinction implies that the predominant airborne [P] source is not related to soil derived road dust. A more likely (albeit unproven) source of airborne [P] is from the combustion of Zinc dialkyldithiophosphates (ZDDP) found as an additive in motor oils. Burning or smoking of motor oil produces particles in the fine size range consistent with our roadside observations.

6 Deposition Velocities

The following analysis describes a novel method to measures particle deposition to vegetated surfaces by measuring the change in atmospheric concentration and size distribution (i.e., particles that have not deposited) downwind of a roadway source.

6.1 Deposition Box Model

For this study, an empirical deposition velocity for large particles was calculated using the particle size concentration measurements (particles m^{-3}) made upwind (background, C_{bkg}), immediately downwind of the source (C'_{src}), and at a distance L downwind of a source (C'_L). The two dimensional (z is vertical, x is horizontal) model shown in Figure 7 depicts a road dust plume transported from left to right at wind speed u ($m\ s^{-1}$) through a control volume (CV) of height H (m) and length L (m). For the flux calculation, the vertical unit area (cross section of the CV) was assumed to be unit width times H and horizontal unit area (cross section) was assumed to be unit width times L.

For ease of notation, the concentrations solely attributable to the road dust are denoted as $C_{src} = C'_{src} - C_{bkg}$, $C_L = C'_L - C_{bkg}$, and $C_{avg} = C'_{avg} - C_{bkg}$. The mass balance for the particle concentration in the control volume (i.e., the sum of the fluxes is 0) is shown in Eq. 1.

$$0 = F_{in} - F_{out} - F_{up} - F_{down} = uHC_{src} - uHC_L - KL\frac{dC_{avg}}{dz} - v_d LC_{avg} \quad (1)$$

Where K is the atmospheric diffusion coefficient ($m^2\ s^{-1}$) and v_d is the deposition velocity ($m\ s^{-1}$).

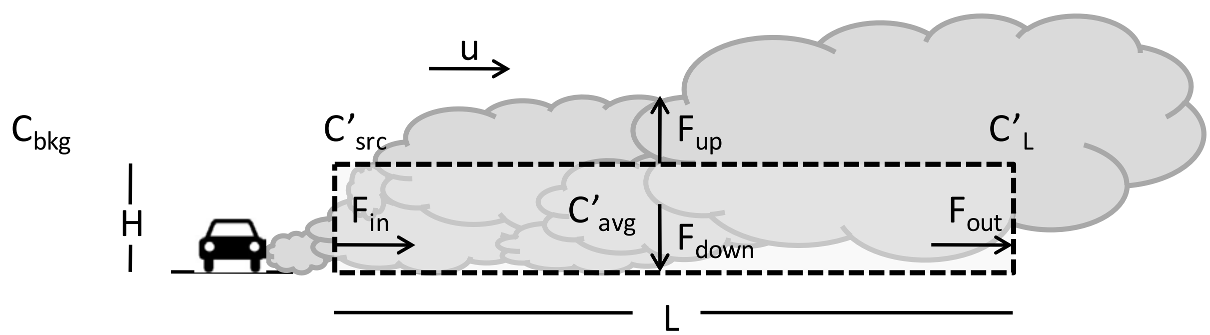

Figure 7. Schematic of the near-field dust deposition model.

The model is based on first principles but makes three assumptions.

- Particles less than 0.5 µm have a v_d that is negligible with respect to particles greater than 1 µm (i.e., $v_d|_{<0.5\mu m} << v_d|_{>1\mu m}$). Submicron particles are slow to deposit by interception, impaction and/or gravitation compared to particles >1 µm and deposit primarily by Brownian diffusion (Seinfeld and Pandis, 1998).
- The average concentration in the control volume is approximated as the average of the concentrations at the upwind and downwind edges of the box: $C_{avg} = (C_{src}+C_L)/2$.
- The vertical diffusion velocity (diffusion flux divided by C_{avg}) is invariant with particle size since the turbulent diffusion coefficient K is much greater than the Brownian

diffusion coefficient, *D* for road dust particles between 0.3 μm and 20 μm (Seinfeld and Pandis, 1998). Valiulis et al. (2002) report a measured coefficient of turbulence of 2000 $cm^2\ s^{-1}$ in a surface layer of up to 20 m height above ground whereas the Brownian diffusion coefficient is small, on the order of $10^{-5}\ cm^2\ s^{-1}$ or less. That is:

$$\left.\frac{K}{C_{avg}}\frac{dC_{avg}}{dz}\right|_{<0.5\mu m} = \left.\frac{K}{C_{avg}}\frac{dC_{avg}}{dz}\right|_{>1.0\mu m} \quad (2)$$

These terms are calculated only at the top of the control volume that is either (1) at the plume boundary, (2) in the background above the plume, or (3) in the plume. For case (1), the term in Eq. 2, reduces as follows and the term -2K/dz is particle size independent:

$$\frac{K}{C_{avg}}\frac{dC_{avg}}{dz} = \frac{K}{\left(\frac{C_{src}+0}{2}\right)}\left(\frac{0-C_{src}}{dz}\right) = -\frac{2K}{dz} \quad (3)$$

For case (2) above the plume, the vertical gradient of particle concentration is assumed to be small with a well-mixed background causing the term on both sides of Eq. 2 to approach 0.

Kuhns et al. (2010) measured vertical dust concentrations near unpaved road sources with a flux tower measurement system. Using Kuhns et al.'s (2010) data, we were able to test the validity of Eq. 2. The vertical dust concentrations C, dC/dz, and (dC/dz)/C were recorded for both PM_{10} and $PM_{2.5}$ using DustTraks (TSI, Shoreview, MN) at five heights from 0.7 m to 9.8 m on a tower at 30 m downwind of an unpaved road source. The dC/dz values for $PM_{2.5}$ and PM_{coarse} (10 μm – 2.5 μm) were approximately constant for the two particle size classes: measured (dC/dz)/C was -0.43 ± 0.10 m^{-1} for $PM_{2.5}$ and -0.46 ± 0.09 m^{-1} for PM_{coarse} over a 4 hour period supporting that Eq. 2 is valid for case (3).

Solving Eq. 1 for v_d for particles greater than 1 μm yields:

$$\left.v_d\right|_{>1.0\mu m} = \left.\frac{2uH}{L}\frac{C_{src}-C_L}{C_{src}+C_L}\right|_{>1.0\mu m} - \left.\frac{K}{C_{avg}}\frac{dC_{avg}}{dz}\right|_{>1.0\mu m} \quad (4)$$

Similarly, solving Eq. 1 for v_d for particles < 0.5 μm and subtracting this from Eq. 4 yields:

$$\left.v_d\right|_{>1.0\mu m} - \left.v_d\right|_{<0.5\mu m} = \left(\left.\frac{2uH}{L}\frac{C_{src}-C_L}{C_{src}+C_L}\right|_{>1.0\mu m} - \left.\frac{K}{C_{avg}}\frac{dC_{avg}}{dz}\right|_{>1.0\mu m}\right) - \left(\left.\frac{2uH}{L}\frac{C_{src}-C_L}{C_{src}+C_L}\right|_{<0.5\mu m} - \left.\frac{K}{C_{avg}}\frac{dC_{avg}}{dz}\right|_{<0.5\mu m}\right) \quad (5)$$

Applying the first assumption and Eq. 2 produces the following equation for the deposition velocity:

$$\left.v_d\right|_{>1.0\mu m} - \left.v_d\right|_{<0.5\mu m} \approx \left.v_d\right|_{>1.0\mu m} = \frac{2uH}{L}\left(\left.\frac{C_{src}-C_L}{C_{src}+C_L}\right|_{>1.0\mu m} - \left.\frac{C_{src}-C_L}{C_{src}+C_L}\right|_{<0.5\mu m}\right) \quad (6)$$

6.2 Deposition Velocity Results

6.2.1 Particle concentration pattern with wind direction

Diurnal variation of hourly average wind speed and direction and wind roses are shown in Figure 8a-c. Figure 8d and e show the time series of the number concentration of PM in the size ranges 0.3-0.5 μm and 5-10 μm downwind of Highway 50 at three distances (5, 30 and 100 m) in the defined monitoring period at the Bourne Meadow site (February 18 to February 21, 2009) following a snow storm . The PM concentrations are hourly averages of 1-sec readings. In the daytime, with higher traffic volume, the total number concentration decreased consistently with distance downwind from Highway 50. The wind direction changed to Northeast offshore wind after 17:00 (close to darkness), and wind speeds decreased from 2.3 m/s measured in the day time onshore flow to 0.5 m/s. Thus, the daytime upwind Box 2 served as the nighttime downwind sampler, and Boxes 1, 3, and 4 served as nighttime upwind samplers. In the morning around 08:00, the wind changed direction to the southwest (onshore), and the particle number concentrations started to increase with traffic flow.

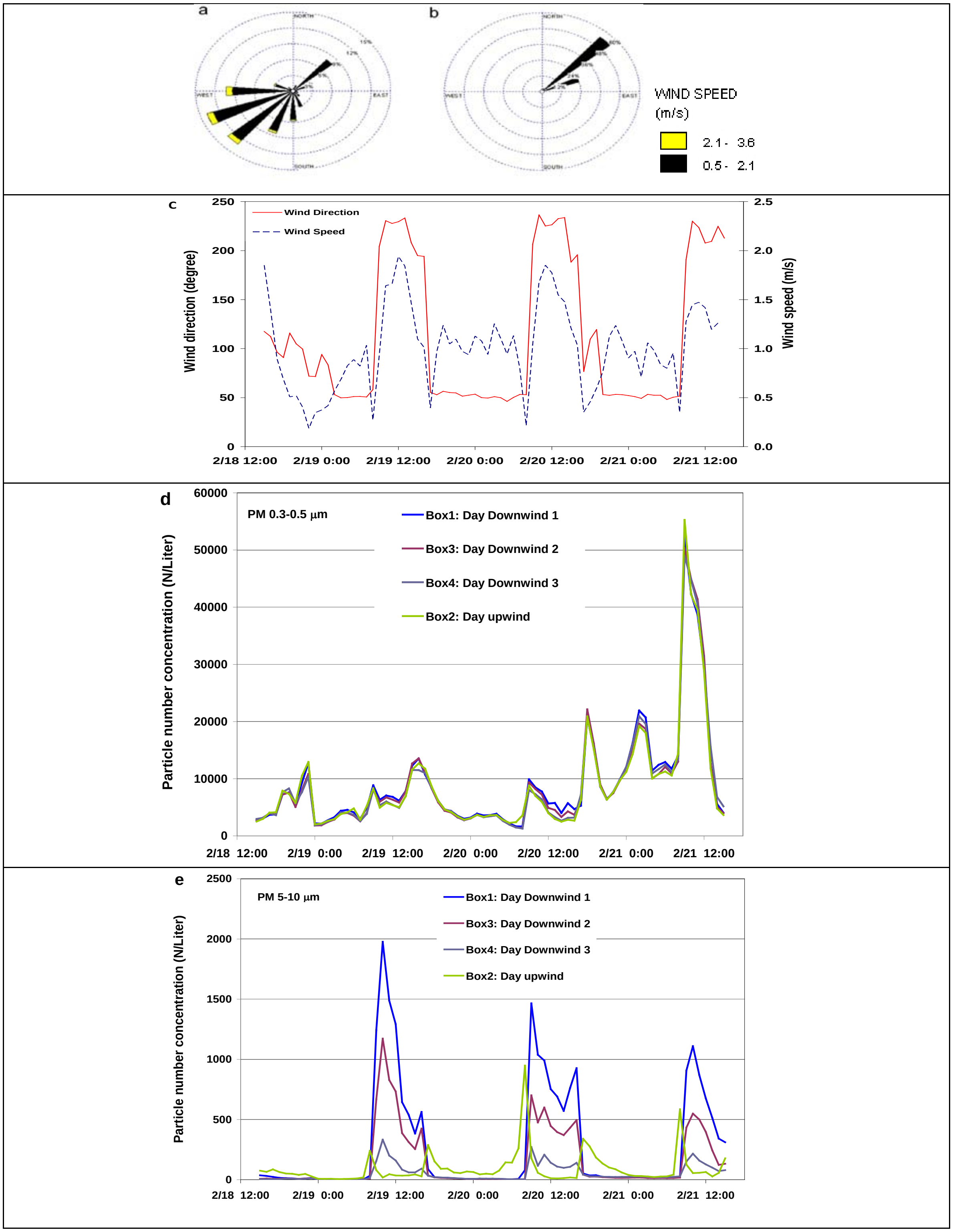

Figure 8. a) Windrose at the Bourne Meadow site on 2009/2/19 daytime from 8:00 to 18:00. b) Nighttime windrose at the Bourne Meadow site from 18:00, 2009/2/19 to 8:00 of 2009/2/20. c) Diurnal variation of hourly average wind speed and directions. d) Time series of PM in 0.3-0.5 µm size range recorded by 4 samplers at Bourne Meadow site. e) PM in 5-10 µm size range recorded by 4 samplers at the Bourne Meadows site.

The smallest particle (0.3-0.5 μm) concentrations show little variability between locations on either side of the road indicating that these particles are generally unrelated to the road source and well mixed throughout the area. The smallest particle concentration showed a weekend increase, while the traffic counts data at Bourne Meadow on March, 2009 did not indicate a corresponding increase in weekend traffic volume. Daily traffic counts at the Bourne Meadow site were 942, 1107, 1113, 1192, 1191, 912 and 713 vehicle passes from Monday, March 13, 2009 to Sunday, March 19, 2009. This further supports the observation that small particle concentrations are unrelated or weakly related to the road source and are more likely from regional sources like residential wood burning. The larger sized particles have more spatial variability and the concentrations are ranked according to downwind distances. When daytime winds are onshore (from the southwest), higher concentrations of coarse particles ($PM_{2.5\text{-}10}$) were observed at Box 1, 3 and 4 than upwind of the road at Box 2. After 17:00, the wind changed direction until 07:00 the next day. The downwind Box 2 recorded higher coarse PM concentration than upwind Box 1, 3 and 4, especially during the early morning traffic peak at 07:00. Road dust induced by the late afternoon to early morning traffic was blown towards the Lake at this site during this sampling period.

6.2.2 Particle concentration profile near the road

For the three-day (February 18 to February 21, 2009) sampling period at Bourne Meadow, during the daytime with favorable onshore southwest wind, PM total number concentration and coarse particle number concentrations showed strong signal peaks in downwind samplers. To display the spatial variation of the PM number concentrations, the average of size-specific number concentrations of the three-day daytime period are shown in Figure 9. Number concentations at Boxes 3 and 4 were represented by an exponential decay relationship with distance from the road. PM total number concentration decreased significantly with downwind distance. Regression exponents decreased from 0.024 m^{-1} for particles greater than 15 μm to 0.017 m^{-1} for particles in the 0.5 μm to 0.7 μm size range. The change represents a difference in deposition velocities between the large and fine aerosol sizes.

The smallest measured particles (0.3 to 0.5 μm) were weakly related to the road sources and their measurement uncertainty precluded drawing a reliable curve through the data points compared with coarse particles.

CARB (2006) fitted the mass concentration decrease into an exponential function $C = Co\ e^{-K(x)}$, with K the depletion coefficient. Exponential fitting was also applied to these data. In that experiment, concentrations of all particle sizes were assumed to be dominated by the nearby road source. Our data indicated that the smallest particles are more uniformly dispersed on both sides of the road and need to be subtracted to properly account for the behavior of particles from the road source. Omitting this step results in an over estimation of the near field deposition of large particles.

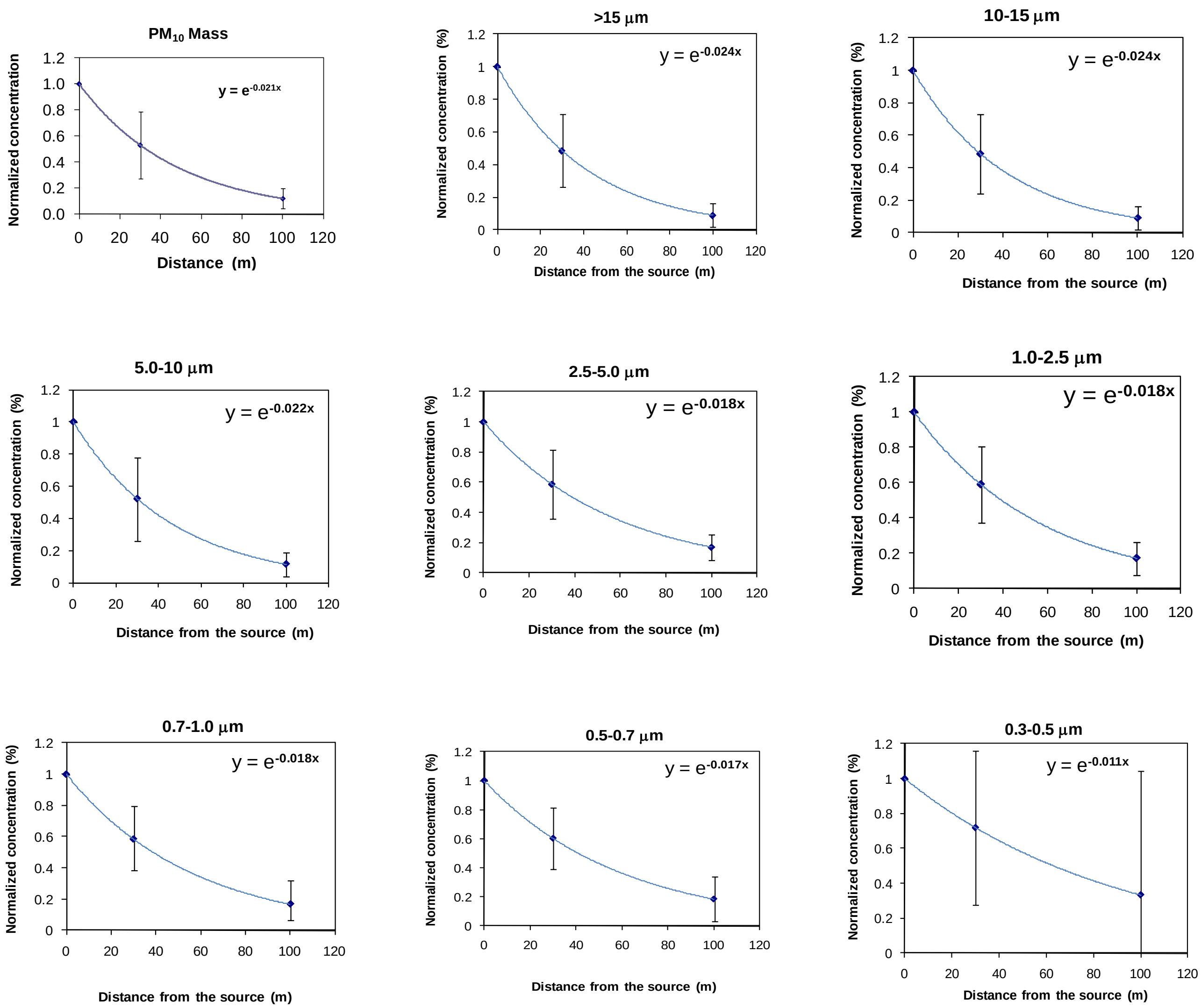

Figure 9. Normalized PM_{10} mass (top left) and number concentration profiles at different size ranges at 30 m and 100 m downwind of the Highway 50 and fitted exponential function. Upwind background concentrations were subtracted to reflect only impact from the road source. Error bars represent the standard deviation of the 3 day daytime-hour averaged values.

Based on the PM counts, data from the profiler, aerosol volume in each size bin was calculated by assuming all the particles were spheres with a diameter of geometric mean of the minimum and maximum size of the bin. PM mass in each size bin was calculated by assuming a particle density of 1 g cm^{-3} for particles <2.5 μm, 1.5 g/cm^3 for particles range from 2.5 to 5 μm, 2 g/cm^3 for particles range from 5 to 10 μm, 2.5 g/cm^3 for particles >10 μm (CARB, 2006). PM_{10} mass was calculated by summarizing the first 7 size channels. At 30 m and 100 m downwind, the PM_{10} mass concentrations decreased respectively to 51% and 11% of the concentrations measured at the 5 m downwind site (Figure 9 upper left panel). These calculated PM_{10} mass concentrations (based on measured PM number concentration) were compared with 26 collocated MiniVol gravimetric 3-day average PM_{10} readings in the same period (Figure 10). A correction factor of 3 is used to covert count based PM to mass concentration in the following discussion. During periods of favorable daytime onshore wind, PM_{10} and $PM_{2.5}$ mass concentrations recorded by the DustTraks decreased with distance from Highway 50. Mass size distributions between 15 m upwind at Box 2 and 5 m downwind at Box 1 at the Bourne Meadow site are shown in Figure 11. In another representation, Figure 12 shows the relative mass distribution between $PM_{2.5}$, PM_{crs}, and PM_{lrg} for the same data set. In both locations coarse and large particles dominate with more than 97% of the airborne mass. $PM_{2.5}$ represents 3% of the upwind mass and less than 0.5% of the downwind mass.

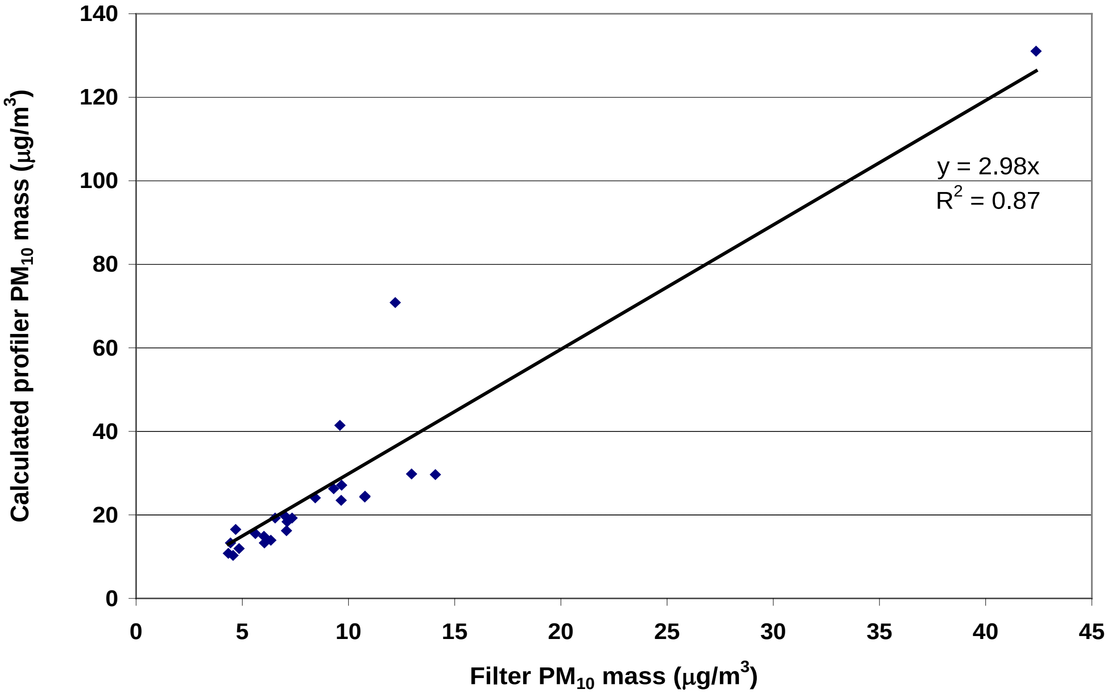

Figure 10. Comparison of calculated PM_{10} mass from profiler PM number concentration with filter PM_{10} mass.

Figure 11. Mass size distribution between upwind sampler (top) and downwind sampler (bottom) for the Bourne Meadow 3-day daytime (onshore wind) average.

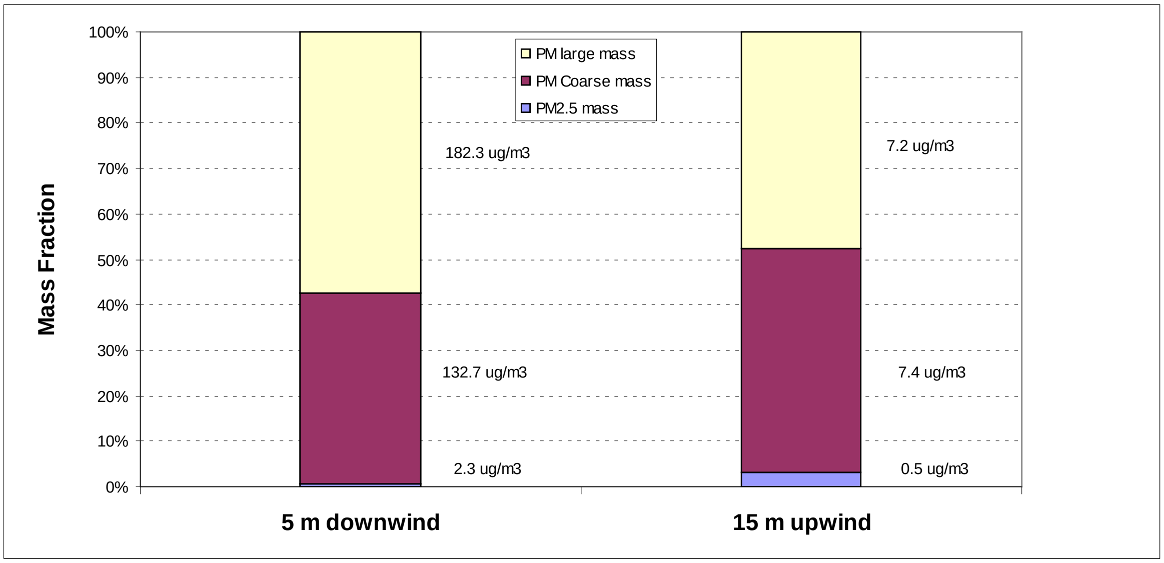

Figure 12. Mass size fraction for $PM_{2.5}$, PM_{crs}, PM_{lrg} between upwind sampler and downwind sampler for the Bourne Meadow 3-day daytime (onshore wind) average.

6.2.3 Deposition velocity calculation

As discussed in the experimental design (Appendix B), when calculating the deposition velocity, the optimal sampler separation, L, is about 60 to 100 m downwind of the road when wind speeds are in the range of 1 to 4 m/s. Data from Boxes 3 and 4 with 70 m distance between them were used to calculate the deposition velocities during daytime periods with onshore southwest winds. Figure 13 shows the size specific deposition velocities (V_d) calculated using Eq. 6 from the Bourne Meadow Site. The error bars represent the propagated standard error of deposition velocities based on the uncertainties of the terms in Eq. 6. In general, the deposition velocities increase with particle size, and in the range from ≈0 to 2 cm/s. This is as expected and similar to the result reported by Etyemezian et al. (2004). In that study, GRIMM optical particle counters were used to measure particle concentration gradients in advecting vehicle-generated dust plumes on three downwind flux towers of 7, 50 and 100 m from an unpaved road in Ft. Bliss, TX.

As mentioned in the discussion of the box model assumptions, the vertical diffusion velocity *K/C* (dC/dz) was assumed to be invariant with particle size. Using a turbulent diffusion coefficient *K* of 0.2 $m^2\ s^{-1}$ (Valiulis et al., 2002), and applying a measured (dC/dz)/C value of -0.43 ± 0.10 m^{-1} for $PM_{2.5}$ and -0.46 ± 0.09 m^{-1} for PM_{coarse} from an unpaved road dust study in Yakima, WA (Kuhns et al. 2010), the *K/C (*dC/dz) difference between small and large particles is indistinguishable with respect to the measurement uncertainty.

The propagated uncertainty of ~0.5 cm/s (Figure 13) for the measured deposition velocity is consistent with particle size. All measured V_d were consistent with Stokes settling velocities, however only those V_d for particles > than 5 μm were larger than the measurement uncertainty.

Figure 14 displays the deposition velocities calculated between Boxes 3 and 4 with 61.5 m separation distance during the daytime and on the downwind side at Rabe Meadow on April 8, 2009. Those hours were chosen for V_d calculation due to higher concentration differences between the two samplers. A similar pattern of V_d increase with particle size was observed.

Higher V_d uncertainties were also observed, due to less resuspendable dust on the roads and more variable wind direction, leading to smaller PM concentration differences between the samplers.

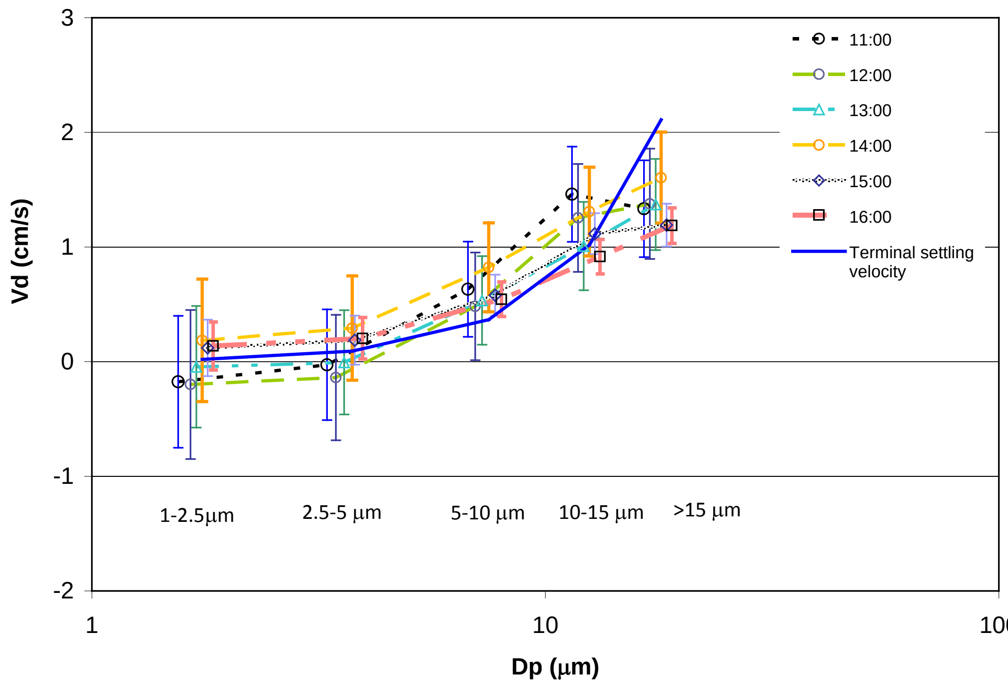

Figure 13. Deposition velocities for different size particles between Box 3 and 4 (70m apart) at Bourne Meadow site 2009/02/20, also compared with calculated terminal settling velocities for the same sized particles. Error bars are propagation uncertainty of V_d.

Deposition velocities were also calculated between Boxes 2 and 4 with 85 m distance at the nighttime downwind side of Highway 50 at Bourne Meadow on March 26, 2009 (Figure 15). As mentioned above, after sunset and until sun rise in next morning, the wind is off-shore. The PM concentration measured at Boxes 2, 3, and 4 decreases with the distance from the road when offshore wind combines with moderate traffic in the early morning and late afternoon.

All measured deposition velocities were consistent (within the limits of uncertainty) with the Stokes settling velocities, implying the Stokes settling velocities (Appendix B) may represent a reliable lower bound on the deposition rate. Higher concentrations beside the road may have shown enhanced particle depostion in densely vegetated landscapes.

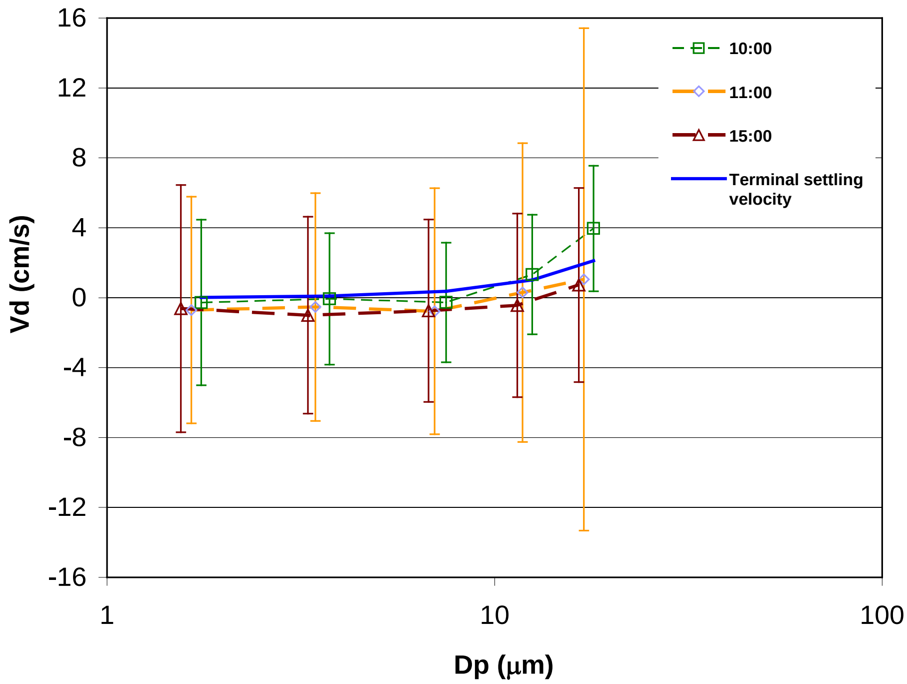

Figure 14. Deposition velocities 4/8/2009 calculated between Box 3 and 4 (61.5 m apart) at the Rabe Meadow site with 3 boxes on 10, 38.5, 100 m daytime downwind side of the road. Error bars are propagation uncertainty of V_d.

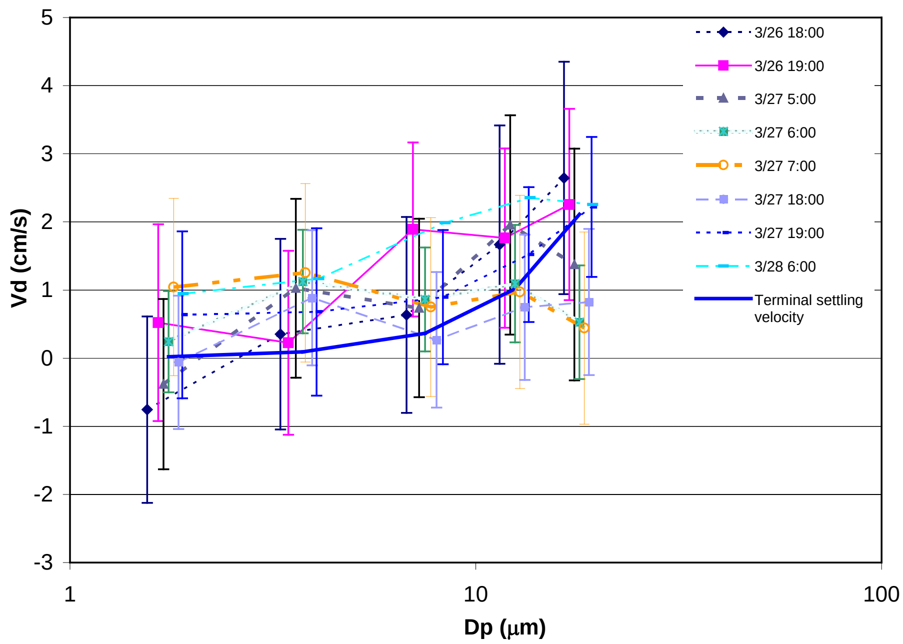

Figure 15. Deposition velocities (March, 2009) calculated between Box 2 and 4 (85 m apart) at Bourne Meadow site with box 2, 3, and 4 on 15, 50, 100 m nighttime downwind (offshore wind) side of Highway 50.

6.2.4 Empirical Deposition Model

We have developed a first order empirical near source deposition model to account for the large particle deposition that occurs within the first kilometer from an emission source:

$$C(x) = C_0 e^{-(k+\frac{V_d}{UH})x} \quad (7)$$

where C(x) is particle concentration at X m of horizontal distance from source, V_d is the deposition velocity, U is horizontal wind velocity, C_0 is particle concentration at source, H is injection height of particle source, meaning the sampling height of the optical particle counter, which is 2.5 m above ground. K is a constant with unit of m^{-1}.

Assuming a zero deposition velocity, the dispersion coefficient, K in Eq 7, for the smallest particles was 0.017 m^{-1} based on the exponential fitting for the 0.5-0.7 μm particles at the Bourne Meadow within the aspen trees. V_d values changes with particle size at different U^* (friction velocity) (Figure 16).

U^* is defined as $U^* = U \kappa \ln (Z/Z_0)$, where U is the mean wind speed, κ is the dimensionless von Kármán constant, approximately equal to 0.4, Z_0 is the surface roughness and Z is the height above ground where the wind speed is measured (2.5 m). With Z_0 assumed 1 cm, wind speed U as 150 cm/s, U* is ~ 50 cm/s. The $PM_{2.5}$, PM_{coarse}, PM_{large} particles then would have a V_d of 0.1 cm/s, 2.5 cm/s and 25 cm/s using the Sehmel (1980) model as shown in Figure 16. The difference of C/C_0 (fraction of survival rate after X m of horizontal transport) between V_d =0 (zero deposition) and a certain V_d is the deposition fraction that deposits to the ground. As mentioned above, the Stokes settling velocities represent a lower bound of deposition, using these conservative measures, 99% of PM_{large}, PM_{coarse}, and $PM_{2.5}$ will deposit within 300 m, 5200 m and 40,000 m of the ground level emission point. Using more realistic deposition velocities based on representative friction velocities and surface roughness effects, distances at which 99% of the particles deposit reduces to 70 m, 400 m, and 19,000 m, respectively. This model has been validated with data from downwind points up to 100 m away.

Figure 16. Depositon velcocity as a function of particle size at different friction velocities. (Seinfeld and Pandis, 1998).

6.2.5 Vegetation capture effect

Cowherd et al. (2006) has reported removal rates of fugitive dust by different vegetation impacted by military training exercises conducted on an unpaved road. In that study, with light winds (0.9-1.8 m/s), PM_{10} mass loss rate over 20 m travel distance was 45-67% for tall cedar trees, 41-50% for oak trees, 29% for short cedar trees, and <10% without trees. Etyemezian et al. (2004) reported for unpaved road dust emissions upwind of short ≈0.5 m shrub vegetation, PM_{10} removed from the air column at 100 m downwind of the source was within the instrumental uncertainty and <5% from modeling result. In this study, for willows/aspen trees with 5-6 m height, and the PM_{10} mass removal rate is 49% and 89% at 30 m and 100 m downwind, respectively (Figure 13). These results are very comparable to Cowherd et al. (2006), who reported~ 50% PM_{10} removal rate at 20 m for tall trees. These findings indicate the tall trees cause substantial reduction of road dust as it moves from the roadway source. Using exponential fitting ($C = Co\ e^{-K(x)}$) to characterize the reduction of PM_{10} mass as a function of distance as observed in this study, the depletion coefficient K is 0.023 m^{-1} for a 5-6 m aspen tree barrier. Based on this exponential depletion, only 11% of PM_{10} mass will survive after 100 m distance from source, and ~1% of PM_{10} will survive after 200 m with 5-6 m high aspen trees barrier.

Figure 17. Vegetation effect on source reduction (Cowherd, et al., 2006) and from Etyezemian et al., (2004) and this study (K=0.0221 for Aspen tress). K as follows: 0.035 m^{-1} for trees, 0.0175 m^{-1} for long grass, and 0.0035 m^{-1} for short grass in exponential function $C = Co\ e^{-K(x)}$.

6.2.6 Vertical dust profile

Traffic induced vertical dust profiles were measured at the Rocky Ridge site (Tahoe City, northwest of Lake Tahoe) with two deposition boxes collocated at 10 m and 110 m (daytime) downwind of Highway 28 of California from April to June, 2010. Meteorological data recorded by the deposition boxes indicate the wind direction was onshore (southwest) during daytime and switched to offshore (northwest) after sunset, and switched back to onshore the next morning. The two deposition boxes 10 m downwind of Highway 28 were equipped with sampling inlets at 2.2 m and 6.1 m above ground level, respectively. As shown in Figure 18, at the near road site (10 m), the profiler with an inlet height of 2.2 m recorded higher PM number concentrations than the profiler with the inlet at 6.1 m for the coarse particle size range, especially in rush hour conditions. At 110 m downwind from the road dust source, the vertical concentration difference (dC/dz) in the coarse size range is much smaller between the two levels.

To validate our assumption that the vertical diffusion velocity [K(dC/dz)/C] is invariant with particle size, the daytime [K(dC/dz)/C] was calculated with a K value of 2000 cm^2/s (Valiulis et al., 2002) as shown in Table 3. The vertical diffusion velocities are generally small (< 1.5 cm/s in magnitude) for particles less than 10 μm, and greater (<4.6 cm/s) for particles larger than 10 μm.

The relative high propagated uncertainty is due to lower downwind PM concentrations observed in the transition from winter to summer as the abrasive material reservoir is depleted throughout the basin. The difference between diffusion velocities is less than 1.5 cm/s for particles <10 μm, 3.4 cm/s for particle in 10-15 μm range, 5.0 cm/s for particles >15 μm. These uncertainties are generally larger than the magnitude of the deposition velocity precluding V_d measurements above the propagated uncertainty as seen in Figure 14 and Figure 15.

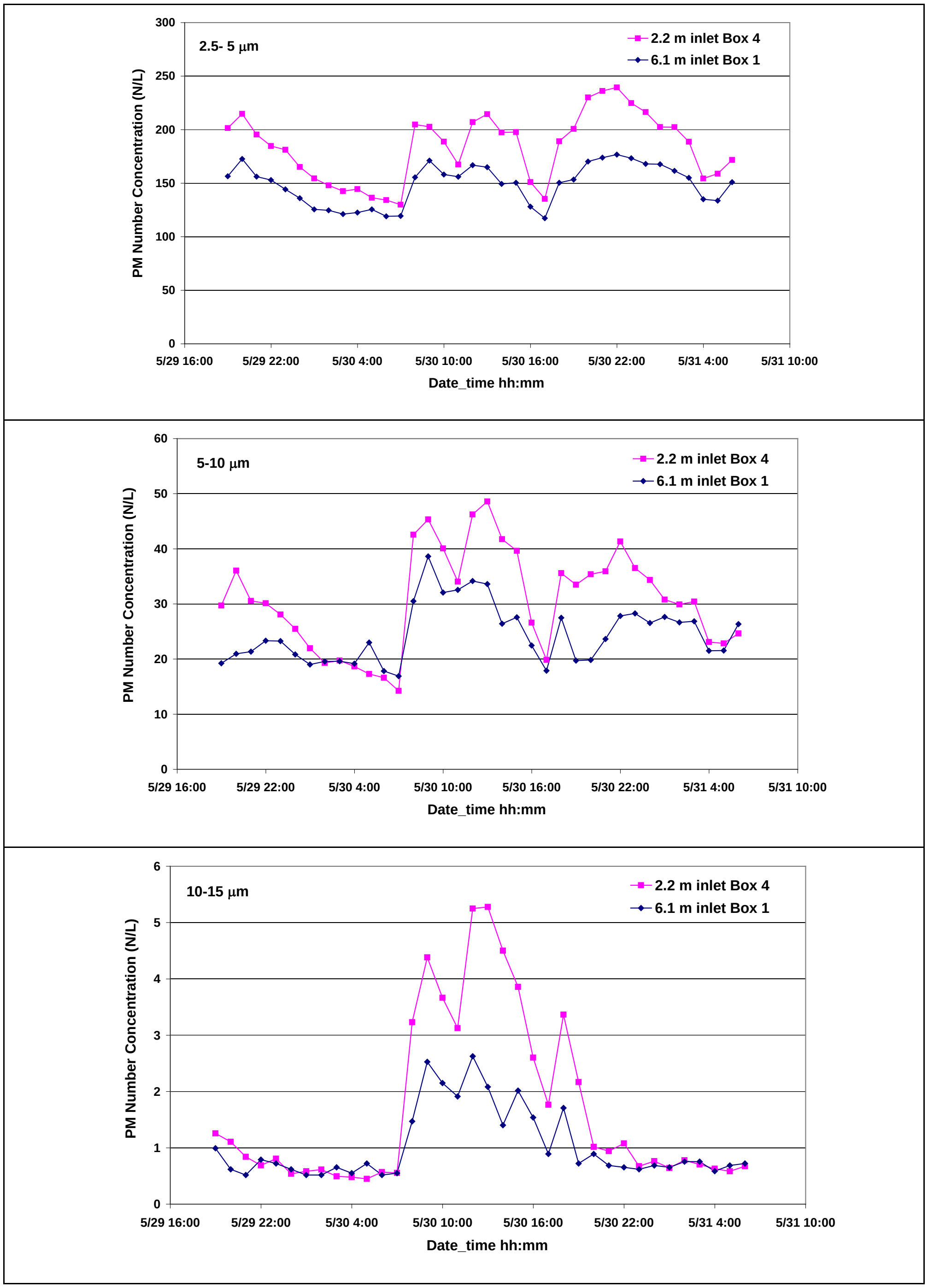

Figure 18. Example of vertical particle profile at 2.2 m and 6.1 m level on 10 m downwind of Highway 28 in Rocky Ridge site.

Table 3. Upward diffusion velocities for particles.

	Diffusion Velocity K(dC/dz)/C (cm/s)	Diffusion Velocity Propagated Uncertainty (cm/s)	$K(dC_1/dz)/C_1 - K(dC_2/dz)/C_2$ (cm/s)
0.3-0.5 μm	0.37	1.47	
0.5-0.7 μm	0.15	0.55	0.22
0.7-1 μm	-0.11	0.42	0.48
1-2.5 μm	-0.53	0.41	0.90
2.5-5 μm	-1.12	0.63	1.49
5-10 μm	-0.94	1.70	1.31
10-15 μm	-3.01	2.61	3.38
> 15 μm	-4.59	2.63	4.96

7 Control Measures and Other Factors Influencing Emissions

7.1 Description of Road Segment Attributes

Road segment properties that may influence airborne road dust emissions in the basin were noted for each of the road segments surveyed by Zhu et al. (2009). The measures included are subdivided into controllable attributes and implicit attributes since emission reductions may only be achieved by changing controllable attributes.

7.1.1 Implicit Attributes

Maintenance Organization: Roads in the Tahoe Basin fall under jurisdictions including State, County, City, and numerous neighborhood general improvement districts. These organizations generally apply the same maintenance practices to each of their roads for primary, secondary, and tertiary road types.

Grade: the physical attribute grade was qualitatively assigned as flat, moderate, and steep since roads on more level terrain require less wintertime traction control treatment (i.e., brining, snow removal, and sanding).

Trackout: Dirty tertiary roads or roads that had many dirty tertiary points of egress were classified as Yes for the Trackout attribute. Although the road manager may have no jurisdiction with the adjacent roads, this attribute may be an important source of material that is later suspended from the road.

7.1.2 Controllable Attributes

Shoulder Improvement: Road shoulders were classified as either: Barrier, Paved, or Unpaved. Both guard rails and curbs prevent vehicles from leaving the paved road surface and prevent tracking loose material onto the roadway. The classification Paved describe roads with at least a three foot paved shoulder delineated from the travel lane. The Unpaved designation describe roads with less than three feet of paved shoulder, which may be more prone to tracking material onto the road when a vehicle leaves and returns to the travel lane.

Pavement Condition: This qualitative measure included: Good, Fair, and Poor as classifications. Roads in poor condition are prone to emit road dust from the native road material in addition to traction control material.

Summer Construction: Construction activity usually involves paving and earth moving equipment tracking out material from unpaved work sites and travel lanes. Roads that were observed to have construction activity were denoted with "Yes" for the Summer Construction classification.

Sweeping Practices: When roads dry after a snow storm, maintenance organizations typically send street sweepers to recover traction control material applied to primary roads in the basin. In many cases, sweepers do not pick up material from secondary and tertiary roads until spring time or during periods of mild winter weather. The sweeping classification of as soon as possible (ASAP) describes the practices of maintenance organizations that deploy sweepers ASAP after a snow storm when the road is dry to recover traction control material. Other road segments are classified as seasonal to indicate roads are swept once or twice after the threat of winter storms has passed.

Anti-Icing: Washoe County, El Dorado County, and state maintenance organizations use brine pretreatment on the highways in the basin to reduce snow accumulation and facilitate snow removal. This technology is not used with smaller maintenance. Anti-icing practices can substantially reduce the amount of abrasives needed.

Abrasive Material: Sand mixed with salt is the predominant traction control material with the exception of El Dorado County and the City of South Lake Tahoe that use volcanic cinders . This material is applied where it is needed but quickly dissipates along roadways after application (Nixon, 2001). The type of abrasive is listed based on the survey response in the Appendix of Kuhns et al. (2007) as: Spec D, Spec G, Washed Sand, or Cinders.

These attributes along with other information about each road segment are provided in Table 4.

Table 4. Listing of each road segment from the Tahoe TRAKER study with associated attributes and seasonally averaged emission factor classification (i.e. clean, average, or dirty).

Section ID	County	From	To	Posted (mph)	TRAKER Average (mph)	Vehicles Per Day	Road Type	Summer EF (g/vkt)	Summer Class	Winter EF (g/vkt)	Winter Class	Grade	Trackout	Shoulder	Pavement Condition	Summer Constr.	Winter Traction Material	Salt Frac.	Sweeping Practice	Brine Pretreat
1	Washoe	Country Club Dr at SR431	County Club Drive at Second Tee Dr	35	32	2080	Secondary	0.09	Clean	0.52	Clean	Steep	Yes	Barrier	Good	No	Spec D	0.25	ASAP	N
2	Washoe	Second Tee Dr at County Club Drive	Village Blvd at Country Club Dr	25	26	197	Tertiary	0.36	Average	1.46	Average	Steep	Yes	Barrier	Fair	No	Spec D	0.25	ASAP	N
3	Washoe	Village Blvd at Country Club Dr	Village Blvd at Lake Shore Drive	35	31	2296	Secondary	0.20	Average	0.82	Average	Steep	Yes	Curbed	Good	No	Spec D	0.25	ASAP	N
4	Washoe	Lake Shore Drive at Village Blvd	Lake Shore Dr at SR28	35	31	7723	Secondary	0.15	Average	0.55	Clean	Flat	No	Barrier	Good	No	Spec D	0.25	ASAP	N
5	NDOT	SR28 at Lake Shore Dr	SR28 at Sand Harbor	45	41	10046	Primary	0.04	Clean	0.24	Clean	Flat	No	Barrier	Good	No	Spec D	0.33	ASAP	Y
6	NDOT	SR28 at Sand Harbor	jct SR28/US50	45	43	8351	Primary	0.03	Clean	0.25	Average	Flat	No	Barrier	Good	No	Spec D	0.33	ASAP	Y
7	NDOT	US50 at Ijct SR28	US50 at Glenbrook	50	51	14541	Primary	0.03	Average	0.27	Average	Flat	No	Barrier	Good	No	Spec D	0.33	ASAP	Y
8	NDOT	US50 at Glenbrook	US50 before Cave Rock tunnel	45	44	14592	Primary	0.03	Clean	0.26	Average	Flat	No	Barrier	Good	Yes	Spec D	0.33	ASAP	Y
9	NDOT	US50 before Cave Rock tunnel	US50 at Lincoln Park	45	45	14742	Primary	0.02	Clean	0.21	Average	Flat	No	Barrier	Good	No	Spec D	0.33	ASAP	Y
10	NDOT	US50 at Lincoln Park	US50 at Zephyr Cove traffic light	45	43	15015	Primary	0.04	Clean	0.23	Average	Flat	No	Barrier	Good	No	Spec D	0.33	ASAP	Y
11	NDOT	US50 at Zephyr Cove traffic light	US50 Lake Shore Blvd at Marla Bay	45	39	16460	Primary	0.03	Clean	0.26	Clean	Flat	No	Barrier	Good	No	Spec D	0.33	ASAP	Y
12	NV GID	Lake Shore Blvd at Marla Bay	Lake Shore Blvd back to US50	20	19	450	Tertiary	0.57	Clean	2.08	Clean	Flat	No	Barrier	Good	No	Washed Sand	0.17	2 per year	N
13	NDOT	US50 at Marla Bay	Elks Piont Road	45	43	20163	Primary	0.11	Dirty	0.23	Clean	Flat	No	Barrier	Good	Yes	Spec D	0.33	ASAP	Y
14	NV GID	Elks Point Road in Round Hill	Elks Piont Road back to US50	25	27	2995	Tertiary	0.29	Average	1.12	Average	Flat	No	Barrier	Fair	No	3/8" Chip	0	1 per year	N
15	NDOT	US50 at Elks Piont Road	US50 to Lake Parkway	35	40	31810	Primary	0.08	Average	0.36	Average	Flat	No	Barrier	Good	No	Spec D	0.33	ASAP	Y
16	SLT	Lake Parkway at US50	Park Ave at US50	25	28	4113	Tertiary	0.96	Dirty	3.23	Dirty	Flat	Yes	Barrier	Fair	No	Cinders	0.25	1 per year	N
18	SLT	Pioneer Trail at US 50	Pioneer Trail at Glenwood Way	30	32	13918	Primary	0.24	Average	1.05	Average	Flat	No	Barrier	Fair	No	Cinders	0.25	ASAP	Y
19	SLT	Glenwood Way at Pioneer Trail	Glenwood Way at US50	25	28	1723	Tertiary	0.73	Dirty	1.53	Average	Flat	No	Barrier	Fair	No	Cinders	0.25	1 per year	N
20	Caltrans S	US50 at Glenwood Way	US50 Lake View Ave	35	33	36938	Primary	0.12	Average	0.50	Clean	Flat	No	Curbed	Good	No	Spec G	0.1	ASAP	N
21	SLT	Lake View Ave at US50	Alameda Ave at US50	25	25	1785	Tertiary	1.11	Dirty	1.27	Clean	Flat	No	Unpaved	Fair	No	Cinders	0.25	1 per year	N
22	Caltrans S	US50 at Alameda	US50 at Tahoe Keys Blvd	45	34	28653	Primary	0.12	Average	0.54	Average	Flat	No	Curbed	Good	No	Spec G	0.1	ASAP	N
23	SLT	Tahoe Keys Blvd at US50	15th St at SR89	25	30	4494	Tertiary	0.14	Clean	0.73	Average	Flat	No	Barrier	Good	No	Cinders	0.25	1 per year	N
24	Caltrans S	SR89 at 15th St	SR89 at Cascade Lk	35	40	9206	Primary	0.10	Average	0.67	Dirty	Flat	No	Curbed	Good	No	Spec G	0.1	ASAP	N
25	Caltrans N	SR89 at Cascade Lk	SR89 at Eagle Falls	40	33	7254	Primary	0.06	Clean	1.04	Average	Steep	No	Barrier	Good	No	Spec G	0.1	ASAP	N
26	Caltrans N	SR89 at Eagle Falls	SR89 at Sierra Dr (Meeks Bay)	40	40	5069	Primary	0.05	Clean	0.72	Dirty	Steep	Yes	Barrier	Good	Yes	Spec G	0.1	ASAP	N
27	El Dorado	Sierra Dr at SR89	Meeks Bay Ave at SR89	25	22	256	Tertiary	2.56	Dirty	3.46	Dirty	Moderate	Yes	Barrier	Fair	No	Cinders	?	?	Y
28	Caltrans N	SR89 at Meeks Bay Ave	SR89 at McKinney Rubicon Springs Rd	40	39	6103	Primary	0.13	Average	0.71	Dirty	Moderate	Yes	Barrier	Good	No	Spec G	0.1	ASAP	N
29	Placer	McKinney Rubicon Springs Rd at SR89	Gray Ave at SR89	25	26	214	Tertiary	1.11	Dirty	6.42	Dirty	Flat	Yes	Unpaved	Poor	No	Spec D	0.1	2 per year	N
30	Caltrans N	SR89 at Gray Ave	SR89 at Cherry St	40	39	6372	Primary	0.14	Average	0.56	Average	Flat	Yes	Unpaved	Good	No	Spec G	0.1	ASAP	N
31	Placer	Cherry St at SR89	Tallac Ave at SR89	25	24	334	Tertiary	4.73	Dirty	7.93	Dirty	Moderate	Yes	Barrier	Poor	No	Spec D	0.1	2 per year	N
32	Caltrans N	SR89 at Tallac Ave	SR89 at Sugar Pine Rd	40	38	6875	Primary	0.24	Dirty	0.47	Average	Flat	Yes	Unpaved	Good	No	Spec G	0.1	ASAP	N
33	Placer	Sugar Pine Rd at SR89	Timberland Lane at SR89	25	25	442	Tertiary	1.99	Dirty	6.70	Dirty	Moderate	Yes	Unpaved	Fair	No	Spec D	0.1	2 per year	N
34	Caltrans N	SR89 at Timberland Lane	SR 89 intersection with SR28	40	37	7427	Primary	0.16	Average	0.74	Average	Flat	Yes	Barrier	Good	No	Spec G	0.1	ASAP	N
35	Caltrans N	SR28 at SR89	SR28 at Lake Forest Rd	40	32	8594	Primary	0.13	Average	0.85	Average	Flat	No	Curbed	Good	No	Spec G	0.1	ASAP	N
36	Placer	Lake Forest Rd at SR28	Dollar Dr at SR28	25	26	903	Tertiary	0.76	Dirty	2.79	Dirty	Moderate	No	Unpaved	Fair	Yes	Spec D	0.1	2 per year	N
37	Caltrans N	SR28 at Dollar Dr	SR 28 at SR267	45	40	11906	Primary	0.14	Dirty	0.51	Average	Flat	No	Barrier	Good	No	Spec G	0.1	ASAP	N
38	Placer	SR267 at SR28	Fox St at SR28	25	23	900	Secondary	0.66	Dirty	2.35	Average	Moderate	Yes	Unpaved	Fair	No	Spec D	0.1	2 per year	N
39	Caltrans N	SR28 at Fox St	SR28 at CA/NV boarder	45	38	15960	Primary	0.13	Average	0.56	Average	Moderate	No	Barrier	Good	No	Spec G	0.1	ASAP	N
40	NDOT	SR28 at CA/NV boarder	SR28 at Red Cedar Dr	35	37	19688	Primary	0.06	Clean	0.40	Average	Flat	No	Barrier	Good	No	Spec D	0.33	ASAP	Y
41	Washoe	Red Cedar Dr at SR28	SR431 at Country Club	25	26	861	Tertiary	0.89	Dirty	2.36	Dirty	Steep	Yes	Barrier	Good	Yes	Spec D	0.25	ASAP	N

7.2 Dynamic Nature of Reservoir of Suspendable Material

The reservoir of suspendable dust on road surfaces has been observed to reduce by 80% in as little as ten vehicle passes over a road artificially dusted with fine silt (Etyemezian et al., 2007; Nixon 2001). Conversely, Kuhns et al. (2003) found that PM_{10} emission factors from paved roads *increased* by 16% immediately after a street sweeper cleaned the road. Both of these examples show that road dust emission factor can change very quickly based on a variety of perturbations. Kuhns et al. (2003) and Chang et al. (2005) concluded that the emission reduction benefits of street sweeping on a tested road segment were short lived, lasting only a few hours. These results may obscure emission reduction benefits on a larger spatial scale since material collected in the sweeper's hopper is sequestered and unable to be emitted as road dust.

The dynamic nature of the road dust reservoir creates a challenge to measure the effectiveness of control measures such as street sweeping or shoulder paving. The concept of a mass balance equilibrium with the rate of deposition to the road matching the rate of emissions has been hypothesized (Cowherd, 1988 and 1990) to explain what appears to be a constant source of material emitted from the roads. Directly measuring emission reductions from road segments with isolated treatments is likely to provide uncertain results. Suspendable material on the road surface will be redistributed quickly and migrate into the test section from untreated sections thereby negatively biasing measured street sweeping efficiencies.

The Tahoe TRAKER data set collected by Zhu et al. (2009), provides an alternative perspective to assess the effectiveness of control measures. Measurements were collected from large areas that represent the maintenance practices of an entire General Improvement District (GID). In a year long experiment, the TRAKER vehicle was driven around the lake on a combination of primary, secondary, and tertiary roads. The TRAKER measures the emission potential from a road by sampling air directly behind the vehicle's left and right tires. These measurements have been calibrated through collocated tests with downwind flux towers to translate the dust concentrations (in mg/m^3) into emission factors (in g/vehicle kilometer traveled (vkt)).

Initial experiments with the TRAKER showed that measured concentrations increased with vehicle speed raised to the power of three when the vehicle was operated on the same road. When controlling for this speed effect, the TRAKER data (Kuhns et al., 2001) and numerous silt loading studies (Muleski and Cowherd, 1993; Teng et al., 2007) show that the emission factor is lower on higher speed roads. This is due to the fact that the turbulent wake around vehicles moves suspendable particles off the road quickly at higher speeds and there are less sources of new material from trackout to replenish the reservoir. Similar findings were observed during the year round TRAKER study where real time data were grouped by road attribute into 41 sections. Higher speed road sections were substantially cleaner (i.e., lower emission factor) than low speed road sections.

The TRAKER measures a quantity that is related to how fast material is emitted from a road (in g/vkt). At equilibrium, this value must be equivalent to the overall rate at which the reservoir of material on the road is replenished from trackout or application of abrasives. Near a source, this reservoir may be larger than its regional equilibrium and material will migrate (on vehicle tires) toward other roads in the network. When roads are in equilibrium emission factors tend to decrease with the inverse of vehicle speed raised to the third power.

The data from that study are revisited here to identify the relative emission reduction benefits from the road maintenance practices used in the Tahoe Basin. Figure 19 shows the relationship of the seasonal average emission factors for each of the 41 road segments versus the average TRAKER speed on that segment. Emission factors are highly variable ranging over 2 orders of magnitude based on location. As expected lower speed roads are dirtier than higher speed roads, and overall emissions in wintertime (bottom panel) are ~5 times larger than in summer. In the summertime, traction control material is not applied to the roads that are typically dry. The 5 times increase does indicate that regardless of the road maintenance practice, all roads in the basin get dirtier due to the rapid mixing of cars tracking in material from dirtier areas.

To normalize for the speed dependence of the road dust removal process, the emission factors were multiplied by the average vehicle speed raised to the third power ($EF*s^3$ (in g/vkt *(mph)^3). This term is referred to as the Emission Equilibrium (EE) and will be consistent for all roads in equilibrium with the supply of road dust material regardless of vehicle speed. These values were sorted and a group of clean roads (approximately 1/3 of the road segments) were selected with the lowest resulting values. These road segments are shown as green markers in Figure 19 and represent the cleanest roads in their speed class. Similarly, the road segments in the top third of $EF*s^3$ are shown as red markers on the graph.

The difference between the red and green lines represents the potential emission reductions that could be achieved if the conditions for the cleanest roads could be replicated for the dirty group. The emission factors on the dirty roads are ~4 times higher than clean roads in the winter and ~7 times higher in the summer. The individual road segments with their speed normalized seasonal emission factor classification are listed in Table 4 and a spatial representation of the location of these roads is shown in Figure 23 and Figure 24.

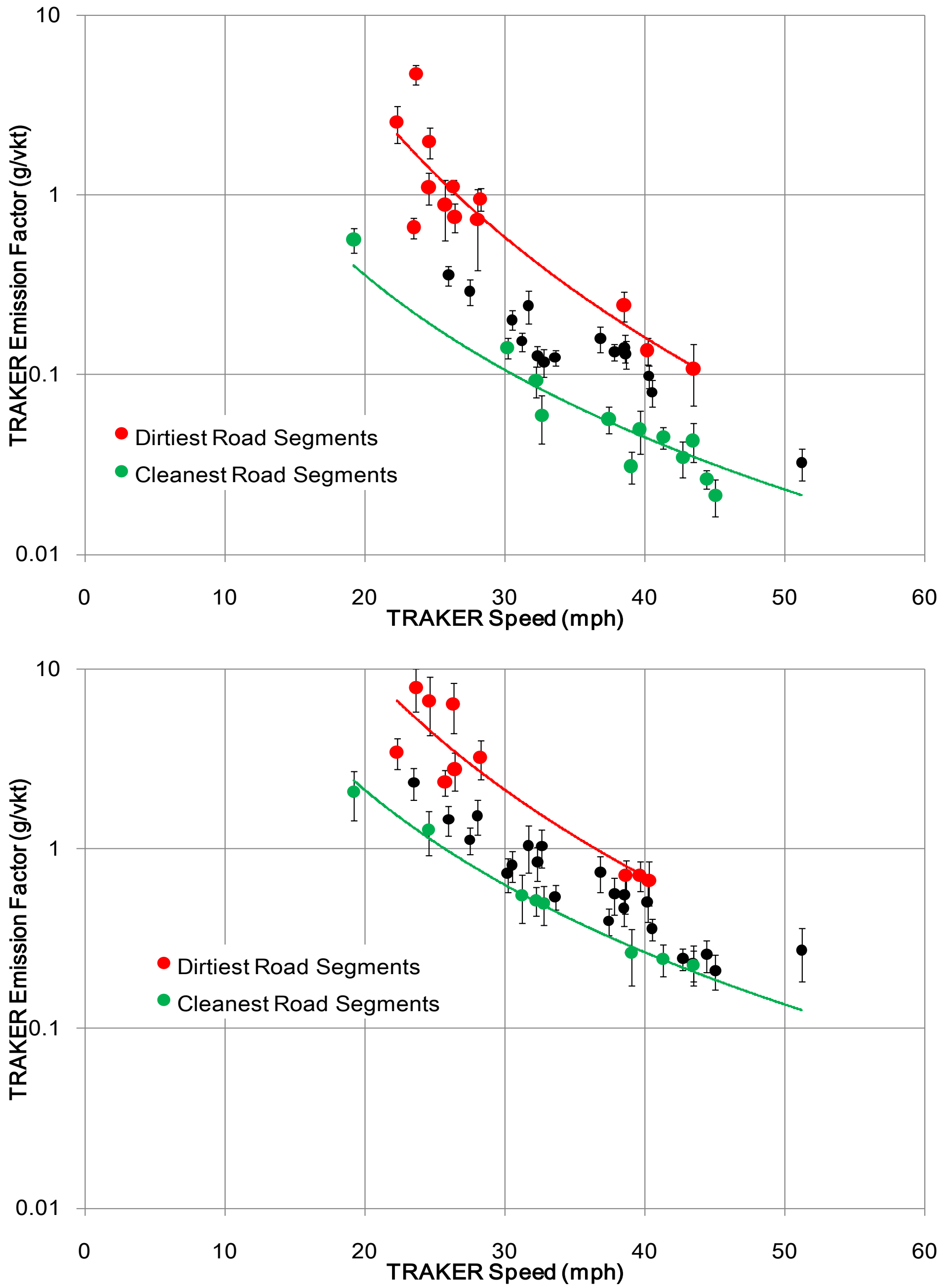

Figure 19. Comparison of seasonal average TRAKER emission factors versus roadway speed for 41 segments throughout the Tahoe Basin. The top panel shows Summer data with cleanest road denoted with green markers and dirtiest roads with red markers. The bottom panel show data from the Winter time. The green line represents the regression line through the cleanest data points and establishes an achievable reference for low emitting roads in the Tahoe Basin.

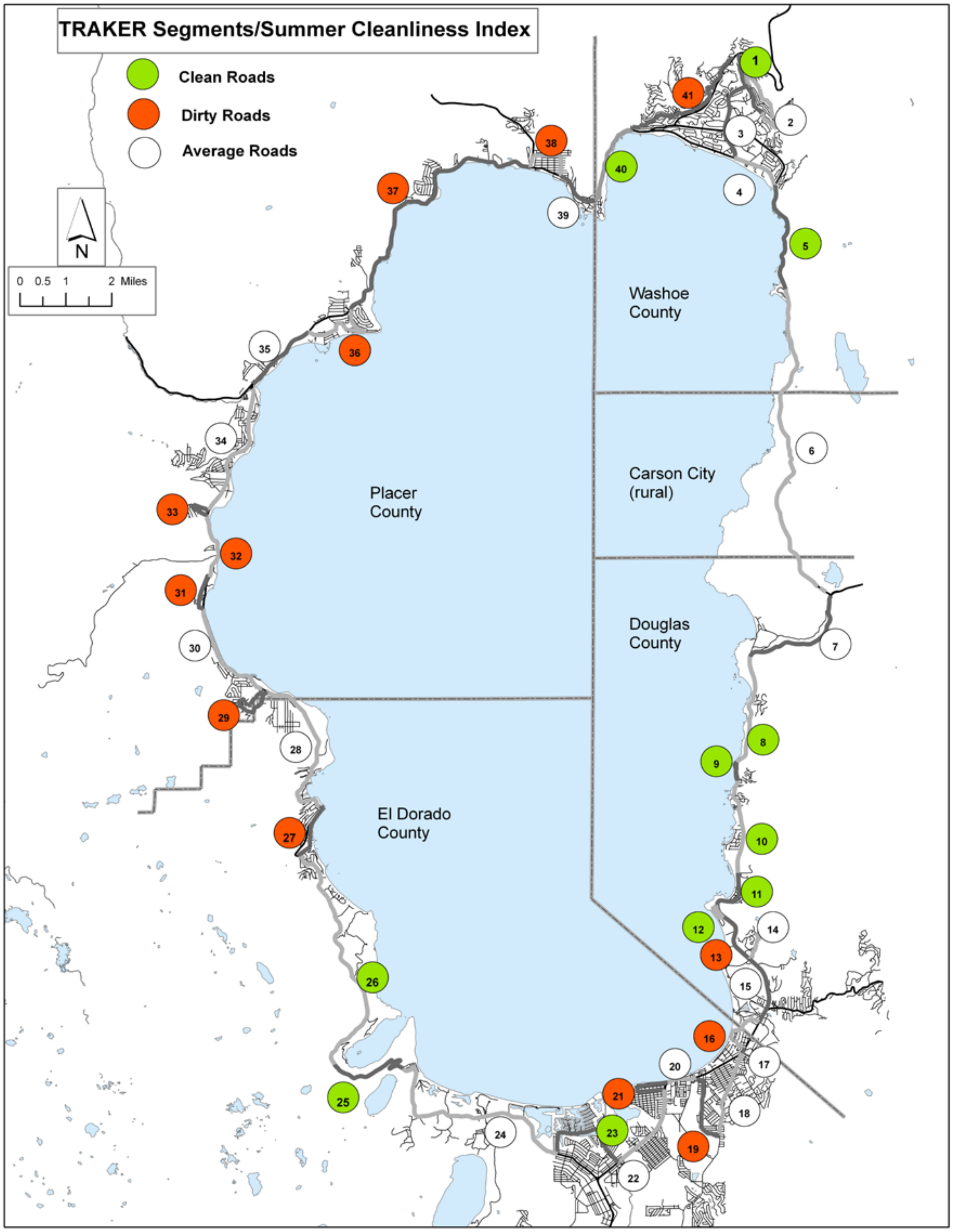

Figure 20. Summer Cleanliness index map for 41 TRAKER sections.

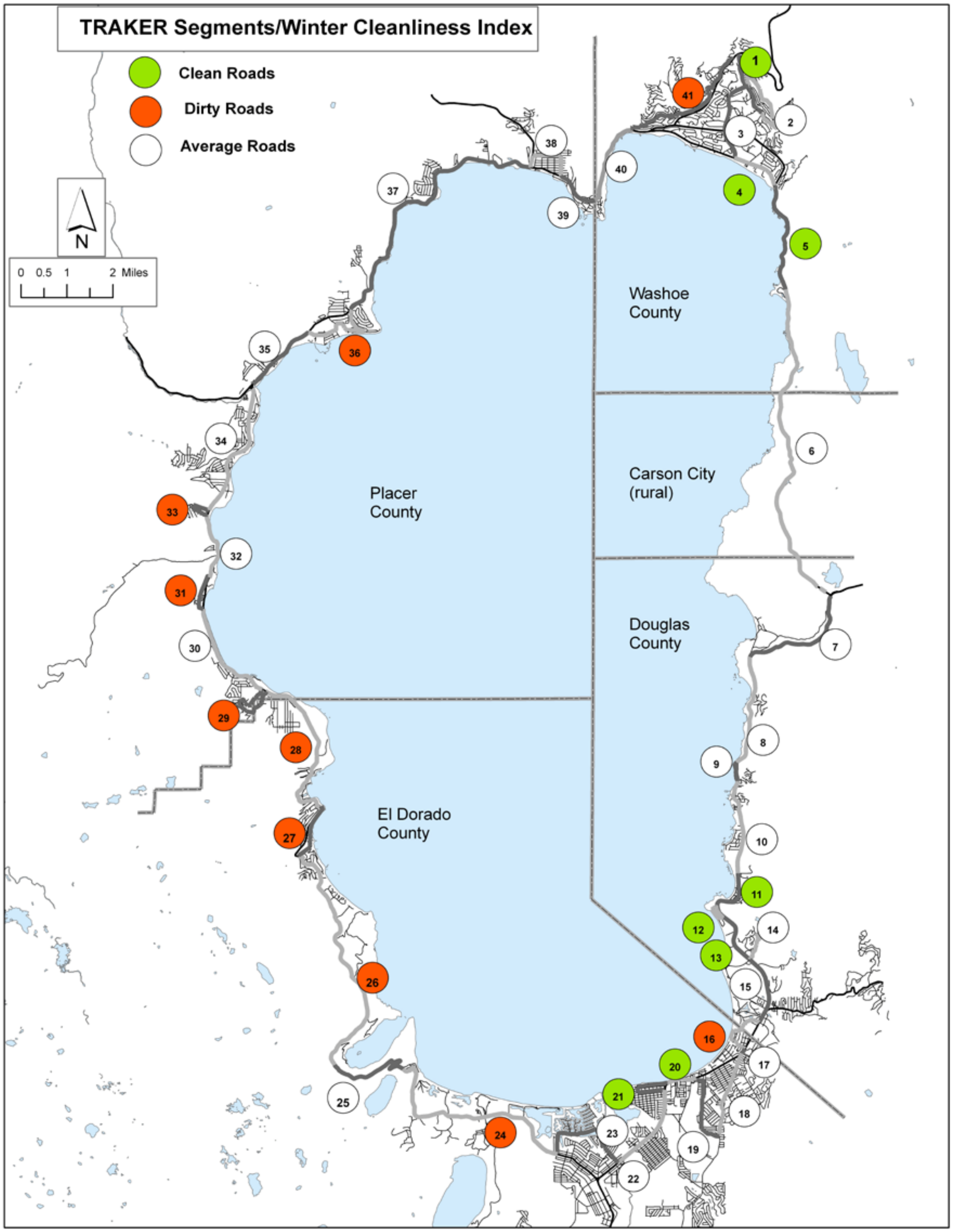

Figure 21. Winter Cleanliness index map for 41 TRAKER sections.

7.3 Effectiveness

Table 4 lists ten attributes (i.e., Maintenance Organization, Road Type, Grade, Trackout, Shoulder Type, Pavement Condition, Abrasive Material, Sweeping Practice, and Anti-Icing) that may impact road dust emissions. There is a high degree of confidence in the measured emission factors and emission equilibriums (EE) values due to the frequency and duration of the TRAKER sampling on each segment. The attributes are not all independent which confounds drawing quantitative conclusions from the data. For example ASAP sweeping was generally conducted on primary roads that also had good pavement condition. It is difficult to isolate and quantify the benefits of only one of these attributes since they are generally correlated to the design and maintenance standards of the maintenance organization. The relationships between the emission equilibrium and each attribute are discussed below. Data from Table 4 were grouped by each nominal attribute value and the average and standard error emission equilibrium was calculated and plotted as bar charts (Figure 22). Bars with no error bars represent only one value. Overlapping error bars indicate that the averages are not statistically significant at the 95% confidence level using a 2 sided T-test. These data represent correlation relationships that should not be overly interpreted as causal relationships. Error bars represent the standard error of the emission equilibrium averages. All comparisons show that summer EEs are substantially lower than winter EEs supporting the claim that winter maintenance practices are the dominant supply of suspendable material from roads.

7.3.1 Implicit Attributes

Maintenance Organization: Roads from Placer County had higher EEs than other organizations in both winter and summer. Some variation exists amongst organizations with SLT showing higher EEs in summer. Placer county roads were also characterized as being in fair to poor condition that may contribute to the increase. SLT is the most urbanized region of the lake basin with many tertiary roads to provide material for suspension.

Road Type: The EE term controls for vehicle speed, however, tertiary roads are higher in both winter and summer by a factor of 2-3. This implies that tertiary roads may be closer to the source of road dust than primary or secondary roads. With the exception of SLT and Washoe County, most tertiary roads are not routinely swept after winter storms.

Road Grade: Sanding truck operators generally apply material where it is most needed (i.e., steep sections, intersections, turns). The bar charts in Figure 22 show that roads with moderate grades have higher (albeit more variable) EE values than either steep or flat roads. The fact that traction material redistributes quickly after application implies that the material does not stay in place long enough to affect local EEs. The continuation of this trend in summer suggests that other factors may be more dominant since no abrasives are applied during the summer season.

Trackout: Roads within the vicinity of dirty tertiary roads had higher EEs by a factor of 2 than those that did not in both summer and winter. This suggests that the dirty roads are a source of suspendable material for adjacent higher speed primary and secondary roads. This also implies that additional control measures applied to these roads may be less beneficial than collecting the material closer to the source.

7.3.2 Controllable Attributes

Shoulder: Roads with paved shoulders greater than 3 feet or a barrier (i.e., guard rail or curb) had half of the EE of roads with narrow or unpaved shoulders. This is intuitively justifiable in that cars that are able to leave the paved travel lane can track material onto the roadway.

Road Condition: This attribute had the largest effect on EE with poor condition roads acting as a source of particles for roads in fair or good condition. Poor condition roads may be their own sources of suspendable material as bits of asphalt are ground up into fine dust by vehicle tires.

Summer Construction: Roads observed to have summer construction activity did not show elevated EEs during summer or winter. Either other factors are more dominant or BMPs already in place to control construction trackout appear to be effective.

Sweeping: Areas that employed ASAP sweeping had EEs that were half of those with seasonal sweeping. This effect extended into the summer time with nearly the same proportion. This result implies that material deposited in the winter can be suspended throughout the year or that other factors may be more dominant.

Anti-Icing: Pretreatment before a storm is correlated with a ~40% reduction in EE during the winter time. The effect is less significant in the summertime.

Abrasive Material: Only one road segment each employed 3/8" chip gravel and washed sand in winter time. EEs associated with cinders, Spec D sand, and Spec G sand were statistically equivalent in summer, but areas that used cinders had higher EEs in summer.

7.3.3 Subset Attribute Selection and Linear Regression

To evaluate which road segment attributes were most predictive of EE, data from Table 4 were analyzed using data mining toolsets. The correlation-based feature subset selection algorithm (Hall, 1998) evaluates the worth of a subset of attributes by considering the individual predictive ability of each feature along with the degree of redundancy between them. The output of this analysis indicated that Trackout and Sweeping Practices were the strongest predictors of winter time EE. Pavement Condition and Trackout were the strongest predictors of summer time EE.

Based on these attribute selections, nominally based linear regressions were performed to quantify the strength of each attribute:

*Winter EE (g/vkt *mph3) =*

*22000 * (Trackout=Yes) + 23000 * (Sweeping Practice=Seasonal) + 19800*

Correlation coefficient = 0.66

Mean absolute error = 12800 g/vkt *mph3

Root mean squared error = 17700 g/vkt *mph3

Relative absolute error = 82 %

Root relative squared error = 75 %

Total Number of Instances = 40

The coefficients in the equation above indicate that proximity to Trackout and Seasonal Sweeping are equally weighted in predicting winter EE.

*Summer EE (g/vkt *mph3) =*

*4600 * (Trackout=Yes) + 9000 * (Pavement Condition=Fair) +*

*(33000 * Pavement Condition=Poor) + 4100.*

Correlation coefficient = 0.80

Mean absolute error = 4200 g/vkt *mph3

Root mean squared error = 6500 g/vkt *mph3

Relative absolute error = 60 %

Root relative squared error = 60 %

Total Number of Instances = 40

The coefficient for Trackout are half that for Fair condition pavement condition and 15% of Poor condition pavement indicating that pavement condition is the strongest predictor of EE in the summer.

Although Trackout from adjacent dirty tertiary roads is a key factor in both winter and summer EE regressions, controlling this source is generally beyond the jurisdiction of the local maintenance organizations. Winter sweeping practices are a controllable factor and the regression suggests that adopting an ASAP sweeping practice will reduce winter EE by 23,000 g/vkt * mph^3 or 41% (i.e., 36% for roads impacted by Trackout and 46% for road not impacted by Trackout). The sweeping practice benefit may be biased low since reducing EE by ASAP sweeping throughout the basins will likely reduce the quantity of material tracked in from adjacent tertiary roads.

As mentioned previously, summer road dust emissions are approximately 20% of winter emissions. In summer, EE is most effectively reduced by improving road conditions. Paving a road in Poor condition will reduce EE by 33000 g/vkt * mph^3 or 84% (i.e. 79% for roads impacted by Trackout and 89% for road not impacted by Trackout). Repaving a road in Fair condition will reduce EE by 9000 g/vkt * mph^3 or ~60% (i.e., 51% for roads impacted by Trackout and 69% for roads not impacted by Trackout)

7.4 Control Costs

7.4.1 Mechanical Sweeping

Excluding capital purchases, mechanical sweeping has an O&M cost of approximately $30 per curb-mile or $20 per curb km (LID, 2005). Seasonal sweeping includes up to two sweeps in the spring and fall. Assuming 10 snow storms per year, the increase in cost of adopting ASAP sweeping is $200 per curb km per year.

7.4.2 Road Resurfacing

Cost of road resurfacing varies depending on the type of road and degree of degradation. Estimates of road reconstruction range from $0.7M per Ln-Mi ($0.5M per Ln-km) for rural roads with shoulders to $1.8M per Ln-mi ($1.2M per Ln-km) for suburban roads (CDTC, 2003). A life span of 10 years is estimated for mountainous roads were vehicles operate with studs and chains during winter time. Per year costs of maintaining road in good condition average ~$100K per Ln-km per year.

7.4.3 Wide shoulders and Anit-icing.

Other factors such as paving road shoulders ($120K/Ln km; VADOT, 2006) and pretreating winter roads with brine (i.e., anti-icing at $10/Ln km; UNH 2007) were correlated with lower EE roads. These factors may be as important wintertime sweeping however these factors were not statistically independent. Maintenance organizations that swept immediately after storms were also very likely to have paved shoulders, apply anti-icing, and keep their roads in good condition.

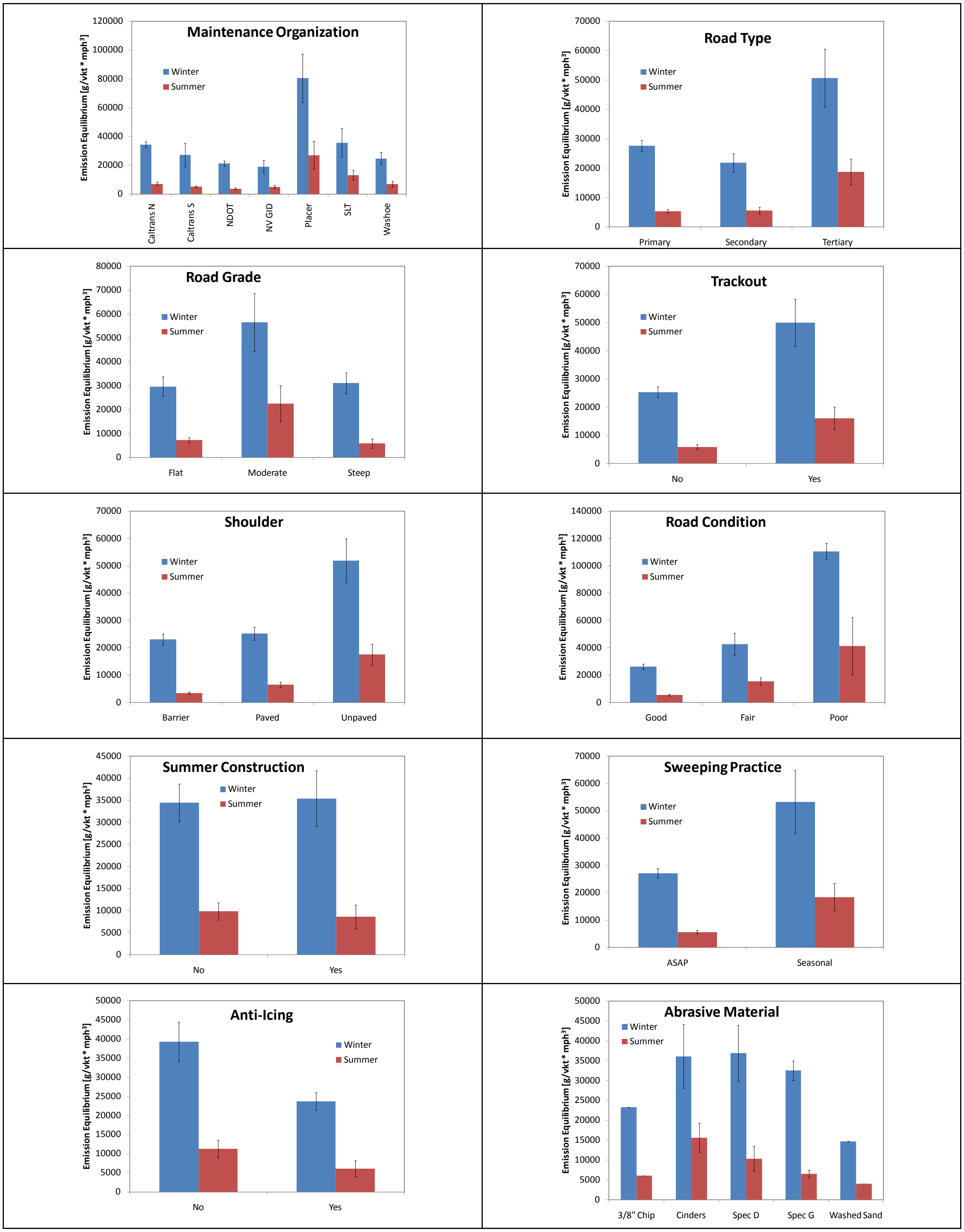

Figure 22. Attribute tests based on emission equilibrium (EE) values. High EEs imply that the attribute is associated with a source of suspendable road dust.

7.5 Cost Effectiveness

The cost effectiveness of the two control measures: ASAP sweeping in the wintertime and resurfacing in the summer are compared using the following equation:

$$\text{Cost Effectiveness (\$/g PM}_{10}\text{ reduced)} = \frac{\text{Cost per kilometer controlled (\$/vkt)}}{\text{Emission Factor (g PM}_{10}\text{/vkt)} \cdot \text{Control Efficiency}}$$

For ASAP Street Sweeping, the annual cost per vkt controlled of ($0.00083/vkt) is calculated by dividing the cost per kilometer controlled ($200) by the average annual wintertime traffic volume (i.e. annual times 0.4) on roads with seasonal sweeping (240,000 vehicles). The average wintertime emission factor for these roads is 3.3 g PM_{10} per vkt and the control efficiency as described above is 41%. The cost effectiveness of transitioning from seasonal to ASAP sweeping is estimated to be $0.6 per kg PM_{10} emissions reduced. As mentioned previously, this estimate may be high since cleaning dirty road should produce the secondary benefit of reducing emissions from adjacent roads.

For summertime pavement improvement projects, the cost per vkt controlled for roads in Fair condition is ($100K/600K vehicles)= $0.17/vkt. The average summertime emission factor is 1.0 g/vkt and the control efficiency is 60% resulting in a Fair road resurfacing cost effectiveness of $300 per kg PM_{10}. The cost per vkt of resurfacing roads in poor condition is ($100K/60K vehicles)= $1.7/vkt. Roads in poor condition emit 2.9 g/vkt but can be controlled by 84% resulting in a control cost effectiveness of $700/kg PM_{10} reduced.

These estimates suggest that the street sweeping after winter storms on all roads is the most cost effective method of PM_{10} emission reduction. It should be emphasized that a program to sweep all roads at this frequency is likely to reduce the reservoir of suspendable material in the basin and may provide more benefits than more frequent sweeping of primary roads as is currently practiced.

Brine application is very likely to provide reduced EE since less sand would be applied to the road and at $10/Ln - km would have a similar cost effectiveness to sweeping at $30/Ln - km. As an emission control strategy, anti-icing appears to be a logical compliment to street sweeping. When roads are pretreated, less abrasives are necessary and the input of salt into the environment is decreased.

Road shoulder widening at $12K/Ln - km per year costs substantially less than road resurfacing at $100K/Ln - km/yr and may have cost effectiveness within a factor of 10 of resurfacing. Although emission reductions due to shoulder improvement can't be isolated from the observations, the relative costs of this control measure in comparison to sweeping and brining suggest that shoulder treatments not be cost effective until all roads have been brought up to the same standard with sweeping and brining.

8 Conclusions and Future Work

This project integrated data from the previous Lake Tahoe TRAKER study (Kuhns et al., 2007; and Zhu et al., 2009) with a new set of field experiments to address hypotheses related to PM propagation downwind of roads and quantifying emission reductions associated with control practices. Particle deposition field studies took place at three sites around Lake Tahoe representing a variety of vegetated landscapes. Measurements included particle size distribution, chemistry, local meteorology, road dust emissions, and traffic counts. These data were used to address the following hypotheses.

8.1 Hypotheses Tested

Specific hypotheses that were tested by this project included:

- Vegetation by the side of the road reduces the fraction of emissions that can be transported over the lake surface.

  Plausible. Size resolved deposition velocities from roadway dust plumes were measured in Ponderosa Pine forests, Aspen and Willow groves, and open fields using novel deposition box instrumentation. In each case, measured deposition velocities (based on changes in size distribution downwind of roads) were within the measurement uncertainty of the Stokes settling velocity. Low concentration plumes and instrument detection limits precluded quantifying deposition differences between the various landscapes.

- The majority of the particles that can potentially deposit fall out prior to reaching the lake.

  True. Measured deposition velocities for particles >2.5 μm are consistent with Stokes settling velocities that represent a lower bound of the deposition rate in areas with vegetation and complex terrain. Using the conservative Stokes deposition velocities, 99% of PM_{lrg}, PM_{crs}, and $PM_{2.5}$ will deposit within 300 m, 5200 m and 40 km of the ground level emission point with wind speeds of 2 m/s. Using more realistic (i.e., larger) deposition velocities for the area based on representative friction velocities and surface roughness, the 99% deposition points reduce to 70 m, 400 m, and 19,000 m, respectively. These modeled values were validated at 100 m downwind of the road. Other factors such as atmospheric mixing height and spatially heterogeneous updrafts may limit the applicability of this model on much larger scales.

- Phosphorous concentrations in resuspended road dust are greatest in the largest size-fractions, which are the most likely to deposit near the source.

  False. Of the PM_{10} samples collected at the Bourne and Rabe Meadow sites, phosphorous concentrations were greatest in fine particles and average concentration was 17±2 and 21±2ng/ m^3, respectively consistent with previous studies. Phosphorus did not appear to be associated with most of the road dust mass since 2/3 of roadside phosphorus was in PM2.5 size fraction compared to only 20% of the crustal species such as silica. A potential source of road side phosphorus is the burning of motor oil that contain the oil additive Zinc dialkyldithiophosphates (ZDDP). Fine PM phosphorus concentrations are greatest during peak travel times.

- Street sweepers are effective means of controlling dust emissions from roads.

  True. Winter street sweeping when roads are dry after storms was the strongest predictor of Emissions Equilibrium on roads. Many secondary and tertiary roads are only swept seasonally and provide a reservoir of material that is suspended into the air when abrasives are tracked onto higher speed roads. Contrary to recommendations of Kuhns et al. (2008) that advised application of control measures only to the highest volume roadways, ubiquitous sweeping of all roads in the basin after storms is likely to be an optimal control strategy by reducing the overall emissions equilibrium reservoir of material on the road surface. On an annual cost effectiveness basis, street sweeping costs \$0.6 per kg PM_{10} emissions reduced. This is less than 0.5% when compared with roads resurfacing of fair conditions roads (\$300 per kg PM_{10} emission reduction) or resurfacing of poor condition roads (\$700 per kg PM_{10} emission reduction).

- Anti-icing reduces road dust emissions when compared to the application of abrasives for traction control.

  Plausible. Road segments that employed anti-icing pretreatment on roadways had lower emission equilibrium values by a factor of two. The application of anti-icing reduces the amount of abrasives needed to maintain road safety. This attribute was correlated with other factors that were stronger predictors of emission equilibrium and its benefits could not be isolated from other likely beneficial factors such as road shoulder improvements, ASAP sweeping, and pavement condition. While being correlated with cleaner roads, anti-icing provides other benefits including reduced salt application, reduced abrasive application, and better utilization of resources since brine can be applied during routine shifts up to three days in advance of a storm. The relatively low treatment cost (compared with resurfacing and shoulder improvement) supports the use of brining and an emission control practice. Although not quantitative, cost benefits are estimated to be on the same order as sweeping (~\$0.6 per kg PM_{10} emissions reduced)

- Paving shoulders and installing curbing prevents material from washing onto the roadway and being emitted into the air.

  Plausible. Roads with paved shoulders or barriers that prevented entrainment of material from the sides of roads had 50% lower emission equilibriums than did roads with narrow (less than 3 feet) or unpaved shoulders. This was not one of the strongest predictors of equilibrium emissions when compared with ASAP street sweeping, trackout from adjacent dirty roads, and pavement condition. Shoulder improvement costs 10%-20% of road resurfacing and may prove to reduce airborne emissions. In comparison, ASAP Sweeping and anti-icing are substantially less expensive and more likely to provide significant emission reduction benefits.

8.2 Additional Findings

With respect to emission controls, one of the most important findings is that despite aggressive programs by some maintenance organizations, road dust from dirty tertiary roads serves as a continuous source of suspendable material for adjacent high speed roads in the wintertime. Potential basin wide emission reductions of 2/3 may be achievable if the emission equilibrium reservoir can be reduced through regional street sweeping. To be most effective, emission control strategies should require that not only primary roads, but *all roads*, be swept after snow storms to recover applied abrasive material. Traction control material is dispersed quickly after application throughout the road network on vehicle tires. Unswept secondary and tertiary roads can serve as a suspendable material sources long after the primary roads have been cleaned.

8.3 Future Work

A follow on study is under way to quantify how the airborne emissions described here deposit to the lake surface. In addition to providing a comprehensive literature review of related work, relevant objectives of that study are to:

- Geographically summarize the seasonal near field deposition of sediment near roadway
- Assess Link Location and Potential for Atmospheric Deposition to the Lake.
- Marginal Impacts of a Vehicle Trip on Re-entrained Dust.

9 References

Bench, G., Grant, P., Ueda, D., Cliff, S., Perry, K., Cahill, T., The Use of STIM and PESA to Measure Profiles of Aerosol Mass and Hydrogen Content, Respectively, across Mylar Rotating Drum Impactor Samples, Aerosol Sci. and Tech. 36: 642–651, 2002.

Byron, E.R. and C.R. Goldman (1986). A technical summary of changing water quality in Lake Tahoe: The first five years of the Lake Tahoe Interagency Monitoring Program. Tahoe Research Group Institute of Ecology. Univ. of Calif. at Davis. 62pp.

CARB 2006. Lake Tahoe Atmospheric Deposition Study (LTADS), final report to the Lahontan Regional Water Quality Control Board, the Nevada Division of Environmental Protection, and the Tahoe Regional Planning Agency, prepared by the Atmospheric Processes Research Section of the California Air Resources Board, Sacramento, CA, September, 2006. (http://www.arb.ca.gov/research/ltads/ltads-report.htm)

Cliff, S.S. (2005) Quality Assurance Analysis of Filter Samples Collected During the Lake Tahoe Atmospheric Deposition Study using Synchrotron X-Ray Fluorescence (LTADS-sXRF QA). Final report for Agreement No. 03-344 http://www.arb.ca.gov/research/abstracts/03-344.htm

C. Cowherd, G.E. Muleski, and J.S. Kinsey (1988) Control of open fugitive dust sources, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency in Research Triangle Park, N.C.

Cowherd, C., Englehart, P., Muleski, G.E., Kinsey, J.S., Rosbury, K.D., 1990. Control of Fugitive and Hazardous Dusts. Noyes Data Corp., Park Ridge, NJ.

Cowherd, C., Muleski, G., Gebhart D.L. 2006. Development of an emission reduction term for near-source dust depletion. Conference Proceedings, 15th International Emission Inventory Conference: “Reinventing Inventories - New Ideas in New Orleans”, New Orleans, LA, May 15 - 18, 2006

Engelbrecht, J., Gertler, A., VanCuren, T. 2009. Lake Tahoe Source Attribution Study (LTSAS): Receptor Modeling Study to Determine the Sources of Observed Ambient Particulate Matter in the Lake Tahoe Basin. Final report. Prepared for USDA Forest Service Pacific Southwest Research Station by Desert Research Institute, Reno, NV September 2, 2009.

Etyemezian V., H. Kuhns, J. Gillies, S. Uppapalli, G. Nikolich, D. Zhu (2007) Clark County Alternative Technologies for Paved Road Dust Emissions Measurement. Prepared for Clark County DAQEM, January 8.

Etyemezian, V., Gillies, J., Kuhns, H., Gillette, D., Ahonen, S., Nikolic, D., Veranth, J. (2004) Deposition and removal of fugitive dust in the arid Southwestern United States: measurements and model results. Journal of the Air & Waste Management Association 54,1099-1111.

Gertler, A.W., E. Weinroth, M. Luria, and J. Koracin (2008). Development of an Air Pollutant Emissions Inventory for the Lake Tahoe Basin that Incorporates Current and Future Land Use Scenarios. Final report prepared for USEPA Region 9, San Francisco, CA, July 31, 2008.

Gillies, J.A., R. Edwards, H. Kuhns, J. Engelbrecht, D. Zhu, G. Nikolich, S. Brown, D. Feller, M. Pook (2010) Source Characterization of Particulate Matter Depositing to Lake Tahoe, Report prepared for EPA Region IX, sponsored by SNPLMA Round 6 (in preparation).

Goldman, C.R., A.D. Jassby, and S.H. Hackley. 1993. Decadal, interannual, and seasonal variability in enrichment bioassays at Lake Tahoe, California-Nevada, U.S.A. *Can. J. Aquat. Sci*. **50**: 1489-1496.

Jassby, A.D., C.R. Goldman, J.E. Reuter, and R.C. Richards. 1999. Origins and scale-dependence of temporal variability in the transparency of Lake Tahoe, California-Nevada (USA). *Limnol. Oceanogr*. **44** (2): 282-294.

Knochel, Basic Principles of XRF with Synchrotron Radiation, *2nd International Workshop on XRF and PIXE Applications in Life Science, Capri, Italy, 29-30 June, 1989*, World Scientific Publishing Co., Singapore, 1990.

Kuhns H, D. Zhu, J. Gillies, A. Gertler, and V. Etyemezian (2007) Measurement and Modeling of Fugitive Dust Emissions from Paved Road Travel in the Lake Tahoe Basin, Report prepared for EPA Region IX, December.

Kuhns H., V. Etyemezian, M. Green, K. Hendrickson, M. McGown, K. Barton, and M. Pitchford (2003) Vehicle-based road dust emission measurement--Part II: Effect of precipitation, wintertime road sanding, and street sweepers on inferred PM10 emission potentials from paved and unpaved roads, Atmospheric Environment, vol. 37, pp. 4573-4582.

Kuhns, H., Chang, M.-C.O., Chow, J.C., Etyemezian, V., Chen, L.-W.A., Nussbaum, N., Nathagoundenpalayam, S.K.K., Trimble, D., Kohl, S., MacLaren, M., Abu-Allaban, M., Gillies, J., Gertler, A., Damm, C., Denney, C., Gallery, C., Skotnik, J. 2004. DRI Lake Tahoe Source Characterization Study: Final Report. Prepared for California Air Resources Board by Desert Research Institute, Reno, NV October 22, 2004.

Kuhns, H., Etyemezian, V., Landwehr, D., MacDougall, C., Pitchford, M., Green, M. 2001. Testing Re-entrained Aerosol Kinetic Emissions from Roads: a new approach to infer silt loading on roadways. Atmospheric Environment 35, 2815-2825.

Kuhns, H., Gillies, J.A., Etyemezian, V., Nikolich, G., King, J., Zhu, D., Uppapalli, S., Engelbrecht, J., Kohl, S. 2010. Particulate matter emissions from wheeled and tracked vehicles operating on unpaved roads. Aerosol Science and Technology 44, 187 – 196.

LID (2005) http://www.lowimpactdevelopment.org/ffxcty/2-5_streetsweeping_draft.pdf

Lundgren, D. A., An Aerosol Sampler for Determination of Particle Concentration as a Function of Size and Time, J. Air Poll. Cont. Assoc. 17, 225-229 (1967).

Malm, W. C., Sisler, J. F., Huffman, D., Eldred, R. A., and Cahill, T. A. (1994). Spatial and Seasonal Trends in Particle Concentration and Optical Extinctionin the United States, J. Geophys. Res., 99(D1):1347–1370.

Muleski, G.E.; Cowherd C. Emission Factor Documentation for AP-42, Sections 11.2.5 and 11.2.6-Paved Roads, EPA Contract No. 68-D0-0123; Midwest Research Institute: Kansas City, MO, 1993.

Nixon, W.A. 2001. "Use of Abrasives in Winter Maintenance at the County Level," Transportation Research Record 1741.

Noll, K.E. 1999. Fundamentals of Air Quality Systems. Design of Air Pollution Control Device. American Academy of Environmental Engineers, Annapolis, MD.

NY CDTC (2003) Unit Costs for Non-State Highway Reconstructions with Federal Funds, http://www.cdtcmpo.org/tipdoc10/solicitation/hwycost03.pdf

Perry K. D., S. S. Cliff, M. P. Jimenez-Cruz, Evidence for hygroscopic mineral dust particles from the Intercontinental Transport and Chemical Transformation Experiment, *J. Geophys. Res*., 109, D23S28, doi:10.1029/2004JD004979, 2004

Raabe, O.G., D.A. Braaten, R.L. Axelbaum, S.V. Teague, and T.A. Cahill, Calibration Studies of the DRUM Impactor, J. Aerosol Sci. v. 19, p 183-195, 1988.

Seinfeld, J.H., Pandis, S.N., 1998. Atmospheric Chemistry and Physics: from Air Pollution to Climate Change. Wiley, Hoboken, pp.1203.

Smith, D., and Kuchnicki, J. (2010). Final Lake Tahoe Total Maximum Daily Load (p. 188). South Lake Tahoe, CA: Lahontan Regional Water Quality Control Board. Accessed 8/30/2010 athttp://www.swrcb.ca.gov/rwqcb6/water_issues/programs/tmdl/lake_tahoe/docs/tmdl_final.pdf

Swift, T.J., J. Perez-Losada, S.G. Schladow, J.E. Reuter, A.D. Jassby, and C.R. Goldman (2006). Water clarity modeling in Lake Tahoe: Linking suspended matter characteristics to Secchi depth. *Aquat. Sci*. **68**: 1-15.

Teng, H., Kwigizile, V., James, D.E., Merle, R. 2007. Identifying influencing factors on paved roads silt loading. Journal of the Air & Waste Management Association 57, 778-784.

Valiulis, D., Čeburnis, D., Šakalys, J., Kvietkus, K. 2002. Estimation of atmospheric trace metal emissions in Vilnius City, Lithuania. Atmospheric Environment 36, 6001-6014.

Zhu, D., Kuhns, H.D., Brown, S., Gillies, J.A., Etyemezian, V., Gertler, A.W. 2009. Fugitive dust emissions from paved road travel in the Lake Tahoe Basin. Journal of the Air & Waste Management Association 59, 1219-1929.

Appendix A: Candidate Sampling Sites

Table 5. Listing of potential sites surveyed as for emissions and deposition monitoring.

Site Number	Site Name	Location	Road Description	Tower Access	Traffic Description	Maintenance Organization	BMPs	Lake-side Veg	Rim-side Veg	Traction Control Material	NOTES
1	Kings Beach	Placer County; SR28 at Kings Beach between Safeway parking lot and SR267	four lanes with C&G	side walk or behind split rail fence on golf course	Heavy Traffic, 35mph	CalTrans	C&G	Beach with some mature trees	parking lot and golf course; some low shrubs	Clean washed sand	Best Open fetch
2	Tahoe Vista	Placer County at Tahoe Vista on SR28 east of Agatam Ave	two lanes	snow storage area adjacent to Agatam Ave	Heavy Traffic, 35mph	CalTrans	?	beach with some sparse trees	Grass and dense Aspen	Clean washed sand	
3	Rocky Ridge	Placer County; SR28 at Rocky Ridge, northeast of Tahoe City	two lanes	road side	moderate traffic, 35mph	CalTrans	?	treed	Meadow and Aspen	Clean washed sand	flat no buildings; Barton Creek; good road side for tower; who owns?
4	Blackwood	Placer County; SR89 Near Tahoe Pines	two lanes with no C&G and no shoulder	snow park access road; Barker Pass Road	heavy summer traffic 30mph	CalTrans	none	beach	Mature trees (Jeffrey Pine)	Clean washed sand	good Jeffrey Pine cover; mild up slope;
5	Sugar Pine Park	El Dorado County on SR89 in Sugar Pine Point State Park	two lanes	road side	heavy summer traffic; 40mph	CalTrans	none	mature trees	mature trees	Clean washed sand	camping area and a potential for tourists to visit the equipment
6	Meeks Bay	El Dorado County: SR89 Meeks Bay Fire Department	two lanes with no C&G and no shoulder	road side	heavy summer traffic 40mph	CalTrans	none	dense Mature trees (Jeffrey Pine)	young pines	Clean washed sand	great stand of young pines; should have greatest depisition; close to camp fires on lake side
7	Baldwin Beach	El Dorado County; SR89 west of Camp Richardson east of Spring Creek Road	two lanes with no C&G and no shoulder	on SR89	heavy summer traffic 35mph	CalTrans	none	treed	very dense aspen	Clean washed sand	US forest service; flat topo; dense, small aspen
8	Camp Richardson	El Dorado County; SR89 south of Camp Richardson north of meadow area	two lanes with no C&G and no shoulder	on SR89	heavy summer traffic 30mph	CalTrans	none	dense Mature trees (Jeffrey Pine)	dense Mature trees (Jeffrey Pine)	Clean washed sand	US forest service; USGS topo shows dirt access road going south off SR89; densest forest
9	Upper Truckee River	SLT; US50 and Upper Truckee River	lanes and C&G	road side	very heavy traffic 35 mph	CalTrans	C&G	Meadow with sparse willows	Meadow with sparse willows	Clean washed sand	road slightly above grade; very heavy traffic; road may not be exactly perpendicular to prevailing winds; site far away from lake
10	Rabe Meadow	Stateline; US 50 at Sewer Plant Rd.	Four lanes with curb and gutter; no shoulder	via Sewer Plant Rd	Heavy Traffic, 35mph	NDOT	C&G	moderate trees, flat	moderate trees with slight slope	Spec-D sand	Likely forest service
11	Tiger's Spot	Stateline; US50 at 525 US50	Four lanes with curb and gutter; no shoulder	Private Drive pull out on US50	Heavy Traffic, 40mph	NDOT	C&G	grass meadow	dense willows and aspen for 500m; constricting topography	Spec-D sand	Private
12	Zephyr Cove	Zephyr Cove; US50 at Zephyr Cove Library	Four lanes with curb and gutter	On US50; tower access may be difficult due to a lack of shoulder	Heavy Traffic, 45mph	NDOT	C&G	Mature trees (Jeffrey Pine); no undergrowth	Mature trees (Jeffrey Pine); no undergrowth	Spec-D sand	forest service or county; horse riding stable and trails on rim side of the road.
13	Ponderosa Ranch	Incline Village; SR28 at the former Bonanza Ranch	two lanes with wide shoulders and C&G on lake side	on SR28	moderate traffic, 30mph	NDOT	C&G on one side?	many Mature trees (Jeffrey Pine) and residential	Parking lot with sparse large trees, but no veg below 40 ft (parking lot)	Spec-D sand	road may not be perpendicular to prevailing winds; there could be issues with access; site will likely be developed in the next couple of years

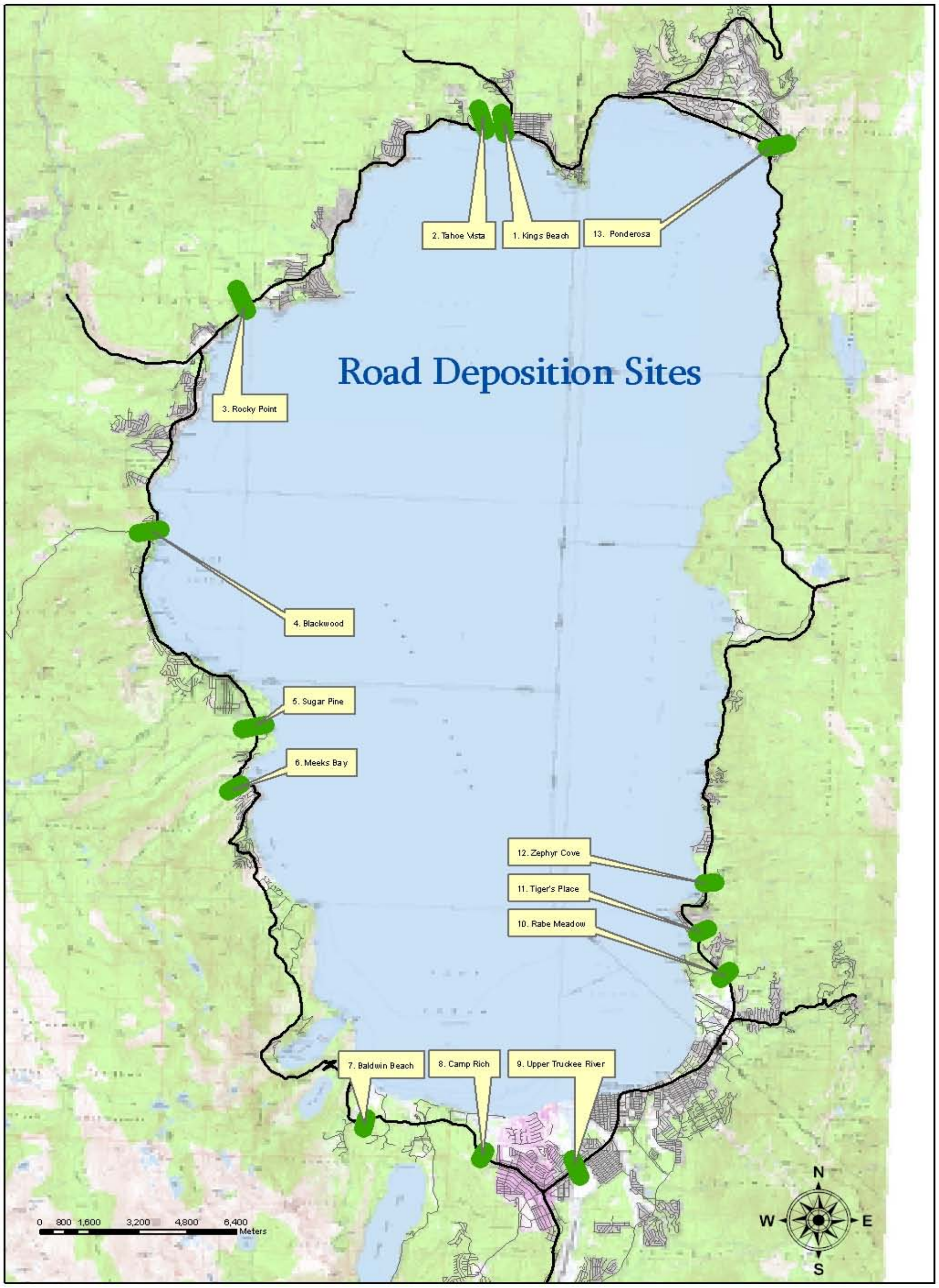

Figure 23. Map of surveyed potential sampling sites along on USGS topographic background.

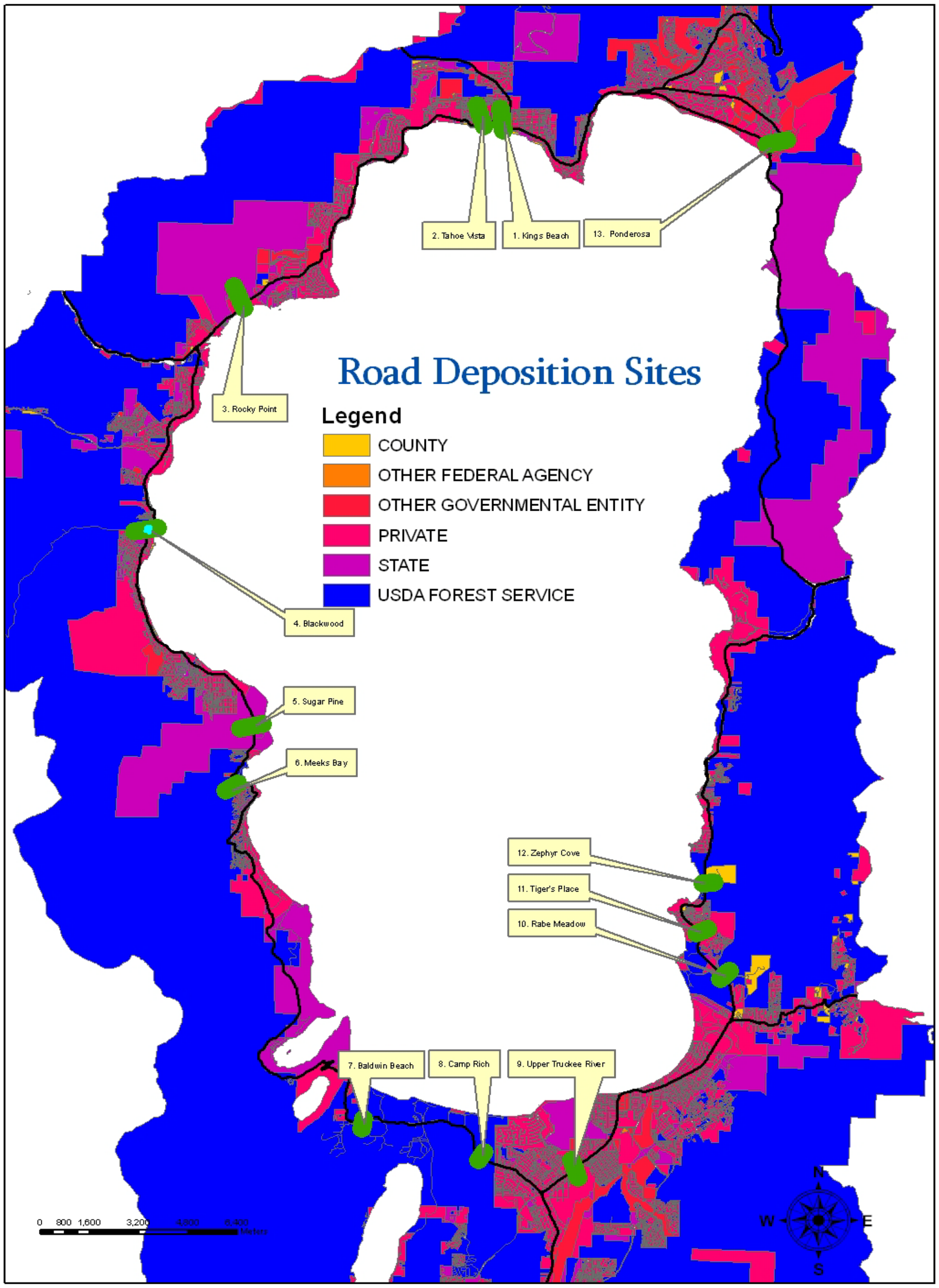

Figure 24. Map of surveyed potential sampling sites along on USGS topographic background.

Appendix B - Deposotition Box Optimization

As a pilot study to determine the feasibility of the deposition box monitoring, four deposition boxes were deployed on each side of four-lane Highway 50 within ≈800m of the southeastern shore (Rabe Meadow) of Lake Tahoe (Fig. 2d). The boxes were deployed from November 13 to November 16, 2008 prior to any significant seasonal snow fall and the application of traction control material to the local roads. During this period, the maximum concentrations measured by the DustTraks was 10 $\mu g\ m^{-3}$. The one hour period beginning 17:00 on November 14, 2008 was chosen to test the model, since this was the period with highest 10-15 µm particle concentration at the first downwind sampler (Box 1) and the lowest background 10-15 µm particle concentrations at Box 3. At this time, winds were Northwesterly at 0.4 $m\ s^{-1}$. The particle size range from 0.5 µm to 0.7 µm was used to represent particles with negligible settling velocity. The standard errors of the regression were propagated through Eq. 6 to produce the deposition velocity values and uncertainties shown in Fig. 3. The applied value of L was 50 m (the distance between samplers) and H was 2.5 m (and approximate height of a vehicle dust plume next to the road). For comparison, the terminal settling velocity v_t was also calculated for the same sized particles using the equation:

$$v_t = \frac{1}{18}\frac{D_p^2 \rho_p g C_c}{\mu} \qquad (7)$$

Where D_p is the particle diameter, ρ_p is the particle density (2 g cm^{-3} for soil particles), g is the gravitational constant (9.8 m s^{-2}), C_c is the Cunningham Slip Correction factor, and µ is the dynamic viscosity of the atmosphere (1.7×10^{-5} kg m-s^{-1}). For most particle sizes, the uncertainties overlap the calculated settling velocities.

An evaluation of the terms in Eq. 6 was used to improve the selection of the appropriate spacing of the instrumentation in subsequent field studies. The precision of the deposition velocity calculation is directly linked to the precision of the ratio term $R = 2*(C_{src} - C_L)/(C_{src} + C_L)$. When the measurements are made too close together, the numerator of R decreases with respect to the propagated measurement uncertainty. When the measurements are made too far apart, the farthest downwind concentration C_L approaches 0 and cannot be resolved from the ambient background concentration. An optimal instrument separation exists when the uncertainty of the deposition velocity calculated by the propagation of the uncertainty of the measured concentrations is at a minimum.

Noll (1999) predicted and Reid et al. (2003) observed in turbulent flow the loss of the particle is given by $C/Co = \exp(-V_d T/H)$, where H is the depth of the dust layer, or particle injection height, T is the deposition time (also defined as X/U where X is distance and U is wind speed). CARB (2006) also demonstrated that concentrations of the same sized particles downwind of a roadway source near Lake Tahoe decreased exponentially (i.e., $C(x) = C_0 \exp(-k'x)$) with distance (x) from a source as a result of both vertical diffusion and deposition. For a constant wind speed u, the distance x and time, t, since emissions occurred are linked by the relationship $t = x/u$. In turn, the exponential equation becomes $C(x) = C_0 \exp(-k\ t)$. The term k can be calculated from the measurements described above as $k = u \ln[C_0/C(L)]/L$.

The relative uncertainty of the calculated v_d (Eq. 6) was simulated for a range of L/u values using particle number concentrations and wind speeds measured on November 14, 2008 at 17:00 (Fig. 3). The standard error of the regressions are listed in Table 1. Fig. 4 shows the relationship between the relative uncertainty and the approximate time since emission (L/u) for a variety of uncertainty scenarios. The upper line represents the observed v_d relative uncertainties for the observed case of 8% and 16% relative uncertainties of the background subtracted roadside concentration (i.e. Box 1) for the 0.5-0.7 μm and >15 μm size bins, respectively. On November 14, 2008 at 17:00, the L/u value for Box 4 with respect to Box 1 was 133 s (L = 50 m; at u = 0.37 m s^{-1}), very close to the estimated optimal time of ≈155 s. The additional curves in Fig. 4 demonstrate the improvement in deposition velocity measurement precision that would be achieved if one or both of the relative uncertainties of the road side concentrations could be reduced to 2%. When both small and coarse concentrations uncertainties are in the vicinity of 2% and the L/u term is in the range of 60 to 400 s, the deposition velocity for particles greater than 1 μm can be measured with an estimated uncertainty of <20%. For typical wind speeds ranging from 1 to 4 m s^{-1}, which are typical for the study site, the L/u values correspond to an optimal L distances of between 60 to 100 m downwind of the road. As mentioned above the concentrations at the site during the study period were less than 10 μg m^{-3}. Vehicle bumper-level PM_{10} concentrations during winter months are frequently 10 times this level (Zhu et al., 2009). It was anticipated that the relative uncertainty of the aerosol profile measurements is lower during periods of higher road dust concentrations. As a result, more accurate measurements of deposition velocity are achievable when road dust emissions are highest.

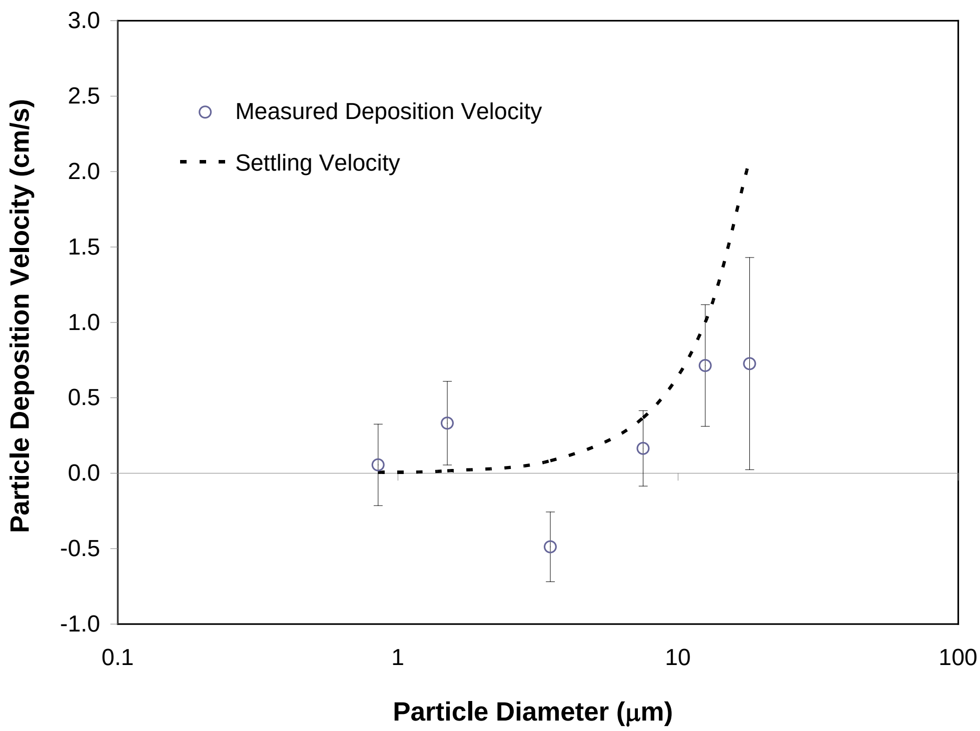

Figure 25. Measured deposition velocity and propagated uncertainty compared with calculated terminal settling velocity.

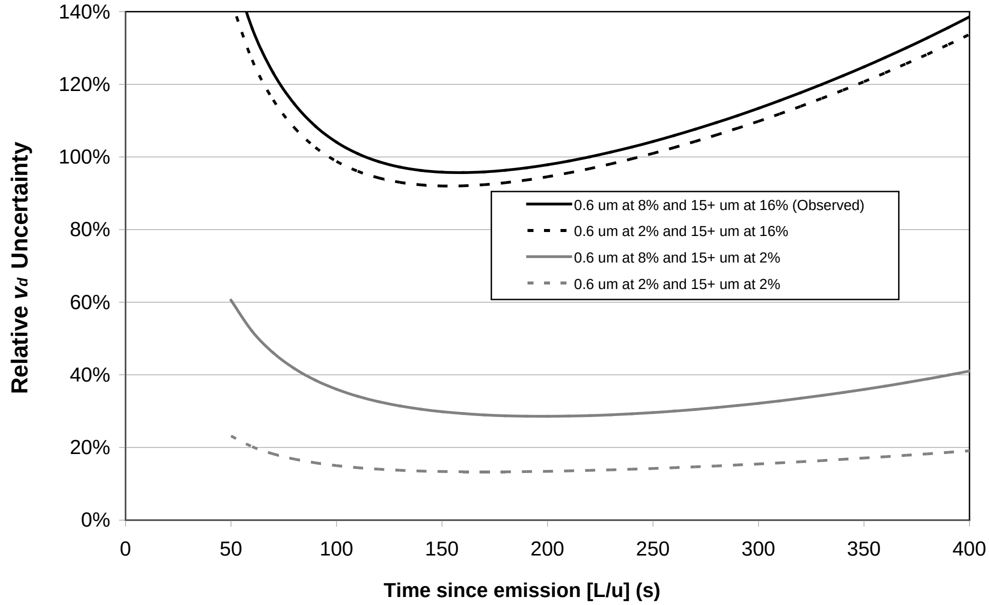

Figure 26. Plot of relative uncertainty of deposition velocity based on approximate time since emission. The family of curves represents the propagated relative uncertainties of the deposition velocity calculation for a variety of measurement uncertainties for the small 0.6 μm and large 15+ μm particles sizes.