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Coverage Transfers across Hydrologically Related Areas (HRAs) - Working Group Meeting #2

MEETING SUMMARY for July 8, 2014

Meeting Attendees (estimated total of 20 persons):

- Working Group: Kevin Prior, California Tahoe Conservancy (CTC); Dan Siegel, CA Attorney General Office; Charles Donohue, NV Division of State Lands (NDSL, substitute for Elyse Randles); Steve Buelna, Placer County; Eva Krause, Washoe County; Lewis Feldman, Feldman McLaughlin Thiel LLP; Shannon Eckmeyer, League to Save Lake Tahoe; and Eoin Doherty, Environmental Incentives.
- TRPA Staff: John Marshall, Adam Lewandowski, Jennifer Cannon, Shay Navarro, and Paul Nielsen.
- Other Attendees: Bob Larson, Jason Kuchnicki, Clem Shute, Steve Teshara, Laurel Ames, Jennifer Quashnick, and Anne Nichols.

Meeting Outcomes:

1. The working group recommended advancing the following proposed amendment to coverage transfer provisions:

   Allow transfers of legally existing hard or soft coverage across HRA boundaries where the following criteria are met:

   a. *The sending site is sensitive land (Land Capability Districts 1 – 3)*
   b. *The receiving site is non-sensitive land (Land Capability Districts 4 – 7 or equivalent IPES scores)*
   c. *The receiving site is further than 300 ft. from the highwater mark of Lake Tahoe, or on the landward side of State Highways in the Tahoe City or Kings Beach Town Centers.*

2. The working group recommended including the following item on the preliminary list of priority projects for possible future Governing Board prioritization. This item would represent a more comprehensive and long-term reform of coverage transfer regulations:

   a. *Replace HRAs with an alternative approach that addresses watershed conditions and/or connectivity with Lake Tahoe and is more effective at meeting HRA objectives while being simpler to administer.*

3. The working group agreed to begin developing recommendations related to excess coverage mitigation fees at the next meeting on August 20, 2014.

Meeting Minutes:

1. Introduction & Background

TRPA staff presentation on the process to date, meeting format, purpose for convening this group and meeting goal (below), objectives for the working group (see Attachment A), and background on the Regional Plan Update Environmental Impact Statement analysis regarding HRAs and coverage transfers and the current coverage transfer provisions. [1]

- Meeting Goal: Revise the coverage transfer area alternatives, as needed, and identify the top recommendation, or prioritize the top two or three alternatives for further refinement and analysis in anticipation of a final recommendation on August 20, 2014.

Public Comments

Jennifer Quashnick (Friends of West Shore):

- Concern over nearshore – written comments submitted and attached to this document (see Attachment C).
- We don't know enough about the conditions of the nearshore to make decisions. We found that the closer the coverage is to the nearshore and the shallower the water depth, the worse the water clarity.

Ann Nichols (North Tahoe Preservation Alliance):

- Felt that the TMDL is not working – written comments submitted and attached to this document (see Attachment C). The Tahoe Resource Conservation District monitoring shows that in some cases, the outflow is worse than inflow possibly because the filters are not working or not maintained. Until this gets fixed nothing should be done. If coverage transfers are allowed, they should only be from Stream Environment Zones (SEZs), and the receiving areas should be analyzed for their ability to handle additional coverage capacity.

2. Land Bank Presentation – Summary

Kevin Prior, CTC, and Charles Donohue, NDSL, presentation on the main types of projects coverage transfers serve and coverage trends by HRA.

- California Land Bank presentation highlights:
    - Based on the coverage amount not on the number of transactions, 62% of the projects served are public service (mostly for public service projects in CA), 37% are residential, and 2% are commercial.
    - The California Land Bank mostly transfers potential coverage and then some hard and soft coverage.
    - Most transactions occur in the Tahoe City and Upper Truckee HRAs. In contrast, the McKinney and Emerald Bay HRAs have no coverage for sale.
- Nevada Land Bank presentation highlights:
    - The Nevada Land Bank primarily serves residential projects (average of 82% from 2006-2014) and a smaller amount of public service and commercial type projects.
    - The Incline HRA has the most Nevada Land Bank transactions and a generous supply of potential coverage, primarily from the Incline Village General Improvement District inventory (estimated at 1.7 million square feet). The Marlette HRA has little to no

[1] Coverage Transfers Across HRAs Working Group #1 Staff Summary with attachments offers more information: http://www.trpa.org/wp-content/uploads/FINAL_Coverage-Transfers-Across-HRAs_Working-Group-1_staff-summary-w-attachment.pdf

demand for coverage since it is mostly comprised of publicly owned land and only a few transactions occur in the underserved Cave Rock HRA due to the lack of supply, despite regular inquires (approximately 25% of all Nevada Land Bank inquiries).

3. TRPA Presentation - Overview of Options and Recommendations

TRPA staff presentation on the six different options, key data findings and pros and cons regarding the options, and preliminary recommendations (presentation provided in Attachment B). As shown below, options #1, #4, and #6 were recommended by TRPA staff for further refinement and analysis. [2]

1. Allow transfers across HRA boundaries for coverage transferred out of sensitive lands. **TRPA staff recommended advancing a revised version for further analysis.**
2. Allow coverage transfers across HRA boundaries to Centers to facilitate environmental redevelopment. **TRPA staff did not recommend advancing this option.**
3. Allow transfers across HRA boundaries for affordable housing and/or EIP projects. **TRPA staff did not recommend advancing this option.**
4. Develop an alternative approach that addresses watershed conditions and/or connectivity with Lake Tahoe and is more effective at meeting the HRA objectives while being simpler to administer. **TRPA staff recommended considering advancing a revised version of this option for further analysis.**
5. Redefine the HRA boundaries to follow jurisdictional boundaries. **TRPA staff did not recommend advancing this option.**
6. Allow transfers across HRAs to registered catchments that meet TMDL load reductions. **TRPA staff recommended considering advancing a revised version of this option for further analysis.**

Discussion Summary – Review of Options

- Lew Feldman discussed how most of the demand for transferred coverage serves public service and residential development projects. Basically, commercial is a non-issue and is not worth discussing. South Lake Tahoe redevelopment has retired over one million square feet of coverage and redevelopment will extend this trend. Hard to argue against option #1. We should address the larger policy issues such as how this would serve the needs of public service and residential projects. Public service and residential projects are not always located in Centers. In terms of residential projects, we may be approaching build-out though the numbers are not fully known. Since the receiving site will need BMPs to be in place, there will be an environmental benefit with this transfer. Since the residential demand might mostly be related to additions, there might not be as much new BMP retrofits for these projects. However there will still be a benefit from removing existing coverage from sending areas.

- Dan Siegel noted concern over the potential impairment from additional coverage in the heavily impacted watersheds such as by generating more algae growth in the nearshore by promoting certain transfers. Two of the proposals in concept appear to benefit Lake Tahoe the most - option #1 (coverage transfers from sensitive lands) and option #4 (IPES watershed approach where transfers occur from high to low impacted watersheds). Overarching concern limiting any concept is the focus on retiring existing coverage as opposed to potential coverage.

[2] Coverage Transfers Across HRAs Working Group #2 Staff Summary offers more detail: http://www.trpa.org/wp-content/uploads/Coverage-Transfers-Across-HRAs-WG2_Staff-Summary_06-30_2014_FinalDraft.pdf

- Eoin Doherty asked about whether Attachment C (Average Loading from Different Land Uses) includes the loading from areas with no land-use development. This Attachment does not include the loading values from different types of undeveloped areas. Bob Larsen noted that undeveloped land uses do have loading concentrations though it varies depending on the environmental conditions. For example, steep lands have high erosion potential and higher natural loading.

- Eoin Doherty suggested a catchment scale approach and supported the inclusion of community wide projects as an addition to option #6 to reduce the cost of modelling loads at the project scale.

- Steve Buelna pointed out that we could try different options, then monitor/track the outcomes of the different tools, and review the progress (or lack thereof) during the four year review cycle. Perhaps this group should look at all of the options and examine how they work over time.

- Dan Siegel felt that option #1 and option #4 are the most practical. However, Bob Larsen pointed out how option #4 would be complex since we do not have a firm and consistent definition of hydrological connectively and since the approach would need to be developed. Dan suggested that the group discuss option #1 and look at option #4 and the near shore conditions over the next 4-year review cycle.

<u>Public Comments</u>

Ann Nichols (North Tahoe Preservation Alliance):

- Martis Valley wants over 1 million square feet of coverage in Agate Bay. Where is that going to come from? There are many resort recreation projects underway. There are many questions and policy issues to address.

Laurel Ames (Tahoe Area Sierra Club):

- This report raises lots of question, such as where is resort recreation coverage going to come from? Since there are only models and no monitoring, we really don't know what we are getting.

Lew Feldman (Working Group member):

- Point of clarification – Resort Recreation areas are limited to base allowable coverage and Resort Recreation does not have anything to do with coverage transfers across HRAs.

Jennifer Quashnick (Friends of West Shore):

- Felt it was premature to make a decision. Thought the TMDL is not functioning since there was runoff out of pipe with a filter. RPU says to transfer from sensitive lands and now it shows there is no capacity. We first need a better understanding of the unique conditions such as related to the biology. What type of environmental review will be involved?

<u>Discussion Summary - Recommendations</u>

- Shannon Eckmeyer recalled that the Bi-State Work Group could not gain consensus on this topic and that is why the group is meeting. There are current limitations on transferring coverage out of sensitive lands that we should address.

- Eva Krause suggested changing the goal to decrease the loading to Lake Tahoe (in other words, we want a net reduction between the sending and receiving parcel).

- Eoin Doherty recommended another option – the allowance of coverage transfers across HRAs only if it is existing hard coverage that is restored. This would be a significant benefit over potential coverage.

- Dan Siegel suggested modifications/caveats to option #1 to create another proposal (final version noted only).
    - **<u>Modified Option #1</u> - Allow transfers across HRAs if 1) it is existing coverage (soft or hard), 2) it is sent from environmentally sensitive areas with land capability classifications 1-3 to high capability lands classified from 4 to 7 or some other equivalent values from the IPES scores, and 3) it is transferred to an area further than 300 feet from the shorezone.** *The earlier version excluding Land Capability 4 areas and limited it to hard coverage.* To allow this transfer, TRPA analysis should determine that there are no nearshore impacts and determine that there would be a net load reduction (not through modeling but through an environmental finding).

    - Charles Donohue pointed out that you could develop less than 300 feet from the Lake and have fewer impacts than in an area with a direct connection to the upper watershed. Dan Siegel noted that this is a crude approach similar to the Regional Plan Update since the analysis cannot be completed in time for option #4.

    - Shannon Eckmeyer stated that this is not the end all; rather it is something we can have in place until the next 4-year review and detailed analysis could be completed for option #4.

    - Eoin Doherty noted that projects will not purchase existing coverage in sensitive land for expansions; rather the land bank would have to facilitate this. Then Kevin Prior pointed out that the California Land Bank currently has no hard coverage inventory to facilitate this approach.

- Dan Siegel emphasized focusing on option #4 to ensure that the approach does not incur impacts to the nearshore. Then, Charles Donohue pointed out that there is not enough funding and resources to analyze option #4. Bob Twiss noted the cross purposes of option #4. Transfers of development should take the watershed conditions into account.

- Eoin Doherty advocated a short term solution and suggested that long term solutions focus on site specific assessments. Though Dan Siegel pointed out that a site specific approach would be too expensive to implement since only large projects could accomplish the modelling. Eoin clarified that the long term analysis could be done for the entire basin.

- Bob Twiss stated that you can't ignore watershed and sub-watershed conditions and noted that the group needs a better understanding of nearshore conditions so we know where to address these concerns. Need a mix of approaches and we need experts to identify where the problem areas are located.

- Eoin Doherty suggested that the modified option #1 would not be viable with all the restrictions. Though Dan Siegel responded that existing coverage has more of an environmental gain than potential coverage. Steve Buelna stated that the group needs to be closer to the middle ground to

gain his support. These stipulations won't actually have benefits on the ground and in the end; we won't actually get any usage. Though Shannon Eckmeyer noted that this is a big change that merits environmental review and with additional time, a compromise and constructive solution will emerge. Eoin pointed out that 90% of the current land bank transactions are for potential coverage not existing coverage. Dan noted that there will not be as much of an environmental gain with potential coverage and that we need to try and avoid over-impacting watersheds. Lew noted that 40% of sending parcels have BMPs and the rest don't so we'll have an environmental benefit with these new BMPs.

- Kevin Prior asked for clarification – restoration credits can get transferred across HRAs for public service projects? Adam Lewandowski responded, yes that is correct.

- Charles Donohue emphasized that a goal is to facilitate residential transactions. Since we have a 4 year update coming up, how about limiting it to residential transfers where we can get BMP benefits? In addition, how about not allowing coverage transfers between NV and CA? Though other working group members wanted inter-state transfer flexibilities.

- Dan Siegel noted the need for a resolution that we can live with and stated that we are trying to find a compromise.

- Eva Krause stated that she cannot support anything where the land banks can't use the potential coverage they have currently banked. Eva noted that the modified option #1 proposal has too many caveats for them to be feasible. The purpose is to facilitate project enablement and assist people to build projects and do BMPs.

- Eoin Doherty: Multiple Working Group members believe transfers of restored existing hard or soft coverage on average will provide significant benefit because the restored coverage most likely did not have BMPs and thus were generating pollutant loading to the lake, while the receiving site will be required to have BMPS and thus will generate no to little pollutant loading. Requiring coverage to not only be existing hard or soft coverage, but also from sensitive sites in order to transfer the coverage across HRAs will significantly reduce the potential supply of coverage that can be transferred and thus limit the number of transfers across HRAs, which will limit environmental and economic benefit that could be generated.

<u>Public Comments</u>

Steve Teshara:

- Felt there is no consensus process in place for this meeting – you are just negotiating on the spot and overthinking this decision. The quantities are small; consequently the risk is low. We will miss an opportunity if the simplest solution - Option #1 is not moved forward.
- Questioned when excess coverage mitigation fees were last updated? They should be adjusted to equal the market value.

Jennifer Quashnick (Friends of West Shore):

- Felt the group needed to take more time to do the research and gain information needed to make decisions. Get the information first to answer questions.

Bob Larsen (Lahontan Regional Water Quality Control Board):

- Pointed out that the amount of coverage and nearshore water quality conditions (attached algae) do not correlate if you look at the mapping provided in the group packet. The nearshore information has been provided and assumptions by Friends of West Shore have not been substantiated.

Laurel Ames (Tahoe Area Sierra Club):

- Pointed out that the map only examines attached algal and it does not consider floating algae.

Requested Action: Identify the top recommendation, or prioritize the top two or three alternatives for further refinement and analysis in anticipation of a final recommendation on August 20, 2014.

The group recommended advancing a modified option #1 in the near term and future prioritization of option #4. The Working Group unanimously agreed to advance these options, although a majority of working group members felt that the modified version of Option 1 was too restrictive and would limit the coverage restoration, project enablement, and BMP acceleration benefits that could result from a less restrictive version. Other Working Group members felt that option 4 was preferable, and that the modified version of Option 1 represented a reasonable compromise with restrictions to prevent unintended impacts.

4. Future Meeting Date: Next meeting date from 1:30 pm to 4:30 pm on Wednesday August 20, 2014.

- Suggested Topic for Next Meeting: Presentations and discussion on the current excess coverage mitigation fee program and identify opportunities for improvement.

Data Needs for Excess Coverage Mitigation Fee Discussions:

1. Presentations from Land Banks on potential options to improve the use of excess coverage mitigation fees
2. Determine when coverage is actually mitigated – coverage reduction on the ground vs. writing a check.
3. What are the economic consequences of excess coverage mitigation fees and how do they affect land banks?

ATTACHMENT A

Coverage Transfers Across HRAs Working Group Approach and Objectives

- Conceptual Approach: Develop feasible and implementable policies and/or other recommendations addressing coverage transfers across HRAs that protect and enhance water quality and meet project objectives.
- Objective I: Support Regional Plan goals including but not limited to protecting and enhancing water quality, accelerating restoration of sensitive lands, facilitating environmental redevelopment of Centers, and promoting affordable housing.
- Objective II: Address limitations, market inefficiencies and other constraints with the existing coverage transfer provisions while maintaining environmental protections.
- Objective III: Simplify operational processes and increase policy flexibility, transparency and accountability to reduce project costs that inhibit beneficial restoration and redevelopment projects, and to enable the policies to be administered at a reasonable cost, while maintaining environmental protections.
- Objective IV: Support effective private and public sector investments, while maintaining environmental protections.
- Objective V: Avoid or minimize unintended environmental effects.
- Objective VI: Focus on the detailed review of coverage transfers across hydrologic zones. Other topics outside the scope may be recommended for future Governing Board prioritization.

ATTACHMENT B

Coverage Transfer Options

Coverage Transfer Working Group

July 8, 2014

1. Allow transfers out of sensitive land across HRAs
2. Allow transfers into Centers across HRAs
3. Allow transfers for affordable housing and/or EIP projects across HRAs
4. Develop an alternative watershed or connectivity based approach
5. Redefine HRAs to follow jurisdictional boundaries
6. Allow transfers across HRAs to registered catchments that meet TMDL load reductions

Option 1: Allow transfers out of sensitive land across HRAs

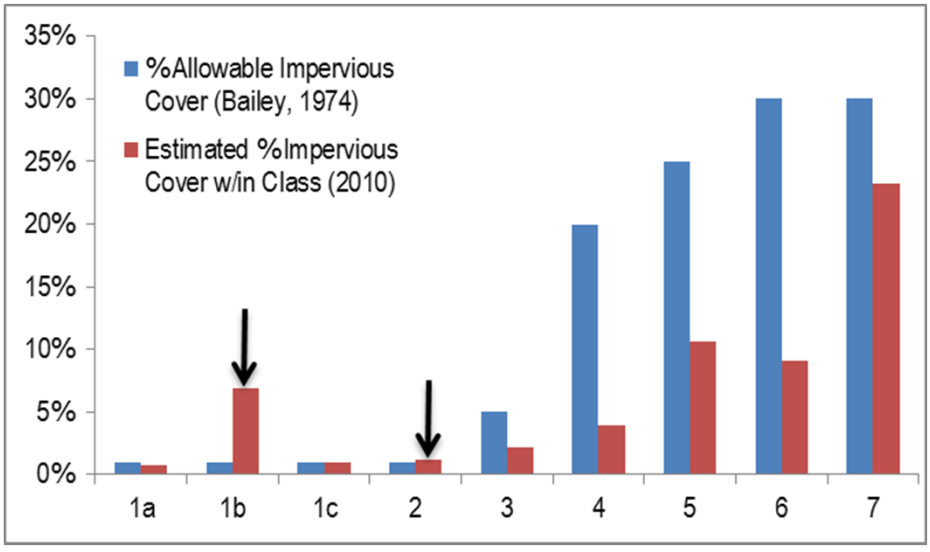
Pros:

- Significantly accelerate coverage removal from sensitive lands (direct threshold benefit)
- Easy to implement and administer
- Benefit all project types seeking coverage

Cons:

- Provide no additional mechanism to address variations in receiving sites

Status of Coverage Threshold[1]



Option 2: Allow transfers into Centers across HRAs

Pros:

- Reduce sprawl and promote compact land use pattern
- Easy to implement and administer

Cons:

- Provide no additional mechanism to address variations in receiving sites
- Significant coverage is already available in Centers resulting in limited ability to accelerate coverage reduction by changing HRA restrictions

Existing Coverage in Centers

Center	Total Percent Covered[2]	Percent of SEZ covered[2]
Tahoe City	41%	25%
Kings Beach	44%	18%
North Stateline	57%	1%
Incline	47%	2%
High Density Tourist District	68%	9%
Kingsbury	57%	3%
Meyers	37%	13%
Regional Center	75%	35%
Stateline/ Ski Run	48%	12%
Bijou/ Al Tahoe	64%	1%
South Y	49%	15%

Estimated Maximum Coverage transfers into Centers

Approach	Max Transferred Coverage Estimate
Full build out of land use commodities in Centers[3]	**64** acres
Maximum allowable coverage for private parcels[4]	**55** acres

Option 3: Allow transfers for affordable housing and/or EIP projects across HRAs

Pros:

- Help facilitate beneficial EIP & affordable housing projects

Cons:

- Provide no additional mechanism to address variations in receiving sites
- Very little unmet demand resulting in limited ability to accelerate coverage reduction by changing HRA restrictions

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Option 4: Develop an alternative watershed or connectivity based approach

Recommended refinements to approach:

1) Use existing IPES watershed condition score
2) Consider individual watershed ranks vs. watershed categories
3) Consider allowing transfer across HRAs based on watershed condition vs. replacing HRAs

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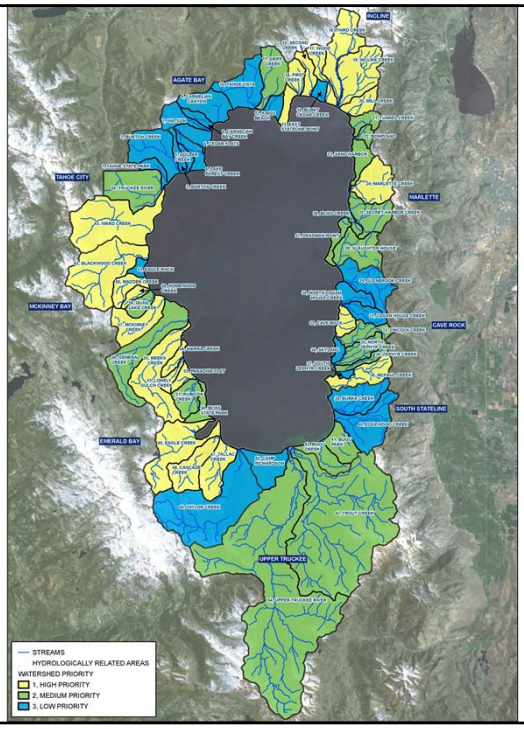
IPES Watershed Condition Score



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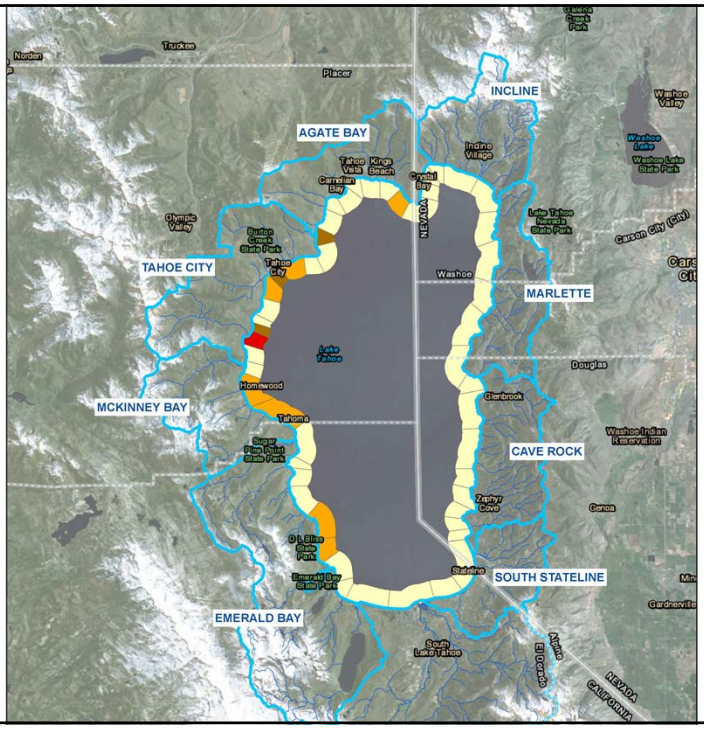
Nearshore Attached Algae



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Option 4 (revised): Allow coverage transfers to watersheds in better condition based on IPES watershed scores

Pros:

- Provide additional mechanisms to address variations in receiving site conditions
- Benefit all project types seeking coverage

Cons:

- Based on static estimates of watershed conditions
- Would accelerate coverage removal in some watersheds but decelerate in others
- Could promote a more spread-out land use pattern

Option 5: Redefine HRAs to follow jurisdictional boundaries

Pros:

- Significantly accelerate coverage removal
- Easy to implement and administer
- Benefit all project types seeking coverage

Cons:

- Provide no additional mechanism to address variations in receiving sites

Option 6: Allow transfers across HRAs to registered catchments that meet TMDL load reductions

Recommended refinements to approach:

1) Use TMDL load reduction models to evaluate loading impact of individual coverage transfer proposals
2) Only allow transfers across HRAs if it does not increase loading

Option 6 (revised): Allow transfers across HRAs if loading analysis shows no increase

Pros:

- Provide an additional site-specific assessment of effects at receiving site

Cons:

- Places an additional financial burden on project applicants, which could:
  - Limit the increases in coverage removal from transfers
  - Only be feasible for larger-scale projects

References

1. Final 2011 Threshold Evaluation Report, December 2012
2. LIDAR data analysis, Attachment A of Working Group packet
3. Regional Plan Draft EIS, Table 3.7-8
4. Regional Plan Final EIS, Vol. 1, Appendix C, Table C-2
5. TRPA Code, Table 53.11.5-1; and Code Sec. 60.4.4.A
6. Heyvaert, A.C., Reuter, J.E., Chandra, S., Susfalk, R.B., Schaldow, S.G. Hackley, S.H. 2013. Lake Tahoe Nearshore Evaluation and Monitoring Framework. Final Report prepared for the USDA Forest Service Pacific Southwest Research Station).

ATTACHMENT C

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"Helping preserve the natural beauty and rural character of North Lake Tahoe"

To: TRPA
Comments on Coverage Transfer Across HRAs
July 8, 2014

1. Transfers across HRA Boundaries should only be allowed for existing coverage (not potential coverage) transferred out of SEZs. Since there is an abundance of SEZ sensitive lands at Lake Tahoe the potential receiving lands/watersheds must be analyzed for carrying capacity before this program is approved by TRPA.

2. TMDL is not working! (See the attached documentation from the Tahoe Resource Conservation District.) The filter systems are unable to reduce the fine sediments to any significant degree.

   Consider the data on the Pasadena Pipe, which has two Contech Stormfilter Vaults in parallel.
   For QU/QC data 10/1/13-2/10/14

   Inflow is 479 NTUs and outflow is 477
   Inflow is 445 NTUs and outflow is 448

   Event ID PI-14-02 (rain/snow)
   Inflow is 82 NTUs and outflow is 282 NTUs (a huge increase)

   Event ID PI-14-02 (rain/snow)
   Inflow is 84 NTUs and outflor is 83 NTUs

   These number aren't even close to the targeted reduction to 14 NTUs. Look at the other measured sites and you'll see disappointing data.

   Before TRPA even considers any change to HRAs or further implementation of the RPU, the failure of TMDL must be addressed.

Implementers' Monitoring Program (IMP)

Component of the
Regional Storm Water Monitoring Program (RSWMP)

Pasadena

The Pasadena monitoring site is located at the northern most end of Pasadena Ave. in the City of South Lake Tahoe. It is monitored as a catchment outfall and BMP effectiveness site. A 36-inch outfall CMP emerging from the side of the steep slope at the end of Pasadena Ave conveys runoff directly to Lake Tahoe. The pipe is the terminus of a 78.9 acre catchment designated the "G12 basin" by the City of South Lake Tahoe. The dominant land uses are moderate density single and multi-family residential and secondary roads. Thirty-nine percent of the catchment is impervious. Two Contech Stormfilter vaults were installed in parallel at the end of the catchment before discharge to the lake through the 36-inch CMP. Pasadena In (PI) is a monitoring station located at the inflow to the Stormfilter vaults, and Pasadena Out (PO) is located in the 36-inch outfall CMP, the outflow from the Stormfilter vaults.

Table 1 summarizes the selected catchments, monitoring sites and their corresponding designation as catchment outfall and/or BMP effectiveness project. Also included are existence/absence of a continuous turbidimeter and total catchment area.

Table 1: Monitoring station specifics.

Catchment (Site) Name	Station Name	Station Acronym	Catchment Area (acres)	Outfall	BMP	Turbidi-meter
Tahoma	Tahoma	TA	49.5	√		√
Incline Village	Incline Village	IV	83.6	√		√
Pasadena	Pasadena In	PI	78.9		√	√
	Pasadena Out	PO		√	√	√
Rubicon	Rubicon In	RI	13.8		√	
	Rubicon Out	RO		√	√	
SR431	Contech In	CI	0.61		√	√
	Contech Out	CO			√	√
	Jellyfish In	JI			√	√
	Jellyfish Out	JO			√	√
	SR431 Outfall	S5		√		√

RAW ANALYTICAL DATA

Table 4 summarizes all available raw analytical data available through February 10, 2014. Laboratory results are pending because data can take up to two months to become available due to staff time to enter results and QA/QC procedures regarding data input and management. The Sample ID is comprised of a two letter monitoring site acronym and a two letter sample type acronym (see Tables 1 and 2 for acronym meanings).

Table 4: Raw analytical data October 1, 2013 – February 10, 2014. *All data is preliminary and subject to change.*

Project	Sample ID	Sample Type	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	NO3+NO4 (um/L)	TKN (um/L)	TN (um/L)	TP (um/L)
IMP	IV-FF	first flush	1/11/14 12:43	121	218	pending	pending	pending	pending	pending
IMP	IV-AC	rising limb	1/11/14 13:06	514	1236	pending	pending	pending	pending	pending
IMP	IV-AC	falling limb	1/11/14 14:15	335	865	pending	pending	pending	pending	pending
IMP	IV-PT	PSD/turb	1/11/14 13:29	na	1438	pending	na	na	na	na
IMP	IV-PT	PSD/turb	1/11/14 14:15	na	727	pending	na	na	na	na
IMP	TA-AC	rising limb	1/11/14 13:55	274	944	pending	pending	pending	pending	pending
IMP	TA-AC	falling limb	1/11/14 15:18	655	835	pending	pending	pending	pending	pending
IMP	TA-PT	PSD/turb	1/11/14 14:11	na	981	pending	na	na	na	na
IMP	TA-PT	PSD/turb	1/11/14 15:18	na	779	pending	na	na	na	na
IMP	IV-FF	first flush	1/29/14 13:33	559	1178	pending	pending	pending	pending	pending
IMP	IV-AC	rising limb	1/29/14 13:59	293	536	pending	pending	pending	pending	pending
IMP	IV-AC	falling limb	1/29/14 21:15	45.0	68.5	pending	pending	pending	pending	pending
IMP	IV-PT	PSD/turb	1/29/14 14:27	na	573	pending	na	na	na	na
IMP	IV-PT	PSD/turb	1/29/14 23:30	na	60.3	pending	na	na	na	na
IMP	PI-FF	first flush	1/29/14 15:15	273	525	pending	pending	pending	pending	pending
IMP	PI-AC	rising limb	1/29/14 15:28	143	68.5	pending	pending	pending	pending	pending
IMP	PI-AC	falling limb	1/29/14 22:42	79.0	94.4	pending	pending	pending	pending	pending
IMP	PI-PT	PSD/turb	1/29/14 18:08	na	221	pending	na	na	na	na
IMP	PI-PT	PSD/turb	1/29/14 19:19	na	108	pending	na	na	na	na
IMP	PO-FF	first flush	1/29/14 15:52	505	508	pending	pending	pending	pending	pending
IMP	PO-AC	rising limb	1/29/14 16:02	171	312	pending	pending	pending	pending	pending
IMP	PO-AC	falling limb	1/30/14 1:17	193	165	pending	pending	pending	pending	pending
IMP	PO-PT	PSD/turb	1/29/14 16:18	na	346	pending	na	na	na	na
IMP	PO-PT	PSD/turb	1/29/14 16:53	na	396	pending	na	na	na	na
IMP	RI-FF	first flush	1/29/14 12:33	338	351	pending	pending	pending	pending	pending
IMP	RI-AC	rising limb	1/29/14 13:03	53.0	33.1	pending	pending	pending	pending	pending
IMP	RI-AC	falling limb	1/29/14 19:10	4.40	4.18	pending	pending	pending	pending	pending
IMP	RI-PT	PSD/turb	1/29/14 13:37	na	108	pending	na	na	na	na
IMP	RI-PT	PSD/turb	1/29/14 16:02	na	29.0	pending	na	na	na	na
IMP	CI-FF	first flush	pending	pending	pending	pending	pending	pending	pending	pending
IMP	CI-AC	rising limb	pending	pending	pending	pending	pending	pending	pending	pending
IMP	CI-AC	falling limb	pending	pending	pending	pending	pending	pending	pending	pending
IMP	CI-PT	PSD/turb	pending	pending	pending	pending	na	na	na	na
IMP	CI-PT	PSD/turb	pending	pending	pending	pending	na	na	na	na
IMP	CO-FF	first flush	pending	pending	pending	pending	pending	pending	pending	pending
IMP	CO-AC	rising limb	pending	pending	pending	pending	pending	pending	pending	pending
IMP	CO-AC	falling limb	pending	pending	pending	pending	pending	pending	pending	pending
IMP	CO-PT	PSD/turb	pending	pending	pending	pending	na	na	na	na
IMP	CO-PT	PSD/turb	pending	pending	pending	pending	na	na	na	na

Table 5: QA/QC data October 1, 2013 – February 10, 2014. *All data is preliminary and subject to change.*

Project	Sample ID	Sample Type	Date Time	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	NO3+NO4 (um/L)	TKN (um/L)	TN (um/L)	TP (um/L)
IMP	IV-FB	QA/QC	1/11/14 21:38	<0.4	0.16	pending	pending	pending	pending	pending
IMP	IV-MS	QA/QC	1/11/14 15:06	361	865	pending	pending	pending	pending	pending
IMP	IV-MS	QA/QC	1/11/14 15:07	367	887	pending	pending	pending	pending	pending
IMP	TA-FB	QA/QC	1/11/14 15:44	<0.4	0.18	pending	pending	pending	pending	pending
IMP	TA-MS	QA/QC	1/11/14 16:45	429	662	pending	pending	pending	pending	pending
IMP	TA-MS	QA/QC	1/11/14 16:46	380	605	pending	pending	pending	pending	pending
IMP	IV-FB	QA/QC	1/29/14 14:35	<0.4	0.11	pending	pending	pending	pending	pending
IMP	IV-MS	QA/QC	1/29/14 14:13	562	528	pending	pending	pending	pending	pending
IMP	IV-MS	QA/QC	1/29/14 14:14	495	639	pending	pending	pending	pending	pending
IMP	RI-FB	QA/QC	1/29/14 15:37	<0.4	0.46	pending	pending	pending	pending	pending
IMP	RI-MS	QA/QC	1/29/14 15:35	80.8	56.7	pending	pending	pending	pending	pending
IMP	RI-MS	QA/QC	1/29/14 15:36	76.8	41.9	pending	pending	pending	pending	pending
IMP	S5-FB	QA/QC	1/29/14 15:21	<0.4	0.16	pending	pending	pending	pending	pending
IMP	TA-FB	QA/QC	1/29/14 16:15	<0.4	0.17	pending	pending	pending	pending	pending
IMP	TA-GS	QA/QC	1/29/14 12:44	2130	2133	pending	pending	pending	pending	pending
IMP	TA-MS	QA/QC	1/29/14 12:45	2184	2268	pending	pending	pending	pending	pending
IMP	PI-FB	QA/QC	2/8/14 11:15	<0.4	0.10	pending	pending	pending	pending	pending
IMP	PI-MS	QA/QC	2/8/14 11:03	253	479	pending	pending	pending	pending	pending
IMP	PI-MS	QA/QC	2/8/14 11:04	253	477	pending	pending	pending	pending	pending
IMP	PO-FB	QA/QC	2/8/14 11:10	<0.4	0.22	pending	pending	pending	pending	pending
IMP	PO-MS	QA/QC	2/8/14 11:16	226	445	pending	pending	pending	pending	pending
IMP	PO-MS	QA/QC	2/8/14 11:17	230	448	pending	pending	pending	pending	pending
IMP	TA-GS	QA/QC	2/9/14 11:25	62.0	52.0	pending	pending	pending	pending	pending
IMP	TA-MS	QA/QC	2/9/14 11:26	79.6	57.3	pending	pending	pending	pending	pending

DATA MANAGEMENT PROCEDURE

Data was offloaded from the auto-samplers with data transfer devices at the time samples were collected or maintenance was required. Any other field measurements and observations were recorded in a field notebook. Samples, data transfer devices and notes were transported to a processing lab immediately after collection. Data transfer devices were offloaded from the site, and all data was input into an Excel template for storing continuous parameters as well as sample dates and times. A separate Excel template was also used for calculating flow-weighted compositing schedules for the rising and falling limb composites at each monitoring station. All samples were measured for turbidity and filtered for TSS; values were recorded on standard data sheets in the laboratory and entered into an Excel template for storing turbidity, nutrient and sediment data. All samples were sent to proper laboratories within appropriate holding times for total phosphorus, total nitrogen, and particle size distribution (FSP) analysis. Results from analytical laboratories are entered into the same Excel template for storing turbidity, nutrient and sediment data. All Excel workbooks are housed on one central computer (with backup device) and managed by District staff.

	Location	Event ID	TN (um/L)	TP (um/L)	0.5 µm (volume %)	<1 µm (volume %)	<2 µm (volume %)	<4 µm (volume %)	<8 µm (volume %)	<16 µm (volume %)	<20 µm (volume %)	<63 µm (volume %)	<125 µm (volume %)	<250 µm (volume %)	<500 µm (volume %)	<1000 µm (volume %)	<2000 µm (volume %)	Notes
ıe	Outfall	IV-14-01	1,555	1,114	0.61	6.22	16.8	31.8	56.9	79.4	85.5	100	100	100	100	100	100	
ma	Outfall	TA-14-01	3,782	1,015	0.90	9.11	23.7	39.9	61.7	78.6	83.8	100	100	100	100	100	100	
ıe	Outfall	IV-14-02	1,556	1,117	0.62	6.41	17.7	33.2	56.5	76.1	81.6	98.2	100	100	100	100	100	
ena	Inflow	PI-14-01	1,884	873	0.38	3.82	10.1	20.0	36.9	55.9	62.8	94.5	97.7	100	100	100	100	
ena	Outfall	PO-14-01	2,583	980	0.38	3.85	9.9	19.7	37.5	60.1	68.3	98.4	99.3	100	100	100	100	
con	Inflow	RI-14-01	378	259	0.51	4.25	10.1	19.5	34.0	51.9	56.7	78.3	78.6	78.6	78.6	100	100	
31	Outfall	S5-14-01	726	57	0.50	5.21	14.5	27.7	48.1	66.9	72.6	93.3	100	100	100	100	100	
ma	Outfall	TA-14-02	1,408	318	0.31	3.07	7.8	14.3	25.9	41.6	48.2	85.0	92.6	97.0	98.9	100	100	
ıe	Outfall	IV-14-03	944	587	0.58	5.35	13.7	25.2	45.4	68.0	75.5	100	100	100	100	100	100	
ena	Inflow	PI-14-02	940	440	0.46	4.41	11.8	22.6	41.1	59.4	66.3	94.5	97.5	100	100	100	100	
ena	Outfall	PO-14-02	544	404	0.62	5.68	15.2	29.0	51.4	70.6	77.2	99.3	100	100	100	100	100	
con	Inflow	RI-14-02	261	95	0.56	3.66	6.8	12.7	23.2	36.2	42.7	76.7	87.2	100	100	100	100	
ma	Outfall	TA-14-03	235	341	0.57	4.83	11.8	21.3	37.8	55.7	61.7	92.9	97.1	100	100	100	100	
31	Outfall	S5-14-02	1,714	922	0.45	4.83	14.3	30.1	54.6	76.5	83.2	100	100	100	100	100	100	
ma	Outfall	TA-14-04	793	984	0.58	5.81	15.2	27.9	47.8	67.1	73.8	99.2	100	100	100	100	100	
ma	Outfall	TA-14-05	346	55	na	na	na	na	na	na	na	na	na	na	na	na	na	Too clear, PSD unreadable
con	Inflow	RI-14-03	417	157	1.49	10.1	24.1	44.2	74.4	87.4	91.1	99.8	100	100	100	100	100	
ma	Outfall	TA-14-06	1,510	942	0.72	6.46	17.0	30.8	54.7	72.3	80.3	100	100	100	100	100	100	
ma	Outfall	TA-14-07	1,554	1,116	0.65	6.17	15.8	29.2	51.6	71.6	79.3	99.5	100	100	100	100	100	

ect	Site	Location	Event ID	Runoff Start (Date Time)	Runoff End (Date Time)	Runoff Duration (hh:mm)	Peak Flow (cfs)	Runoff Volume (cf)	Storm Total (inches)	Type of Runoff	Sample Pacing Set	Samples Collected	Singles Analyzed	Composites Analyzed	% of Storm Sampled	Sampling Start (Date Time)	Sample Type or EMC	Sampling End (Date Time)	Interval Volume (cf)	TSS (mg/L)	Turbidity (NTU)	FSP (mg/L)	NO3+NO 4 (um/L)	T (u
P	Incline	Outfall	IV-14-01	1/11/14 12:40	1/11/14 18:50	6:10	0.08	757	0.28	rain/snow	100cf	8	1	2	90%	3/6/14 1:14	EMC	3/30/14 14:33	3,856	269	334	193	53	1,
P	Tahoma	Outfall	TA-14-01	1/11/14 11:30	1/11/14 22:10	10:40	0.16	2,048	0.52	rain/snow	100cf	13	0	2	75%	1/11/14 13:55	EMC	1/11/14 19:15	2,047	486	884	383	227	3,
P	Incline	Outfall	IV-14-02	1/29/14 13:30	1/30/14 5:00	15:30	0.15	3,207	0.94	rain/snow	200cf	15	1	2	100%	3/30/14 5:03	EMC	3/30/14 14:33	7,577	267	331	191	54	1,
P	Pasadena	Inflow	PI-14-01	1/29/14 15:10	1/30/14 3:40	12:30	0.87	10,109	1.54	rain/snow	500cf	14	1	2	70%	1/29/14 15:15	EMC	1/30/14 1:45	10,109	110	82	64	157	1,
P	Pasadena	Outfall	PO-14-01	1/29/14 15:50	1/30/14 2:40	10:50	0.55	10,072	1.54	rain/snow	100cf	18	1	2	100%	1/29/14 15:52	EMC	1/30/14 1:45	10,072	185	282	110	232	2,
P	Rubicon	Inflow	RI-14-01	1/29/14 12:30	1/30/14 2:30	14:00	0.11	392	3.29	rain/snow	100cf	20	1	2	100%	1/29/14 13:03	EMC	1/30/14 1:20	1,829	43	27	28	14	3
P	SR431	Outfall	S5-14-01	1/29/14 15:20	1/30/14 1:20	10:00	0.02	180	1.09	rain on snow	100cf	2	2	0	10%	1/29/14 15:22	EMC	1/29/14 16:27	180	95	141	63	45	6
P	Tahoma	Outfall	TA-14-02	1/29/14 9:10	1/30/14 2:20	17:10	1.30	34,160	2.79	rain/snow	2,000cf	21	1	2	100%	1/29/14 9:17	EMC	1/30/14 1:05	34,160	262	309	120	40	1,
P	Incline	Outfall	IV-14-03	2/8/14 7:00	2/10/14 21:30	62:30	0.81	23,950	pending	rain on snow	250-750cf	25	1	2	85%	2/8/14 8:08	EMC	2/10/14 2:59	23,950	151	170	103	46	8
P	Pasadena	Inflow	PI-14-02	2/8/14 9:10	2/10/14 5:20	44:10	1.45	90,918	3.93	rain/snow	1,000-10,000cf	24	1	2	100%	2/8/14 9:15	EMC	1/30/14 1:45	90,918	77	84	46	36	9
P	Pasadena	Outfall	PO-14-02	2/8/14 9:20	2/10/14 6:30	45:10	1.54	90,934	3.93	rain/snow	1,000-10,000cf	17	1	2	100%	2/8/14 9:28	EMC	2/9/14 17:11	90,934	64	83	46	21	5
P	Rubicon	Inflow	RI-14-02	2/8/14 2:50	2/10/14 4:50	50:00	0.40	16,441	5.60	rain/snow	100-500cf	18	1	2	100%	2/8/14 2:59	EMC	2/10/14 1:52	16,441	29	14	11	5	2
P	Tahoma	Outfall	TA-14-03	2/8/14 1:20	2/10/14 4:30	51:10	1.76	120,236	9.32	rain/snow	1,000-15,000cf	23	1	3	100%	2/8/2014 1:52	EMC	2/9/14 22:46	120,236	86	73	51	16	2
P	SR431	Outfall	S5-14-02	3/5/14 23:50	3/6/14 3:00	3:10	0.04	200	pending	rain on snow	50cf	2	2	0	10%	3/6/14 0:52	EMC	3/6/14 1:14	200	416	515	319	31	1,
P	Tahoma	Outfall	TA-14-04	3/5/14 22:20	3/6/14 8:40	10:20	0.58	5,672	0.05	rain on snow	500cf	12	1	2	100%	3/5/14 23:29	EMC	3/6/14 6:11	5,673	287	291	179	9	7
P	Tahoma	Outfall	TA-14-05	3/14/14 16:00	3/16/14 16:00	48:00	0.005	175	na	non-event snowmelt	2hr	24	0	2	100%	3/14/14 16:33	EMC	3/16/14 14:33	176	5	9	na	111	2
P	Rubicon	Inflow	RI-14-03	3/25/14 20:20	3/26/14 20:50	24:30	0.06	1,073	0.47	event snowmelt	100cf	13	1	2	100%	3/25/14 20:21	EMC	3/26/14 19:33	1,072	18	22	16	21	3
P	Tahoma	Outfall	TA-14-06	3/29/14 3:00	3/29/14 17:00	14:00	1.89	10,630	0.37	rain	200-500cf	20	1	2	100%	3/29/14 3:02	EMC	3/29/14 14:55	10,631	237	324	170	185	1,
P	Tahoma	Outfall	TA-14-07	3/30/14 2:40	3/30/14 23:50	21:10	0.48	3,735	0.50	snow	200cf	14	1	2	70%	3/30/14 2:48	EMC	3/30/14 14:33	3,735	263	326	188	54	1,

Lahontan Regional Water Quality Control Board
Attn: Mr. Daniel Sussman
971 Silver Dollar Avenue
South Lake Tahoe, CA 96150

February 12, 2014

Subject: Comments on Lake Tahoe Nearshore Update – Draft Nearshore Water Quality Protection Plan

Dear Members of the Lahontan Regional Water Quality Control Board and Mr. Sussman:

Thank you for the opportunity to comment on the draft Lake Tahoe Nearshore Water Quality Protection Plan ("Nearshore Plan").

As expressed during the 1/30/2014 public workshop, we are concerned that the Nearshore Plan fails to include sufficient and direct monitoring to evaluate the relationship between development and activities on the lands near the shore and conditions in the Lake's nearshore. If the suggested causes are not adequately monitored in connection with the impacts, determining the most appropriate control measures, and assessing how effective they are, will be exceedingly difficult.

We note that the mid-lake clarity study, reports, and decisions took ten years and ten million dollars. Since the DRI report[1] notes that the nearshore is more complicated, variable, and without the great amount of data available to the TMDL managers, it is important that this beginning monitoring program be as robust as possible, and treated as an extremely important study as the nearshore is the area that is most visible to the visitor and resident to the "Jewel of the Sierra".

While the table on page 12 of the draft Nearshore Plan is helpful, the details in the DRI report provide a much better understanding of these factors. However, not enough information is provided with the bulleted list on page 6 to assess whether and how the recommended metrics take into account the specific recommendations throughout Appendix B of the DRI report Questions include, but are not limited to:

- The proposed study does not appear to sufficiently address the impacts of boats on the nearshore. At the 1/30/2014 public meeting, we submitted a recent publication regarding boat impacts on nearshore conditions in Lake Tahoe,[2] and believe the monitoring program must assess the impacts of boat props stirring up the fish spawning substrate, and the fish feed and cover substrate. In addition, the boat props stir up the fine sediments and re-distribute them into the lake. Man's impacts on the nearshore are many and complicated, and a thorough understanding of those impacts is necessary to understand the nearshore reactions.
- Although the recommended metrics on p. 6 of the Draft plan include phytoplankton, it is unclear whether this metric will be based on existing measurements, or if the revisions suggested by the NeST on page B-21 will be used (e.g. "We suggest instead that the nearshore metric for phytoplankton be expressed as cell counts that identify both the species

[1] Lake Tahoe Nearshore Evaluation and Monitoring Framework, Final. October 15, 2013.
[2] Michael T. Alexander and Russell C. Wigart (2013). Effect of motorized watercraft on summer nearshore turbidity at Lake Tahoe, California-Nevada, Lake and Reservoir Management, 29:4, 247-256.

composition and their abundance."). The state standards noted on p. B-20 are based only on counts.

- Page B-25 includes a recommendation that numerical standards for periphyton (not just management or narrative standards) be developed. Will action be taken to add this recommendation, and if so, how will the monitoring program account for this (and when)?
- With regards to macrophytes, macroinvertebrates, fish, and crayfish, the NeST recommends a new indicator called "Community Structure." (p. B-52). The monitoring program needs to incorporate this recommendation.
- The draft Nearshore Plan notes: "Controllable factors, such as proximity of impervious surface to the lake, sewer line exfiltration and uncontrollable factors such as climate change and geology may be responsible for observed conditions. The nearshore agencies have identified increased periphyton growth on the northwest shore (from Tahoe City south through the outlets of Blackwood and Ward Creeks) as an initial hotspot to begin causal assessment analysis." (p. 8) [Emphasis added].
    - It is unclear how extensive the studies of causal factors in the northwest nearshore areas will be, and there appears no guarantee this will occur.
    - In addition, we are concerned that focusing solely on periphyton growth on the northwest shore fails to account for the floating algae affecting the nearshore in other areas of the Lake. For example, the nearshore bottom along South Shore will not have as much periphyton because there is far less substrate for it to attach to. However, as observations alone will attest, the floating algae in this area creates a significant negative visual impact. Further, as the Lahontan report also notes, impervious surfaces affect nearshore conditions; the existing and proposed development in several areas close to the Lake (by TRPA's Regional Plan Update) are significant, and changes must be clearly monitored and at a scale sufficient to identify local sources, impacts, and other factors.

We appreciate that this process is now moving forward and look forward to participating in same. Please feel free to contact Jennifer Quashnick at jqtahoe@sbcglobal.net or Laurel Ames at laurel@watershednetwork.org if you have any questions.

Sincerely,

Laurel Ames,
Conservation Chair,
Tahoe Area Sierra Club

Susan Gearhart,
President,
Friends of the West Shore

Jennifer Quashnick
Conservation Consultant
Friends of the West Shore

Investigation of Near Shore Turbidity at Lake Tahoe

Prepared in March 2002 for the Lahontan Regional Water Quality Control Board as part of Contract 00-117-160-0, and for The Nevada Department of State Lands as part of LTLD 01-008. Desert Research Institute, Division of Hydrologic Sciences Publication No. 41179.

Kendrick Taylor
Desert Research Institute
University and Community College System of Nevada

SUMMARY

The spatial and temporal variability of turbidity in the near shore zone of Lake Tahoe was investigated using an instrumented boat to map the spatial distribution of turbidity. 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. Undeveloped areas such as Rubicon and Deadman Point consistently had low turbidity. There is a strong correlation between elevated turbidity near the shore and development on the shore. It is likely that most of the clarity loss near the shore is caused by processes that occur along a small percentage of the lakeshore.

INTRODUCTION

Lake Tahoe is well known for its exceptional clarity. Maintaining this clarity is important for aesthetic, economic, public health and ecological reasons. The clarity of Lake Tahoe is most apparent near the shore, which we call the near shore zone and define as the portion of the lake that has a depth less than 7.5 m, or is within 100 m of shore, which ever extends further from shore. The near shore zone is similar to the littoral zone, which is the portion of the lake where enough light reaches the bottom for macrophytes (rooted plants) to grow. At Lake Tahoe the littoral zone is the portion of the lake were the depth is less than about 30 m; this can be a zone a few tens of meters to several kilometers wide. Except for atmospheric deposition all the clarity degrading material such as nutrients and particles that enter the lake pass through the near shore zone, making the near shore zone a good place to search for undesirable inflows to the lake. 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. The near shore zone is also be the portion of the lake that responds first to local restoration activities, because it is more influenced by local changes than the center of the lake.

The Tahoe Research Group at the University of California, Davis, has been monitoring the clarity of Lake Tahoe using a secchi disk for 34 years. This measures the greatest depth at which a black and white 20 cm diameter disk is visible. These measurements cannot be made in most of the near shore zone because the water depths are not greater than the 20 to 25 m depth at which the secchi disk commonly fades from view. There has been a progressive decline in clarity as measured by the secchi depth during the last 34 years.

Another measure of clarity is turbidity, which is a quantitative measure of how much light is scattered by the particles in a water sample. High turbidity water is murky, low turbidity water is clear. Turbidity is expressed in Nephelometric Turbidity units (NTU), which are based on standard concentrations of formazin in water. At Lake Tahoe clarity is traditionally thought of in terms of secchi depth, which is easier to understand than turbidity. For example it is easier to understand the significance of being able to see a dinner plate 30 meters below the surface, than the turbidity is 0.1 NTU. However, secchi measurements cannot be done in shallow water and are time consuming. Turbidity can be measured in water of any depth and can be measured continuously from a moving boat; this makes turbidity well suited for investigating the spatial variability of

water clarity in the near shore zone. Turbidity values at Lake Tahoe range from 0.06 NTU in the middle of the lake to greater than 4 NTU at Tahoe Keys. For reference filtered distilled water typically has a turbidity of 0.02 NTU and the EPA standard for drinking water is 0.5 NTU.

METHODS

For this project we primarily used two measurement systems, one for investigating spatial changes and the other for investigating temporal changes. The first system was on a moving boat and measured spatial changes in turbidity. The second system was fixed on a pier and measured the temporal variability of light attenuation. Light attenuation is a proxy measurement for turbidity.

Method 1: Spatial Measurements

The turbidity measurement system had a probe that extended in front of the boat. A submersible pump on the probe pumped water from a depth of ~1 m up to instruments on the boat. The water entered a glass tube (5 cm x 2 cm) in a Hach-2000 turbidity meter. The turbidity was determined by measuring the amount of light scattered at a 90-degree angle from an incoming light beam by water in the glass tube. The turbidity instrument was calibrated with formazin standards every three weeks, and with solid turbidity standards before and after each day of surveying. A computer read the voltage output of the turbidity meter. The computer also read the location of the boat from a global positioning system that has an accuracy of about 20 meters. The computer recorded the turbidity, time and boat location in a data file. This information was recorded every second, which corresponded to about one measurement for every 10 m of distance traveled. The computer also displayed a real time moving map that showed the track of the boat. The color of the boat track on the display was determined by the value of the turbidity at that location. The real time map display of turbidity and position allowed the operators to adjust the survey parameters in the field in response to areas of high turbidity.

On one survey a Turner 10-AU fluorometer was also used. After the water passed through the turbidity meter it entered the glass tube in the fluorometer. A monochromatic light shined on the water in the glass tube. Chlorophyll in the water fluoresced with a different wavelength of light. The amount of light fluoresced was proportional to the chlorophyll concentration in the water.

Surveys were repeated with a positioning accuracy of about 30 m. Typically the surveys were conducted 20-300 m offshore and the operator selected a distance that was free of obstacles such as buoys and boats. Under these conditions we operated at speeds of 15 to 20 kilometers an hour. Some surveys occurred within the obstacles at a slower speed. About 10% of each survey was immediately repeated. This was done by turning the boat around and repeating a portion of the survey. This was done occasionally when rapid changes in turbidity were observed. The survey data was processed to convert the recorded voltage and position values to meaningful units and files that are suitable for use by the geographic information system Arcview.

Method 2: Temporal Measurements

The second system measured the amount of light attenuation in the lake water over a 30 cm path. The instrument, a Hobilabs C-Beta, was lowered into the lake. A light source on the instrument shined a light beam to a light sensor located 30 cm away from the light source. The attenuation of

the light over the 30 cm path was expressed in units of % absorption/meter, or more commonly as 1/m. The optical design of the instrument reduced interference caused by sunlight.
The C-Beta had an internal data logger that allowed it to be moored at a fixed location and measure light attenuation at regular intervals. In this survey the light attenuation was measured every 20 minutes. This allowed a proxy for turbidity to be measured continuously at a fixed location without an operator. A rough empirical estimate of the relationship between turbidity and light attenuation was developed, but it should only be used to estimate changes in turbidity, not the absolute value of turbidity. With more effort a better relationship could be obtained.

SPATIAL SURVEY RESULTS

General Comments

The results of spatial surveys are displayed on maps that show the track of the boat in different colors. The color of the boat track is selected to represent a property of the water. For example, red indicates high turbidity, green indicates intermediate turbidity, and blue indicates low turbidity. The turbidity value assigned to the colors is different on different figures so small differences in turbidity relevant to the discussion can be displayed. With a few exceptions the surveys do not show how the turbidity changes perpendicular to the shore. When surveys where conducted away from the shore, the turbidity decreased with increasing distance from shore.

Short-term Variations

To investigate the short-term variability of turbidity several sets of surveys were carried out a few days to weeks apart. Figure 1 shows two surveys made of the lakeshore 11 days apart in September 2001. The high turbidity areas with large extent (more than 3 km in extent and greater than 0.2 NTU, shown as orange and red) in Emerald Bay and off Tahoe City and South Shore occur in both surveys. The moderate turbidity areas with smaller extent (less than 1 km in extent and between 0.16 and 0.25 NTU, shown as yellow and orange) such as Incline Village and Glenbrook change over the 11 days between the surveys. There was no precipitation during this time. During the period between the two surveys the Star Fire, a large fire about 30 km west of Lake Tahoe, filled the Tahoe Basin with thick smoke for about a week that at times reduced visibility to a few miles. There was not a lake wide change in turbidity associated with the influx of thick smoke that occurred between the two surveys.

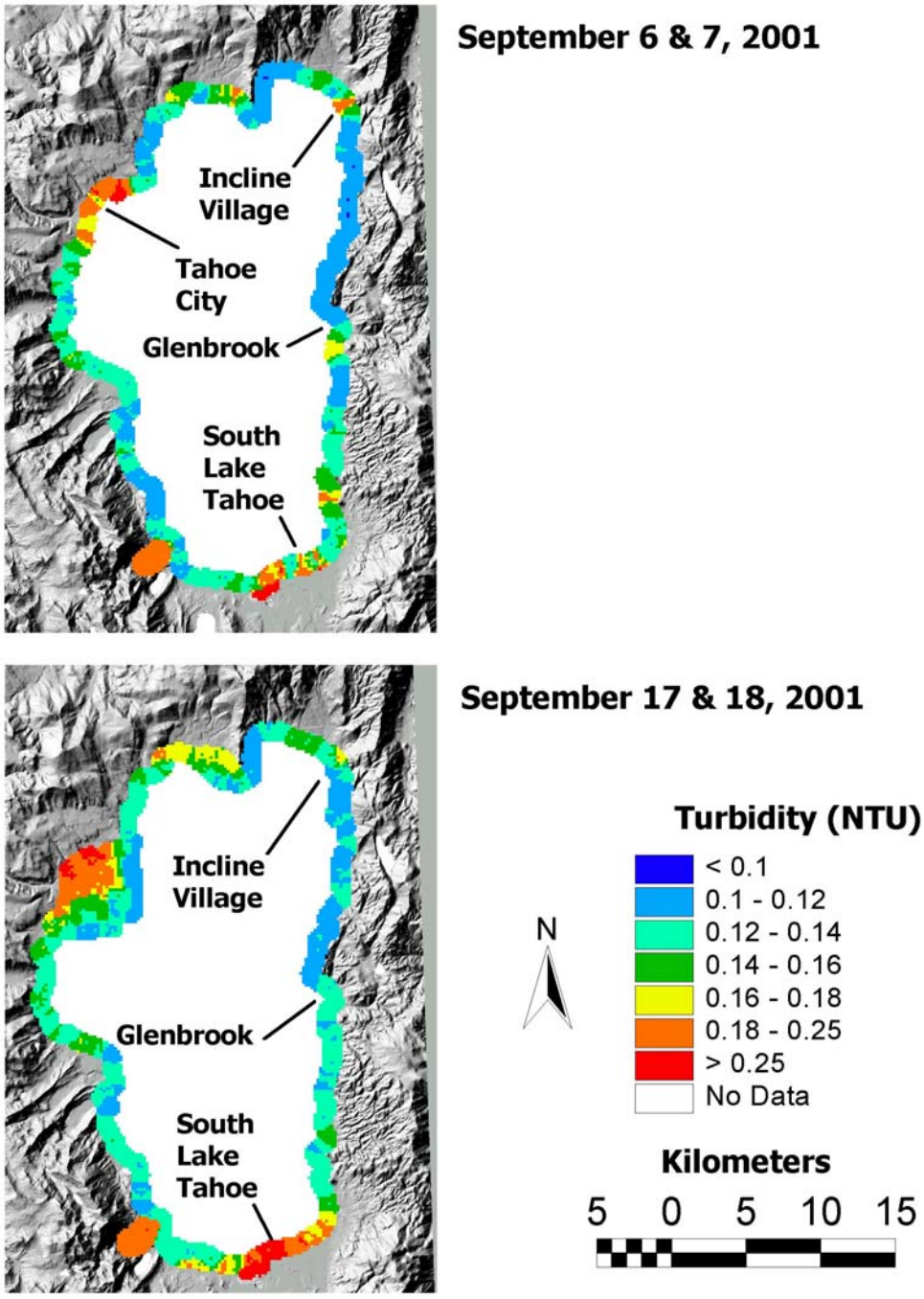

Figure 1. Results from two near shore turbidity surveys of the entire lake taken 11 days apart in September 2001.

A closer inspection of the area off Glenbrook (Figure 2) shows that on September 6, 2001, there was a zone of elevated turbidity (greater than 0.17 NTU, shown as yellow, orange and red) bounded to the south by low turbidity (less than 0.13 NTU, shown in blue). Eleven days later the elevated turbidity zone was gone. The cause of this minor and short duration increase in turbidity is not known. It is unlikely there was a change in surface inflows between these surveys because there was no precipitation and there is no stream outlet it the area. Upwelling of high turbidity water is a possible cause for this transient phenomenon.

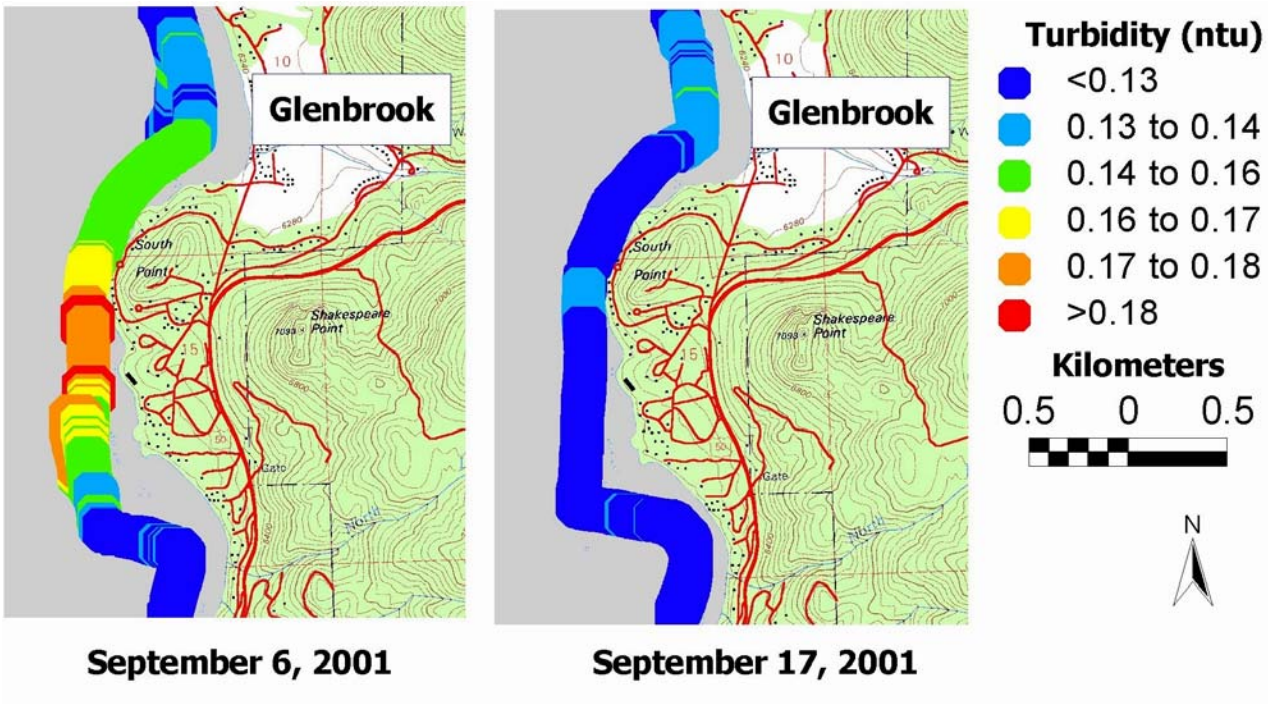

Figure 2. Detailed view of two near shore turbidity surveys off Glenbrook taken 11 days apart in September 2001.

A second example of short-term changes in turbidity is two surveys off Homewood on March 8 and 14, 2001 (Figure 3). From a lake wide perspective this is a low turbidity area. The lowest turbidities in this area are less than 0.07 NTU and the highest turbidity levels are around 0.11 to 0.13 NTU. There was only a small change (~0.03 NTU) close to shore between the two surveys. The area at the mouth of Homewood Creek, which runs through Homewood ski area, had the highest turbidities (0.10 to 0.13) during this period, however these values were still low relative to other locations along the lakeshore.

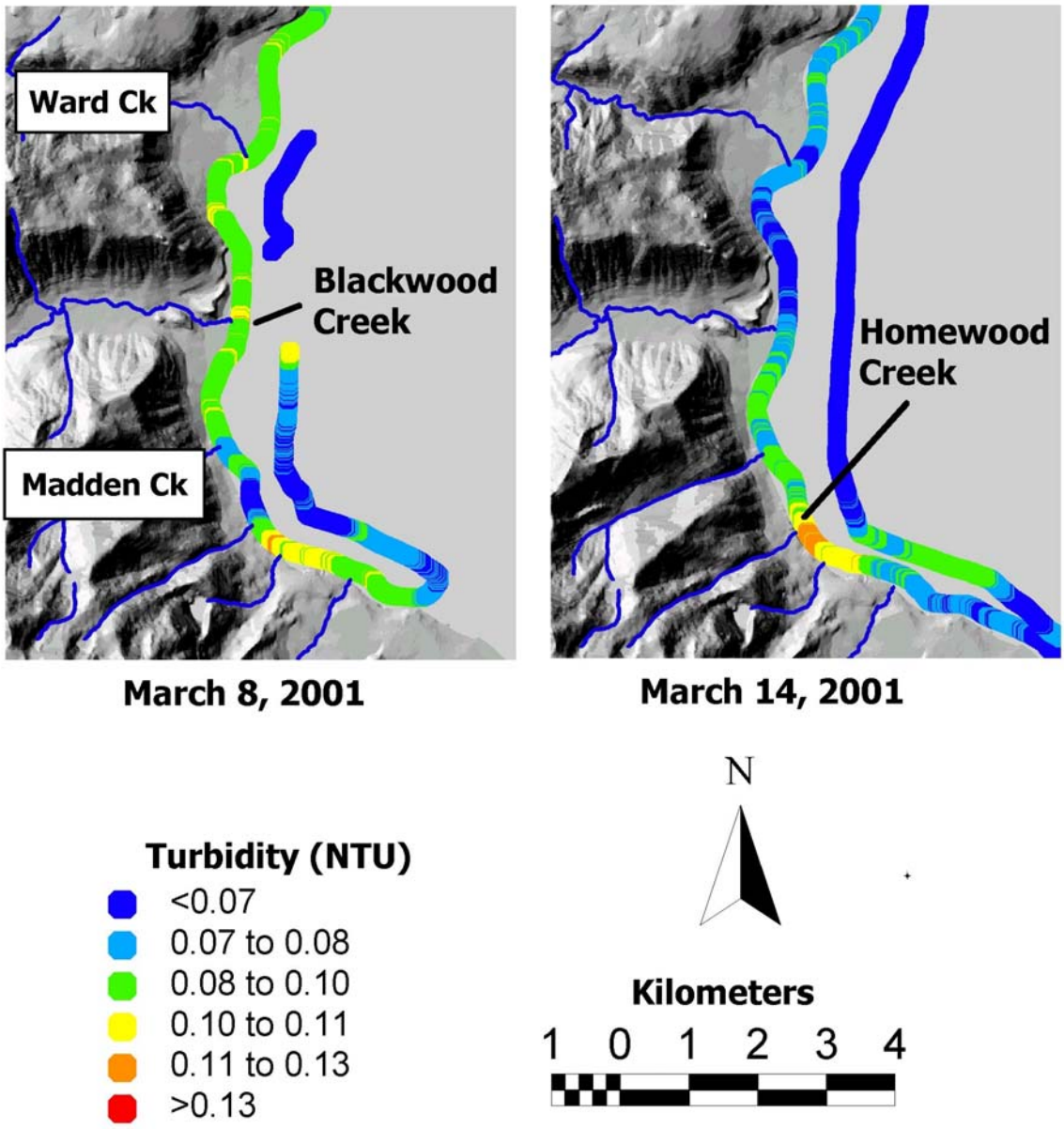

Figure 3. Turbidity surveys in McKinney Bay.

A third example of short-term changes in turbidity is four surveys off of Tahoe City conducted during March 2001 (Figure 4). Three of the four surveys showed elevated turbidities between the Tahoe City Marina and the outlet to the Truckee River (elevated to levels of 0.12 to 0.16 NTU above a background of less than 0.08 NTU). Two of three surveys also showed elevated turbidity in the vicinity of Star Harbor (elevated to levels of 0.1 to 0.16 NTU above a background of less than 0.08 NTU shown as dark blue). These features were also observed in August 2001 and are discussed later in this report.

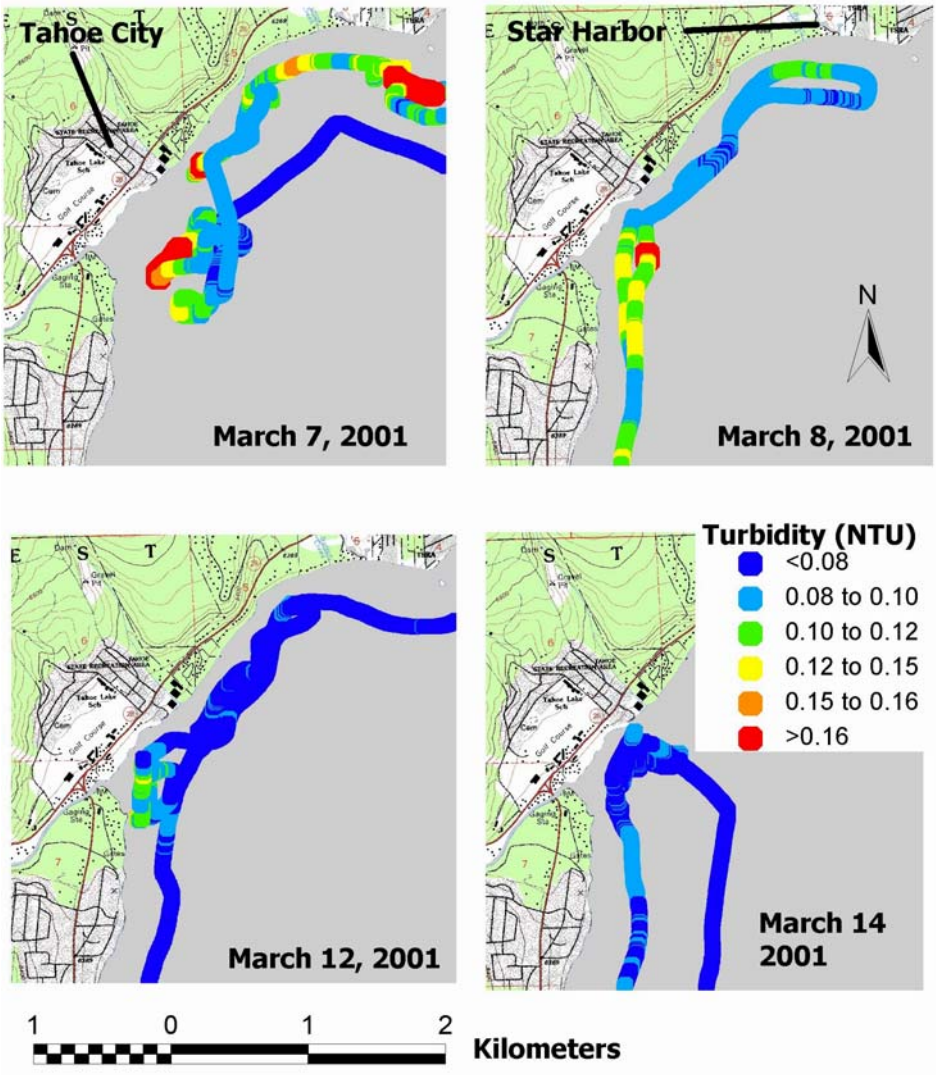

Figure 4: Turbidity surveys off Tahoe City in March

These examples show that areas of elevated turbidity with an extent of many kilometers can be persistent on time scales of weeks, but areas with elevated turbidity with an extent of less than a kilometer can change significantly in a few weeks. These examples highlight how repeated spatial turbidity surveys can identify areas with persistent elevated turbidities.

Seasonal Surveys

Surveys were made during different seasons to identify seasonal patterns in turbidity. Generally the seasonal surveys (Figure 5) were made during periods when the weather had been calm for several days preceding the survey. Precipitation occurred during the September 2001 and March 2002 surveys, and repeat measurements of parts of survey show the storms did not influence the turbidity.

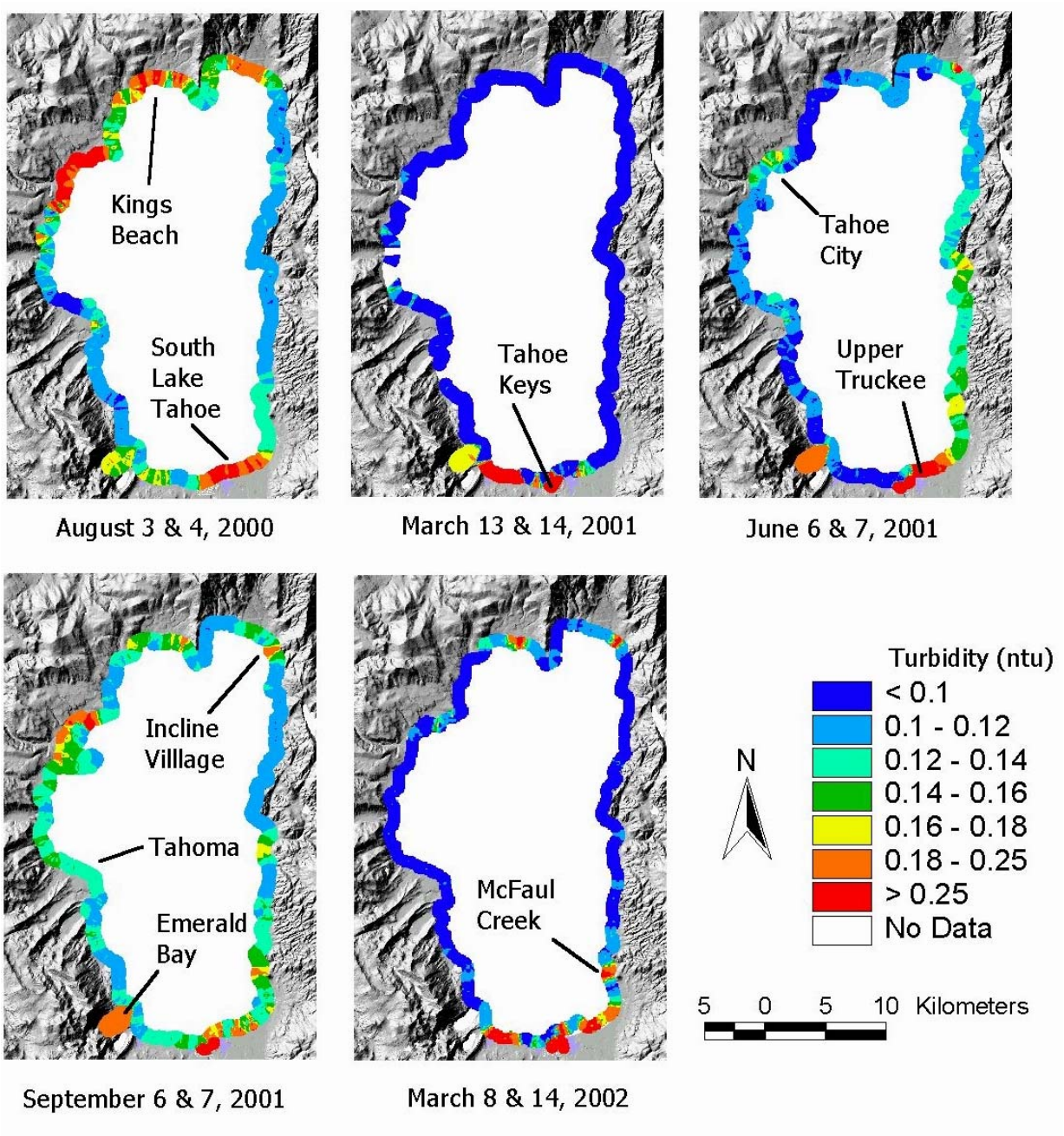

Figure 5. Results from near shore turbidity surveys around the entire lake in different seasons.

On August 3 and 4, 2000 there was high turbidity in both a relative and absolute sense (0.20 – 0.25 NTU) off the developed areas of Tahoe City, Kings Beach, Incline Village, and South Lake Tahoe. All of these areas have shallow water close to shore. However, the shallow areas off the southwest corner of the lake and off Tahoma, which are not heavily developed, do not have high turbidity. Hence, the high turbidity appears to be associated with developed areas and not with shallow water. Stream inflow of particles is negligible in August. In August the lake is warm, favoring algae growth. Algae growth early in the summer consumes the nutrients that accumulated in the lake during the winter and spring, so that in August there is not a supply of nutrients stored in the lake for algae to consume. Any algae growth in August is likely associated with an inflow of nutrients to the lake that is occurring in August, as opposed to consumption of nutrients that are stored in the lake from winter and spring. The high turbidity levels could be caused by boat traffic resuspending lake sediment, by the release of nutrients by lake sediment, or by nutrient rich groundwater inflows.

On March 13 and 14, 2001 a survey showed high turbidity centered at Tahoe Keys (greater than 1.0 NTU) and the Upper Truckee River outlet. This survey was taken during a warm spell when there was melting snow at lake level but the higher elevations where still frozen. The cold lake temperatures reduced algae growth and the main part of spring runoff had not yet occurred. The majority of the lake had a turbidity of less than 0.1 NTU, which is low relative to other seasons.

On June 6 and 7, 2001, a survey showed high turbidity (0.25 to 0.3 NTU) centered at South Lake Tahoe with a connected area of elevated turbidity (0.12 to 0.18 NTU) extending up the southeast shore. This survey was taken after spring runoff on the east side of the lake and during the last stages of spring runoff on the west side of the lake. The area of elevated turbidity along the southeast shore may be material that has driven along the shore from the South Lake Tahoe area by the prevailing winds. Moderate turbidity areas (0.12 to 0.18 NTU) with small spatial extent occurred off Glenbrook, Tahoe City and Incline Village.

On September 6 and 7, 2001, a survey showed high turbidity areas with a large extent (more than 2 km in extent and greater than 0.2 NTU) off Tahoe City and South Lake Tahoe. High turbidity areas were located off Kings Beach, Incline Village, Glenbrook and Round Hill but they had a smaller spatial extent.

On March 8 and 14, 2002 a survey showed several high turbidity areas with a large spatial extent along the south shore. Typically these areas were about 1 km in extent and had a turbidity of 0.25 to 0.3 NTU. There may be a strong correlation between turbidity and depth in this region during this season but we do not have enough data to determine if this is the case. Off Tahoe Keys there were locations in the lake with turbidity greater than 2 NTU. There were slightly elevated high turbidity areas with a small spatial extent (~500m in extent and 0.25- 0.3 NTU) off Kings Beach and Incline Village. There was an elevated turbidity area with a small extent (~500 m in extent and 0.25 to 0.3 NTU) off McFaul Creek, which also shows up in the September 2001 and August 2001. This creek was flowing when the survey was conducted. This survey was taken on two days. On March 8, the area from Tahoe City along the east shore to Tahoe Keys was surveyed. On March 14 the area from Tahoe City along the west shore to Tahoe Keys was surveyed. The day

before each survey was made several inches on snow had fallen at lake level, which had not melted when the surveys were made.

These surveys indicate a close association between developed areas and elevated turbidity during the summer. Several interpretations of these data are possible. For example, summer surface inflows are probably not a factor in this association because summer surface inflows are small. Increased boat traffic around developed areas in the summer may resuspend lake sediments and increase the turbidity. Nutrients from developed areas may be entering the lake during the summer by groundwater inflow and enhancing algae populations. Nutrients from developed areas may also be entering the lake during the winter by surface and groundwater inflows and be stored in lake sediments. These stored nutrients may be released during the summer when the increased algae concentrations deplete the nutrients in the lake, creating a gradient in nutrient concentrations that draws nutrients out from storage in the sediments. With the available data it is not possible to definitely determine a cause for the spatial correlation of development and high summer turbidities.

Emerald Bay has consistently elevated turbidity values. This is likely caused by the limited exchange of water between the relatively shallow Emerald Bay and the deep water of the lake, the steep slopes with large road impacts around the bay, and the large inflow of surface water relative to the small and restricted area of the bay. These conditions make the water quality issues in Emerald Bay considerably different than other parts of Lake Tahoe.

Tahoe Keys/Upper Truckee River Outlet

The area around the outlet of the Upper Truckee River and the two entrances to the Tahoe Keys is discussed separately because the turbidity levels were an order of magnitude greater than any place else on the lake. Figure 6 shows the results from seasonal surveys at Tahoe Keys. At the scale of these figures, the track of the boat can be seen. The values of turbidity assigned to the colors are significantly greater than in the previous figures. In all cases when the boat entered the Tahoe Keys there was very high turbidity (greater than 0.5 NTU), in some cases the turbidity exceeded the 2-NTU maximum range of the measurement system. The two surveys in March 2001 and 2002 showed plumes of particularly high turbidity (values in excess of 2 NTU) in the lake. It is possible that during the late winter low elevation snow melt around the Tahoe Keys creates a flux of material from the Keys into the lake. The two summer surveys (August 8, 2000 and June 7, 2001) show that the highest turbidity areas are closer to the outlet of the Upper Truckee River than the entrances to Tahoe Keys. This suggests that during summer the Upper Truckee River or the Truckee Marsh is more of a problem than Tahoe Keys. More surveys, conducted in a grid pattern and during all seasons will be needed to characterize the spatial and temporal variability in this area so that the sources of turbidity degrading material can identified.

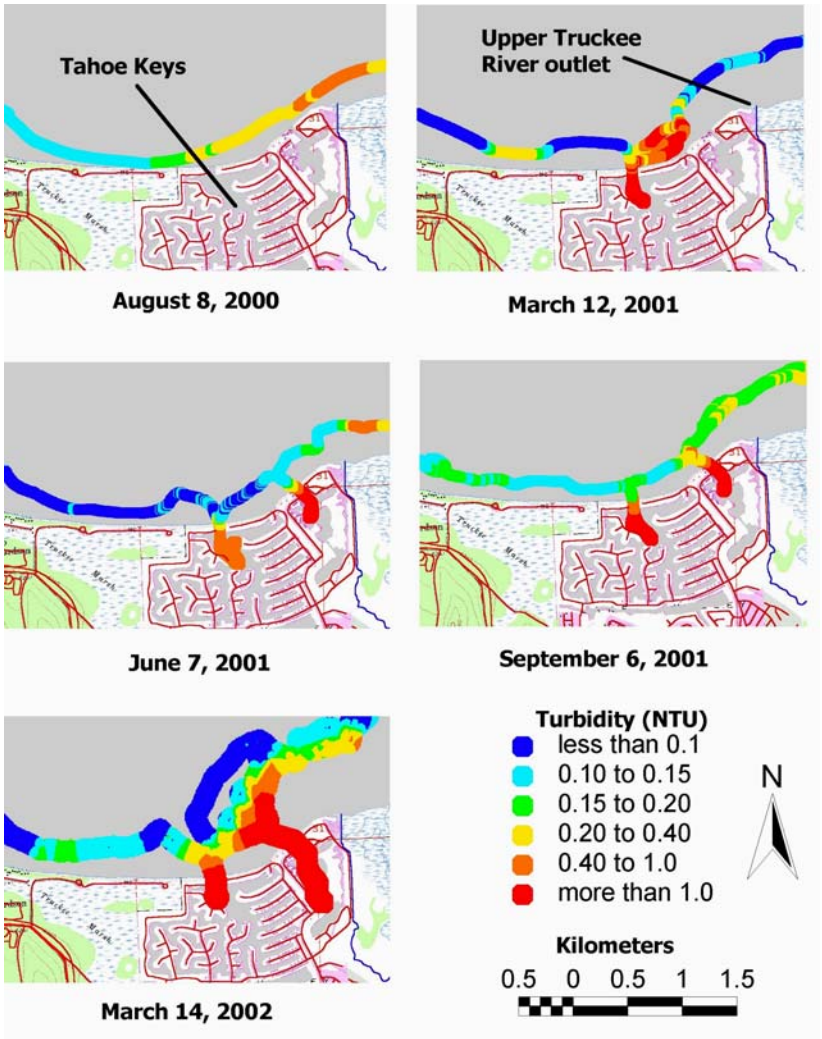

Figure 6. Results from near shore turbidity surveys around Tahoe Keys in different seasons.

Surveys Associated with Short Term Hydrologic Disturbances

We had two opportunities to measure turbidity before and after hydrologic disturbances, allowing us to determine the influence of the disturbances on turbidity. These results are presented in maps that show the difference between the turbidity values observed on different dates. Areas were the turbidity increased after the disturbances are shown in red. Areas were the turbidity did not change are shown in green. Areas were the turbidity decreased are shown in blue. For an area to be included in these surveys the survey tracks from before and after the storm had to be within 50 m of each other.

The first opportunity to measure the influence of a hydrologic disturbance on turbidity was associated with a summer thunderstorm. A survey had been conducted on August 3, 2001. In the afternoon of August 4, 2001, there was an intense thunderstorm producing 1.3 cm of rain in 12 minutes at the Thunderbird Lodge. This storm was accompanied by large amounts of overland flow, displacement of forest litter, and erosion and mobilization of the Highway 28 shoulder along the east side of the lake. On the morning of August 5, 2001, a second survey was conducted. Figure 7 shows the turbidity difference between the two surveys. The magnitude of the turbidity changes was very small and changes only occurred within a 100 meters of the discharge from Third and Incline creeks, and at the outlet of an unnamed drainage 200 m east of the Thunderbird Lodge. An even smaller increase was observed at Marlette creek. This result is only from one event, but it suggests that summer thunderstorms only contribute minor amounts of inorganic particles that imediately increase the turbidity. These surveys do not shed any light on the issue of if storm related inorganic material is transporting nutrients to the lake that promote algal growth and increase the turbidity at a later time.

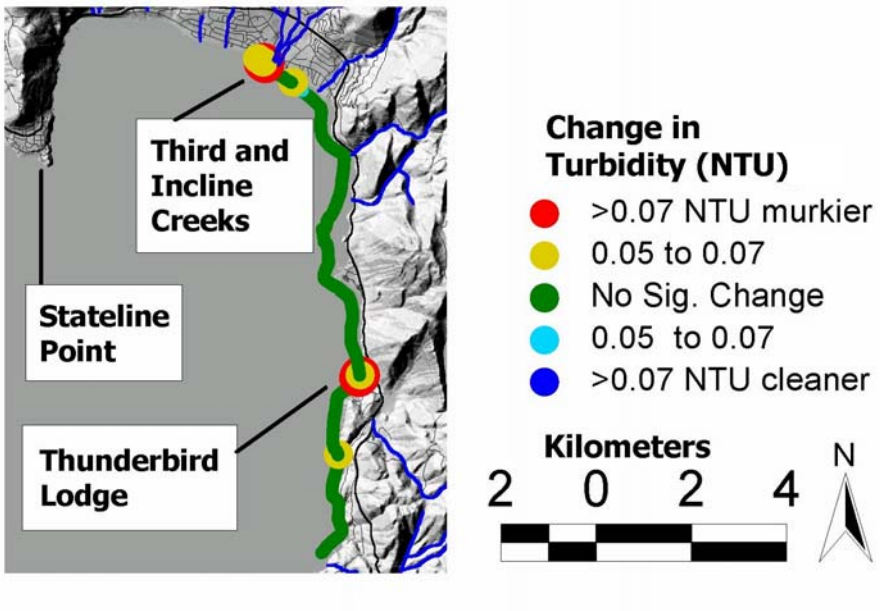

Figure 7. Change in near shore turbidity after an intense August thundershower.

The second opportunity to measure the influence of a hydrologic disturbance on turbidity was in September 2001. A turbidity survey was conducted on September 3, 2001. For the next three days there were high winds from the southwest and wave heights in the Incline Village area reached 0.7 meters. There was no precipitation during this time. A turbidity survey was conducted on September 7 and the difference between the two surveys is shown in Figure 8. The turbidity difference is very small, and only occurs within less than 100 m of the discharge from Third and Incline creeks. It is suspected that the increase in turbidity is caused by the resuspension of fine sediments associated with previous discharges from the creeks. This result suggests that moderate wave action along the northeast shore does not suspend enough particles to directly increase the turbidity 100 m off shore. These surveys do shed any light on the issue of if storm related inorganic material is transporting nutrients to the lake that promote algal growth and increase the turbidity at a later time.

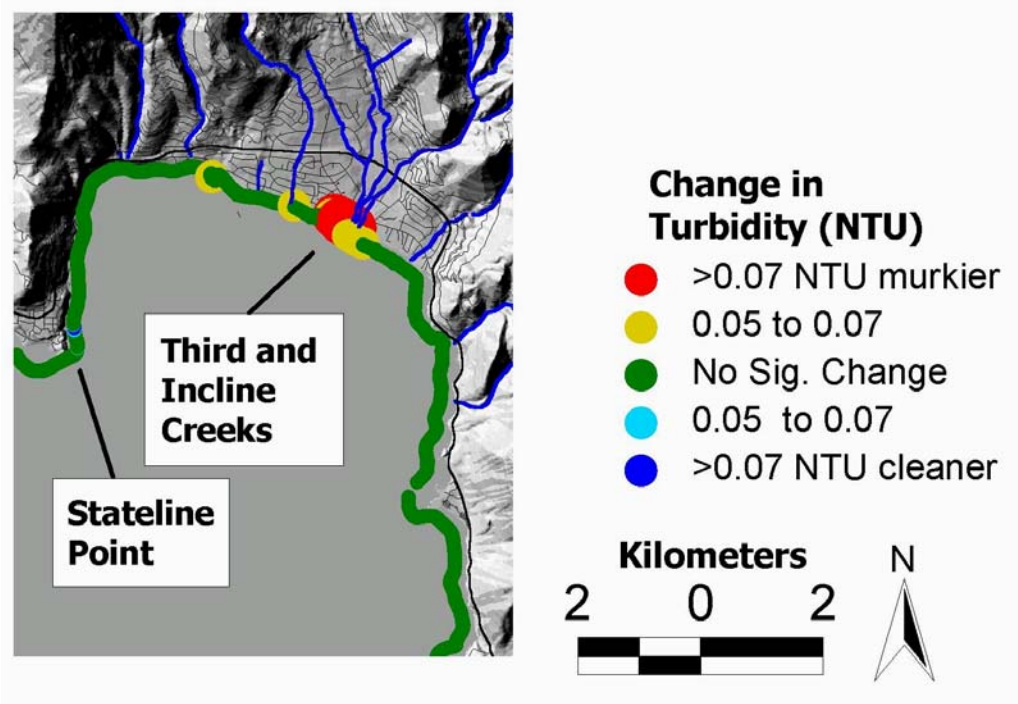

Figure 8. Change in near shore turbidity after three days of high winds and no precipitation in September 2001.

Tahoe City Surveys

On September 16, 2001, a survey was conducted in a grid pattern off of Tahoe City. For this survey we used the turbidity instrument and a fluorometer. The voltage output of the fluorometer is proportional to the chlorophyll concentration. To convert the voltage output of the fluorometer to chlorophyll concentration, water samples have to be collected and filtered, and the filters analyzed for chlorophyll. In this project we only report relative concentrations of chlorophyll. The chlorophyll concentration is of interest because it is an indication of the abundance of algae. The survey (Figure 9) identified two areas that both had high turbidity and chlorophyll concentrations, one off Tahoe City and one near Burton Creek. Each area extended for about a 1 km along the shore. These are the same areas that had elevated turbidities in March 2001 (see Figure 4).

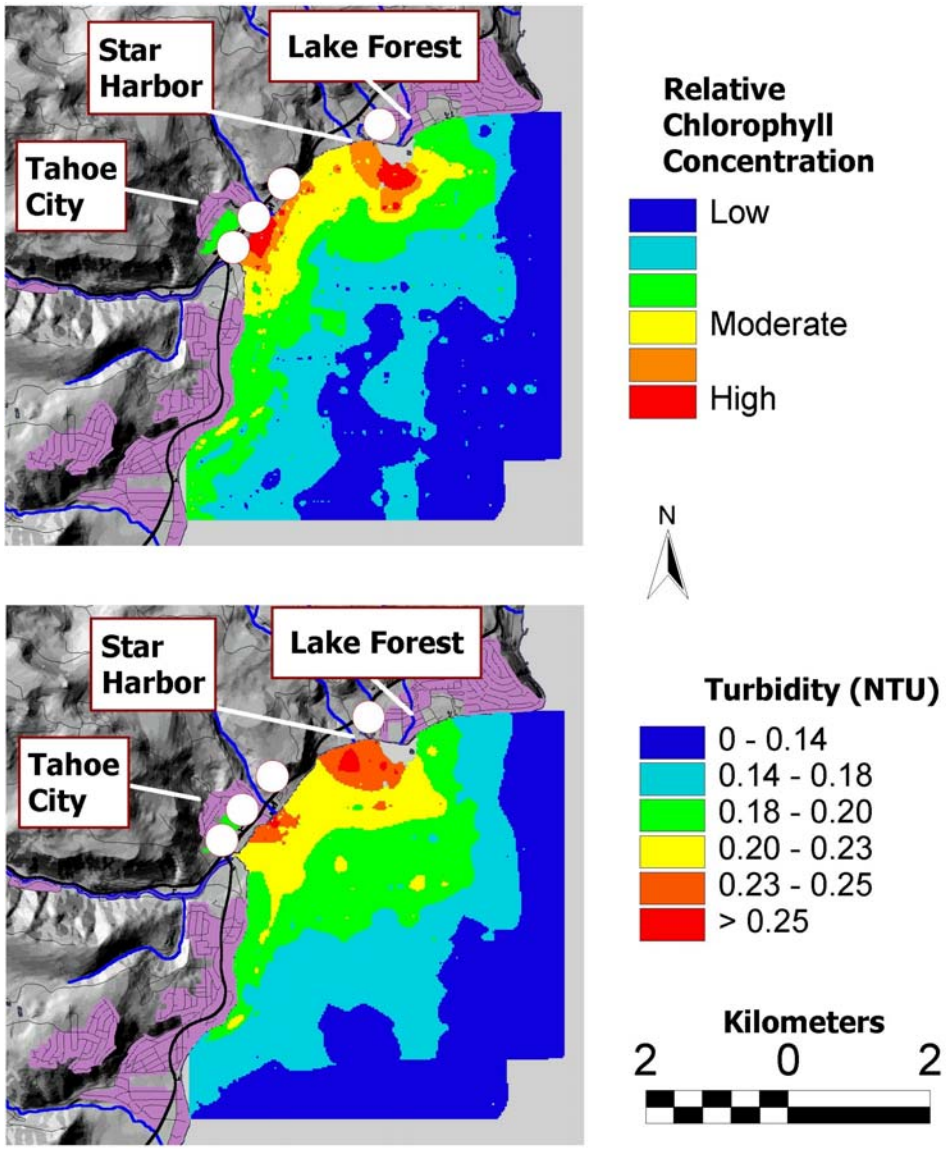

Figure 9. Maps of turbidity and relative chlorophyll concentration off Tahoe City and Lake Forest in September 2001. The purple areas onshore are developed areas and roads are shown as black lines. The green area onshore is a golf course. The white circles are sewage pumping stations.

On June 2, 2001, three months before these surveys were made, teams of volunteers organized by the Citizen Monitoring Working Group of the Lake Tahoe Environmental Education Coalition collected water samples at 44 locations around the basin. The samples were analyzed for many parameters including fecal coliform that is commonly found in the feces of warm-blooded animals. The highest concentration of fecal coliform (706 CFU/100 ml) was observed in Hatchery Creek at Star Harbor (Segale, personal communication, 2001). This fecal coliform value is almost two times greater than at any other site and about ten times greater than the average for all the sites. Repeat fecal coliform measurements in July 2001, and August 2001, did not have elevated values. It is tempting to speculate that groundwater transport of sewer exfiltration may have increased the flux of nutrients to the lake in these areas, however the data are too limited to draw this conclusion.

With the available information it is not possible to determine what caused the high turbidity areas off Tahoe City. The turbidity and chlorophyll surveys show a high degree of spatial correlation, however it is not possible to determine if high levels of algae are the leading cause of the high turbidity, or if inorganic material is the main cause of the increased turbidity and the algae is also elevated because of an increase in nutrients associated with the inorganic material. It is unlikely the increases in turbidity and chlorophyll were caused by atmospheric deposition because their spatial extent is much smaller than would be associated with atmospheric deposition patterns. It is also unlikely they were associated with an inflow of nutrients by surface water because the creeks were dry this late in the summer and many creeks with greater flows did not have high turbidity areas associated with them.

It is possible the high turbidity areas were caused by the resuspension of lake sediments by heavy boating traffic in these areas. It is also possible the high turbidity areas were caused by the release of nutrients stored in lake sediments that enhanced late summer algae growth in these areas. These stored nutrients may have been deposited during periods of greater stream flow with nutrient rich water from urban runoff. Limnology factors such as the characteristics of the bottom, and wind and water currents may also make these locations more favorable for algal growth. It is also possible that the high turbidity areas were caused by the inflow of nutrient rich groundwater that enhances algae populations in these areas. The close spatial correspondence of the areas with elevated turbidity and algae, sewer pumping stations, and the one high fecal coliform value, suggest sewer exfiltration leading to discharges of nutrient rich groundwater as a possible cause. Other possible sources of nutrient rich groundwater include soil disturbance and fertilizer use. We stress that sewer exfiltration is only one possibility. Additional work to determine the relative concentrations of inorganic and organic particles in the lake, and possible groundwater sampling, will be required to resolve this.

CONTINUOUS LIGHT ATTENUATION STUDIES

An instrument that measures the attenuation of light passing through the lake water was deployed at Homewood. The instrument (described in the methods section) was mounted on a private pier ~1 m below the surface, 1.0 meters above the bottom, and 15 m from shore. It had to be cleaned once a week to keep the optics free from biological material that would otherwise adversely influence the measurement. The intention of this deployment was to obtain a continuous proxy turbidity record at a fixed location as a check on the occasional spatial surveys made with the boat mounted turbidity measurement system. The need for two different types of instruments, each measuring different properties, arises because the turbidity instrumentation required for the low turbidity levels in Lake Tahoe requires too much maintenance for unattended operation, and the light attenuation instrument available to us was not suitable for deployment from a moving boat. We are trying to obtain a light attenuation instrument that can be used on a moving boat simultaneously with the turbidity instrument.

To use light attenuation as a proxy for turbidity it is necessary to develop an empirical relationship between the two measurements. This relationship will depend on the optical characteristics of the particles and water. For example, different mixtures of inorganic particles and algae, or different types of algae, will alter the relationship between light attenuation and turbidity. We developed a rough empirical relationship between light attenuation and turbidity by making simultaneous measurements of light attenuation and turbidity in different parts of the lake that had different levels of turbidity. We do not show this relationship because we are concerned that the light attenuation instrument may not have been properly calibrated. This would make the relationship unsuitable for use with another instrument that was correctly calibrated. Originally we had hoped to use measurements of light attenuation from the moored instrument to verify temporal changes observed with the boat mounted turbidity system. However after considering the calibration methods of the light attenuation and turbidity instruments, and the empirical and rough nature of the relationship between turbidity and light attenuation, we concluded the spatial turbidity measurements were more dependable than the estimation of the turbidity from the light attenuation measurements.

The record of estimated turbidity (Figure 10) is dominated by a daily cycle with amplitude of 0.05 NTU. It is not known if this cycle is an instrument artifact caused by increased ambient light levels during the day, or if it is a change in the optical properties of the water associated with daily changes in biological activity or wind stirring of sediments. There are several instances where storms briefly elevated the light attenuation. This is expected because of the shallow water depth were the instrument was moored. The multi day tends of the data collected at night, shown in red in figure 10, are considered to be real changes in turbidity. No attempt was made to record weather or other lake conditions to determine the causes of these variations because this project intended to use the light attenuation instrument only as a check on the boat mounted turbidity system.

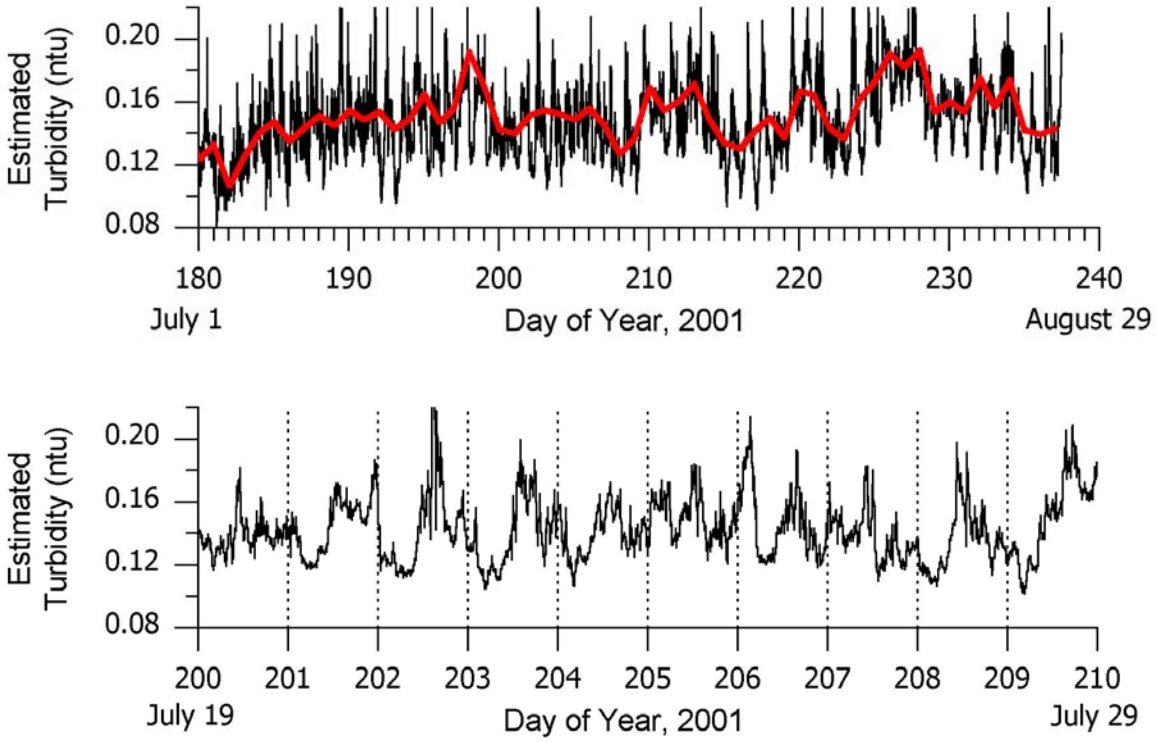

Figure 10. Estimated turbidity derived from light attenuation measurements with the C-Beta. The red line is the average value during the night. The lower graph is a detailed view of a portion of the upper graph so that the daily variation can be observed. The daily variation may be an instrument artifact caused by sunlight.

The continuously recording light attenuation instrument was not useful as a check on the boat turbidity system because the temporal changes were small relative to the uncertainty of the relationship between light attenuation and turbidity, and because of concerns about the ability of the instrument to resolve small changes in light attenuation in the presence of sunlight. In lake light attenuation instruments may be suitable for long term monitoring at a fixed location if the issue of the possible influence by sun light and the need for frequent cleaning can be resolved. The use of light attenuation instruments to continuously monitor clarity at Lake Tahoe is promising but it will require more development of the field methods.

RELEVANCE TO LONG TERM MONITORING OF LAKE CLARITY

To determine if the Environmental Improvement Projects being conducted around the basin are restoring lake clarity, it is desirable to determine how the near shore clarity is changing over time. This project has shown that near shore clarity, as measured by turbidity and light attenuation, has significant spatial and temporally variability.

An effective monitoring program should be able to determine how the clarity is changing over time at a specific location. (i.e. In the last 5 years has the clarity in summer at a monitoring buoy offshore of Tahoe City increased or decreased?) The best way to do this is with a clarity measurement made several times a day. This will allow seasonal averages to be obtained that are not based on conditions that occurred on a single day. An effective monitoring program should also determine how the spatial patterns of clarity are changing over time. (i.e. In the last 5 years has the size of the low clarity area off Tahoe City gotten bigger or smaller?) The best way to do this is with periodic spatial surveys of clarity.

Light attenuation measurements may be a useful long-term monitoring tool at Lake Tahoe. Light attenuation instruments can be deployed in the water for continuous unattended measurements or deployed on a moving boat. Instruments from different manufactures have a similar design and it is likely that instruments with similar optical responses will still be available several decades from now.

Turbidity measurements are also suitable for long term monitoring programs because instruments with similar characteristics are likely to be available many decades from now and because the measurements can be made from a moving boat in shallow water. However, it is difficult to continuously measure turbidity in the clean water of Lake Tahoe with an unattended instrument because a pump is required to move water into the sample cell. Turbidity instruments that have an open water design which do not require a pump will not respond to the small changes in turbidity in the low turbidity waters of Lake Tahoe. Light attenuation instruments have the advantage over turbidity instruments that they do not require a pump to move water into a sample cell and hence are simpler to deploy for unattended measurements in the low turbidity water of Lake Tahoe.

A less desirable approach is light scattering instruments. Light scattering instruments cannot be deployed in shallow water because they are influenced by light scattering off the bottom. Light scattering instruments are designed with different scattering angles and it may not be possible to obtain light scattering instruments with similar optical characteristics over the many decades of a long term monitoring program.

Secchi disk measurements are not well suited for monitoring the near shore zone because the water is frequently too shallow to make a measurement. Another method to monitor the optical properties of water is the light extinction coefficent. This is a measure of the attenuation of natural light with depth. This measurement is influenced by environmental conditions such as waves, clouds and sun angle because natural light is used instead of a controlled light source. This method is not suitable for long term monitoring of clarity because it is dependent on environmental conditions that are not related to clarity.

At this time we do not have enough experience to suggest an optimal program for monitoring near shore water clarity. However a long term monitoring program should have a combination of spatial and temporal measurements utilizing methods that are efficient and that will be consistent over many decades. We hope to address the issue of an optimal monitoring program for near shore clarity in a future project.

RELEVANCE TO TRPA TURBIDITY MONITORING PROGRAM AND WATER QUALITY THRESHOLD

The Tahoe Regional Planning Agency (TRPA) has set environmental thresholds for the Tahoe Basin. This project is relevant to one of these thresholds. The only TRPA water quality threshold for near shore waters is the littoral zone turbidity threshold (TRPA threshold WQ-1). The TRPA program for monitoring compliance with this program consists of 9 sample sites in water 25 ft deep (Figure 11) (Whitney, 2002, Personal Communication). These sites range from tens to hundreds of meters offshore. Discrete samples are collected four times a year from depths of 5, 10, 15, 20, 25 ft. The small number of sample sites cannot delineate high turbidity areas like the ones associated with Tahoe Keys and Tahoe City and do not monitor the undeveloped sections of the shore that have the greatest clarity. The infrequent measurements will make it difficult, and maybe impossible, to determine temporal trends.

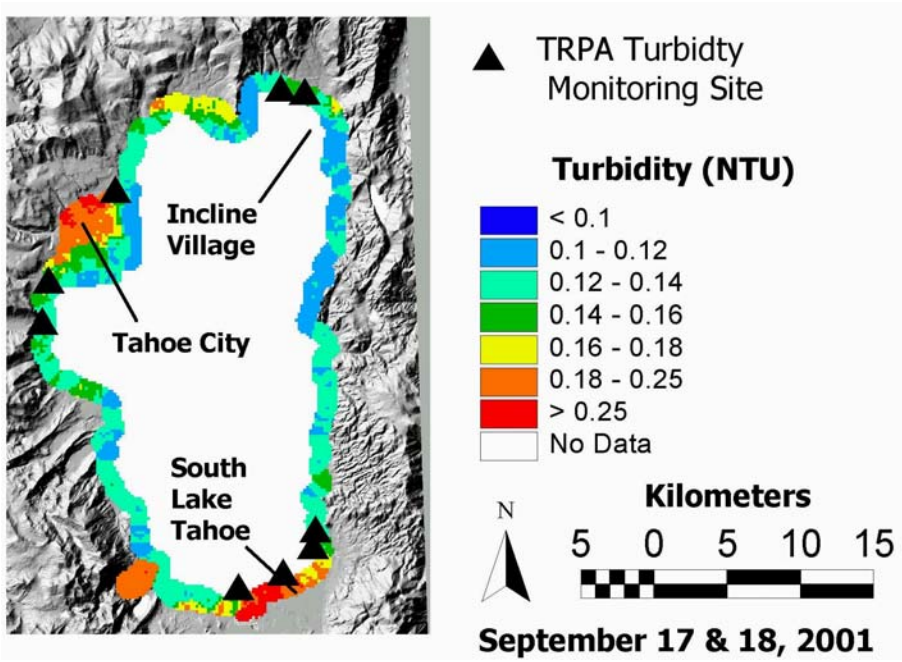

Figure 11. Location of TRPA turbidity monitoring sites and near shore turbidity on September 17 and 18, 2001.

The TRPA turbidity threshold for the littoral zone is 1 NTU in areas not influenced by streams and 3 NTU in areas influenced by streams. This 1 NTU threshold is a factor of 10 times greater than existing conditions off undeveloped areas and a factor of 4 times greater than existing conditions in the most turbid areas of the lake excluding Tahoe Keys. For reference the turbidity of the entire near shore zone would be similar to the turbidity of the Tahoe Keys marina in June before the TRPA threshold was exceeded. The secchi disk depth along the entire shore would be less than ~4 m before the TRPA turbidity threshold was exceeded.

The TRPA littoral turbidity threshold is the only TRPA water quality threshold that is being met. This is because the turbidity threshold is set at a level much greater than ambient conditions and the tight environmental standards of the other thresholds. TRPA staff is aware of the limitations of the current turbidity threshold and monitoring program and is proceeding along a path that may

lead to changing the threshold and monitoring program when all the thresholds are reviewed in 2004.

Other indicators of water clarity are also used in Lake Tahoe. One of these is Secchi depth, which is the greatest depth that a black and white disk 20 cm in diameter, can be observed. Another is vertical extension coefficient, which is a measure of the rate that light intensity decreases with depth. Both of these measurements use natural sunlight that passes through the lake surface. The measurements are dependent on the angle of the sun above the horizon, cloud cover and the roughness of the water surface. These methods also require water that is deeper than most of the areas studied in this project. These methods are influenced by conditions over a range of depths as opposed to the turbidity measurement, which is only influenced by conditions at a single depth. It will be possible to develop an approximate empirical relationship between turbidity measured near the surface and the Secchi depth, and this will be done in future projects.

CONCLUSIONS AND HYPOTHESES

This was the first project to conduct detailed studies of the spatial variability of near shore turbidity at Lake Tahoe and hence when the project was developed it was not clear how useful spatial turbidity surveys would be. The project was designed with a broad focus instead of targeting specific issues. This section is divided into conclusions that are well supported by data, and hypotheses that are suggested by the data but not proven.

Conclusions

●There is a large spatial and temporal variability in near shore turbidity. A general pattern is that turbidity is greater during the summer than during the winter. The areas with consistently high turbidity are South Lake Tahoe, Tahoe Keys, and Tahoe City. Kings Beach and Incline Village have high turbidity too, but to a lesser degree. The Tahoe Keys and adjacent lake waters consistently have the highest turbidity and are occasionally greater than the TRPA WQ-1 threshold.

● Emerald Bay consistently has an elevated turbidity. The steep watershed, significant lands disturbance imediately adjacent to the bay due to road construction and avalanche activity, shallow depths and major stream inflow with restricted mixing with deep lake water, make this a unique area.

●Turbidity values are greatest near the shore. If the near shore clarity issue is resolved, the mid-lake clarity issue may also be resolved. However, it maybe possible to have acceptable mid-lake clarity and still have poor clarity near the shore.

●Although atmospheric deposition of nutrients may contribute to a lake wide decline in clarity, it occurs over too large an area to explain the small size of the areas with elevated turbidity. Hence, most of the near shore clarity loss is caused by neighborhood scale local problems.

●The TRPA turbidity monitoring program does not provide an effective means of locating problem areas and does not provide a way to measure changes over long time periods.

●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.

Hypotheses

●Groundwater inflow of nutrients may be enhancing algae growth in some areas. The nutrient source may be sewer exfiltration, soil disturbance or fertilizer use.

●Summer thunderstorms and moderate waves may not have a significant short term impact on near shore turbidity.

●Most of the clarity problem may be the result of what is occurring along a small percentage of the shoreline**.**

RECOMMENDATIONS

●Information on the spatial and temporal variability of turbidity and light attenuation should be collected so that an informed discussion of the TRPA littoral zone turbidity threshold (TRPA water quality threshold WQ-1) can occur before the thresholds are reviewed in 2004.

●An effective near shore clarity monitoring program should be developed that will observe spatial and temporal variations in clarity. The program should monitor the entire lakeshore and portions of the mid-lake, but also have special emphasis on areas known to have low clarity. The program should be constructed so that changes that occur gradually over several decades can be documented.

●Spatial surveys should be conducted to identify sections of the lakeshore that are associated with high turbidity areas. These surveys should be conducted in different seasons because different areas will respond differently during different seasons.

●A program should be developed to identify the relative extent that algae and inorganic particles are responsible for increasing the turbidity. It should be anticipated that high turbidity has different causes in different areas and different seasons. This will require examination of the particles and cannot be done with just the methods presented here.

CONTACT INFORMATION

The data and figures in this report, and the report itself, are available on the web at: http://www.tahoenearshore.dri.edu

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PRINT-ON-DEMAND CHARTS

This chart is available in a version updated weekly by NOAA for Notices to Mariners and critical corrections. Charts are printed when ordered using Print-on-Demand technology. New Editions are available 5-8 weeks before their release as traditional NOAA charts. Ask your chart agent about Print-on-Demand charts.

Formerly C&GS 5001, 1st Ed., July 1923 V-1923-231 KAPP 1865

DEPTHS IN METERS

SCALE 1:40,000

Nautical Miles

Statute Miles

Yards

Meters

LOGARITHMIC SPEED SCALE

To find SPEED, place one point of dividers on distance run (in any unit) and the other on minutes run. Without changing divider spread, place right point on 60 and left point will then indicate speed in units per hour. Example: with 4.0 nautical miles run in 15 minutes, the speed is 16.0 knots.

AIDS TO NAVIGATION

Consult U.S. Coast Guard Light List for supplemental information concerning aids to navigation.

UNITED STATES

CALIFORNIA - NEVADA

LAKE TAHOE

Mercator Projection
Scale 1:40,000
North American Datum of 1983
(World Geodetic System 1984)

SOUNDINGS IN METERS AND DECIMETERS

AT LOWEST LAKE LEVEL

Additional information can be obtained at nauticalcharts.noaa.gov.

The lake level varies between 1898 and 1898 meters above mean sea level. Average summertime lake level is 1897 meters above mean sea level.

POLLUTION REPORTS

Report all spills of oil and hazardous substances to the National Response Center via 1-800-424-8802 (toll free), or to the nearest U.S. Coast Guard facility if telephone communication is impossible (33 CFR 153).

HORIZONTAL DATUM

The horizontal reference datum of this chart is North American Datum of 1983 (NAD 83) and for charting purposes is considered equivalent to the World Geodetic System 1984 (WGS 1984). Geographic positions referred to the North American Datum of 1927 must be corrected an average of 0.334" southward and 3.665" westward to agree with this chart.

NAVIGATING LAKE TAHOE

Lake Tahoe is to be navigated by leaving all white with orange band buoys to port when transiting in a clockwise direction. Safe water will always be found toward the center on the lake from the white and orange band federal buoys. The water level changes daily. Unmarked rocks and other hazards could be exposed due to low water levels. Mariners should use caution when approaching the shore.

WARNING

Mariners are warned that numerous uncharted buoys, snags, wrecks, and rocks exist along the shore of the lake. Mariners should use caution when transiting near the shore.

CAUTION

SUBMARINE PIPELINES AND CABLES

Charted submarine pipelines and submarine cables and submarine pipeline and cable areas are shown as:

Pipeline Area — Cable Area

Additional uncharted submarine pipelines and submarine cables may exist within the area of this chart. Not all submarine pipelines and submarine cables are required to be buried, and those that were originally buried may have become exposed. Mariners should use extreme caution when operating vessels in depths of water comparable to their draft in areas where pipelines and cables may exist, and when anchoring, dragging, or trawling.

Covered wells may be marked by lighted or unlighted buoys.

RADAR REFLECTORS

Radar reflectors have been placed on many floating aids to navigation. Individual radar reflector identification on these aids has been omitted from this chart.

SUPPLEMENTAL INFORMATION

Consult U.S. Coast Pilot 7 for important supplemental information.

CAUTION

Limitations on the use of radio signals as aids to marine navigation can be found in the U.S. Coast Guard Light Lists and National Geospatial-intelligence Agency Publication 117.

Radio direction-finder bearings to commercial broadcasting stations are subject to error and should be used with caution.

Station positions are shown thus:
⊙(Accurate location) o(Approximate location)

WARNING

The prudent mariner will not rely solely on any single aid to navigation, particularly on floating aids. See U.S. Coast Guard Light List and U.S. Coast Pilot for details.

NOTE A

Navigation regulations are published in Chapter 2, U.S. Coast Pilot 7. Additions or revisions to Chapter 2 are published in the Notice to Mariners. information concerning the regulations may be obtained at the Office of the Commander, 11th Coast Guard District in Alamida, California or at the office of the District Engineer, Corps of Engineers in Sacramento, California.

Refer to charted regulation section numbers.

ABBREVIATIONS (For complete list of Symbols and Abbreviations, see Chart No. 1.)

Aids to Navigation (lights are white unless otherwise indicated):

AERO aeronautical	G green	Mo morse code	R TR radio tower
Al alternating	IQ interrupted quick	N nun	Rot rotating
B black	Iso isophase	OBSC obscured	s seconds
Bn beacon	LT HO lighthouse	Oc occulting	SEC sector
C can	M nautical mile	Or orange	St M statute miles
DIA diaphone	m minutes	Q quick	VQ very quick
F fixed	MICRO TR microwave tower	R red	W white
Fl flashing	Mkr marker	Ra Ref radar reflector	WHIS whistle
		R Bn radiobeacon	Y yellow

Bottom characteristics:

Blds boulders	Co coral	gy gray	Oys oysters	so soft
bk broken	G gravel	h hard	Rk rock	Sh shells
Cy clay	Grs grass	M mud	S sand	sy sticky

Miscellaneous:

AUTH authorized; Obstn obstruction; PD position doubtful; Subm submerged
ED existence doubtful; PA position approximate; Rep reported
(21) Wreck, rock, obstruction, or shoal swept clear to the depth indicated.
(12) Rocks that cover and uncover, with heights in feet above datum of soundings.

HEIGHTS

Heights in meters above Mean High Water.

AUTHORITIES

Hydrography and topography by the National Ocean Service, Coast Survey, with additional data from the U.S. Coast Guard, Geological Survey, and National Geospatial-Intelligence Agency.

CAUTION

Temporary changes or defects in aids to navigation are not indicated on this chart. See Local Notice to Mariners.

NOTE Z

NO-DISCHARGE ZONE, 40 CFR 140

This chart falls entirely within the limits of a No-Discharge Zone (NDZ). Under the Clean Water Act, Section 312, all vessels operating within a No-Discharge Zone (NDZ) are completely prohibited from discharging any sewage, treated or untreated, into the waters. All vessels with an installed marine sanitation device (MSD) that are navigating, moored, anchored, or docked within a NDZ must have the MSD disabled to prevent the overboard discharge of sewage (treated or untreated) or install a holding tank. Regulations for the NDZ are contained in the U.S. Coast Pilot. Additional information concerning the regulations and requirements may be obtained from the Environmental Protection Agency (EPA) web site: http://www.epa.gov/owow/oceans/vessel_sewage/vsdnozone.html.

SOURCE

B4 1900-1939 NOS Surveys partial bottom coverage

SOURCE DIAGRAM

The outlined areas represent the limits of the most recent hydrographic survey information that has been evaluated for charting. Surveys have been banded in this diagram by date and type of survey. Channels maintained by the U.S. Army Corps of Engineers are periodically resurveyed and are not shown on this diagram. Refer to Chapter 1, United States Coast Pilot.

This nautical chart has been designed to promote safe navigation. The National Ocean Service encourages users to submit corrections, additions, or comments for improving this chart to the Chief, Marine Chart Division (N/CS2), National Ocean Service, NOAA, Silver Spring, Maryland 20910-3282.

11th Ed., Aug./04 ■
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Corrected through NM Aug. 28/04
Corrected through LNM Aug. 10/04

CAUTION

This chart has been corrected from the Notice to Mariners (NM) published weekly by the National Geospatial-Intelligence Agency and the Local Notice to Mariners (LNM) issued periodically by each U.S. Coast Guard district to the dates shown in the lower left hand corner.

DEPTHS IN METERS

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U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
COAST SURVEY

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FATHOMS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
FEET	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102
METERS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Lake Tahoe
SOUNDINGS IN METERS - SCALE 1:40,000

18665

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