Appendix B-8

LAKE TAHOE RESTORATION PROJECTS
ESTIMATED DIRECT COSTS & KEY MILESTONE DATES

Project Name:	Impervious Cover/Stream Environment Zone (SEZ) Quality Indicator Study	**Agency:**	Sponsor -USFS-LTBMU Implementing - TRPA		
Prepared by:	Denise Downie	**Phone:**	530-543-2683	**EIP #:**	10162

Identify estimated costs of eligible reimbursement expenses:

1. **Planning, Environmental Assessment and Research Costs** (specialist surveys, reports, monitoring, data collection, analysis, NEPA, etc.)	$		%
2. **Direct Labor (Payroll) to Perform the Project**	$	20,000	%
3. **Project Equipment** (tools, software, specialized equipment, etc.)	$		%
4. **Travel** (including per diem where official travel status required to carry out project, such as serve as COR, experts to review reports, etc.)	$		%
5. **Official Vehicle Use** (pro rata cost for use of Official Vehicles when required to carry out project)	$		%
6. **Cost of Contracts, Grants and/or Agreements to Perform the Project**	$	200,000	%
7. **Other Direct Costs** (direct labor for agency personnel to do project procurements; COR; PI; personnel assigned as NEPA lead; personnel assigned to review contracted surveys, designs/drawings, reports, etc.; project manager and/or project supervisor; and contracted costs for project manager and/or project supervisor if contracted separately	$	30,000	%
TOTAL*:	$	250,000	100 %

Estimated Key Milestone Dates:

Milestones/Deliverables:	Date:
Post RFP for Consultant Proposals	June 2005
Consultant Team Selection	July 2005
Consultant Contract & Commencement of Work	August-Sept. 2005
Submittal of Interim Status Report	December 2005
Submittal of Draft Report	March 2006
Submittal of Final Report	May 2006
Final Completion Date:	June 2006

COMMENTS: It is anticipated that TRPA will spend approximately $10,000 in staff time administering the consultant contract for this work. Each of the P-7 agencies will also spend staff time during consultant selection, project scoping, and the review and comment on interim, draft and final reports.

SCIENCE, RESEARCH & MONITORING
TAHOE PROJECT PROPOSAL

Project Name: IMPERVIOUS COVER/STREAM ENVIRONMENT ZONE QUALITY INDICATOR STUDY **EIP #** 10162

Lead Agency: (Sponsor) – USFS-LTBMU
Implementing Agency: TRPA

Threshold: Soil Conservation
Threshold Standard: Impervious Cover Management Standard and Stream Environment Zones Numerical Standard

Is this a multi-year project? No

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Total Project Cost: $250,000.00
Round 6 Funding requested: **$**250,000.00

Project Description:
This study will analyze linkages between impervious cover and stream environment zone (SEZ) quality indicators in the Lake Tahoe Basin. The intent of this study is to identify impervious cover thresholds for urbanized watersheds and subwatersheds within the Tahoe Basin: (1) the threshold beyond which most SEZ quality indicators begin to decline; and (2) the threshold beyond which severe degradation of SEZ quality indicators begins to occur. The purpose of this research is to develop a scientific basis for: (1) assigning desirable limitations on the amount of impervious cover in Tahoe Basin watersheds and/or subwatersheds, and (2) setting maximum percentages of impervious cover that should not be exceeded in developed watersheds and/or subwatersheds within the Basin. Key tasks involved include:

- Review of existing data on SEZ quality indicators in watersheds and subwatersheds in the Tahoe Basin;
- Identification of SEZ quality indicators for which data are sufficient for conducting analysis;
- Selection of urbanized watersheds, subwatersheds, and aggregates of subwatersheds to be used for this analysis and selection of non-urban control watersheds, subwatersheds, etc.;
- Organization of existing data for SEZ quality indicators in forms suitable for a comparative analysis with the amount of impervious cover in each watershed and/or subwatershed;
- Assembly of impervious cover data for each watershed, subwatershed, or aggregates of subwatersheds included in the study;
- Development of a methodology for separating out the effects of impervious cover on SEZ quality indicators from the impacts of other anthropogenic disturbances on SEZ quality indicators in each watershed and subwatershed involved in the analysis;
- Comparative analysis of the ranked condition of each SEZ quality indicator relative to the percentage of impervious cover in each watershed, subwatershed, or aggregates of subwatersheds included in the study;
- Evaluation of the effectiveness of SEZs (riparian buffers) and SEZ setbacks in mitigating the potential adverse effects of impervious cover on SEZ quality indicators;
- Analysis of data in an attempt to identify an impervious cover threshold beyond which each SEZ quality indicator begins to decline;
- Analysis of data in an attempt to identify an impervious cover threshold beyond which severe degradation of each SEZ quality indicator begins to occur;
- Development of an Impervious Cover Model applicable to the Lake Tahoe Basin; and,
- Preparation of draft and final reports summarizing findings and including recommendations for desirable limitations on the amount of impervious cover in Tahoe Basin watersheds and/or subwatersheds, and maximum percentages of impervious cover that should not be

exceeded in developed watersheds and/or subwatersheds within the Basin.

For Science & Research Projects briefly summarize the current state of knowledge of this subject matter:

Hydrologists have long recognized that impervious surfaces affect hydrology and water quality by diverting subsurface flow to surface runoff. Impervious surfaces, including compacted areas, prevent rainfall and snowmelt from infiltrating into the soil, and form a direct conduit for the delivery of water and nutrients to the drainage system and tributary streams, thereby short-circuiting the watershed's nutrient removal mechanisms (TRPA 2001). Urbanization of a watershed also increases the density of drainage channels, because streets, roads, sidewalks, driveways, and other structures, create new unnatural drainage ways. As the amount of impervious cover and drainage density increase in a developing watershed, a number of results occur: (1) surface runoff increases; (2) sources of sediment increase; (3) sediment yield increases; (4) nutrient yield increases; (5) peak flow increases; (6) flow velocities increase; (7) stream energy and the ability to transport sediment increase; (8) lag time decreases; and (9) flow time decreases. These changes in watershed hydrology translate into altered stream channel conditions and degraded stream ecosystem integrity.

In recent years, impervious cover (IC) has emerged as a key paradigm to explain and sometimes predict how severely stream quality indicators change in response to different levels of watershed development. There is mounting evidence of stream impairment as the amount of impervious cover in a watershed increases. For example, there is an increasing recognition that runoff volume can influence physical and biological indicators within some receiving waters (Center for Watershed Protection, 2003). A study conducted by Strecker and Reininga (1999) found that watershed processes are measurably disrupted by the placement of over 10 percent impervious coverage in the watershed (TRPA 2001). Research findings regarding the impacts of urbanization on aquatic systems indicate that at about 10% impervious cover in a watershed sensitive stream elements are lost from the aquatic ecosystem (Schueler 1995, Stormwater Center 2003). Additionally, there is a decrease in the amount of large woody debris (LWD) found in urban streams at around 10% impervious cover (Booth, et. Al. 1996 per Stormwater Center 2003). Booth (1991 per Stormwater Center 2003) found that channel stability and fish habitat quality declined rapidly after 10% impervious area. A second threshold appears to exist at around 25 to 30% cover, where most indicators of stream quality consistently shift to a poor condition (e.g., diminished aquatic diversity, water quality, and habitat scores) (Stormwater Center 2003).

In 2003, the Center for Watershed Protection published a monograph entitled *"Impacts of Impervious Cover on Aquatic Systems"*. This monograph reviews the findings of more than 225 research investigations that have studied the impact of impervious cover and other indicators of urbanization on aquatic systems. These scientific investigations have documented how urbanization influences hydrologic, physical, water quality, and biological indicators of aquatic health. Collectively, these investigations have identified 26 different stream quality indicators that are adversely affected by impervious cover and increasing urbanization in watersheds within many regions of North America. The balance of these studies indicate a progressive change in the following indicators as the amount of impervious cover increases in a watershed: increased runoff volume; increased peak discharge; stream channel enlargement; increased channel modification; loss of riparian continuity; reduced large woody debris; decline in stream habitat quality; changes in pool/riffle structure; decline in streambed quality; increased stream temperature; violations of bacteria standards; decline in aquatic insect diversity; decline in fish diversity; loss of coldwater fish species; reduced fish spawning; decline in amphibian community.

About 50 primary studies have tested the IC/stream quality indicator relationship, with the largest number looking at biological indicators of stream health, such as the diversity of aquatic insects or fish. In some cases, the IC/stream quality indicator relationship is considered so strongly established by historical research that it has been directly incorporated into accepted engineering models. This has been particularly true for hydrological and water quality indicators (Center for Watershed

Protection 2003). The Center for Watershed Protection has integrated these research findings into a general watershed planning model, known as the Impervious Cover Model (ICM). The ICM predicts that most stream quality indicators decline when the amount of impervious cover in a watershed exceeds 10%, with severe degradation expected beyond 25% impervious cover (ibid.).

In applying this model it is important to recognize that the progressive loss of forest cover (FC) has been linked to declining stream quality indicators. FC is perhaps the most powerful indicator to predict the quality of streams within the "sensitive" category (zero to 10% IC) (Center for Watershed Protection 2003). Additionally, turf cover (TC) often comprises the largest fraction of land area within low-density residential development and could play a significant role in streams that fall within the "impacted" category (10 to 25% IC) (ibid.). It has been speculated that the combined area of IC and TC might provide better predictions about stream health than IC areas alone, particularly within impacted subwatersheds (ibid.).

Describe the purpose and need for the project:
The purpose of this study is to identify thresholds that should be set by environmental planning and resource protection agencies in the Tahoe Basin (especially TRPA) for the percentage of impervious cover permissible in developed watersheds and/or subwatersheds within the Basin. The goal of this investigation is to develop a scientific basis for: (1) assigning desirable limitations on the amount of impervious cover in Tahoe Basin watersheds and/or subwatersheds, and (2) setting maximum percentages of impervious cover that should not be exceeded in developed watersheds and/or subwatersheds within the Basin.

Using preliminary data derived from the Impervious Cover GIS Layer developed by DRI (based on 2002 IKONOS satellite imagery), TRPA has determined that one (1) watershed in the Basin exceeds 25% impervious cover, two (2) watersheds (including the aforementioned) exceed 20%, six (6) watersheds (including the aforementioned) exceed 15%, and a total of nine (9) watersheds exceed 10%. Since nine (9) watersheds in the Tahoe Basin already exceed 10% impervious cover, it is highly possible that some stream quality indicators have already declined (i.e., loss of sensitive stream elements and/or sensitive organisms) due to the effects of impervious cover on the SEZs in these watersheds. There are 12 additional watersheds exceeding 5% impervious cover that should be considered for inclusion of this study making a total of at least 21 watersheds that flow directly to Lake Tahoe that should be included in this study. Additionally, large watersheds such as the Upper Truckee River watershed need to be evaluated either on a subwatershed basis or using aggregated subwatersheds representing no greater that 3rd order stream systems. (Note: The Center for Watershed Protection cautions that the ICM applies only to 1st, 2nd, and 3rd order streams.) It will also be important to include non-urbanized watersheds/subwatersheds with little impervious cover in this study as reference areas.

Although TRPA's Code of Ordinances Chapters 20 (Land Coverage Standards) and 37 (Individual Parcel Evaluation System) already set the level of allowable land coverage for undeveloped parcels in accordance with the coefficients in the Bailey Land Capability System, many of the remaining undeveloped parcels are in areas where the impervious transportation infrastructure (e.g., roads, streets, sidewalks) has not been fully taken into account. In many watersheds throughout the United States, two-thirds of all impervious cover is automobile-related (Gibbons 1998). Urbanization in the Tahoe Region has resulted in an extensive road network, which exposes new sources of sediment, requires drainage ditches to collect and drain water away, and intercepts subsurface flow, bringing it back to the surface and adding to runoff (TRPA 2001). Thus, it is possible that the overall amount of impervious cover that may be permitted in certain watersheds or subwatersheds under TRPA's current Code of Ordinances may exceed the sum total of the Bailey coefficients for the land capability classes in that watershed/subwatershed.

TRPA's preliminary analysis of impervious cover data basin-wide indicates that the total amount of existing impervious cover for some land capability classes exceeds the total maximum allowable

amount of land coverage for these land capability classes. These data indicate that existing hard coverage (i.e., impervious cover) within land capability classes 1b, 2, and 7 currently exceeds the allowable coverage coefficients of the Bailey Land Capability Classification System within the overall area of the Tahoe Basin. Class 1a lands are also near the threshold limit of 1% allowable coverage. Although the Bailey Land Capability Classification System was not designed to be implemented on a watershed basis, it is important to note that the preliminary impervious cover data further indicate that 57 of the 64 watersheds of the Basin have at least one land capability class exceeding the allowable coverage coefficients. This information, together with documentation of degraded SEZ quality indicators in many watersheds in the Basin, substantiates the need for this investigation.

The Land Capability Classification of the Lake Tahoe Basin California-Nevada: A Guide to Planning was developed by Dr. Robert Bailey of the USDA Forest Service in cooperation with TRPA in 1972. The science upon which this system is based is now more than 30 years old. Therefore, there is a need for updating our understanding of the impact of impervious cover on SEZ quality indicators in the Tahoe Basin, especially in light of recent analyses that indicate imperious cover thresholds function on a watershed and/or subwatershed basis.

Describe the goals and objective of the project (Describe Key Management Questions being addressed):

Goals of Proposed Project:

The goals of this investigation are to develop a scientific basis for: (1) assigning desirable limitations on the amount of impervious cover in Tahoe Basin watersheds and/or subwatersheds; and (2) setting maximum percentages of impervious cover that should not be exceeded in developed watersheds and/or subwatersheds within the Basin.

Objectives of Proposed Project:

- Determine linkages between impervious cover and SEZ quality indicators in the watersheds, subwatersheds, and/or aggregates of subwatersheds in the Lake Tahoe Basin;
- Determine the impervious cover threshold after which most SEZ quality indicators begin to decline;
- Determine the impervious cover threshold beyond which severe degradation SEZ quality indicators can be expected;
- Evaluate the role of forest cover in affecting the response of SEZ quality indicators to impervious cover;
- Evaluate the combined impact of impervious cover and turf cover on SEZ quality indicators;
- Evaluate the effectiveness of SEZs (riparian buffers) and SEZ setbacks in mitigating the potential adverse effects of impervious cover on SEZ quality indicators;
- Develop an Impervious Cover Model that can be applied to the Tahoe Basin watersheds, subwatersheds, and/or aggregates of subwatersheds;
- Develop scientifically supportable recommendations for: (1) desirable limitations on the amount of impervious cover in Tahoe Basin watersheds and/or subwatersheds; and (2) maximum percentages of impervious cover that should not be exceeded in developed watersheds and/or subwatersheds within the Tahoe Basin.

Project Approach: The general approach for conducting this study is outlined in the Project Description. The specific approach for conducting this study will be developed through the RFP process and the submittal of research proposals from qualified teams of experts. The RFP will be developed by the Pathway 2007 Collaborating Agencies (USDA Forest Service-LTBMU, TRPA, Lahontan Regional Water Quality Control Board, and the Nevada Department of Environmental Protection).

Key Management Questions Being Addressed:

1.1.2. What is the linkage of human disturbance and nutrient loading to Lake Tahoe?

1.2.1. What non-structural tools can be used to reduce sediment and nutrient delivery to Lake Tahoe?
1.2.4. What are the features of wetlands, riparian habitat and other stream environment zones that maximize pollutant removal?
4.4.3. How is the ecosystem most likely to respond to EIP implementation and related environmental policy actions?
4.4.6. Is there a limit to community growth and its use of the natural environment versus the health and diversity of the natural biological community? Where are we now?
4.5.1. Are current basin thresholds adequate to protect the health of the ecosystem, and should they be modified to improve their effectiveness?
4.5.2. How effective are land-use regulatory strategies in attaining basin thresholds?

It should be noted that there are no categories of "Key Management Questions" pertaining to Soil Conservation or Impervious Cover. This is an oversight that needs to be corrected since much of the N, P, and fine sediment that enter Lake Tahoe comes either from the land or from streambed and streambank erosion.

This project will inform the development and understanding of additional key management questions pertaining to the impacts of impervious cover on SEZ quality indicators (including water quality). Some additional important management questions addressed by this study include:

- What is the relative effect of impervious cover on stream channel form and condition?
- What is the relative effect of impervious cover on streambank and streambed erosion and sediment transport to the Lake?
- What is the relative effect of impervious cover on water quality indicators?
- What is the relative effect of impervious cover on biological indicators of stream health?
- What is the relative effect of impervious cover on other SEZ quality indicators?
- What is the impervious cover threshold after which most SEZ quality indicators begin to decline?
- What is the impervious cover threshold beyond which severe degradation SEZ quality indicators can be expected?
- What is the role of forest cover in affecting the response of SEZ quality indicators to impervious cover?
- What is the combined impact of impervious cover and turf cover on SEZ quality indicators?
- How effective are SEZs (riparian buffers) and SEZ setbacks at mitigating the potential effects of impervious cover on SEZ quality indicators?
- What limitations should be set on the amount of impervious cover in Tahoe Basin watersheds and/or subwatersheds?

Describe the anticipated project accomplishments:
The results and recommendations from this project will aid the Pathway 2007 agencies in assigning desirable limitations on the amount of impervious cover in Tahoe Basin watersheds and/or subwatersheds. By applying this Desirable Impervious Cover Threshold Standard on a watershed/subwatershed basis, LTBMU, TRPA, LRWQCB, and NDEP will be able to ensure that Tahoe Basin's SEZs remain in a healthy condition (i.e., SEZ quality indicators are not degraded), and that SEZs are capable of performing their water quality functions to the greatest extent possible. Thus, by maintaining a healthy balance between development (i.e., impervious cover) and SEZ functionality, we will minimize the transport of N, P, and fine sediment from developed watersheds to the Lake.

The results of this project will also provide a scientifically defensible basis for the Pathway 2007 agencies to set maximum allowable percentages of impervious cover that should not be exceeded in

developed watersheds and/or subwatersheds within the Tahoe Basin. By applying this Maximum Impervious Cover Threshold Standard on a watershed/subwatershed basis, LTBMU, TRPA, LRWQCB, and NDEP will be able to ensure that severe degradation of SEZ quality indicators will not occur as a result of development (i.e., impervious cover) in these watersheds/subwatersheds. Thus, by ensuring that severe degradation of SEZ quality indicators does not occur, we will be able to prevent catastrophic reductions in SEZ functionality and large-scale inputs of N, P, and fine sediment from developed watersheds to the Lake.

Additionally, the results of this project will also provide a scientific rationale for funding EIP projects aimed at reducing the amount of impervious cover in watersheds and subwatersheds that presently exceed the Maximum Impervious Cover Threshold Standard.

Also see discussions above for more information on "anticipated project accomplishments".

Describe the "readiness" of this project to move forward:
TRPA and collaborating agencies have already taken, or are in the process of taking, the following steps to be in the position to retain consultants to conduct this study:

- TRPA (on behalf of the USFS, CTC, CalTrans, & TRPA) contracted with Space Imaging to purchase high resolution one meter panchromatic and four meter multispectral IKONOS™ image data for the entire Tahoe Basin, a total of 19 IKONOS scenes excluding the Lake itself (USFS, CTC, CalTrans, & TRPA combined cost = $100,250.00);
- TRPA contracted with Desert Research Institute (DRI) GIS and image processing experts to conduct a pilot study to develop a methodology to identify and map impervious cover in a pilot project area in the City of South Lake Tahoe (TRPA cost = $50,000.00);
- TRPA contracted with DRI (Mr. Tim Minor and Dr. Mary Cablk) to identify and map hard impervious coverage throughout the Lake Tahoe Basin using advanced satellite technology and remote sensing techniques (TRPA cost = $94,968.00);
- TRPA contracted for a readjustment of the parcel-based SEZ maps to conform with the updated parcel base maps (Consultant Contract = $7,125.00)
- TRPA staff are in the process of completing a necessary refinement of the SEZ map layer to be used in updating the Land Capability GIS layer (TRPA staff time = 280 hrs.);
- TRPA staff will update the Land Capability GIS layer so it can be used in recalculating the amount of impervious coverage by land capability class in watersheds and subwatersheds in the Basin (TRPA staff time = 20 hrs.)
- TRPA staff will re-perform calculations of impervious cover in each watershed and subwatershed utilizing the Impervious Cover Layer developed by DRI, the revised Land Capability Layer, and the watersheds and subwatersheds GIS layers (TRPA staff time = 40 hrs.)
- TRPA, NDEP, LTBMU have contracted for an updated mapping of the vegetation in the Tahoe Basin that will aid in taking forest cover (FC) into account when evaluating the impact of impervious cover in forested vs. developed watersheds (Consultant Contract = $110,000.00);
- USDA Natural Resource Conservation Service is working on an update of the 1974 Soil Survey of the Lake Tahoe Basin with revised information on infiltration, saturated hydraulic conductivity, and runoff potential;
- LTBMU and TRPA are in the process of assembling data on stream channel conditions and benthic macroinvertebrates at selected sites on Tahoe Basin streams;
- LTBMU is commencing on a Terrestrial Ecological Unit Inventory that will provide an updated landscape stratification of the Tahoe Basin taking into account updated

information on the geology, geomorphology, soils, climate, and potential vegetation.

No environmental documentation is required in order to conduct this project.

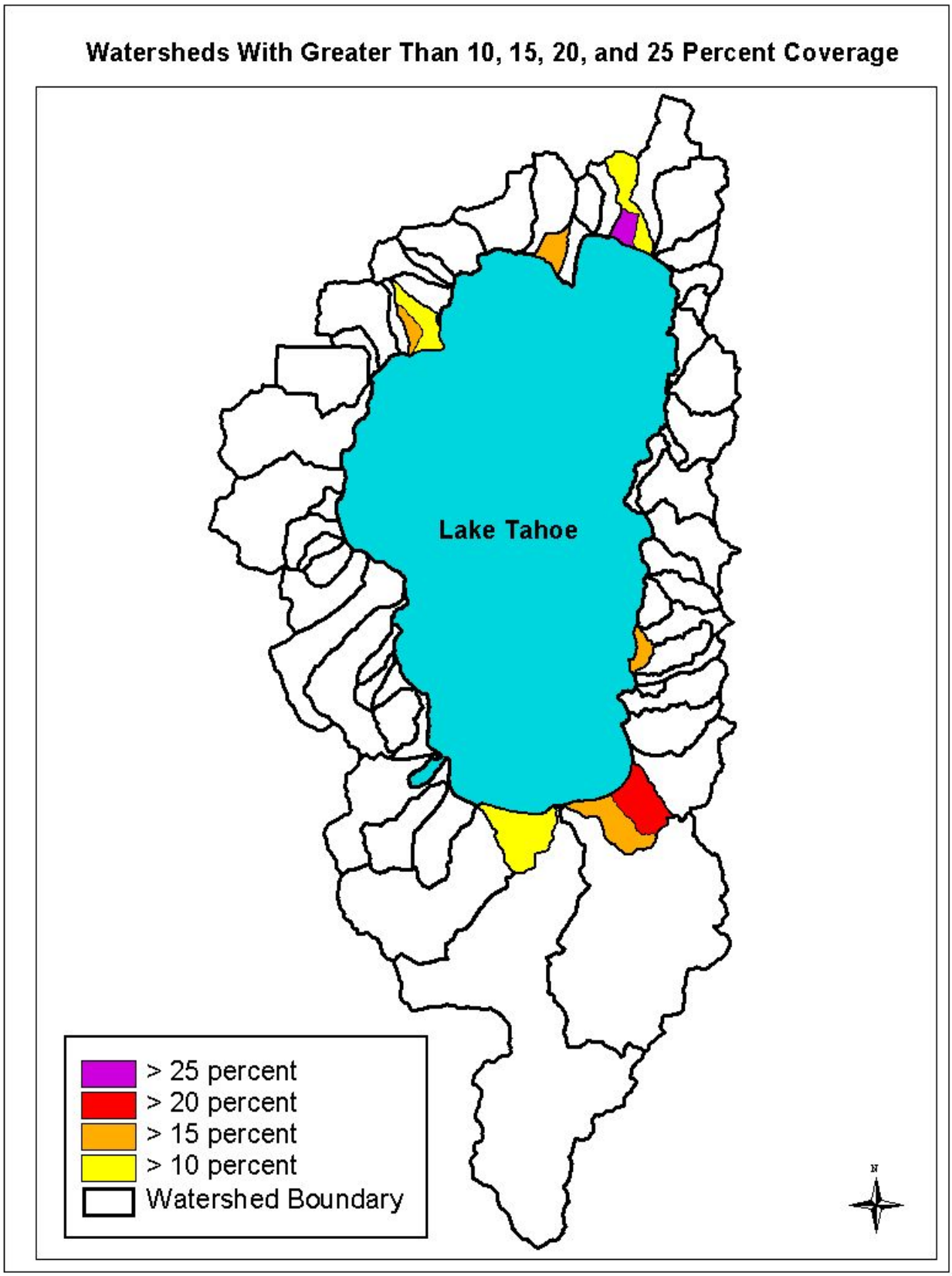
Describe potential partnerships for this project and include supporting documentation:
Potential partners for this project include TRPA, LRWQCB, NDEP, CTC, and NDSL.

- LTBMU, TRPA, LRWQCB, and NDEP share a common concern regarding the effectiveness of current policies and ordinances limiting the amount of impervious cover in the Tahoe Basin.
- LTBMU and TRPA have been conducting stream surveys and surveys of benthic macroinvertebrates in Tahoe Basin streams for several years. LRWQCB has provided some of the funding for these investigations. LTBMU and TRPA's Fisheries Threshold Program are interested in establishing an Index of Biological Integrity for evaluating stream quality indicators in the Tahoe Basin. Impervious cover is one of the important factors that will be evaluated as a causal factor in explaining differences in the abundance and diversity of benthic macroinvertebrates in Tahoe Basin streams.
- LRWQCB and NDEP are currently working on the Lake Tahoe TMDL. Impervious cover is an important watershed variable that is being taken into account in the watershed model developed for the TMDL. A better understanding of the relative effect of impervious cover on water quality in Tahoe Basin streams will aid public agencies in setting public policy regarding land coverage so as to achieve the prescribed TMDLs.
- CTC and NDSL operate programs for the reduction of impervious cover in the Basin utilizing Excess Coverage Mitigation Funds collected by TRPA. They also operate land banks that are used by private parties needing to acquire additional land coverage.

Describe how this project will guide future management activities:
The results of this investigation will be used to by the Pathway 2007 agencies to (1) assign desirable limitations on the amount of impervious cover in Tahoe Basin watersheds and/or subwatersheds, and (2) set maximum percentages of impervious cover that should not be exceeded in developed watersheds and/or subwatersheds within the Tahoe Basin.

Include an 8 ½ X 11 map depicting the project, or research/study area.

SEE MAP ON NEXT PAGE


Watersheds With Greater Than 10, 15, 20, and 25 Percent Coverage
Lake Tahoe
> 25 percent
> 20 percent
> 15 percent
> 10 percent
Watershed Boundary
N