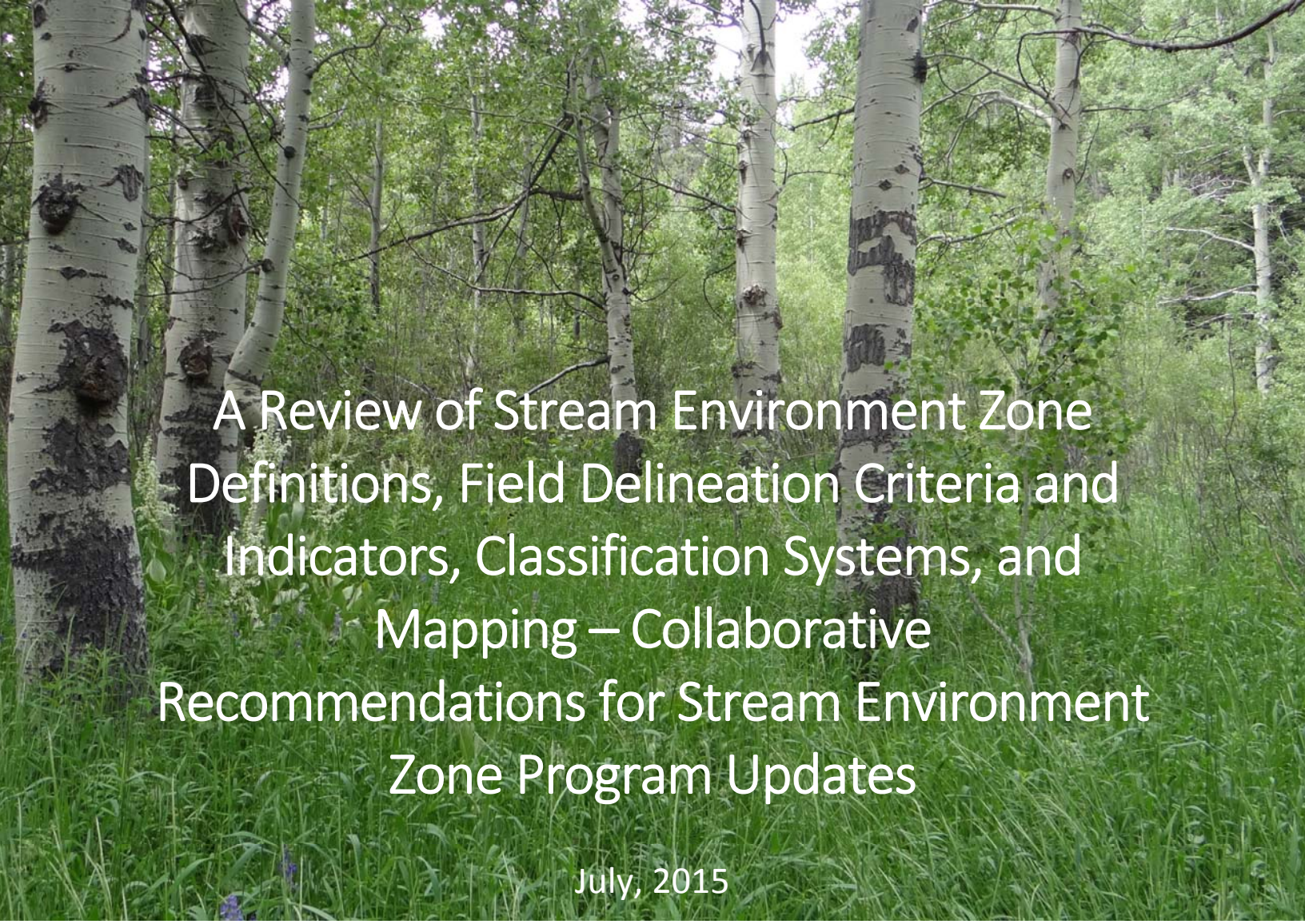

A Review of Stream Environment Zone Definitions, Field Delineation Criteria and Indicators, Classification Systems, and Mapping – Collaborative Recommendations for Stream Environment Zone Program Updates

July, 2015

Prepared By

Spatial Informatics Group

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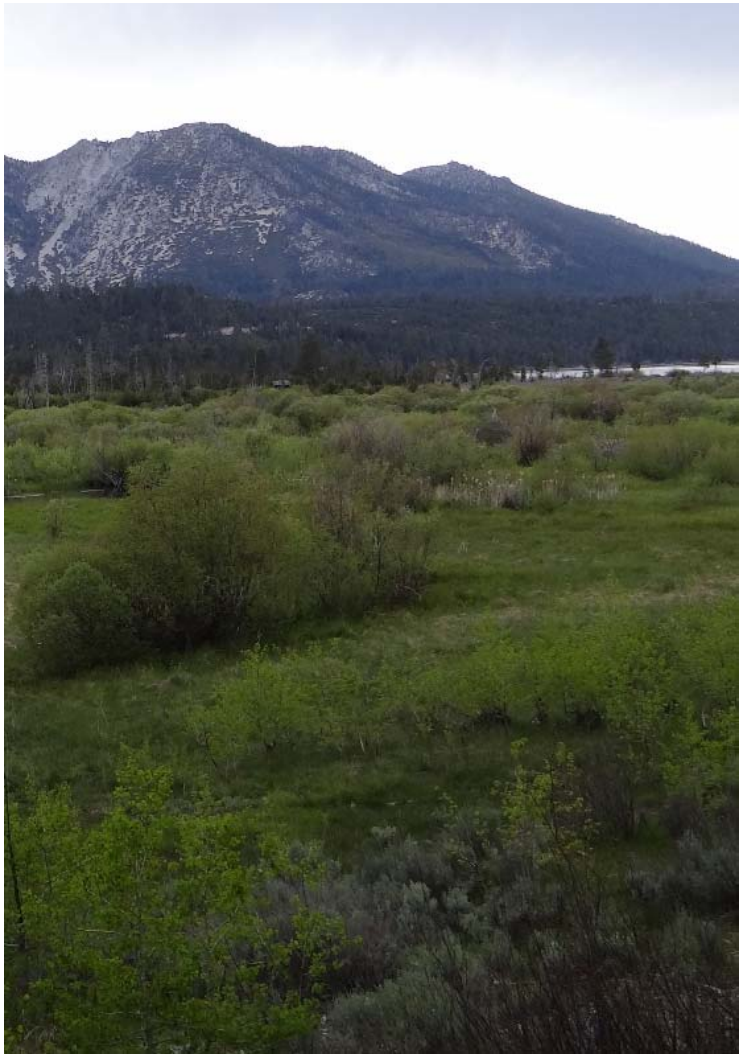

An example of the 'freshwater estuary' stream environment zone type at the mouth of Taylor Creek in spring 2015, southwest Lake Tahoe, CA. Source: Travis Freed.

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EXECUTIVE SUMMARY

The Stream Environment Zone (SEZ) is a land designation unique to the Lake Tahoe Basin that includes lands surrounding and including streams, lakes and wetlands – areas that owe their physical and biological characteristics to the presence of surface water and/or shallow groundwater. In addition to providing water quality protection, SEZ conservation policies and management strategies conserve and protect aquatic and associated upland and riparian habitats, provide recreational opportunities and enhance scenic quality and associated real estate values. This project responded to Lake Tahoe Basin stakeholders' identified needs to review and potentially update the current SEZ policy to ensure implementing ordinances and program elements are consistent with best available science and data, and support desired SEZ conditions, functions, processes and values.

For this project, our project team and individuals representing technical expertise from multiple Tahoe Basin agencies, a non-profit environmental group and other topic area experts were organized into task workgroups. One workgroup was tasked with the review and providing recommendations for potential changes to: 1) SEZ definitions, 2) SEZ field delineation criteria and indicators, 3) desired SEZ conditions, functions, processes and values, and 4) SEZ classification approaches. A second workgroup was charged with mapping aquatic resources (e.g., streams, wetlands, lakes, seeps, and springs) and SEZs in the Tahoe Basin using current data and mapping procedures. This report summarizes the findings and recommendations of these workgroups.

No changes to TRPA SEZ definitions are recommended, however several recommended changes to SEZ field delineation indicators are proposed for consideration by implementing agencies. Recommended changes would provide indicators that are technically sound and can be consistently applied across SEZ specialists. Proposed changes maintain the fundamental purpose and elements of the current SEZ delineation criteria in that the approach would still be based on soil, geomorphic, hydrologic and vegetation characteristics and the existing core concept of primary and secondary SEZ indicators would also be retained. The primary recommended changes are related to vegetation and soil saturation indicators and are based on advances to the understanding of riparian and wetland systems that have been incorporated into industry standards since the adoption of existing Lake Tahoe Basin SEZ policy. Minor refinements to aquatic habitat and floodplain indicators are also recommended to improve clarity in their application.

Existing direction for the use of vegetation to identify SEZ boundaries is based on a description of Tahoe Basin vegetation communities published in 1971. Field work related to SEZ field delineation has since demonstrated that that several of the plant species listed within different identified riparian vegetation communities are rarely, if ever found in the Tahoe Basin. To make consistent with current wetland vegetation identification standards, the Field Delineation Workgroup recommends using "wetland species indicator status" instead.

Existing soils indicators include and rely heavily on soil maps units. This approach has proved problematic, because soil map units include some areas that would be improperly defined as SEZ and also miss areas that should be defined as SEZ. Consequently, the Field Delineation Workgroup recommends eliminating soil map units as a means of identifying SEZ, and instead using soil characteristics observed in the field. The specific recommended indicators include presence of hydric soils, presence of groundwater and evidence of saturated soils.

Another Field Delineation Workgroup finding recommends three intensities of SEZ survey and delineation depending on the type of project being proposed. The most spatially extensive (and least field intensive) survey and delineation level includes mapping of SEZs for broad scale planning and tracking. An intermediate level of intensity would be applied for delineating SEZ boundaries in the field when extensive and non-permanent activities, such as fuels reduction projects, are proposed in or near SEZs. In such cases, physical and ecological SEZ indicators would be used but would be applied conservatively to yield SEZs boundaries typically wider than those delineated by the most intensive delineation survey. The most intensive SEZ field delineation techniques would be applied on the ground when a precise determination of SEZ boundaries is needed, for example in cases where a permanent development project is proposed.

Three map and map-related products were produced for this project: 1) a Basin-wide aquatic resource map (showing more accurate and precise locations, boundaries and alignments of stream tributaries, wetlands, springs, seeps, ponds and lakes), 2) a SEZ classification scheme based on the review of previously established riparian and wetland classification system and informed by the project's field and mapping workgroups, and 3) a Basin-wide SEZ map showing the approximate boundaries of different SEZ types (following the classification scheme agreed to by workgroup participants).

TABLE OF CONTENTS

Acknowledgements 1
Executive Summary 2
Introduction 6
Project Approach 8
Documentation of SEZ Desired Conditions, Values, Functions, and Processes 10
Review of Stream Environment Zone Definitions and Setback Standards 12
Field Delineation Criteria and Indicators for Identifying Stream Environment Zone Boundaries 15
- Background 15
- Issue Identification and Recommendations 16
  - Vegetation Indicators 18
  - Soil Indicators 19
  - Aquatic Habitat Indicators 23
  - Floodplain Indicator 23
- Proposed Field Delineation Methods 23
  - Vegetation 24
  - Soils 24
  - Floodplains 25
- Proposed Application of SEZ Delineation 25
  - Level I Delineation 25
  - Level II Delineation 25
  - Level III Delineation 26

Stream Environment Zone Classification 26
- Evaluation Criteria 27
- Proposed Stream Environment Zone Types 31
  - Lacustrine 31
  - Freshwater Estuaries 31
  - Meadows 32
  - Riverine 32
  - Forested 33
  - Seeps and Springs 34
  - Fens 34

Aquatic Resources and Stream Environment Zone Mapping 34

Background 35
Methods 37
Aquatic Resources 37
Stream Environment Zone 39
Mapping Results 41
Aquatic Resources 41
Stream Environment Zone 43
Conclusions and Recommendations 46
Literature Cited 48
Appendix A. Description of Project Workgroups 53
Appendix B. Desired Conditions, Processes, Functions and Values of the Stream Environment Zone in the Lake Tahoe Basin 55

INTRODUCTION

The stream environment zone land designation is unique to the Lake Tahoe Basin. Stream environment zones (SEZ) are land areas that owe their physical and biological characteristics to the presence of surface water and/or shallow groundwater for a significant duration of the growing season in most years (TRPA 1977). SEZ typically encompass streams, wetlands, ponds, lakes, seeps, springs and the transitional areas that exist between surface waters and adjacent upland plant communities (ibid). SEZ provide beneficial physical, chemical, and biological functions and services that in turn provide or enhance wildlife and fish habitat, water filtration and storage, scenic quality, recreation experience, vegetation and soil quality. By conserving viable riparian soils and biomass associated with SEZ, these areas may also serve to sequester carbon - a function important for moderating the effect of climate change.

Multiple Tahoe Basin agencies have goals, policies and programs related to the conservation and restoration of SEZ. Principal among these is the Tahoe Regional Planning Agency (TRPA), whose Regional Plan (TRPA 2012) requires achievement of several environmental threshold standards related to SEZ. These include numerical and management standards for water quality, wildlife, fisheries, scenic resources, vegetation preservation and soil conservation as well as a SEZ restoration target. TRPA and other agencies have adopted and implemented various conservation measures, management guidelines and restoration programs to achieve Threshold Standards associated with SEZ. Although land management agencies have made significant strides in protecting and conserving SEZs in the Tahoe Basin under existing policies and regulations, new science-based information, state initiatives, federal guidance and identified issues with existing SEZ program elements has prompted a comprehensive review and update of Regional SEZ policies and conservation program elements. As a result, the TRPA and other Basin agencies endeavor to review SEZ conservation policies and program elements and provide recommendations on how to improve consistency with United States Environmental Protection Agency's (EPA) Core Elements of an Effective State and Tribal Wetlands Program Framework.

Collaborative planning between 2001 and 2007 by key resource Tahoe Basin agencies, technical experts, stakeholders and the public (known as the "Pathway" planning process) to identify a common vision and strategy for the Lake Tahoe Basin's natural resources and socioeconomic conditions also produced reviews and recommendations for SEZ program elements. In July 2010, the Tahoe Interagency Executive Steering Committee directed agency staff to prepare a briefing paper outlining steps necessary to update policies and program elements related to the conservation of SEZ in the Lake Tahoe Basin. The resulting memorandum (the so called "SEZ roadmap") recommended ten steps for the review and update the Region's SEZ policies and program. The recommended steps included foundational actions such as clear documentation of desired SEZ values, processes and functions, creating an updated SEZ map using current data and mapping procedures (e.g., soil survey, LiDAR and multispectral imagery), the development of a SEZ classification system, and review of SEZ field and mapping delineation indicators and procedures. This information could then be used to inform SEZ assessment and monitoring and more effectively help to plan for restoration of the SEZ. Also included in the SEZ Roadmap (and not addressed in this project) were steps to update SEZ condition standards, permitting and regulations related to SEZ consistent with the EPA's Core Wetland Elements Framework.

Subsequent to the "SEZ roadmap", research funding was received for this project to address needs associated with improving current understanding of distribution and abundance of SEZ per steps outlined in the SEZ roadmap memorandum. Specifically, this project addresses the following SEZ program update objectives: 1) document desired SEZ functions, processes and values – to clarify what outcomes are

desired as a result of management, restoration and regulation (Step 1 of the SEZ Roadmap), 2) conduct a review and provide recommendations for the revision of SEZ definitions and field delineation indicators (Step 2 of the SEZ Roadmap), 3) produce maps showing - a) aquatic resources and b) SEZ boundaries - utilizing new and more accurate data, and mapping standard procedures (Step 3 of the SEZ Roadmap), and 4) provide recommendations for a SEZ classification system based on soils, hydro-geomorphology and/or vegetation that is protective of identified SEZ desired functions, processes and values (also Step 3 of the SEZ roadmap).

Perhaps the most important need for this project expressed by stakeholders was a review of existing SEZ field delineation indicators with an aim of recommending changes to address conflicts with a more current Tahoe Basin soil survey (USDA-NRCS 2007) and resolve technical deficiencies of existing SEZ delineation guidance. Currently adopted SEZ field delineation criteria include soil types delineated in a soil survey that was conducted in 1971 (Rogers 1974). Though an updated soil survey was completed in 2007 (USDA-NRCS 2007), revisions have not been incorporated into regulatory code for SEZ (TRPA 2012).

Workgroups composed of multiple agency representatives, stakeholders and topic area experts were organized to complete tasks for this project. One workgroup was tasked with review and recommendation of changes to SEZ definitions, field delineation criteria, desired SEZ conditions and functions, and SEZ classification approaches. A second group was charged with utilizing current data and mapping approaches to map aquatic resources and SEZ throughout the Tahoe Basin. This report summarizes the results of these efforts.

PROJECT APPROACH

Three groups, comprising the "SEZ Workgroup", were formed to manage and address different aspects of this project (*Figure 1*). An Administrative Group provided coordination and administration of project elements. The Administrative Group was made of members of the project team from Spatial Informatics Group (SIG) and San Francisco Estuary Institute (SFEI). The Core Group was composed of the Field Delineation Workgroup and the Mapping Workgroup. The Field Delineation Workgroup (field workgroup) was responsible for the review of SEZ definitions, desired functions and processes, field delineation indicators, and classification systems. The Field Delineation Workgroup was composed of agency technical experts, a local environmental NGO, private soil experts, and members of the project team. The Mapping Workgroup focused on mapping aquatic resources following California Aquatic Resources Inventory (CARI) standard operating procedures (as amended for the Tahoe Basin – "Tahoe Aquatic Resources Inventory" or "TARI") as well as the details of mapping SEZ boundaries and SEZ types (Collins *et al*. 2014). The Mapping Workgroup was composed of agency mapping experts, a local NGO and the project team (representing SIG and SFEI). The Stakeholder Group was composed of higher-level management from federal, state and local agencies, NGO representatives, local government entities, and interested citizens and was involved with the initial project kickoff meeting and in the review of final project products. Appendix A further describes the groups involved with this project.

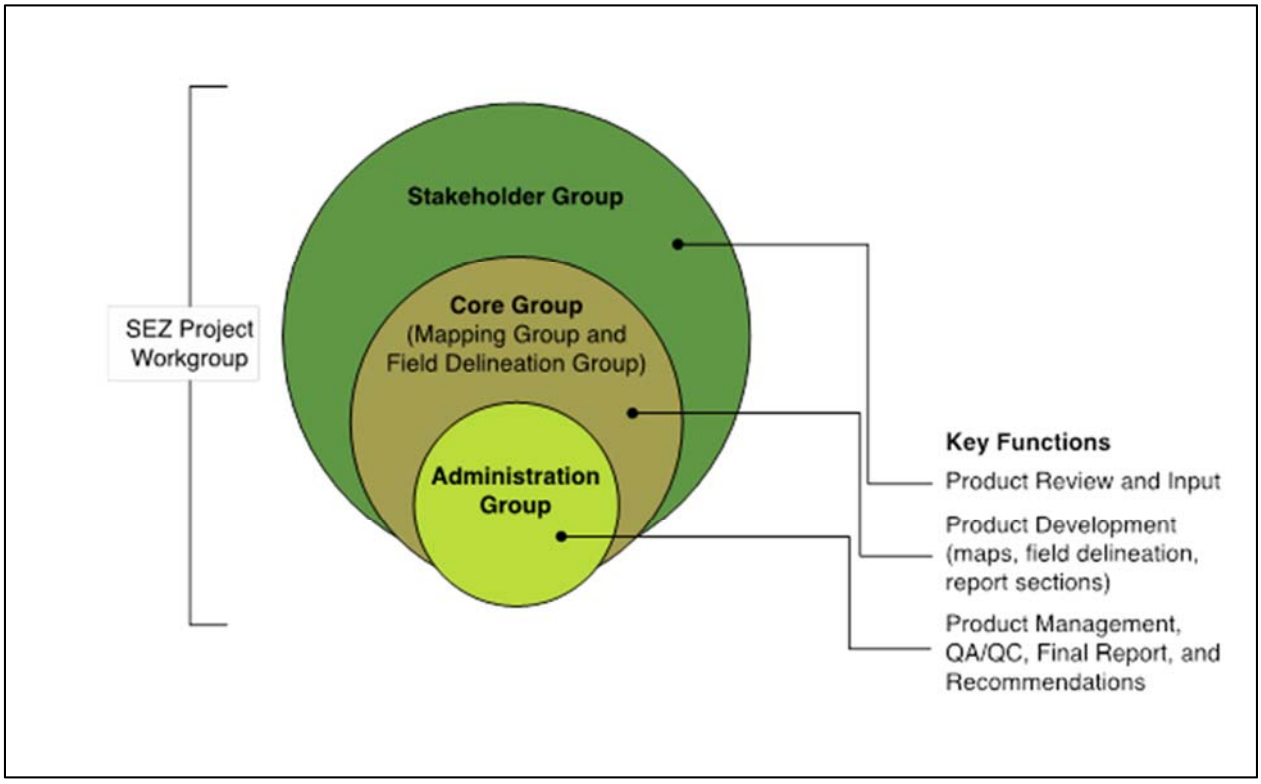

Figure 1. Diagrammatic representation of the overall Tahoe Stream Environment Zone Project Workgroup (Workgroup) with respect to the Administrative Group, Core Group (Field Delineation and Mapping Workgroups) and the Stakeholder Group, and each groups associated functions. The SEZ Project Workgroup is an advisory body charged developing products and recommendations related to stream environment zone mapping and classification approaches and field delineation procedures. The SEZ Project Workgroup served a review function and did not have authority to modify any existing agency policy or planning direction related to stream environment zones.

The project was initiated with a Stakeholder Group meeting to ensure there was a general and broad understanding the project's overall objectives and tasks. After initial input was received at the first meeting, the Field Delineation Workgroup was formed and set out to review and gain resolution on the following topic areas:

- Review and documentation of SEZ desired conditions, functions, process and values
- Review SEZ definitions
- Review of SEZ field delineation criteria and indicators
- Review of wetland and riparian area classification schemes with an eye towards identifying which system might be most applicable to SEZ

The Field Delineation Workgroup met more than 10 times over the course of the project and was able to provide recommendations for each of the above listed topic areas.

The Mapping Workgroup was assembled and began meeting after the Field Delineation Group had established its recommendations. This schedule was necessary because the recommendations in many ways influenced which indicators and SEZ types would be used for mapping SEZ. Once established, the Mapping Workgroup was responsible for the following tasks:

- Confirm the SEZ classification scheme recommended by the Field Delineation Workgroup.
- Map aquatic resources as a foundation to SEZ mapping. It was reasoned, based on the definition and field delineation indicators of SEZ, that aquatic resources were core to producing a Basin-wide map of SEZ.
- Release the aquatic resource map to an impartial third party to judge the extent to which the aquatic resource map produced for this project was consistent with current California wetland and riparian mapping standards.
- Produce a Basin-wide SEZ map based on proposed SEZ classification scheme and proposed indicators provided by the Field Delineation Group

The mapping group accomplished these tasks in three meetings.

Once all mapping products were completed, a final Stakeholder Group meeting was held. At this meeting, findings, recommendations and mapping products were displayed and discussed. All input was noted and incorporated into the final report and map products as appropriate.

DOCUMENTATION OF SEZ DESIRED CONDITIONS, VALUES, FUNCTIONS, AND PROCESSES

Sound land stewardship starts by clearly defining the natural resource conditions, values, processes and functions desired as an outcome of restoration, management and regulation. To accomplish this, and prior to this project in October of 2011, the Tahoe Science and Management Integration Team (SMIT) organized a Stream Environment Zone Workgroup meeting of greater than 20 stakeholders and technical experts to initiate dialogue around SEZ program update. The meeting of this workgroup focused on the listing of desired SEZ conditions, functions, values and processes – to capture the purpose of SEZ management and policy. The list developed was based on work completed through the Tahoe Pathway planning process, previous technical and planning documents and participant's personal and profession experiences related to SEZ. The project team and the field group for this project used information documented at this meeting in addition to a review of published literature and historic TRPA documents related to the development of Tahoe Basin SEZ policy to clearly document SEZ desired conditions, values, functions and processes in this report.

Our review found that SEZs perform a variety of ecological functions (i.e., physical, chemical, and biological) and also provide Tahoe Basin residents and visitors with a number of social and economic benefits which are desirable to maintain and perpetuate. Identification of these values, functions and processes was important for providing context for the review of SEZ definitions, field delineation criteria and indicators, and for mapping products. Consideration of desired SEZ functions and processes should also be useful in the identification of indicators and targets in the context of SEZ monitoring efforts. A description of SEZ desired conditions, values, processes and functions is provided in Appendix B and summarized in *Table 1* below.

Table 1. Summary of desired Stream Environment Zone conditions, processes, functions and values by issue category

Issue Category	Desired SEZ Conditions, Values, Functions and Processes
Disturbances	Control flooding
	Minimize human-caused mass wasting
	Wildfire abatement
Water Quality	Reduce sediment, nutrient and pollutant loading to surface waters
	Moderate water temperature for aquatic species
Water Quantity	Flow maintenance and moderation
	Allow groundwater recharge
Aquatic Habitats	Provide suitable aquatic habitats for native and desirable species and connectivity throughout the stream continuum
Riparian Habitats	Contribute to native vegetation community diversity, provide suitable habitat for rare plant species
	Contribute to regional native wildlife habitat diversity and provide movement corridors; provide suitable habitat for special interest species
	Promote natural soil productivity and nutrient cycling
Socioeconomics	Protect cultural and historic heritage and resources
	Moderate noise and provide visual diversity and screening
	Provide educational opportunities
	Enhance real estate value
	Provide for low-impact recreational opportunities where appropriate
	Contribute to regional tourist economy

REVIEW OF STREAM ENVIRONMENT ZONE DEFINITIONS AND SETBACK STANDARDS

The primary purpose of SEZ policy was to buffer stream and water bodies from urban development and other degrading activities to reduce the delivery of nutrients and sediments to surface waters and Lake Tahoe. In doing so, many other natural resource conservation benefits were realized. The utility of buffer strips in protecting water quality from timber harvest, road construction and other land disturbances was gradually accepted by resource managers following studies of their effectiveness beginning in the late 1950s (e.g., Trimble and Sartz 1957, Haupt and Kidd 1965; Brazier and Brown 1973). The value of buffers adjacent to streams in protecting the quality of water flowing to Lake Tahoe was identified in "*Hydrology and Water Resources of the Lake Tahoe Region*" (TRPA 1971). This report stated that "*stream quality can be protected by preserving buffers of undeveloped land adjacent to streams*".

The Stream Environment Zone is defined in the TRPA Code of Ordinances (TRPA 1987, TRPA 2012) as: "*Generally an area that owes its biological and physical characteristics to the presence of surface or ground water. The precise definition is an area determined to be an SEZ by application of the criteria set forth in TRPA's Water Quality Management Plan for the Lake Tahoe Region, Volume III, SEZ Protection and Restoration Program, dated November 1988. The criteria for identifying SEZs in Section 53.9 shall be used for purposes of implementing IPES*."

Because the definition of SEZs has evolved over time, the field group reviewed earlier versions of SEZ definitions to assess its original intent and provide context for the review of the adopted SEZ delineation criteria and indicators. The following definitions, included in the Tahoe Region Water Quality Management Plan, Volume III SEZ Protection and Restoration Plan (TRPA 1988) proved useful:

"*Stream Environment Zone (SEZ) is the term used to denote the major and minor streams, intermittent streams, drainage ways, meadows and marshes and other areas of water influence within the Lake Tahoe Basin. The term applies equally to areas where surface and subsurface waters are involved. The term 'wetlands' is specifically used to refer to areas where standing water or saturated soils are present most of the year*". And "*That region: 1) which surrounds a stream, including major streams and drainage ways, which owes its biological and physical characteristics to the presence of water; 2) which may be inundated by a stream; or 3) in which actions of man or nature may directly or indirectly affect the stream. A stream includes small lakes, ponds and marshy areas through which the stream flows*".

In addition to aquatic features (e.g., stream channels, ponds, wetlands, lakes, etc.) maintained in the current definition, the SEZ includes a setback, or buffer zone. A SEZ setback is a strip of land adjacent to the edge of a SEZ, the designated width of which is considered the minimum width necessary to protect the integrity of the various characteristic of the SEZ. The width of the setback is established in accordance with the procedure set forth in TRPA Code subsection 53.9.3. SEZ setbacks are based on SEZ type (channel, other) with additional consideration for flow regime, channel type and slope condition. Setback widths range from 10 feet (lakes and ponds) to 15 to 60 feet for some channels, as shown in *Table 2*.

The field workgroup devoted time to evaluating the effectiveness of current SEZ definitions and associated setbacks in meeting their intended objectives – to protect surface waters. This was done by reviewing literature related to buffer strip effectiveness and comparing findings with objectives for Tahoe SEZ and through review of the limited research on the question conducted in the Tahoe Basin.

Most research on buffer effectiveness has been conducted on stream channels, with studies evaluating various buffer widths from the edge of the channel (Johnson and Ryba 1992, Welsch 1991). Tahoe SEZ setbacks measure from the edge of riparian/wetland vegetation and floodplain boundaries, so their widths are typically much greater than a buffer that is commonly drawn from a channel's edge in other regions.

Limited research has been conducted on effectiveness of stream and meadow restoration in improving SEZ function (e.g., 2nd Nature 2013), but none on the effectiveness of SEZ (including setbacks) typically found within the individual parcel scale. The consensus of the field workgroup, who collectively represent years of experience in observing and delineating SEZ, was that existing definitions of SEZ, and effectiveness of SEZ setbacks was adequate – and more protective of desired conditions than at other areas where setback buffers are applied.

*Table 2. Setback widths applied to the Stream Environment Zone (*when present, lesser distance applies).*

SEZ Type	Flow Regime	Channel Type	Slope Condition	Setback Width (feet)	
				from SEZ edge	from Terrace*
Stream	Perennial	Confined	Good	25	15
			Average	35	20
			Poor	60	35
		Unconfined		50	
	Seasonally Flowing (ephemeral or intermittent stream)	Confined	Good	15	10
			Average	25	15
			Poor	40	25
		Unconfined		25	
Lake or Pond				10	
Other				10	

SEZ are an administrative land designation unique to the Lake Tahoe Basin. At times, confusion has arisen over differences between SEZ and wetland designations traditionally applied by agencies operating outside of the Lake Tahoe Basin, including wetlands (Clean Water Act, Section 404) as implemented by the US Army Corp of Engineers (USACE), and Waters of the United States, as defined by the United States Environmental Protection Agency (EPA). The definitions follow:

"*Wetland means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas*".

"*For purposes of all sections of the Clean Water Act, 33 U.S.C. 1251 et seq. and its implementing regulations, subject to the exclusions in paragraph (t) of this section, the term 'waters of the United States*' means:

1. All waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
2. All interstate waters, including interstate wetlands;
3. The territorial seas;
4. All impoundments of waters identified in paragraphs (s) (1) through (3) and (5) of this section;
5. All tributaries of waters identified in paragraphs (s) (1) through (4) of this section;
6. All waters, including wetlands, adjacent to a water identified in paragraphs (s) (1) through (5) of this section; and
7. On a case-specific basis, other waters, including wetlands, provided that those waters alone, or in combination with other similarly situated waters, including wetlands, located in the same region, have a significant nexus to a water identified in paragraphs (s)(1) through (3) of this section.

It was concluded by the field workgroup that the SEZ generally occupies a larger land area surrounding an aquatic feature than prescribed by either USACE or EPA regulations and as a result, found no basis for recommending changes to currently adopted SEZ definitions or setback standards.

FIELD DELINEATION CRITERIA AND INDICATORS FOR IDENTIFYING STREAM ENVIRONMENT ZONE BOUNDARIES

Background

Protection and management of SEZ in the Tahoe Basin is comprehensive and multi-scaled. Regulations are intended to preserve existing naturally functioning SEZ lands in their natural hydrologic condition. At the scale of individual parcels disturbance in the SEZ is prohibited. Presence of a SEZ, along with the Bailey land capability system, governs the amount of impervious surface allowed on a parcel. Restoration of currently disturbed SEZ at the Tahoe Basin scale is also a program priority as indicated by the adoption of a regional SEZ restoration target embodied as a TRPA Threshold Standard to - *Preserve existing naturally functioning SEZ lands in their natural hydrologic condition, restore all disturbed SEZ lands in undeveloped, un-subdivided lands, and restore 25% of the SEZ lands that have been identified as disturbed, developed or subdivided, to attain a 5 % total increase in the area of naturally functioning SEZ lands*. To support these policies, scientifically supported indicators and measurement methods are needed to ensure confidence in the delineation of SEZ boundaries.

Although the term Stream Environment Zone was not used in "*Land-Capability Classification of the Lake Tahoe Basin, California-Nevada: A Guide for Planning*" (Bailey 1974) which is implemented through code and project review by TRPA, "high hazard" lands were designated as Class 1 (i.e., lands not suited for development, grazing, or forestry). Within this class, a Subclass 1b was designated for lands that are naturally wet and poorly drained (e.g., stream channels, marshes, flood plains, riparian areas, and meadows). Class 1b lands were identified as "*critical areas for the management and protection of water resources*" (*ibid*) and functionally similar to SEZ. Bailey (1974) recommended that policy for these lands "*should reflect their value as floodwater and sediment storage areas, wildlife habitat, and fish spawning grounds*".

TRPA documented the importance of preserving and restoring SEZ in TRPA (1977). TRPA identified the following landscape types: 1) major rivers, streams, creeks, lakes, ponds, marshes, and wetlands, 2) 100-year floodplains, 3) areas of topographic depression, 4) riparian vegetation, 5) alluvial soils, and 6) buffer strips. Guidelines for the identification and delineation of SEZs were originally established in Chapter III of the "*Handbook of Best Management Practices*" (TRPA 1978). The BMP Handbook also addressed restrictions on disturbance within the SEZs.

Implementation of the TRPA Individual Parcel Evaluation System (IPES) triggered the next stage of SEZ management and protection, which is still in place today. The IPES Technical Committee was composed of professional hydrologists, soil scientists, engineers, and planners. This group developed procedures for the identification of SEZ based on the presence of key or primary and secondary indicators. TRPA adopted indicators and delineation procedures in 1989 (see Box 1).

Box 1: Existing Stream Environment Zone Delineation Criteria

A stream environment zone (SEZ) shall be determined to be present if any one of the following key indicators is present or, in absence of a key indicator, where any three secondary indicators coincide; or, if Lo, Co, or Gr soils are present, where two secondary indicators coincide. Plant communities shall be identified in accordance with the definitions and procedures contained in the 1971 report entitled "*Vegetation of the Lake Tahoe Region, A Guide for Planning*."

A. Key Indicators

Key indicators are:

1. Evidence of surface water flow, including perennial, ephemeral, and intermittent streams, but not including rills or man-made channels;
2. Primary riparian vegetation;
3. Near-surface groundwater;
4. Lakes or ponds;
5. Beach (Be) soil; or
6. One of the following alluvial soils:
  a. Elmira loamy coarse sand, wet variant (Ev); or
  b. Marsh (Mh).

B. Secondary Indicators

Secondary indicators are:

1. Designated flood plain;
2. Groundwater between 20 - 40 inches;
3. Secondary riparian vegetation; or
4. One of the following alluvial soils:
  a. Loamy alluvial land (Lo);
  b. Celio gravelly loamy coarse sand (Co)
  c. Gravelly alluvial land (Gr)

SEZ Vegetation - Species of a plant community indigenous to the Lake Tahoe Region which are commonly associated with the landscape position and land form, soil type, hydrology, elevation, and climate of an SEZ type, such as a wet meadow, mesic meadow, or stream. The plant communities include primary and secondary indicator species listed in Section 53.9.

Source: TRPA Code of Ordinances (CHAP 53: INDIVIDUAL PARCEL EVALUATION SYSTEM): 53.9 Procedure for Establishing SEZ Boundaries and Setbacks 53.9.2 SEZ Boundaries.

Issue Identification and Recommendations

The stream environment zone was first defined in 1978; however, field delineation criteria and indicators were not outlined until 1987 as part of TRPA's Individual Parcel Evaluation System (IPES, Box 1). Experience has shown that identification of SEZs based on location of stream channels, wetlands and other identifiable aquatic features is relatively easy, but applying field delineation indicators at the border or edge of SEZ has proven difficult in some situations across different SEZ practitioners. The primary task of the field workgroup for this project was to review currently adopted field delineation criteria and indicators, with the objective of making recommendations that would improve the technical basis for SEZ criteria and indicators.

The recommendation of the field workgroup is to maintain the existing SEZ definitions, but to refine SEZ field delineation indicators so that they can be consistently applied across SEZ practitioners. The recommended changes would retain the fundamental elements of the current SEZ delineation criteria; that is, the field delineation approach is based on presence of the geomorphic, hydrologic and vegetation characteristics. The core concept of primary and secondary SEZ indicators would also be retained where the presence of a single primary or co-occurrence of two secondary indicators would determine the location/occurrence of an SEZ. The key recommended changes are to the vegetation and soil saturation indicators (*Tables 3* and *4*). These recommended refinements are further discussed below and based on advances to the understanding of riparian and wetland systems, and have been incorporated into professional and industry standards since the initial development of the land capability system, IPES and other SEZ policy.

It should be noted that recommendations included in this document are limited to scientific and technical aspects of SEZ field delineation. If changes to SEZ policy or program elements were to be considered for adoption by an implementing agency, additional stakeholder and decision-maker review would need to occur and regulatory guidance drafted to explain the processes by which to apply policy (e.g., protocols for groundwater monitoring methods, canopy cover, etc.). These methods would need to be based upon best available professional industry standards and updated periodically by agency staff as appropriate.

Table 3. Recommended Primary SEZ Delineation Indicators.

Recommended Primary Indicators (one must be present to be considered SEZ)		
Indicator		**Description**
A	Hydrophytic Vegetation	Canopy cover is dominated (greater than 50% of total canopy cover) by obligate wetland (OBL) and/or facultative wetland (FACW) plant species, excluding any overhanging cover from stems that are outside of the plot.
B	Hydric Soils	Soils meeting the criteria for Hydric Soils using the latest version of the Field Indicators of Hydric Soils in the United States for USDA Major Land Resource Area 22A (NRCS).
C	Presence of Groundwater	Observable water table between 6" and 20" (when soil temperature > 5C)
D	Aquatic Habitats and Features	The occurrence of channels, lakes, ponds, springs, wetlands as defined by the USACE.
E	Man Made Channels	These features have a bed, bank, and ordinary high water mark and connect directly or indirectly to a traditional navigable or interstate water; and have one of the following four characteristics: natural streams that have been altered (e.g., channelized, straightened or relocated); conduits that have been excavated in an SEZ, including wetlands; conduits that connect two or more SEZs or water bodies; or conduits that drain flow from an SEZ (including wetlands) into the tributary system of stream or wetland.
F	Lake Tahoe Beaches	Single grained surfaces adjacent to Lake Tahoe, lacking surface horizon development and owing their existence to current or historic wave or wind action.

Table 4. Recommended Secondary SEZ Delineation Indicators.

Recommended Secondary Indicators (two must be present to be considered SEZ)		
Indicator		Description
A	Hydrophytic Vegetation	Canopy cover is dominated (greater than 50% of total canopy cover) by obligate wetland (OBL) and/or facultative wetland (FACW) and/or facultative (FAC) plant species, excluding any overhanging cover from stems that are outside of the plot.
B	Evidence of Soil Saturation (presence of any of these indicator meets criteria)	1 - A continuous 4" horizon layer between 6" and 40" containing 2% or more distinct or prominent redoximorphic features.
		2 - Reduced matrix (as defined in the latest version of NRCS *Keys to Soil Taxonomy*[1]) between 6"and 40".
		3 - Positive response to alpha, alpha dipyridyl in a zone between 6" and 40".
C	Floodplains	Within Federal Emergency Management Agency (FEMA) or US Army Corps of Engineers (USACE) delineated floodplains, or other floodplains delineated by a professional using currently accepted standards and approved by TRPA.

Vegetation Indicators

Currently, primary and secondary riparian vegetation indicators are based on the "*Vegetation Guide for Lake Tahoe*" (TRPA 1971). When SEZ policy was first adopted the 1971 vegetation guide provided the best information for using vegetation as an indicator of riparian areas and wetlands. The 1971 vegetation guide was based on vegetation community types. Professional experience in the practice of SEZ delineation has shown that several of the plant species listed within different identified riparian vegetation communities are rarely, if ever found in the Tahoe Basin. Since the implementation of SEZ regulations, considerable progress has been made in understanding of riparian and wetland ecology. Initiated by the U.S. Fish and Wildlife Service in 1977, an interagency effort resulted in a publication of the first list of wetland species 1988 (Reed 1988). Wetland scientists compiled and evaluated the presence of vascular plant species in wetlands, and developed a system that denotes the probability of individual species occurring in wetlands. This list categorized plant species based on their occurrence in wetland and other habitats.

Indicator species categories:

- **Obligate wetland** (OBL). Species almost always occurs in wetlands (estimated probability > 99%) under natural conditions.

[1] Most recent version at time of this report was: Soil Survey Staff. 2014. Keys to Soil Taxonomy, 12th ed. USDA-Natural Resources Conservation Service, Washington, DC.

- **Facultative wetland** (FACW). Species usually occurs in wetlands (estimated probability 67% – 99%), but occasionally found in non-wetlands.
- **Facultative** (FAC). Species is equally likely to occur in wetlands (estimated probability 34% – 66%) or non-wetlands.
- **Facultative upland** (FACU). Species usually occurs in non-wetlands (estimated probability 67% – 99%), but occasionally found in wetlands (estimated probability 1% – 33%).
- **Obligate upland** (UPL). Species almost never occurs in wetlands (estimated probability of occurrence in wetland < 1%) under natural conditions.

The list was revised in 1996 and 1998, and updated again on July 11, 2013, and April 3, 2014. These regular updates included changes in the species names, the addition of new species, and the removal of species that were listed as obligate upland in all regions of the United States. In 2000, the Lake Tahoe Basin Management Unit compiled a list of vascular plants found in the Tahoe Basin (Holst and Fergusen 2000). When this list was compared with the National List of Wetland Species, 445 plant species with wetland indicator status of OBL, FACW or FAC were identified. Plant communities from the 1971 TRPA vegetation guide listed as SEZ indicators included 79 species (or about 18% of plants found on both the Tahoe Basin and National Wetland Species lists). In addition, several species listed in the 1971 vegetation guide are not wetland indicator species.

The Field Delineation Workgroup recommends incorporating advances in the understanding of riparian/wetland species relationships that have occurred since the "Vegetation Guide for Lake Tahoe" was written. The Field Delineation Workgroup recommends the agencies consider using "wetland species indicator status", rather than vegetation community types because many of the communities listed in the 1971 vegetation guide are rare and the vegetation guide is incomplete – representing only 18% of the species that occur in the Lake Tahoe Basin and are listed as either OBL, FACW or FAC on the National List of Wetland Species. Specifically, this indicator would change from "primary riparian vegetation" to:

"*Canopy cover is dominated (greater than 50% of total canopy cover) by obligate wetland (OBL) and/or facultative wetland (FACW) plant species, excluding any overhanging cover from stems that are outside of the plot*."

Wetland indicator species status denotes the probability of individual species of vascular plants occurring in wetlands. Wetland status is based on inventory information compiled by the U.S. Army Corps of Engineers. The Western Mountain, Valleys and Coast list is applicable to the Tahoe Basin. The list has been revised several times, most recently in 2014 (Lichvar, et al, 2014). Note that plot size varies by the sampling method used and that sampling methods are described in the "Proposed Field Delineation Methods" section of this report.

Soil Indicators

Soil Map Units

A soil map unit is a collection of areas defined and named the same in terms of their soil components (e.g., series) or miscellaneous areas or both. Currently, several soil map units (e.g., Be, Ev, Mh, Lo, Co, GR) are listed as either primary or secondary indicators. While these map units generally contain soils found in SEZs, they contain inclusions that do not exhibit characteristics of soil saturation necessary to support SEZ functions. In brief, the scale of soil map units is not consistent with application to SEZ delineation on

individual lots (relatively small residential parcels). The use of soil map units includes some areas that would be improperly defined as SEZ and also misses areas that should be defined as SEZ. Consequently, the Field Delineation Workgroup recommends eliminating "soil map units" as a means of identifying SEZ, and instead using soil characteristics observed in the field that are indicative of soil saturation as represented in *Tables 3* and *4* (above).

Beach Soils

The existing SEZ delineation criteria include Beach soil (Be) as a primary indicator. The 2007 NRCS Soil Survey defines the "Beaches" component as a miscellaneous land type, not a soil. The soil survey shows this "Map Unit" limited to areas around Lake Tahoe. Unfortunately, the soil survey is at a scale (i.e., > 5 acres) and not appropriate for delineating the "Beach" land type. The major problem is that this map unit contains many minor components that are not wet and should not be SEZ. For example, Cagwin and Gefo are inclusions in "Beach" soil. Another problem is that fluctuating lake levels convert soil to beach and beach to soil, so conditions are dynamic.

Consideration was given to using the definition for "Wave Run-up" (TRPA Code Section 85.3.1 in the Backshore definition) as an SEZ indicator: "The area of wave run-up, plus ten feet" adequately covers any area that is active beach by technical definitions. The field workgroup felt that this definition was arbitrary and did not reflect geomorphic or ecological processes that were the basis of other SEZ field indicators. Instead, the field workgroup's recommended change is to eliminate the existing beach soils indicator, and replace it with a "Lake Tahoe Beaches" indicator. The following definition is recommended: "*Single grained surfaces adjacent to Lake Tahoe, lacking surface horizon development and owing their existence to current or historic wave action*".

Soil Saturation

Currently, near surface groundwater and groundwater at 20"-40" are primary and secondary indicators, respectively. Guidance for methods to determine presence of these indicators comes from the IPES Field Procedures Manual (1987). These procedures recognized that soils may not be saturated at the time of field sampling, and therefore used mottling as an indicator of soil saturation.

Figure 2. Soil from an SEZ in the Tahoe Basin, showing nodules of Fe and Mn oxides (rust coloration).

Since 1987, soil scientists have replaced the term "mottling" with the broader term "Redoxymorphic Features". In an anaerobic environment, soil microbes reduce iron from the ferric (Fe3+) to the ferrous (Fe2+) form and manganese from the manganic (Mn4+) to the manganous (Mn2+) form. Of the two, evidence of iron reduction is more commonly observed in soils. Ferric iron is insoluble but ferrous iron easily enters the soil solution and may be moved or translocated to other areas of the soil. If a soil reverts to an aerobic state, iron that is in solution will oxidize and become concentrated in patches and along root channels and other pores. These areas of oxidized iron are called redox concentrations. Color in soils is brighter in areas of accumulation of this oxidized iron and duller in areas where the iron has been reduced and/or removed. Concretions are

another redoxymorhphic feature. They are localized nodules or cemented bodies of Fe-Mn oxides that result from accrual or phase change in the Fe-Mn minerals (*Figure 2*). All of the features described here are a result of oxidation and reduction resulting from saturation that is either permanent or seasonal.

The issue of redoxymorphic features as indicators of soil saturation resulted in considerable debate among the Field Delineation Workgroup and with technical experts asked to provide additional review. At issue was whether both reduced chroma and concretions should be present in soil, or if concretions alone were sufficient to define a soil as being in and indicate soil saturation consistent with SEZ criteria.

Definitions of soil drainage classes in effect at the time the IPES criteria were developed included low chroma mottles as descriptors. These low chroma mottles were indicative of reduction and/or depletion. The SEZ characteristic of somewhat poorly drained soil therefore led to the consideration of reduced chroma as an indicator for SEZ. Reduced chroma is also one of the characteristics used to identify hydric soils. It should be noted that soil drainage classes have since been revised by the NRCS in California and no longer include low chroma mottles as descriptors.

A primary difference between the development of reduced chroma and concretions is the duration of saturation necessary to develop them. Lindbo (2005) reported that redox depletions were significantly correlated to saturation of greater than 21 days. Saturation duration necessary to result in redoxymorphic concretions has been less studied. Stoops, et al (2010) reported that Mn nodules can form after 2-3 days of saturation.

Reduced chroma indicate longer durations of saturation. This is due to the fact that a water table carries Fe2+ with it as it rises. This iron then oxidizes to Fe3+ and is left behind as the water recedes. Low chroma mottles are either a result of the presence of Fe2+, or areas where the iron has been depleted due to extended periods of saturation. This requires either very recent anaerobic conditions or previous prolonged periods of saturation.

Since water saturation is necessary for both reduced chroma and redox concentrations to form, the issue the Field Delineation Workgroup needed to resolve was the length of time soils must be saturated to be considered SEZ. While the existing definition of SEZ speaks to inundation of the area by floodwaters, it does not provide a threshold for the period or duration of the water inundation. Another way of looking at this issue is to ask if there is a difference between delineation of wetlands (as delineated by USACE) and SEZ.

Currently, SEZ are defined as an area that "*owes its biological and physical characteristics to the presence of water*". The presence of vegetation indicative of saturated conditions along with indicators in the soil at a site would provide a stronger basis for the determination than either indicator separately. While the use of depletions (chroma of 2 or less) as indicators would certainly delineate areas with hydrophytic vegetation, there are areas that support hydrophytic vegetation that do not exhibit depletions in the upper 40". Some studies of soil-vegetation relationships have shown that hydrophytic communities can occur on soils that are not hydric (Venenman and Tiner 1990, Light et al. 1993). These soils tend to be coarse-textured (loam to sandy) and most occur on river floodplains subject to seasonal flooding (Committee on Characterization of Wetlands 1995).

Research shows that soil water saturation is typically 1.5 to 2 feet above redox depletions of chroma 2 or less (Lindbo 2005). For example, a site with a water table at a depth of 1 foot might not have chroma less than 2 redox depletions until a depth of 3 feet. If TRPA code defines SEZ based on the depth to seasonal high ground water then the use of chroma 2 as the soil saturation indicator would result in

underestimating the wetness of the site. In other words the use of chroma 2 or less depletions would not be as protective. Historically, low chroma depletions were used to determine appropriate agricultural practices. If the goal is to determine the "Seasonal High Water Table" as defined in TRPA code, it appears that the use depth of the first clear sign of redox features (concretions) would provide the best evidence to support the intent of the code.

In rare cases, soil characteristics or disturbance to natural soils features may confuse the interpretation of indicators. These situations include soils that are very coarse grained, in which redoximorphic features may not develop. More typically, the inability to interpret redoximorhphic features is due to prior disturbance of the area by compaction, grading, excavation, irrigation and other activities.

The recommended primary indicator of water saturation in soil is the presence of hydric soils. These soils would meet the criteria for hydric soils using the latest version of the "*Field Indicators of Hydric Soils in the United States*" (USDA NRCS, 2012). This indicator is consistent with delineation of wetlands per USACE methods, and includes use of the chroma of 2 or less discussed above.

The second recommended primary indicator is observable water table at a depth of between 6"and 20" when soil temperature is >5C. The 6" depth is recommended to avoid the influence of irrigation which is essentially an observation of standing water. Presence of past saturation is detected by the soil indicators that follow. The 20" depth is recommended to be retained for continuity with the existing criteria. The soil temperature requirement is included to avoid field delineations at times when snow melt and other snow-related runoff might be present and could provide inconclusive determinations.

Indicators of Soil Saturation are also recommended as secondary indicators. The proposed secondary soil indicator is the presence of any of the following at soil depths of 6" to 40": a horizon between 6" and 40" containing 2% or more distinct or prominent redoximorphic features; reduced matrix (as defined in *Keys to Soil Taxonomy (NRCS, 2014)*); and/or positive response to alpha, alpha dipyridyl.[2]

The use of a horizon, defined as "*a layer of soil or soil material that lies approximately parallel to the land surface and differs from adjacent genetically related layers in properties such as color, structure, texture, consistence, and chemical, biological, and mineralogical composition*" is applied to avoid use of isolated redoximorphic features as indicators of saturation.

A positive response to alpha, alpha dipyridyl in a zone between 6" and 40" is conclusive for the presence of ferrous iron and thus confirmation of reducing conditions. Sometimes relict features or features resulting from the parent material can be misleading as to the presence of a seasonal high water table, but a positive response to alpha, alpha dipyridyl would confirm ferrous iron and contemporary wetness. It should be noted that alpha, alpha dipyridyl has a history of producing false negative test results.

The depth at which redoximorphic features are first observed is 6 inches is a change from the current delineation criteria of 0 inches. This recommendation is proposed to eliminate confusion caused by redox

[2] Alpha-alpha-Dipyridyl solution is used to confirm the presence of ferrous (Fe^{++}) iron in soils. It is used to indicate reducing conditions and the possibility of aquic conditions. Spraying several drops on freshly exposed, uncontaminated soil material will develop a bright pink (or red) color within a few seconds if Fe++ is present at adequate concentration levels. This reaction indicates the soil is reduced and anaerobic at the time of application at least in the area where the reaction occurred. Soil material must be at least moist (usually saturated) for positive reactions to occur (NRCS - Hydric Soils Technical Note 8).

features in the soil's surface that result from irrigation and runoff from impervious surfaces, ponding caused by surface compaction, and other human induced features not reflective of the water table.

The practical effect of these recommendations would be to delineate SEZ boundaries that in some cases would be wider than those delineated using methods to delineate wetlands as per USACE procedures. This was based on the conclusion that the intent of TRPA direction was to protect areas where soils were saturated for less than a period of time necessary to produce depletions indicated by presence of chroma 2 or less (as above, roughly three weeks). Use of soil indicators to assess saturation is not unique to the Tahoe Basin. Currently, 26 states use soil colors or soil morphology to evaluate or determine seasonal high water table. For example several states use the presences of redoxymorphic features to determine the water table; others describe specific color patterns beyond just 2 chroma colors. A few states (e.g., MA, ME, MN, MT, NH, RI, UT) are now using or will be using redoxymorphic features to determine the water table or soil wetness conditions (Lindbo 2005).

Aquatic Habitat Indicators

Existing TRPA ordinances (Box 1) includes two aquatic feature indicators: lakes and ponds and evidence of surface water flow, including perennial, ephemeral, and intermittent streams (not including rills or man-made channels). The Field Delineation Workgroup recommends revisions and clarifications for this indicator group.

Primary indicators D (Aquatic Habitats) and E (Man-Made Channels) in *Table 3* represent the recommended changes. The first recommendation is to expand the description to include "springs" and "wetlands" as these features, by definition, are SEZ. The second recommendation is to add "man-made" channels that are the result of altering a natural channel, have been excavated in or drain SEZs, or are above ground conveyances that connect SEZs. Man-made channels ultimately convey surface water to Lake Tahoe or other surface waters and should therefore be provided protection similar to SEZ. In addition, some members of the field workgroup believed that additional work to map the boundaries of jurisdictional wetlands (section 404) in comparison to SEZ boundaries would be worthwhile. This comparison could also improve understanding of relationship between SEZ program elements and the EPA's wetland protections policy – a stated objective of the "SEZ roadmap."

Existing direction defines the extent of channel SEZs as the bank full width of the stream at the level of frequent high flow. This flow has a recurrence interval of approximately 1.5 years. The Field Delineation Workgroup recommends no changes to this definition.

Floodplain Indicator

The currently adopted SEZ indicator is "designated floodplain", however the specific meaning of "designated" is not defined in the TRPA Code. The Field Delineation Workgroup recommends clarifying that floodplains must be delineated and designated by either Federal Emergency Management Agency (FEMA) or US Army Corps of Engineers (USACE) to be considered SEZ. An alternative recommended indicator would be floodplains delineated using currently accepted standards and approved by TRPA.

Proposed Field Delineation Methods

Since the SEZ concept was first implemented in the Tahoe Basin, experience and research have led to numerous changes in understanding of wetland, riparian and fluvial systems. In addition, improvements to field survey and monitoring procedures have occurred. Recognizing that similar advances and changes will certainly occur in the future, one objective of the field group was to recommend delineation methodologies that allow for future changes to sampling methods and advances in the understanding

and delineation of aquatic features. As a result, the field group is recommending that agencies use SEZ delineation methods that are widely accepted and periodically updated by technical/professional organizations. The recommended changes to SEZ delineation rely heavily on field survey of vegetation and soil redoxymorphic features as well as the ability to delineate floodplain. Methods currently used to assess these features and that are applicable to SEZ delineation are discussed below.

Vegetation

The USACE has established an interagency National Advisory Team for Wetland Delineation whose role is to review new data and make recommendations for needed changes in wetland-delineation procedures. The Tahoe Basin is located within the Sierra Nevada Mountains Major Land Resource Area of the USACE and covered by Version 2.0 of the Western Mountains, Valleys, and Coast Regional Supplement. General field testing procedures applicable to survey for wetland vegetation species, including site selection and approach are also provided by the USACE.

The Regional Supplement is available on line at:
http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/reg_supp/west_mt_finalsupp2.pdf

General survey procedures relevant to the supplement are available on line at:
http://www.usace.army.mil/Portals/2/docs/civilworks/regulatory/reg_supp/FieldTestingProtocolWesternMtns9-26-2006.pdf. Note that the general approach described here is applicable to delineation of SEZs. Other elements of this direction, including organization of field review teams, site selection and reporting will need to be adapted to meet the specific needs of SEZ delineation.

The Western Mountains, Valleys, and Coast Regional Supplement (USACE, 2010) is one of a series of Regional Supplements to the USACE Wetland Delineation Manual (USACE, 1987). Both provide technical guidance and procedures for identifying and delineating wetlands. The Regional Supplements were produced as part of a nationwide effort to address regional wetland characteristics and improve the accuracy and efficiency of wetland-delineation procedures. If differences are found between the Regional Supplement and the Wetlands Delineation Manual, the Regional Supplement would take precedence.

Amendments to the Regional Supplement are planned, and will be issued periodically in response to new scientific information and user comments. Between published versions, Headquarters, U.S. Army Corps of Engineers is a source for Supplement updates and any other supplemental information. Information and updates are available at the Corps of Engineers Headquarters regulatory web site (http://www.usace.army.mil/CECW/Pages/cecwo_reg.aspx).

Soils

Protocols for conducting soil sampling associated with SEZ delineation are included in NRCS "Field Book for Describing and Sampling Soils" (Schoeneberger *et al*. 2012). The field guide includes instructions, definitions, concepts for sampling soils as presently practiced in the United States. Soil sampling methods were developed by soil scientists over a long period of time. The USDA first published small instruction booklets for field parties, including soil descriptions, in 1902–1904, 1906, and 1914. As with the Wetlands protocols, soils information is updated periodically. Previous Field Books were released in 1998 and 2002. The NRCS Field Guide is currently available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054184.

Floodplains

Floodplains are included as a secondary SEZ indicator and the field workgroup has made a recommendation that agencies further clarify the source of floodplain delineation as either USACE, FEMA or a method accepted by TRPA. There are several techniques for assessment and delineation of floodplains. These techniques will surely be improved and modified in the future. SEZ practitioners are directed to FEMA or USACE (which are maintained by local county jurisdictions) for the most current floodplain maps. Several methods for floodplain delineation can be found online or obtained from a qualified water resources engineer or hydrologist.

Proposed Application of SEZ Delineation

The current SEZ criteria and indicators are used to delineate the boundaries and extent of SEZ present on individual parcels. Since adoption of the SEZ program, implementation of SEZ policy has become engrained in the land development and management culture of Lake Tahoe. Managers consider the SEZ as an important characteristic that must be reviewed during project planning, regardless of the scale or nature of a proposed project. SEZ management standards are used to protect values and functions during implementation of activities other than the development of individual parcels. Examples are fire management and fuels protection projects that might include hundreds or thousands of treatment acres and numerous aquatic habitats and associated SEZ.

Intensive, individual parcel scale SEZ delineation is not practical or cost-efficient at larger planning or land management scales. In addition, since there is no permanent development or loss of SEZ involved with traditional forest management activities, the precision of the IPES (i.e., parcel scale) delineation are not necessary. The Field Delineation Workgroup recognized that the practical application of SEZ field delineation has evolved since the original adoption of the policy and that it would be useful to define the purposes and level of effort associated with current SEZ field delineation practices applied at different project types and scales. The following SEZ delineation intensity levels, based on project types and scale, are recommended for consideration:

Level I Delineation

Under this level of SEZ delineation, practitioners would take advantage of current day high-resolution aerial and satellite imagery, vegetation and soils survey data, and map products (such as those developed for this project) to map the boundaries of SEZ on the landscape. Maps, remotely sensed data, and other cartographic data are used to provide approximate location and extent of SEZs using features such as vegetation, water or topography. This information would be used in broad-scale/planning assessments and evaluations such as watershed assessments or regional-scale change detection and require the least amount of field effort. Products from this level may be used to compare potential consequences of proposed alternatives for some types of projects (e.g., vegetation management). This level may also include site visits for reconnaissance or validation purposes. The actual implementation of planned management or development actions would require Level II or III delineation, depending on the nature of proposed actions.

Level II Delineation

Under this level of delineation, field extensive delineation would be used to locate and mark the extent of SEZs on the ground, and may be used to produce maps based on field-collected GPS data. Delineation at this level is applied to projects such as fuel treatments, when there is no proposed permanent development or construction in SEZs. This level relies primarily on above-ground indicators such as hydrophytic vegetation and aquatic habitats including perennially wet areas. A conservative approach

to delineation would be applied when there is doubt about whether or not an area is SEZ, the area in question would be assumed to be SEZ and buffered appropriately. This approach will typically yield a larger (wider) SEZ buffer than those delineated by Level III methods (described below).

Level III Delineation

Under this level of delineation, field intensive delineation would be used for projects that propose SEZ disturbance (e.g., fill, reconfiguration), construction or permanent development in or adjacent to an SEZ, typical of residential development, including stream/wetland restoration projects. This level would require fine-scale confirmation and documentation of the indicators described in *Tables 3* and *4*. This level of delineation would be required for land capability verification, challenges, or IPES.

In cases where the indicators listed in *Tables 3* and *4* cannot be clearly interpreted, groundwater monitoring may be required by TRPA and/or requested by the property owner. In such cases, sub-surface water would be measured using methods generally accepted by practicing professionals. Standard methods are described in USACE (2005).

STREAM ENVIRONMENT ZONE CLASSIFICATION

Though a few types of SEZ have been suggested under current SEZ policy directives (see SEZ Types in *Table 2*), no classification system for Tahoe Basin SEZs has been formally applied programmatically. The need for a SEZ classification system was recognized during Pathway planning efforts and identified as a research need in Round 12 of the SNMPLA Research Program. Wetland classification is also encouraged in the monitoring and assessment elements of EPA's wetland protection policies (EPA, 2006). Some practitioners responsible for managing and regulating SEZ in the Tahoe Region believe that a standardized SEZ classification system based on hydrogeomorphic, soils, and/or vegetation characteristics would improve their ability to characterize the distribution, extent and conditions of different types of SEZ. Classification could also help to improve SEZ restoration planning and/or ensuring appropriate compensatory mitigation.

The success and utility of any classification system is based on its ability to meet the objectives for which it was established. The field and mapping workgroups struggled with the task of recommending a classification system, believing that different systems might be most appropriate, depending on the specific issue or question at hand. Ultimately, the question applied was what classification system would be best to map the different SEZ types found in the Tahoe Basin for the purposes of monitoring, regulation and mitigation.

The objective of any classification is to group together units or elements based on their common attributes. The end product of a classification system is a set of groups derived from the units of observation where units within a group share more attributes with one another than with units in other groups (Grossman *et al*. 1999). Classification systems are hierarchical. They first group members of a population by fundamental characteristics (for instance, flowing water versus standing water) and then use increasing levels of detail to further group and distinguish types. The management implications of an SEZ classification are that all representatives of each SEZ type should respond similarly to both natural changes and management practices.

Both field and mapping workgroups recognized that there were several existing wetland classification systems that could be applicable to SEZ classification in the Tahoe Region. These classification approaches

had been developed and vetted by technical experts and recognized by land management or regulatory agencies elsewhere.

After review of numerous classification systems, the field workgroup selected five that seemed most applicable for further consideration. These were "*Classification of Wetlands and Deepwater Habitats of the United States*" ("Cowardin", Cowardin *et al*. 1992), California Aquatic Resource Classification System ("CARCS", CARCS 2013), USACE Hydrogeomorphic (HGM) Classification (Brinson 1993) and "*A Field Key to Meadow Hydrogeomorphic Types for the Sierra Nevada and Southern Cascade Ranges in California*" ("Weixelman", Weixelman *et al*. 2011). Also reviewed were site descriptions included in the NRCS soil survey as "*General Site Descriptions*" for the Tahoe Basin (USDA-NRCS 2007). Broad classes/types associated with each of these classification schemes are provided in *Table 5*.

Table 5. Wetland Classification Systems considered for application in the Lake Tahoe Basin. Listed are the broadest of classes used in each system.

HGM	CARCS	Cowardin	NRCS General Site Description	Weixelman
Riverine	Riverine	Riverine	Stream Corridors	Riparian
			Floodplains	
Lacustrine Fringe	Lacustrine	Lacustrine	Lakes and ponds	Lacustrine Fringe
Slopes	Slope		Forested sites in glacial outwash and glacial terraces	Discharge Slope
Depressional	Depressional		Micro-depressions in floodplains	Depressional
			Organic Soils in closed depressions	Dryland grasses and sedges
Mineral Flats	Estuarine	Estuarine	Areas affected by wave action	Subsurface
Organic Flats		Palustrine		
Tidal Fringe		Marine		

Evaluation Criteria

The field workgroup identified several evaluation criteria that could be used to help determine which system might be most applicable to classifying SEZ in the Tahoe Basin. Evaluation criteria included:

- **Includes all types of SEZ found in the Tahoe Basin.** The system should include (or be easily adapted to include) all aquatic habitats found in the basin.
- **Does not include types not found in the Tahoe Basin.** To avoid confusion, the ideal classification would include only aquatic habitats found in the basin.
- **Includes environmental features found in existing policy, management or regulatory direction.** Although there is no existing SEZ classification system, existing SEZ policy, management standards and regulation refers to and applies direction to different hydrologic features, namely confined

and unconfined channels. The work group felt that a classification system should include these habitat types to avoid confusion and conflicts with existing regulation.

- **Is understandable by the public and stakeholders.** Regulations associated with SEZs affect land use and land management, including controls on the location and extent of improvements to individual parcels/lots. The group felt it important that SEZ types be understandable to the public at large, especially those whose property might be directly affected by SEZ regulations.
- **Classification elements lend themselves to mapping with existing tools.** An application of the classification system is to display and quantify the amount and distribution of SEZ types within the Tahoe Basin. A classification which lent itself easily to this purpose would be beneficial.
- **The system's SEZ types are compatible with regulatory wetland definitions and determination methods.** Activities in the Tahoe Basin that affect wetlands are governed by federal and state authorities as well as TRPA. It would aid project proponents, natural resource managers and regulators if SEZ types were compatible with state and federal wetland descriptions and definitions.

Also considered was if the systems could be refined in the future if research, regulation or practice found further distinction between SEZ types would be beneficial. The group felt this was an attribute of all the classification systems reviewed and so was not included as a criterion.

There are two general ways to that wetlands are classified. One is based on vegetation, the other on physical features. As shown in *Tables 5* and *6*, all five systems reviewed are similar, especially at the broadest classification level. All divide wetlands into categories that include riverine, lacustrine and slope types. Below this level the systems take different approaches in describing types. The Cowardin approach divides types based on water regime (perennial, intermittent) and habitat type (lotic, lentic) and then uses substrate and habitat location to arrive at classes (types). The group felt that while SEZ types in the Tahoe Basin could be described in terms of the Cowardin classes, the result was not the clearest of the systems evaluated.

Table 6. Evaluation of Wetland Classification Systems

System	Includes All Tahoe SEZ types	Includes Only Tahoe SEZ Types	Includes Confined and Unconfined Channel types	Understandable to Public	Can Be Mapped	Compatible with Regulatory Definitions and Methods
HGM	Yes	No	No	Moderate	Yes	Yes
CARCS	Yes	No	Yes	Moderate	Yes	Yes
Cowardin	Yes	No	No	Low	Yes	Yes
NRCS Ecological Site Description	Yes	Yes	No	Moderate	Yes	Yes
Weixelman	No	Yes	No	Moderate	Yes	Yes

The approach developed by Weixelman and others was considered because it was developed for the Sierra Nevada and therefore represents the most localized approach that includes the Lake Tahoe Basin. This system differs from the others in that the broadest differentiation of meadow types is based on whether the features have mineral or peat soils. The classes displayed in *Table 5* for this system represent differentiation within the mineral soils category. This system is intended to include only meadows and so does not include all SEZ types. However, its use of similar categories to the other systems applied to the Sierra Nevada lends credence to use of meadow typology in the Tahoe Basin.

As illustrated in the classification systems evaluated (*Table 6*), use of the evaluation criteria to compare the systems does little to distinguish between them – no one system meets all of the evaluation criteria. None of the classifications rated as high relative to understanding by the public, because terms not commonly used by the public to refer to aquatic features, such as "depressional" are used. In most cases, these terms are employed as secondary tier classifiers of wetlands. Most of the types at the bottom of the hierarchies are described by labels that are more broadly employed, such as "wet meadow" and "seeps and springs". All of the systems except the NRCS soil survey (which was specific to the Tahoe Basin) include at some level, aquatic features that are not found in the Tahoe Basin, notably playas and vernal pools.

Any of the systems discussed here could be used (with some with revision) as the basis to classify SEZs in the Tahoe Basin. The field workgroup believed that clarity of terms was important because the system is likely to have very practical applications. For that reason, a classification based on the California Aquatic Resource Classification System or CARCS (*Table 7*), but including only SEZ types found in the Tahoe Basin and using common terminology was developed and agreed to by both the field and mapping workgroups. The group felt that while it was important to have a solid ecological basis for differentiation of types (for example, the peat/mineral soils classes in Weixelman, and the flow through, non-flow through classes used in CARCS) inclusion of these broad types was not necessary to display the hierarchy in an SEZ classification, because only the finer scale categories would be used for practical purposes. Finally, the classification includes one SEZ type (Lake Tahoe Beaches) that is specific to the Basin. This SEZ type is associated with a specific SEZ delineation indicator.

The recommended classification system is shown in *Figure 3*. It includes nine types of SEZ found within the Tahoe Basin that the field and mapping workgroups agreed were simple, distinctive and useful for SEZ monitoring and may also prove useful for planning, regulation and restoration activities.

There is one subtle difference between the recommended classification system and the other systems evaluated. The recommended classification uses the aquatic feature type as the means for distinguishing between them. It does not matter by what mechanism the feature was formed. For instance, the CARCS typology would classify a pond as open water, with the area surrounding the water body as depressional. From a SEZ perspective, it would make more sense to characterize both the lake and the adjacent area as lacustrine. More specifically with ponds, the CARCS and HGM approaches classify features as lacustrine if they are less than 8 ha (about 20 acres) in size. However, the proposed classification would classify any lentic water feature that holds water all year and is at least 0.01 acres (20'x20') as a pond or lake – making no differentiation between the two.

Table 7. California Aquatic Resource Classification (CARCS) major classes, classes and types

Major Class	Class	Type
Open Water	Lacustrine	
	Riverine	Confined
		Unconfined
	Estuarine	Lagoon/Dune Strand
		Bar Built Estuary
		Open Embayment
	Marine	Inter-tidal
		Subtidal
Wetland	Depressional	Depression, Other
		Vernal Pool Complex
		Playa
	Lacustrine	
	Slope	Wet Meadow
		Forested Slope
		Slope, Other
	Riverine	Confined
		Unconfined
	Estuarine	Lagoon/Dune Strand
		Bar built Estuary

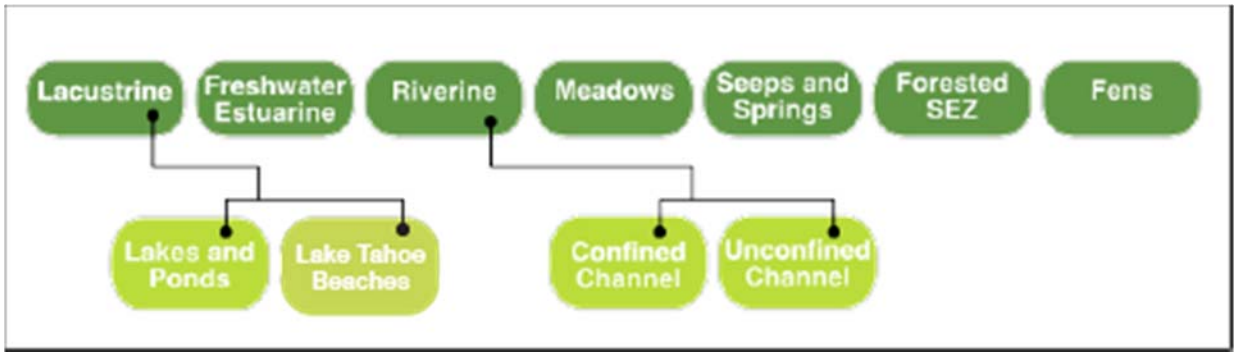

Figure 3. Recommended Tahoe Basin Stream Environment Zone Classification Scheme

Proposed Stream Environment Zone Types

The following provides a brief description and representative image of each type within the proposed SEZ classification system. For some SEZ types, addition references are provided that should be used for a complete description of the type.

Lacustrine

- The *Lake Tahoe Beaches* type is defined as grained surfaces adjacent to Lake Tahoe, lacking surface horizon development and owing their existence to current or historic wave or wind action.

An example of the "Lake Tahoe Beaches" SEZ type. Location: Baldwin Beach. Source: Travis Freed

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- *Lakes and Ponds* are perennially open water bodies, at least 0.01 acre in size. Vegetation within and surrounding this type is sometimes absent, but often comprised of obligate and facultative obligate wetland plant species.

An example of lake and pond SEZ type. Location: Quail Lake in the foreground and Lake Tahoe in the background. Source: Travis Freed

Freshwater Estuaries

Freshwater estuaries are defined by three characteristics: 1) a drowned river mouth; 2) a zone where lake and river waters mix; and 3) influence from lake levels, seiche or wind tides. A fourth characteristic that some (but not all) freshwater estuaries have is a bar or spit that partially or sometime fully encloses the river mouth. Vegetation in freshwater marshes typically includes obligate wetland and facultative wetland vegetation types, such as cattail or bull rush (genus *Typha*).

An example of the freshwater estuary SEZ type. Location: Upper Truckee Marsh. Source: California Tahoe Conservancy.

Meadows

Meadows are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface. Meadows are dominated by graminoids (grasses, sedges and rushes) and forbs (herbaceous flowering plants) and can include a complex of streams, depressional ponds, marshes, bogs, or similar areas. For the purposes of this classification meadows must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; or (3) the substrate is saturated with water or covered by shallow water at some time during the growing season of each year. Weixelman *et al*. (2011) provides addition discussion and characterization for this SEZ type. The NRCS soil survey map unit for this type is 9001.

An example of the meadow SEZ type. Location: near Ward Creek. Source: Travis Freed.

Riverine

- *Confined Channels and associated riparian areas* are open man-made or naturally created water conduits that have a bed, bank, and ordinary high water mark. That is, a confined channel can be more simply referred to as a stream, creek, run, tributary, or man-made conveyance ditch. These features periodically or continuously contain moving water, or form a connecting link between surface waters. Areas associated with the interface with confined perennial, intermittent, and ephemeral channels can support a wide variety of riparian associated vegetation, sometimes intermixed with terrestrial vegetation. A typical range of riparian vegetation types can be found at the channel's edge, from grasses to forbs to willow, and other woody riparian species. These are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. Adjacent land area significantly influences the exchange of energy and matter with aquatic ecosystems. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional sources may be interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics.

An example of the confined riverine SEZ type. Location, McKinney Creek. Source: Travis Freed.

- *Unconfined Channel and Associated Riparian Areas* - Unconfined channels typically occur in low gradient geomorphic settings (<0.5%) and are braided where no individual channel dominates water conveyance. Water flow can be perennial, intermittent, and ephemeral. Riparian areas associated with unconfined channel edge are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes and biota. They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems. A range of riparian vegetation types can be found in the transition area between the edge of an unconfined channel and upland/terrestrial habitats, from grasses to forbs to willow, and other woody riparian species. The NRCS soil survey mapping units for these types are 7041, 7042, 7043 and 9011.

An example of an unconfined channel SEZ type (during low water flow conditions). Location: Blackwood Creek. Source: Travis Freed.

Forested

Forested SEZ are dominated by riparian woody vegetation (e.g., aspen, cottonwood, willow, alder and sometimes lodgepole pine) and found in association with the discharge of groundwater to the land surface or sites with saturated overflow with no channel formation. Forest SEZ also can be found adjacent to riverine confined and unconfined channel types. Forested SEZ commonly occurs on sloping land ranging from slight to steep. The predominant source of water is groundwater or interflow discharging at the land surface (i.e., seeps and springs). Precipitation is often a secondary contributing source of water. The NRCS soil survey mapping units for these types are 7431, 7471, 7491 and 7492.

An aspen stand typical of the forested SEZ type. Location: near northeastern side of Fallen Leaf Lake. Source: Shane Romsos

Seeps and Springs

Seeps and springs occur on hillsides or at the base of, hills, alluvial fans, levees, etc. Springs are indicated by groundwater emerging and flowing across the ground surface. Seeps are similar to springs but lack a single-dominant origin of surface flow. Most of the flow is confined to the root zone and is not evident on the ground surface. Herbaceous riparian vegetation is common near seeps and springs, and may or may not support woody vegetation.

An example of the spring and seep SEZ type in the foreground. Location: seep near Meeks Creek. Source: Shane Romsos

Fens

Fens occur in closed basins in areas of valley bottoms and relict glacial lakes. Soils are characterized by seasonal ponding and year-round saturation. They consist almost completely of slightly decomposed moss fibers and have very little mineral material (Sikes *et al*. 2011). The texture is peat or mucky peat. The soils are very poorly drained and rapidly permeable. The NRCS soil survey map unit for this type is 7021.

An example of the fen SEZ Type. Location: below Freel Peak. Source: Travis Freed

AQUATIC RESOURCES AND STREAM ENVIRONMENT ZONE MAPPING

TRPA's Code of Ordinance (Section 10.3.2.B) directs the agency to maintain land capability overlay maps that include stream environment zones and other relevant sensitive land boundaries. Despite this direction, no SEZ map for the entire Lake Tahoe Basin has been formally adopted by TRPA. To date, several attempts have been made to produce an "SEZ" map. Three of these are referenced in TRPA documents (TRPA 1978, TRPA 1981, TRPA 1988). Two other efforts, by Foster circa 1979 and Sinclair circa 1998 were never properly documented. From available and limited documentation, these maps appear to vary in terms of mapping approaches and features represented and as a result are difficult to reproduce for comparison. The most recent of these maps (Sinclair) is nearly 20 years old and as a result do not reflect the current conditions nor do they incorporate current remote sensing and mapping data and technologies. The need for a basin-wide SEZ map was articulated in Step 3 of the "SEZ roadmap" memo produced by agency stakeholders. A basin-wide SEZ map is an essential planning tool for depicting (and calculating) the distribution and extent of different SEZ types within the Lake Tahoe Basin. Such information is helpful for tracking changes in SEZ over time, including representing the effectiveness of SEZ protection policies and restoration efforts.

Background

There has been general stakeholder agreement that Bailey's (1974) representation of "high hazard" lands was sufficient for general SEZ planning purposes because the TRPA Code ultimately requires field verification of land capability of individual parcels (G. Barrett pers. comm. 2015). TRPA Code Section 30.3.2 (TRPA 2012) states that stream environment zones, as defined in TRPA Code Chapter 90, are treated as Land Capability District 1b. In the early 1970's, the USDA Forest Service (Rogers 1974), in cooperation with the TRPA and others, mapped the soils and geomorphic characteristics of the Lake Tahoe Basin. This information was subsequently used by the USFS and TRPA to construct a land capability system for the Tahoe Basin (Bailey 1974) that could be used as a planning tool to reduce the negative impacts of development. Although the term "Stream Environment Zone" was not used by Bailey (*ibid*), Bailey (*ibid*) designated certain "high hazard" lands as Class 1 lands (i.e., lands not suited for development, grazing, or forestry). Within Class 1 lands, a Subclass 1b was designated for lands that are naturally wet and/or poorly drained (e.g., stream channels, marshes, flood plains, riparian areas, and meadows). These lands were identified as "*critical areas for the management and protection of water resources*" (Bailey *ibid*). Bailey (ibid) recommended that policy for these lands "*should reflect their value as floodwater and sediment storage areas, wildlife habitat, and fish spawning grounds*." According to Unsicker et al. (1984), the SEZ is essentially equivalent to lands classified as 1b under the Bailey system, although Unsicker et al. (ibid) recognized that the criteria for identifying the SEZ are more expansive (and would include more land area) in some respects. Discussions with a former long-term TRPA staffer (G. Barrett, pers. comm. 2015) confirmed Unsicker's conclusions related to the similarities and differences between SEZ and Class 1b lands.

As part of the development of the 1978 Water Quality Management Plan, TRPA mapped SEZ using six delineation criteria (or factors) outlined in a 1977 report titled "*Stream Environment Zones and Related Hydrologic Areas of the Lake Tahoe Basin*" (TRPA 1977). The criteria (factors) were:

1. Major rivers, streams, creeks, lakes, ponds, marshes and wetlands
2. 100 year flood plain
3. Areas of topographic depression
4. Riparian vegetation
5. Alluvial soils
6. Buffer strips (ranging from 25 to 100 feet depending on stream order).

Around 1977 existing maps and aerial photography were used to produce a SEZ map (G. Barrett, pers. comm. 2015). SEZ boundaries on this map were based on the attribute furthest from the stream or water body. The resulting "SEZ map" was included in a 208 Water Quality Management Plan (TRPA 1978), however this plan was never certified by EPA or adopted by TRPA (G. Barrett, pers. comm. 2015). Though not officially adopted, these maps have been used. TRPA (ibid) referenced these maps and used them as the basis for the estimate of "*approximately 17,700 acres of SEZ in the Lake Tahoe Basin*".

A second 208 Water Quality Management Plan (TRPA 1981) also used the 1977 TRPA SEZ map. This plan (and by extension, the map) was certified by EPA (G. Barrett pers. comm. 2015). In 1978, TRPA refined some SEZ identification criteria (TRPA 1978) however; no changes to SEZ maps were made because of these refinements. Not long after the 1981 208 Plan was certified, TRPA developed the Individual Parcel Evaluation System (IPES). This effort further refined SEZ delineation criteria to include "primary and secondary" indicators. The IPES SEZ delineation criteria were codified and are currently applied during land capability verifications as part of TRPA permit system.

In the 1990's Tom Sinclair, a member of the TRPA's land capability team, initiated efforts to map SEZ and land capability districts throughout the Lake Tahoe Basin. To construct the map, TRPA SEZ criteria (per the Individual Parcel Evaluation System) and the Bailey Land Capability were applied. Delineations were drawn by applying codified IPES criteria, as well as many Bailey land capability verifications (LCV) determinations were also incorporated making it difficult to differentiate SEZ boundaries from 1b boundaries. Sinclair gathered and mapped data from thousands of IPES determinations, IPES appeals, LCVs, land capability challenges (LCC). This information was supplemented with infrared and black and white aerial photographs, floodplain maps, available stream maps and NRCS soil maps (from 1971). Through this effort, Sinclair identified many more streams than had been mapped previously. Following this effort, Sinclair rectified the old land capability maps with updated GIS parcel and road layers acquired from Sierra Pacific Power. The resulting maps were digitized by the Jones and Stokes consulting firm around 2000.

According to Sinclair (pers. comm. 2012), there were numerous cases throughout the Basin where SEZ determinations from the 1970's and 1980's were "incorrectly" applied and others needed significant modifications. As a consequence, one would find areas where SEZ maps differed (sometimes significantly) from SEZ boundaries determined by field survey on properties in prior decades. Some differences were likely the result of the update to the Regional Plan in 1987 and the implementation of IPES improved LCV procedures. In some case the original IPES teams simply delineated SEZ at the wrong location(s).

Sinclair's SEZ map did not include all SEZs within the Lake Tahoe Basin, for a number of reasons. TRPA grid maps were the primary information source. The focus of these maps was concentrated on developed areas in the basin as information on undeveloped areas was not as complete. Additionally, several hundred "man-made" ditches and other channels were not included on the map, because a large majority were roadside drainages ditches. However, several of these drainage channels were considered SEZs by TRPA, namely those where diverted stream had been relocated (e.g., at Incline Village) or otherwise were connected to surface waters.

Another area Sinclair identified as an issue for SEZ mapping was "Beach soils" or "Be" soil, which are presently included as an SEZ indicator. Sinclair pointed out problems with the using "Be" to map SEZ as there was differences of professional opinion on "dunes" and "beaches" not washed by normal wave action – some felt that dunes should not be classified as 1b since they are not "wet." In addition, there was disagreement and discussion about how far upland the beach features should be mapped. An extreme example is Nevada Beach, where the beach grades far inland into Elmira (Class 7) and Cagwin soils.

The USDA-Natural Resources Conservation Service (NRCS) completed the "*Soil Survey of the Tahoe Basin Area, California and Nevada*" in 2007 (USDA-NRCS 2007a). This update to the Rogers (1974) soil survey was important, because soil information is foundational to TRPA's land use policy (e.g., SEZ and land capability). The scale of 1974 survey presented problems when used to map SEZs. Some soil complexes (including small areas of SEZ) were grouped into fairly broad units. Units had a minimum size of about five or six acres. Smaller features were not delineated. Conversely, small units of upland (non-SEZ) were also lumped into larger SEZ units (e.g., Upper Truckee River floodplain and areas of Tahoe City). The 2007 survey utilized newer more accurate mapping technologies and improved soil survey protocols relative to the 1974 survey. The result of the new soil survey was higher mapping resolution. Soon after the 2007 soil survey was published, TRPA contracted with NRCS to update tables referenced in Bailey (1974). Information contained in the "*Report to Tahoe Regional Planning Agency on revision of Tables 1, 2, 4, 5 and Appendix in Land-Capability Classification of the Lake Tahoe Basin, California-Nevada, A Guide for Planning (Bailey, 1974)*" (USDA-NRCS 2007b) was used by TRPA to update the Regional land

capability map. Although the revised land capability map was never formally adopted by TRPA, it was used in the 2011 Threshold Evaluation (TRPA 2011) impervious surface analysis. It represented the best available information related to the distribution and abundance of land capability districts and by extension SEZ. Based on revised Bailey tables and the subsequent Land Capability map, an estimated 11,304 acres of class 1b occurs in the Lake Tahoe Basin (TRPA 2011).

In 2011, TRPA (in collaboration with the Lahontan Regional Water Quality Control and California Tahoe Conservancy) received an EPA grant to pilot test EPA's "Level 1" and "Level 2" riparian area map and assessment methods (following California Aquatic Resource Inventory (CARI) and California Rapid Assessment Method (CRAM)) in the Upper Truckee and Third Creek watersheds of the Lake Tahoe Basin (Collins *et al*. 2014). Level 1 assessments rely almost entirely on Geographic Information Systems (GIS) and remote sensing data to obtain information about watershed conditions and the distribution and abundance of wetland types in the watershed. One of the objectives of the project (known as the *Tahoe Wetland and Riparian Area Monitoring Plan Project* or "Tahoe WRAMP") was to utilize 2010 basin-wide LiDAR and multispectral remote sensing data in combination with standard operating procedures prescribed by CARI mapping procedures to produce a map showing the distribution and extent of aquatic resources in the two pilot watersheds. The result, CARI methodology augmented with local data produced the Tahoe Aquatic Resource Inventory ("TARI") - the Tahoe Basin version of CARI that could serve as a base map for SEZ delineation in the Tahoe Region.

Another objective of the project was to compare the best available "SEZ" map (i.e., the Sinclair SEZ map) in the lower reaches of the Upper Truckee River Watershed to a "WRAMP SEZ Map" produced for the Tahoe WRAMP pilot project (Collins *et al*. 2014). The purpose was to understand whether data, tools and mapping procedures developed for implementing California's Wetland Protection Policy could reasonably represent SEZ. The aquatic resources (i.e., streams, water bodies and wetlands) represented in the TARI map were augmented using the program's "Riparian Width Estimator Tool" (otherwise known as the "Riparian Zone Estimator Tool" or "RipZET") and other data including 100-yr floodplains as mapped by FEMA, and soil map units indicative of SEZ. The resulting "WRAMP SEZ map" represented numerous aquatic features that were not shown on the "Sinclair SEZ map". Use of RipZET in combination with TARI produced estimates of the likely width and length of riparian areas in the pilot area greater than SEZ represented in the Sinclair SEZ map. It was concluded that because the application of RipZET was not constrained by TRPA adopted SEZ indicators/criteria it may have included more land area than would be delineated by SEZ field indicators alone and thus was probably not the most appropriate approach to represent TRPA's SEZ policy.

Methods

One of the primary goals of this project was to produce an updated Basin-wide SEZ map using new methodologies and data in consultation with the project's mapping workgroup. The process for producing the SEZ map was a two-step process. First, aquatic resources were mapped for the entire Lake Tahoe Basin using an automated version of the TARI standards (SFEI 2012) to produce a base set of aquatic features. Second, available map layers representing different SEZ types and indicators (as proposed for modification in this project) were systematically overlaid with the aquatic resource map (i.e., aquatic resources map produced for this project) to generate a SEZ map layer. The following describes the data, approach and conclusions resulting from of this effort.

Aquatic Resources

Aquatic resources/features were divided into three general groups for the purposes of mapping: 1) open water polygonal features, 2) stream centerlines, and 3) wetlands. The source data consisted of the 2010

LiDAR and 2010 WorldView-2 imagery, both of which were available basin-wide. Each one of these groups was mapped separately using similar source data but with slightly differing methodologies. The LiDAR data used consisted of both the point cloud along with derivative products such as a hydrologically corrected Digital Elevation Model (DEM), a Normalized Digital Surface Model (nDSM), and LiDAR intensity. Aquatic features were mapped according to the original CARI/TARI standards (SFEI 2012) but with automation, and was thus more cost effective. The general approach for mapping each of the aquatic feature mapping groups is presented in *Figure* 4. In this approach the source LiDAR and imagery were integrated into an automated system designed to extract the features of interest, the output of which was then manually reviewed and edited to create the final output.

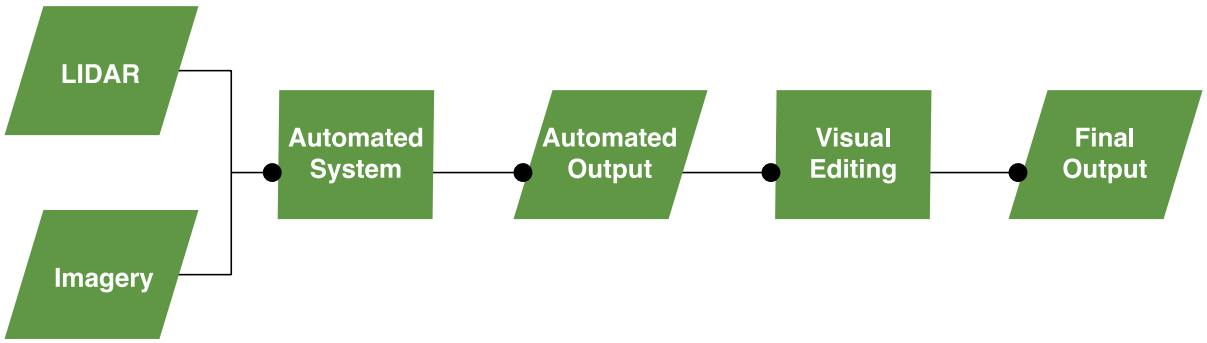

Figure 4. General approach to aquatic features mapping.

Stream centerlines were mapped using a hydrologic modeling approach. The hydrologically corrected DEM was the single source dataset used in the automated system. Within the automated system flow direction was computed using a multi-flow direction algorithm (Holmgren, 1994). Flow accumulation was then computed from the flow direction layer and streams were extracted by establishing using a flow threshold approach. The threshold was set artificially low because it easier to delete features rather than create new ones. Manual editing was then done at a scale of 1:1000 primarily based on a hillshade layer generated from the hydrologically corrected DEM supplemented by the WorldView-2 imagery. Technicians performing the edits used the stream features from the TARI pilot watersheds as their image interpretation keys.

Open water polygons and wetland features were mapped using an object-based feature extraction approach following methods developed by O'Neil-Dunne *et al*. (2014). The improved stream layer, WorldView-2 imagery, and LiDAR derived products, to include intensity and the Compound Topographic Index (CTI) (Gessler *et al*., 1995), were imported into an object-based image analysis framework. A rule-based expert system was developed that employed segmentation, classification, and morphology algorithms to extract open water polygons and wetlands based on their spectral and spatial properties. As with the stream centerline mapping, the output of the automated mapping was reviewed at a scale of 1:1000 using the TARI pilot watershed features as a guide. An example of the mapping process for wetland aquatic features is presented in *Figure* 5.

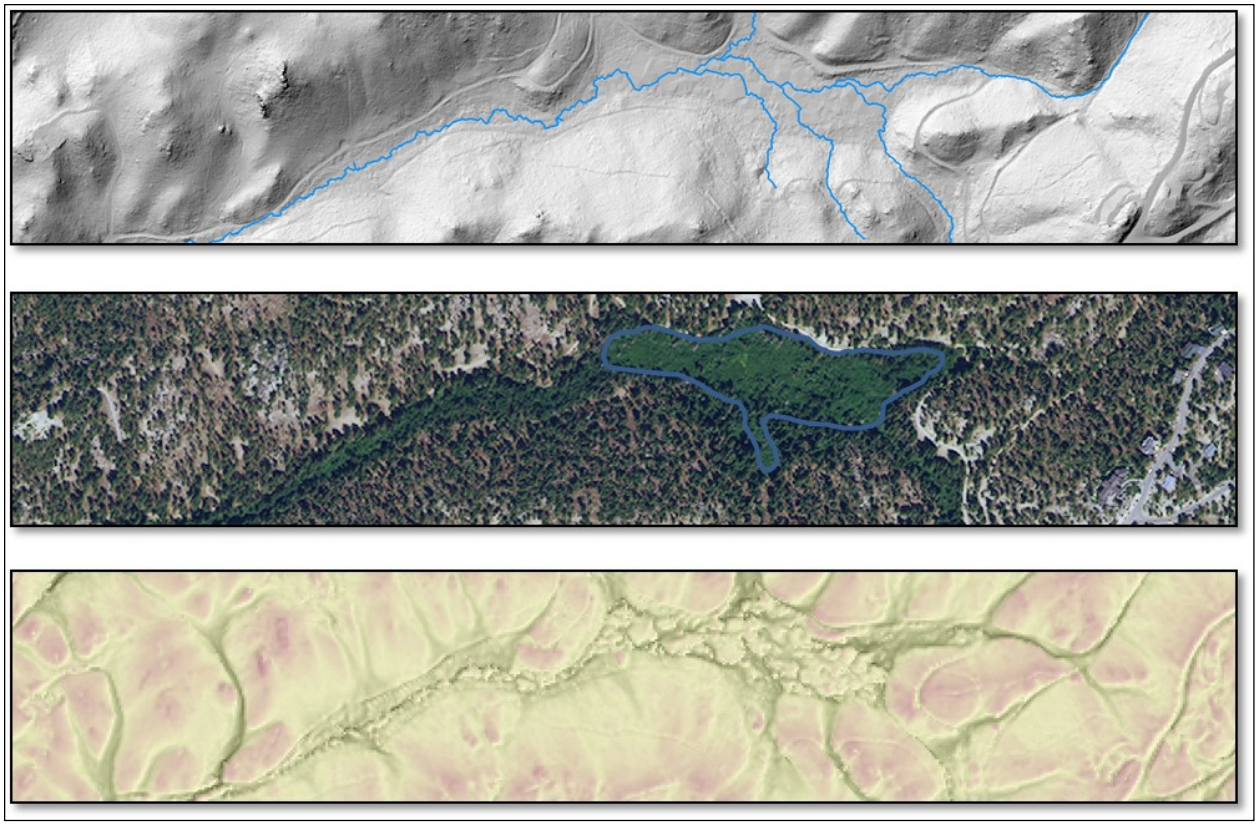

Figure 5. Example of wetland aquatic features mapping using a combination of a LiDAR DEM and stream centerlines (top), WorldView-2 imagery (center), and a Compound Topographic Index (CTI) layer derived from LiDAR (bottom).

Stream Environment Zone

In addition to the aquatic features mapped as part of this project, other GIS datasets were available for use in developing a final SEZ map, including thematic layers for riparian vegetation, fens, and seeps\springs from the U.S. Forest Service, soils from the U.S. Natural Resources Conservation Service (SSURGO), and 100-year flood zones (FEMA). These layers were not designed with SEZ mapping in mind, but they nonetheless capture specific types of the recommended SEZ classification and also leverage resources previously committed to mapping projects in the Lake Tahoe Basin. All pertinent layers were compiled into a single, seamless map using eCognition (Trimble). This is a state-of-the-art image classification software that permits efficient and rapid analysis of large volumes of data in multiple formats, including multispectral imagery, LiDAR, and thematic GIS datasets. This functionality was especially helpful in refining the initial SEZ map, permitting spectral classification of available WorldView-2 imagery (leaf on, acquired in August 2010) when the thematic datasets could not capture individual types in their entirety. The software also facilitated smoothing of the final product.

The SEZ classification scheme recommending by the mapping workgroup was designed with seven primary types: Fens, Forested, Freshwater Estuarine, Lacustrine, Meadows, Riverine, and Seeps\Springs (*Figure 3* above). Two of these types were further divided into sub-categories: Lacustrine into permanent water bodies (Lakes and Ponds) and beaches along Lake Tahoe's shoreline (Lake Tahoe Beaches); and Riverine into two channel types (Confined Channel vs. Unconfined Channel). Note, however, that no systematic, reliable criteria/method could be identified for differentiating Unconfined Channels from

other riparian classes (e.g., Meadows and Forested), so this type (unconfined) was not differentiated in the final map classification. The modeling criteria for the eight remaining types is shown in *Table 8*.

Table 8. Modeling criteria for SEZ types. All types were based on existing thematic GIS layers except for the Beach category, which was modeled with a combination of multispectral imagery and soils data.

SEZ Type	Input Data Layers	Specific Criteria
Fens	Fens (U.S. Forest Service - LTBMU 2012)	All polygons
Forested	Riparian Vegetation (LTBMU U.S. Forest Service 1987)	**"DESCRIPTION"** field equal to Coniferous riparian, Deciduous riparian, Deciduous/coniferous riparian
	Soils (SSURGO 2003)	**"Map Unit"** field equal to 7471, 7483, 7491, and 9011
Freshwater Estuarine	SIG TARI Wetlands (from this project)	Manually-selected polygons for Pope Marsh, Taylor Marsh, and Tallac Marsh
	Soils (SSURGO 2003)	Map Unit field equal to 7071 and coinciding with Upper Truckee Marsh
Lacustrine (Lakes and Ponds)	SIG TARI Wetlands (from this project)	**"Wetland_Type"** field equal to Lacustrine Open Water Natural, Lacustrine Open Water Unnatural, Depressional Open Water Natural, Depressional Open Water Unnatural, Lacustrine Vegetated Natural
	Hydrography Open Water (SIG 2010)	Manually-selected lakes and ponds that appeared to be permanent water bodies in growing-season imagery
Lacustrine (Lake Tahoe Beaches)	Soils (SSURGO 2003)	**"Map Unit"** field equal to 7011
	Multispectral imagery (WorldView-2 imagery acquired in 2010)	Various spectral (e.g., Visible Brightness, Normalized Difference Vegetation Index) and contextual (i.e., adjacency) criteria used to model beaches not represented in soils layer
Meadows	SIG TARI Wetlands (from this project)	**"Wetland_Type"** field equal to Wet Meadow, Forested Slope
	Riparian Vegetation (U.S. Forest Service LTBMU 1987)	**"DESCRIPTION"** field equal to Wet meadow, Moist meadow
	Soils (SSURGO 2003)	**"Map Unit"** field equal to 7021, 7041, and 9001
	100-year Flood Zone (FEMA) and Soils	**"Zone"** equal to "A" or "X500" and soils "**Map Unit**" equal to 7071
	Hydrography Open Water (SIG 2010)	Manually-selected lakes and ponds that appeared to be meadows in growing-season imagery
Riverine (Confined Channel)	Hydrography Open Water (SIG 2010)	Manually-selected streams represented by polygons
	Hydrography Stream Network (SIG 2010)	All streams represented by lines, buffered by 1.5 meters
Seeps\Springs	SIG TARI Wetlands (from this project)	**"Wetland_Type"** field equal to Seep or Spring Natural
	Seeps Springs (U.S. Forest Service LTBMU)	All points, buffered by 25 meters

Some of the SEZ types were developed by simply extracting specific polygon types from existing layers (e.g., Forested SEZ) while others required manual interpretation of thematic features relative to the WorldView-2 imagery (e.g., Freshwater Estuarine and Lacustrine (Lakes and Ponds)). More sophisticated modeling was necessary for the Lacustrine (Lake Tahoe Beaches) sub-type; it was based in part on soils but also required analysis of spectral criteria (Visible Brightness, Normalized Difference Vegetation Index)

and spatial context (i.e., adjacent to Lake Tahoe). The Riverine (Confined Channel) type was developed from stream features from the aquatic resource map layer developed for this project, and lines features were buffered by a small margin (1.5 meters) to better represent actual stream channels. Similarly, Seeps\Springs were based on both polygons and point locations provided by the USFS-LTBMU; the seeps\springs point features were buffered by 25 meters to make them more interpretable in the basin-wide map.

Mapping Results

Aquatic Resources

When compared to previous basin-wide mapping efforts the aquatic feature layers generated as part of this project showed a marked improvement in several areas including completeness, spatial accuracy, and precision. *Figure 6* shows a comparison between the previously best available stream centerline data obtained from the National Hydrography Dataset (NHD) for the Lake Tahoe Region to the stream centerlines developed by SIG as part of this project. *Figure* 7 shows a similar comparison of the existing TRPA open water layer to the one developed by SIG for the aquatic features mapping effort. An example of the wetlands features is shown in *Figure 8*.

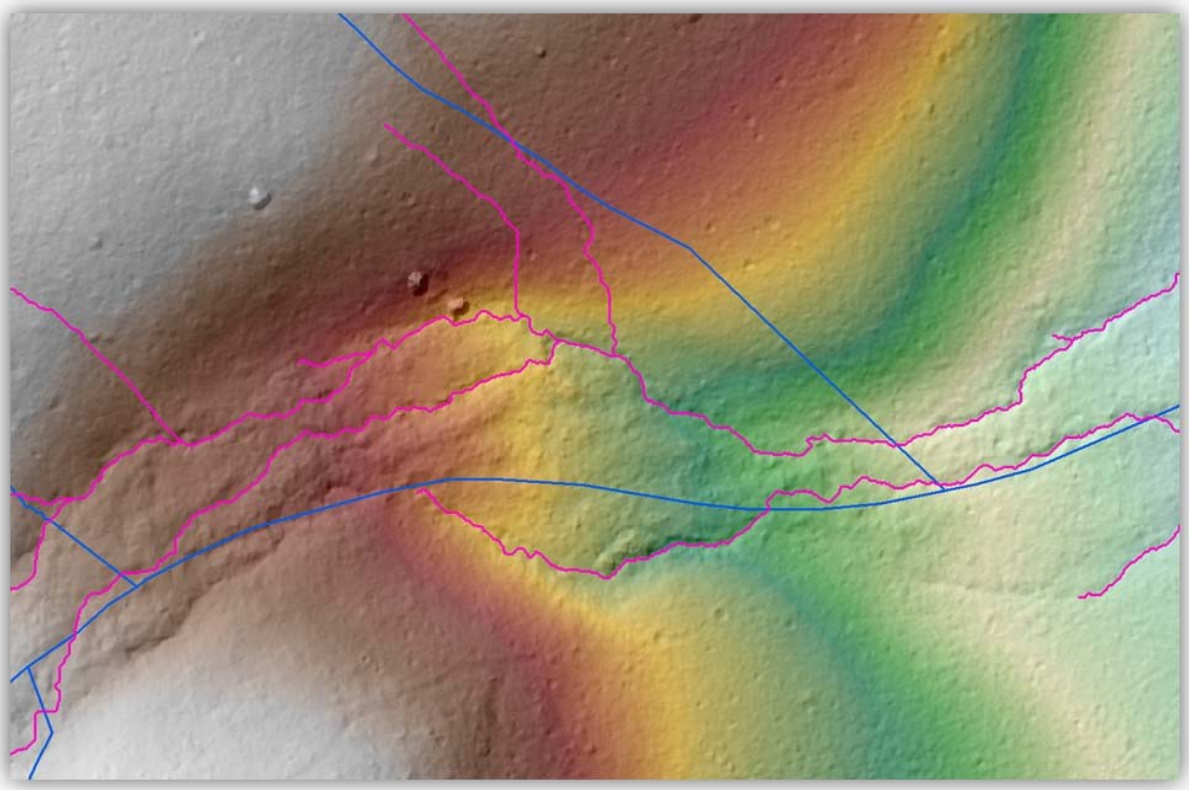

Figure 6. Aquatic feature streams (pink) generated as part of this project as compared to the best available streams (blue) from the National Hydrography Dataset (NHD).

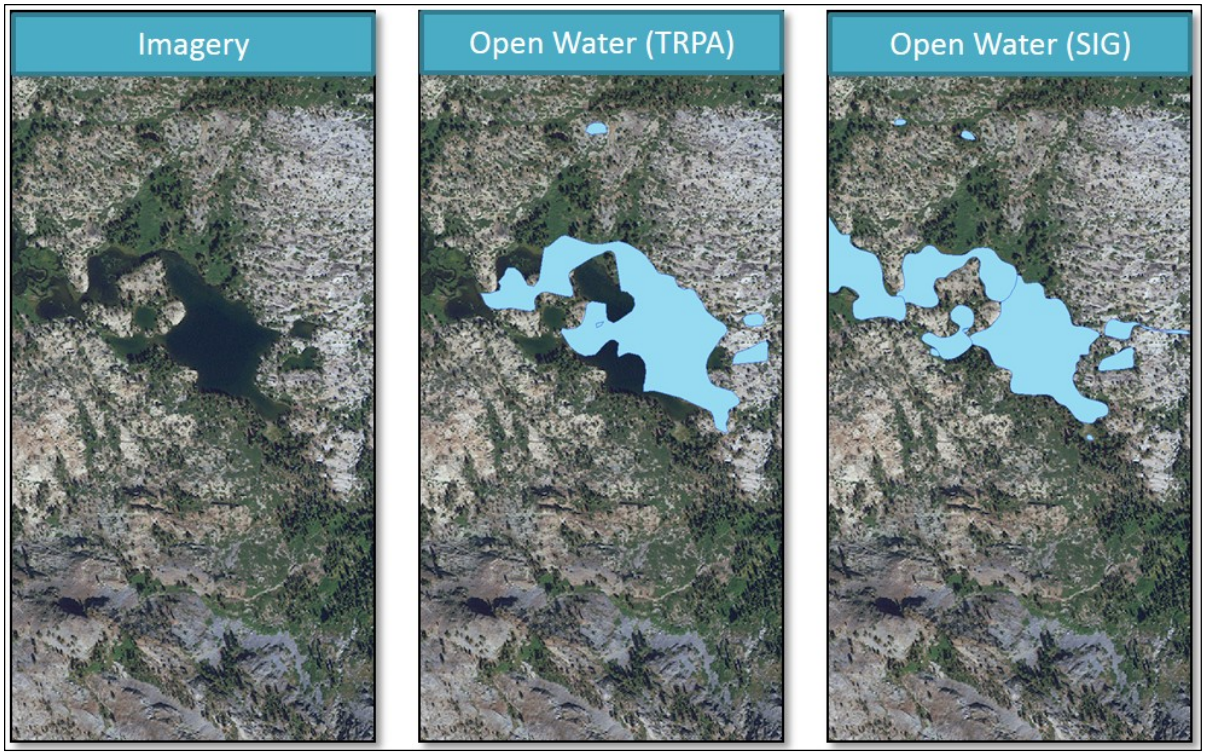

Figure 7. Results of the open water mapping.

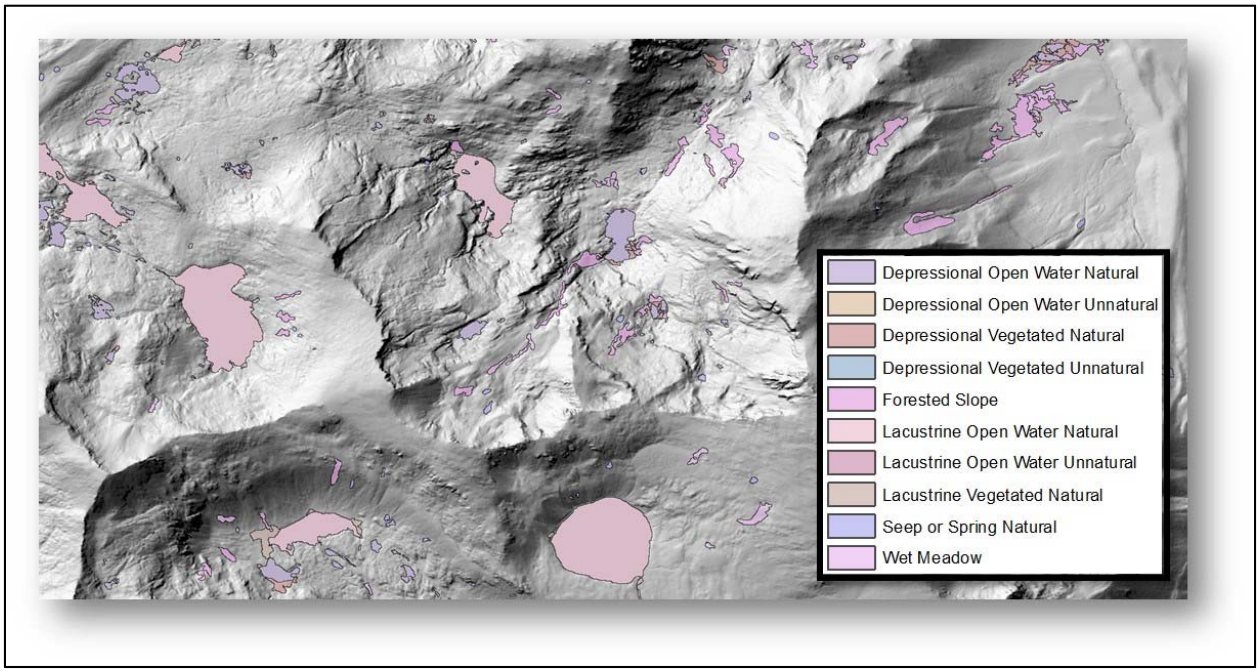

Figure 8. Example output of wetlands features, labeled according to CARCS.

An independent quality assurance (QA/QC) review was carried out by staff at the San Francisco Estuary Institute (SFEI) who had complied the TARI aquatic features for the pilot Third Water and Lower Truckee sub-watershed discussed earlier (Collins *et al*. 2013). The findings of this review are detailed in Kauhanen (2015) and summarized here.

SFEI applied the standard CARI QA/QC methodology to 10% of the map area of interest. To implement this requirement, SFEI developed a grid of one square mile cells for the full extent of the SIG TARI, and randomly selected cells for QA/QC. Cells that were mostly covering Lake Tahoe or that were fully within the two watersheds previously mapped by SFEI were excluded. Ultimately, 28 of the 348 candidate plots were selected, representing slightly more than 8% of the assessment area of the SIG aquatic features mapping effort.

This review found that the SIG TARI met most standards and was more consistent with the TARI SOP than any other existing dataset that covers the Tahoe Basin as a whole. The primary issues identified were over-mapping of stream centerlines and misclassification of some wetland types. For streams, the main issue concerned headwater channels (first order) that were not evident using CARI. For wetlands, the largest inconsistency pertained to wetland classification, specifically the conflation of wet meadows and forested slopes. These two wetland types are particularly difficult to distinguish using remote sensing data. The review also found a number of wetland features were confused with seeps or springs. The project team subsequently corrected this by reclassifying all wetland features under 0.5 acres as seeps or springs.

Although the aquatic resources map produced for this project "*is very likely the best existing map of aquatic resources for the Tahoe Basin as a whole*" (Kauhanen 2015), additional work is needed to make the map fully compliant with CARI/TARI and NHD standards. Additional work could be completed in the following areas:

- Streamlines were not classified. That is, the channels had not been attributed as "Fluvial Channel", "Channel Natural", "Channel Unnatural", "Artificial Path", or "Subsurface Drainage". Streamlines need to be classified and attributed in order to fully comply with CARI standards.
- Validate/link all stream intersections. Streamlines should be merged by type and source and then planarized.
- The streamline network needs to be attributed with Strahler stream order classification.
- First-order streams that are less than 50 meters in length in the map should be removed.
- Stream flow direction for all segments needs to be validated.
- Additional accuracy and precision refinements of wetland boundaries might be resolved with the use of other data sources, such as: National Agriculture Imagery Program (NAIP) imagery displayed in both natural color and color infrared, reviewing multiple years of imagery from sources like Google Earth, local aerial photography when available (from sources such as Bing Maps), other data such as the Sierra Nevada wet meadow dataset from UC Davis, NHDPlus, and USGS topographic quadrangles.

Stream Environment Zone

At coarse scales, the final SEZ map illustrates the distribution and extent of aquatic features across the Lake Tahoe Basin (*Figure 9*). At finer scales, it highlights the complex inter-relationship between feature types in stream environments (*Figure 10*). The map's features include a total area of 11,894 hectares (29,391 acres) of SEZ, with about half this total in the Forested type (*Table 9*). At the Lake Tahoe Basin scale, Forested wetlands comprise more than 6% of the total watershed area (minus Lake Tahoe). Meadows, Lacustrine (Lakes and Ponds), and Riverine (Confined Channel) features also constitute significant landscape components by area, each greater than 10% of the basin's aquatic features. The remaining types all contain less than 2% of the total SEZ area. Of course, areal extent is not the only measure of ecological importance; the Fens, Freshwater Estuarine, and Seeps\Springs types capture aquatic features with unique biotic and abiotic characteristics that make them integral components of the basin's physical and biological diversity.

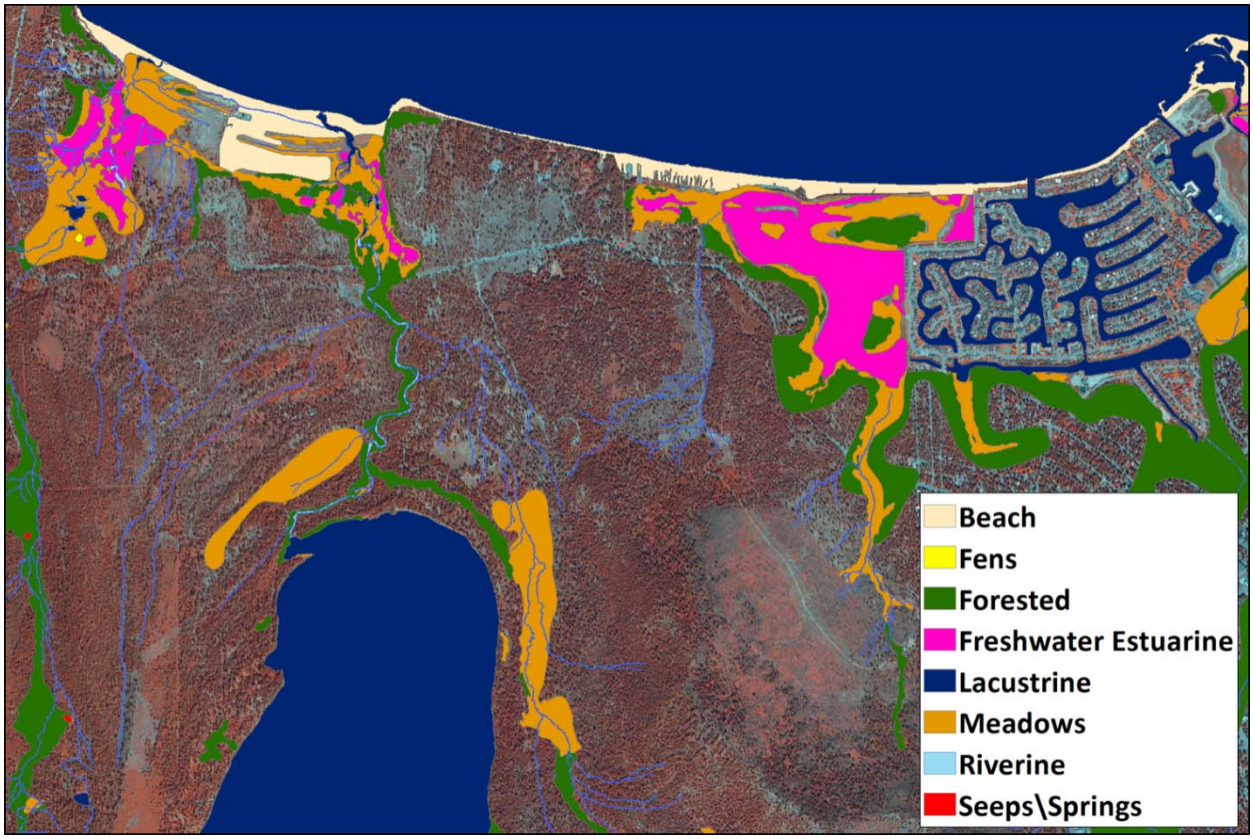

Figure 9. SEZ map for a portion of the Lake Tahoe Basin. Color-infrared imagery (2010 WorldView-2) is shown in the background.

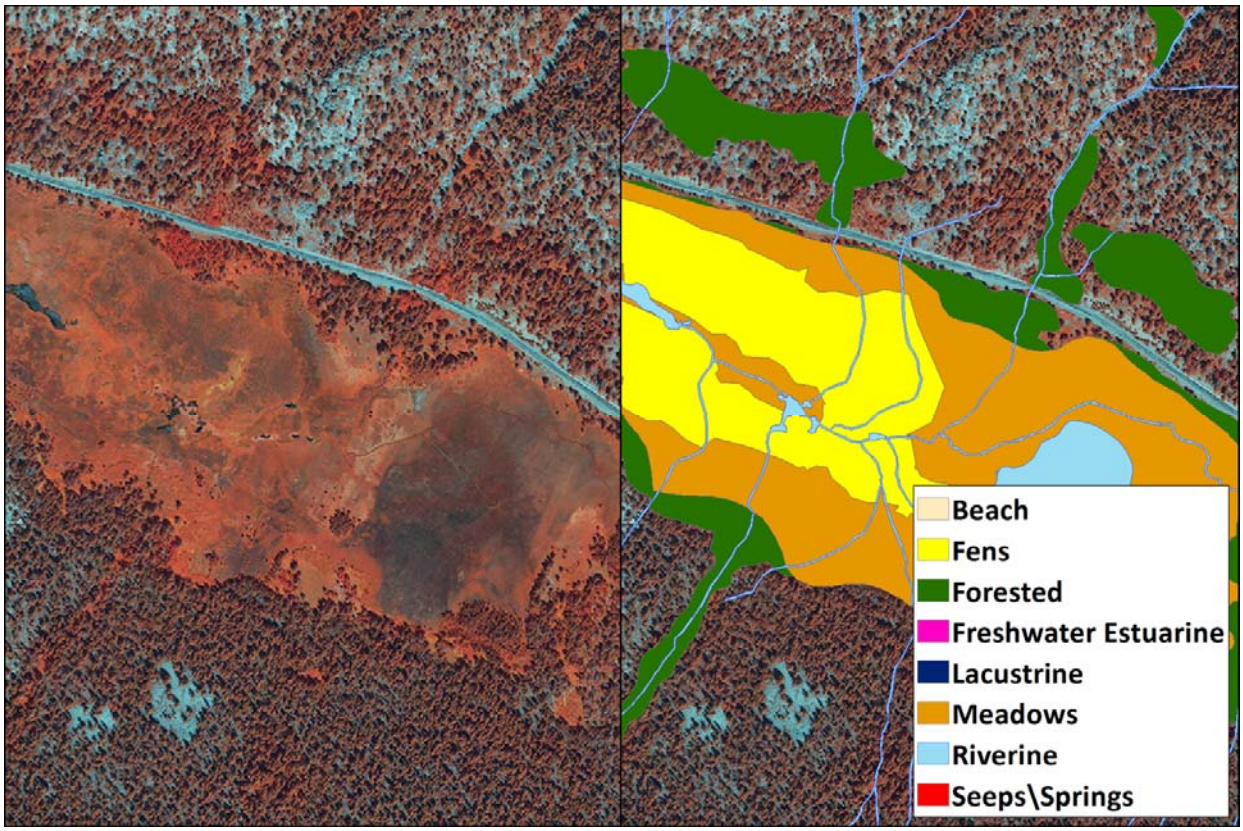

Figure 8. Close up of SEZ features for a portion of the Lake Tahoe Basin. Color-infrared imagery (2010 WorldView-2) is shown on the left; SEZ types superimposed with the imagery is shown on the right.

Table 9. SEZ types summarized by total area, proportion of aquatic features, and proportion of the Lake Tahoe Basin.

SEZ Type	Area (acres)	Area (hectares)	Percent Aquatic Features	Percent Basin[1,2]
Fens	171	69	0.6%	0.1%
Seeps\Springs	256	103	0.9%	0.1%
Freshwater Estuarine	317	128	1.1%	0.1%
Lacustrine (Shoreline of Lake Tahoe)	521	211	1.8%	0.2%
Riverine (Confined Channel)	3,349	1,355	11.4%	1.5%
Meadows	6,632	2,684	22.6%	2.9%
Forested	14,578	5,899	49.6%	6.4%
Lacustrine (Lakes and Ponds)	3,568[1]	1,444[1]	12.1%	1.6%
Total	29,391	11,894	100%	12.9%

[1]Excluding area of Lake Tahoe.

[2]Tahoe Regional Planning Agency basin boundary, buffered by 400 meters.

CONCLUSIONS AND RECOMMENDATIONS

Perhaps the greatest value of this project was the contribution of the different individuals that participated in workgroups in combination with the project team. Each individual brought their respective technical expertise and years of institutional knowledge that combined, through many hours of discussion, has addressed several identified SEZ program update needs. Together, workgroups have forwarded a set of recommendations that can be integrated into Tahoe SEZ program with some additional stakeholder, public and decision-maker review and discussion. The process followed in this project has resulted the following findings and recommendations:

- A review of existing SEZ definitions were found to be adequate and indicate that there is no need for revisions.
- Desired SEZ conditions, functions, processes and values have been documented in this report and can help to focus management and regulatory actions.
- Although there are no recommendations for adjusting the overarching criteria (i.e., vegetation, hydrology, geomorphology, and soils) for SEZ delineation, several updates are proposed for SEZ indicators. The Field Delineation Workgroup found that updates to soil, vegetation, aquatic habitat, and floodplain indicators (*Tables 3* and *4*) would bring the SEZ program up to date with current industry standards. Similarly, current methods for evaluating proposed indicators and thus determining SEZ boundaries are suggested to improve the consistency of SEZ delineation across SEZ practitioners.
- The Field Delineation Workgroup has proposed a pragmatic scheme for SEZ delineation and review that takes into account the different types and scales of project actions. Implementation of this system could lead to cost savings without a reduction in SEZ protection.
- A simple SEZ classification scheme is proposed based on California's Aquatic Resource Classification System and augmented to reflect Tahoe Basin ecology and existing SEZ policy. The proposed classification scheme includes and describes the different types of SEZ that exist in the Basin and should be valuable in supporting monitoring, restoration and regulatory efforts.
- The aquatic features mapping resulted in the most accurate and comprehensive datasets ever developed for the Lake Tahoe Basin. While no mapping effort is perfect, and the quality assurance review identified some deficiencies, the stream centerlines, open water polygons, and wetlands are far more accurately represented on the landscape and precise than any layers ever produced for the region. The success of the aquatic resource mapping can be attributed to both the quality of the source input datasets, specifically the LiDAR and WorldView-2 imagery, along with the processing methods developed for this project. The foundation laid by this project will substantially reduce the cost of making future updates and improvements. However, additional attribution work is needed to bring the aquatic resource map into compliance with CARI and NHD standards.
- The aquatic resource map was core to developing the first ever basin-wide map of SEZ. It is important to note that the SEZ types and boundaries should be considered as *potential SEZ*; because some of the features were developed from soils and LiDAR-derived topographical and hydrological models, they do not necessarily reflect on the ground conditions. This reality is particularly evident in the "forested" type, which encompasses developed land uses (e.g., roads, buildings) south of Lake Tahoe and in other suburbanized parts of the basin. Thus it is recommended that field verification be conducted to validate the occurrence of SEZ as appropriate prior to any on-the-ground actions.
- The map of potential SEZ produced in this project indicates that there is considerably more SEZ (approximately 29,391 acres) than has been previously reported (approximately 17,700 acres according to TRPA 1978). These differences probably do not indicate an increase in SEZ area since last mapped, but are more likely a function of higher resolution base data used for this project. Higher resolution data provided the ability to more accurately map stream tributary networks and

better reveal wetland and riparian associated vegetation. In addition, previous SEZ mapping efforts may have been biased toward representing the extent of SEZ in the urban context where the greatest development pressures exist in the Tahoe Basin.

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APPENDIX A. DESCRIPTION OF PROJECT WORKGROUPS

The overall SEZ Workgroup consisted of interacting groups – an Administration Group, a core workgroup (i.e., Field Delineation Workgroup, and a Mapping and Classification Workgroup) and a Stakeholder Group. Members of the Administration Group participate in all Core Group meetings, and members of the Administration and Core Groups participated in the Stakeholder Group meetings as appropriate. There was overlap in administration and core group membership. The Stakeholder Workgroup only participated in Stakeholder Workgroup meetings. The follow describes groups and workgroups of the SEZ Workgroup.

Field Delineation Workgroup

The SEZ Field Delineation Workgroup (field group) was comprised of local, state and federal agency representatives, as well as regional non-profit environmental groups, and was coordinated by SIG personnel. Entities represented included the Tahoe Regional Planning Agency (TRPA), the Tahoe Resource Conservation District (TRCD), the League to Save Lake Tahoe (League), California Tahoe Conservancy (CTC), California State Parks, California Regional Water Quality Control Board – Lahontan Region, the United States Forest Service - Lake Tahoe Basin Management Unit (LTBMU), the United States Environmental Protection Agency (EPA), private consultants, and the United States - Natural Resources Conservation Service (NRCS). The group met greater than ten times between May 2013 and August 2014, and used a consensus approach to review existing SEZ guidance and techniques and propose and iteratively evaluate alternative criteria and techniques. The group used their collective technical experience in applying the existing SEZ delineation standards to assess necessary changes, and supplemented this knowledge with review of research pertinent to wetland delineation and classification. The core group solicited review of interim products by professional soil scientists with experience in identifying SEZs. Finally, the group conducted site visits to test the application of recommended field indicators.

Mapping Workgroup

The SEZ Mapping Workgroup (mapping group) was comprised of local, state and federal agency and non-profit organization representatives with skills and experience in mapping natural resource features. Members included representatives of the League to Save Lake Tahoe, California Tahoe Conservancy (CTC), the California Regional Water Quality State Control Board (Lahontan), US EPA, US Forest Service-LTBMU, San Francisco Estuary Institute-Aquatic Science Center (SFEI-ASC), Nevada Division of State Lands (NDSL), Nevada Division of Environmental Protection (NDEP) and Natural Resources Conservation Service (NRCS). This group met three times over the course of the project to review and provide input on various SEZ mapping products and to review and discuss options for SEZ classification. SFEI-ASC provided an independent review of the aquatic feature map produced for this project to gauge the degree that TARI standard mapping procedures were followed (The SFEI-ASC report is provided in Appendix C). The project team used input provided by the mapping group to refine map products produced as part of this project – especially input provided on the SEZ map product.

Administration Group

The Administration Group was comprised of personnel from Spatial Informatics Group and in part San Francisco Estuary Institute. The primary responsibility of this group was to provide project management and oversight. Specific responsibilities include: product review, QA/QC and approval, data coordination, field and meeting logistics and project management such as staffing and finance oversight. The Administration Group was also responsible for presenting progress reports, findings and recommendations to the field and mapping workgroups and stakeholder group.

Stakeholder Group

The Stakeholder Group was comprised of selected members of the Administration Group and the core group, plus stakeholders and interested public, professionals and wetland restoration practitioners who will be able to provide expertise on a wide range of subjects, including: wetland restoration science, conservation, biology, chemistry, toxicology, ecology of special status species, plant ecology, and hydraulic and restoration engineering. Because of the overlapping areas of expertise commonly observed in science and in restoration work, one member can cover more than one area of expertise. Individuals selected are anticipated to represent one to many of a variety of constituencies, including local, state, and federal agencies, universities, non-governmental organizations, public and the private sector. The primary responsibility of the Stakeholder Group was to 1) provide review and input on project products, 2) raise issues or concerns with the direction of this project, 3) share progress and findings from this project with their respective constituents (e.g., agency executives) and 4) aid in identifying opportunities to coordination with other efforts.

The final selection of members, including any changes made to the team throughout the course of this project, was at the discretion of the Administrative Group. However, membership of the Stakeholder Group was broad and inclusive with no individual barred from participating.

Decision Making

The SEZ Workgroup was a recommendation body - it did not have the authority to make policy or management decisions, or functional changes to any agencies' respective planning documents. However, decisions and recommendations related to the project were based on consensus of the representatives present at the group meetings whenever possible. However, if consensus was not possible then a simple majority voting structure was used to reach a decision or recommendation related to the project.

APPENDIX B. DESIRED CONDITIONS, PROCESSES, FUNCTIONS AND VALUES OF THE STREAM ENVIRONMENT ZONE IN THE LAKE TAHOE BASIN

The SEZ provides a variety of ecological (i.e., physical, chemical, and biological) functions and also provide Tahoe Basin residents and visitors with a number of social and economic benefits. This section provides a brief overview of the functions and processes provided and supported by Stream Environment Zones in the Tahoe Basin that are desirable to achieve and maintain. Identification and consideration of these functions and processes provided a basis for the review of SEZ definition, field delineation criteria and indicators, and mapping efforts.

This compilation of SEZ desired functions, processes, values and conditions was derived from a list originally assembled by the Tahoe Science Management Integration Team - SEZ Working Group in October of 2011. The list was supplemented with other background information found in the scientific literature, the 1977 208 Water Quality Plan, and codified SEZ descriptions (TRPA 2012).

Natural Disturbance

Flood Attenuation

Flooding is a natural process essential to the ecological health of riparian and river systems (Resh, et al, 1987). SEZs provide space for channel meanders, stream movement, and floodwaters to spread laterally. This reduction in stream power is important for the maintenance of channels and other aquatic habitats as well as protection of human investments in and around the floodplain. Riparian and wetland SEZs buffers promote floodplain storage due to backwater effects; they intercept overland flow and reduce floodwater volume through absorption (Scott, 2012). Interception and storage increase water travel times, resulting in reduced flood peaks (Abu-Zreig, et al 2004). Maintaining SEZs in natural functioning condition help maintain or restore natural floodplain, groundwater recharge and channel processes while simultaneously protecting human investments (Phillips, 1996).

Mass Wasting and Debris Flows

Mature SEZ vegetation and large woody debris in streams can serve to limit the downstream impacts of mass failures/debris torrents, particularly in headwater streams (Swanson, et al, 1982). Streamside forests reduce the potential for local failures, and downstream riparian stands intercept and impede the flow of sediment and debris (Sidle, et al 1985). The length of the debris flow may be reduced by standing trees that intercept and slow the flow. Likewise, boles of trees swept into the flow may lodge against standing trees and provide "reinforcement" that slows down or limits the distance the flow travels.

Role of Fire

Impacts of wildfire are of increasing concern in the Tahoe Basin. There is concern for both the impacts of fire on SEZ condition, and for the contribution of SEZs to fire response and effects at a landscape scale. Periodic fire shaped the vegetation structure and composition of SEZs. Fire assists in keeping meadows open by helping to remove invading conifers. Fire may also help to improve the species composition and vigor of meadow vegetation.

During wildfires, riparian plant communities often have a higher survival rate than nearby hill slope areas. Higher humidity and damper soils adjacent to water bodies may help protect plants in SEZs, particularly the larger conifers. SEZs that are relatively open (e.g., wet marsh or meadow and wet mesic meadow) serve as natural fuel breaks separating adjacent upland forested areas. Streams, ponds, and lakes also serve this function. Likewise, SEZs along perennial streams may also act to modify fire behavior due to lower temperatures and higher humidity. Riparian forests may also play a role in colonizing upland

forest communities following stand replacing wildfires. These values may be compromised when fuel loadings and stem density in SEZs are high due to suppression of the historic fire regime.

The 2007 Angora Fire provided an example of SEZ influences on wildfire behavior. In some areas of the fire, SEZs provided pathways for high-intensity fire to move within treated upland forests (Murphy *et al*. 2007). Other SEZs, including those in the Angora SEZ Project completed by El Dorado County on USFS and Tahoe Conservancy land acted to slow or stop spot fires due to relatively high moisture and humidity, and lower conifer tree densities in the restored area.

Water Quality

Sediment, Nutrient and Other Water Pollutant Reduction

SEZs are critical for the protection and enhancement of water quality in Tahoe Basin streams, ponds, and lakes and play an important role in the maintenance of the clarity of Lake Tahoe. SEZs aid in maintaining water quality through the trapping and filtering of sediments, nutrients and other pollutants. The seasonally inundated soils associated with some SEZs are also conducive to denitrification (Mayer *et al*. 2010).

The value and effectiveness of riparian buffers in trapping delivery of pollutants from both natural and human-caused sources is well documented and the conservation and management of SEZs is an integral part of the strategy to protect and improve the water quality of Lake Tahoe. This strategy is in the Lake Tahoe Water Quality Management Plan (TRPA, 2012). The plan emphasizes control of waste discharges and implementation of Best Management Practices to reduce generation of pollutants on site, so that pollutants from stormwater are treated before entering SEZs. Rather, SEZ are critical components of the overall policy to restore Tahoe's natural hydrologic system. Intact and functioning SEZs help to produce runoff, nutrient and sediment regimes that existed pre-development.

SEZs in good condition moderate the delivery of sediment and nutrients in numerous ways (Ma, et al, 2008). Perhaps most importantly, they prevent water quality problems by displacing sediment-producing activities away from flowing water (through SEZs and setbacks). Runoff from adjacent upland areas (especially urbanized areas) and floodwaters that percolate through SEZ/floodplain soils are filtered, resulting in the removal of sediment (including fine sediment) and some nutrients (e.g., sediment attached phosphorus) and contaminants. The ability of SEZs to remove pollutants from precipitation runoff was measured by the TRPA (TRPA 1977) and by the Environmental Protection Agency (EPA) (Morris *et al*. 1980). The TRPA study showed 94% removal of suspended solids, 74% removal of total nitrogen, 86% removal of total phosphorus, and 72% removal of iron as runoff passed through an undisturbed SEZ.

SEZ vegetation and soils improve the quality of water reaching watercourses through the uptake and processing of nutrients and pollutants carried in surface runoff and subsurface flow. Some SEZ plant species (especially wetland-associated plants) have the capacity to uptake certain pollutants (e.g., heavy metals) and temporarily sequester them. Streambank vegetation also uptakes some nutrients in the hyporheic zone, the area beneath and alongside the stream bed, where surface water mixes with shallow groundwater. Oxidation/reduction within hydric soils results in anaerobic denitrification (i.e., the transformation of nitrate to nitrite, nitrogen gas and ammonia), which can reduce leaching of nitrate to groundwater. Oxidation/reduction within hydric soils can result in the reduction, translocation, and/or accumulation of iron and other reducible elements.

Water Temperature Control

The role of streamside vegetation in regulating stream temperature is one of the most important functions of naturally functioning riparian SEZs (Brazier and Brown 1973). Shade created by vegetation canopy helps to lower water temperatures in summer and moderates harsh winter temperatures by trapping back-radiation. Sources of cold water throughout a watershed are important to cold water fishes and aquatic communities. Water temperature moderation maximizes dissolved oxygen content in streams and increases the capacity to process nutrients and pollutants.

Water Quantity

Flow Maintenance and Moderation

Influence of SEZs on flooding was discussed earlier, but they are also important to watershed runoff dynamics in general. Current understanding of runoff processes holds that saturated areas expand and contract in size between storms and during the course of individual events (Dunne and Black 1970). These variable source areas are located near channels and other aquatic features. It follows that SEZs in undisturbed condition (i.e., no or little impervious cover and comprised of native vegetation cover) contribute to runoff regimes that approximate natural conditions in which native aquatic organism have evolved. Watersheds that have been overdeveloped (over-covered with impervious surface) and disturbed are unable to absorb flooding events and thus lead to a more flashy flow regime that generates more erosion and sedimentation leading to impacts on water quality and native aquatic organisms (Karr and Chu 1999).

SEZ influence on the runoff regime extends beneath the soil's surface. Groundwater moves into and out of streambanks and the streambed through the hyporheic zone the area between surface stream and ground-water. Exchanges of water, nutrients, and organic matter occur in response to variations in discharge and bed topography and porosity. Upwelling subsurface water supplies aquatic organisms with nutrients while down welling stream water provides dissolved oxygen and organic matter to microbes and invertebrates in the hyporheic zone. Release of groundwater during the drier summer/fall months helps to maintain base (low) flows in stream channels, thus maintaining aquatic habitats.

Aquatic Habitats

Functioning SEZs provide aquatic communities with suitable water quality and food, and contribute to formation and maintenance of habitat for aquatic species (Beshchta *et al*. 1987). Intact and diverse vegetation within and adjacent to SEZ plays a large role in supplying quality aquatic habitats.

Root systems of native riparian vegetation help to stabilize streambanks thereby reducing in-channel erosion and sediment discharge to the lake. Large woody debris produced in the SEZ (e.g., tree truck, root wads) falls or is carried by flood flows into the stream channel where it helps to create in-stream habitat diversity (e.g., pools), captures and stores sediment and provides cover for fish and aquatic life (Beshchta and Platts 1986). SEZ vegetation growing in the backshore of lakes helps to stabilize shorelines and reduce re-entrainment of sediment in the water column.

Leaf litter from deciduous riparian trees falls into the water and becomes feeding substrate for benthic invertebrates (e.g., shredders) (Cummins *et al*. 1989). Insects associated with wetland and riparian vegetation growing on streambanks and in the channel fall into or land on the water providing a food source for fish and aquatic life. SEZ vegetation acts to moderate water temperature - shading in warmer summer months and retaining heat and reducing winds in colder winter.

In urbanized watersheds, channel erosion can be the major source of sediment to receiving waters (Trimble 1997). As a result, one of the most important roles of Tahoe's SEZ is to protect streambanks. SEZ vegetation helps stabilize stream banks, maintains a stable alignment, and reduces undercutting and stream bank collapse that are sources of sediment production and delivery (Barling and Moore 1994). Tree and shrub roots in SEZs bind soil and increase the strength of the soil matrix.

Riparian Habitats

The diverse native plant populations that comprise the riparian plant communities support a diverse assemblage of wildlife species. About 21% of Sierra vertebrates and at least 17% of Sierra plants are associated with riparian and wet areas (Kattelmann and Embury 1996).

Vegetation

Plant associations in SEZs constitute only a small portion of the Tahoe Basin's land area, but are perhaps the most valuable plant communities in terms of their role in providing wildlife habitat and scenic esthetics. Riparian areas are critical contributors to plant diversity in the Tahoe Basin. Areas adjacent to streams, including floodplains, display complex topographic features influenced by substrate composition, soil moisture, nutrient regime and disturbance frequency. Different successional stages of plant communities occur in a mosaic of patches in these areas and as a result, the number of plant species in riparian forests is much greater than upland forests. Lacustrine and wetland SEZs, such as bogs, seeps and springs also support diverse associations of plants, including rare species. In addition, many species of native forbs can survive only in areas near water.

Wildlife Habitat

Ecotones between wetland/riparian systems and streams, lakes and ponds, ecotones between different types of SEZ plant communities, and ecotones between SEZ plant communities and adjacent upland plant communities create a mosaic of habitat and microhabitats for native wildlife species (Semlitsch and Bodie 2003). High flows and overbank flooding deposits substrate help to perpetuate the establishment of new plant growth and pioneer species. Typically, SEZ plant communities are diverse, with great horizontal habitat complexity. Downed logs and other woody debris, which originate from the riparian and hill slope stands, contribute to horizontal structural complexity. The patch mosaic of herbs, shrubs, deciduous and coniferous trees, and standing dead snags also create a multilayered canopy, leading to high vertical diversity. In addition, openings above streams, ponds, and wetlands provide gaps or natural breaks in the forest canopy. The complexity of riparian plant communities is mirrored in the high numbers of animal species, both aquatic and terrestrial, dependent on the riparian area (Stewart 2007). The vertical and horizontal dimensions of SEZs provide multiple habitat niches. Trees provide cavities for birds and small mammals to rest, nest, and breed. Native trees, shrubs, grasses and forbs of riparian forests provide foliage and seeds and harbor a diversity of insects that provides food for a variety of native wildlife species.

Evapotranspiration from wetlands and shade from riparian vegetation modify temperature and humidity. Many mammals spend a large portion of their lives on or near surface waters (Doyle 1990). Some species, including beaver, otter, muskrat, star-nosed moles, and water shrews, spend their entire lives within riparian areas (Anthony *et al*. 1987). Other large mammals use riparian areas for cooling, foraging, travel corridors, and as connecting habitat through otherwise uninhabitable regions. SEZs also provide for wildlife passage including seasonal or diurnal movements within home ranges, and dispersal routes for juveniles of many species (Lehtinen, et al 1999). SEZs serve as wildlife migration corridors providing spatial and temporal connectivity for riparian and aquatic-dependent species within and between watersheds (Fisher *et al*. 2000). SEZs also transcend elevation gradients, providing connectivity from lower to higher areas within watersheds. Riparian tree canopy allows for movement of certain wildlife species across watercourses. In addition, SEZs serve as refugia for wildlife during upland forest fires, and upslope

portions of SEZs, tall vegetation within SEZs, and SEZ setbacks areas serve as refugia for wildlife during flood events.

Riparian areas support a wide variety of bird species from resident songbirds and neotropical migrants to waterfowl and birds of prey because these areas harbor an abundance and diversity of insect and a variety of structural diversity.

A large part of the life cycles of amphibians and reptiles occur in mature riparian forest buffers. Deciduous riparian vegetation supplies leaf litter and logs which provide important cover for amphibians and reptiles in the SEZ. The same is true for many aquatic insects, which use riparian vegetation as reproductive swarming sites, adult emergence sites, and for food.

Soil Productivity

Soils in SEZs perform a variety of important functions. Soils in good condition serve as the medium for a complex set of physical, chemical, and biological processes and interactions that enable SEZs to provide the ecological functions described in this document, including:

- Capture and storage of water from adjacent uplands
- Infiltration of water from these different sources for gradual release into streams and ground water
- Attenuation of floods and recharge of aquifers
- Providing a medium for plants and microorganisms to cycle nutrients
- Storage of nutrients that would otherwise be discharged from the watershed
- Filtering of nutrients, sediment and other pollutants

Certain SEZ soils (e.g., hydric soils) serve as a sink for nutrients for extended periods of time (Phillips 1996).

Societal Functions and Values

Recreation

Recreational use is often concentrated in and around lakes, stream and adjacent riparian areas, where scenic values are high. Much of the Tahoe basin's developed and dispersed recreation occurs in or near SEZs. A wide range of recreational activities depends on healthy riparian areas, including picnicking, fishing, boating and water play, and wildlife viewing. Most campgrounds and day-use facilities in the Tahoe Basin are located within or adjacent to SEZs areas, and most back country campsites are located near streams and lakes. Recreational trails within SEZs provide opportunities for walking and hiking along watercourses and through SEZ communities. Both constructed and user-created trails along streambanks provide access for fishermen and other outdoor enthusiasts.

Noise Reduction and Visual Screening

SEZs provide natural vegetative buffers along streams and other aquatic habitats within developed areas of the basin. In these areas, SEZs act as visual and acoustical screens, and add to the natural character of the area. Effectiveness of SEZs as screens is dependent on their location, type, vegetative capacity and condition, as well as the nature of the development screened by the SEZ (Bentrup 2008). SEZ serves as open space by providing a greenway corridor through urbanized areas. SEZ adjacent to residential parcels increase the aesthetic values of the environs surrounding the parcels. SEZ vegetation, like terrestrial vegetation, helps to buffer noise occurring in the uplands on one side of the SEZ as perceived by residents and visitors on the opposite side. SEZs within urban areas offer a relatively noise-free environment where urban dwellers can escape from the sounds of the city. SEZ vegetation in the backshore helps to screen shoreline development as viewed from the lake and roadsides.

Aesthetics and Real Estate Values

SEZs serve as important open space areas within the developed portions of the Basin. They provide a scenic and aesthetic value to adjacent property owners and visitors to the Tahoe Basin. The character of the Tahoe Basin is largely dependent upon the natural appearance including vegetation, on both publicly and privately owned properties. Development that damaged SEZs or removed SEZ vegetation would not only deplete valuable natural resources, they would also disrupt the view sheds and habitats that contribute to the value of property. At the basin scale, SEZs are critical to maintenance and improvement of the quality of water delivered to Lake Tahoe. Sustaining clarity of the lake is also a factor affecting desirability and demand for property in the Basin. The flood protection afforded by SEZs also contributes to real estate values (Duffy 2010). Most climate change models predict higher peak flows and more common flood events. Limiting development in SEZs limits potential property damage that could result from a changing precipitation regime (Safford 2012).

Cultural and Historic Values

SEZs were important areas for the Washoe, there are important archaeological sites within, and immediately adjacent to, SEZs. There are important historical sites located within SEZs. Numerous plant species used for Washoe cultural purposes grow in aquatic, riparian, and meadow ecosystems. The Wetlands Conservation Plan for Meeks Meadow and Taylor Creek Marsh is an example of consideration of cultural practices in SEZs.

Educational Values

SEZs serve as an outdoor laboratory for students and researchers interested in gaining a greater understanding of ecology and the functions and values of SEZs. As such, and if appropriately designed to not impact other SEZ values, SEZ could provide areas for interpretative trails where residents and visitors can learn about Tahoe Basin vegetation, wildlife, fisheries, etc.

Tahoe Economy

Recreational trails within SEZs provide a segment of the tourist population that visits the Tahoe Basin with an enjoyable experience thereby increasing the likelihood of their returning to the area to pursue their outdoor recreation interests. Many tourists visit the basin to view the beauty and clarity of Lake Tahoe. SEZ's are an important policy component in the efforts to maintain water quality of the lake.

Many studies have revealed increases in property values in instances where property is located near or adjacent to open spaces (Bin *et al*. 2008, Bark *et al*. 2009). An increase in property values generally results in increased tax revenues for local governments.