
Lake Tahoe Region

Aquatic Invasive Species Management Plan

CALIFORNIA - NEVADA



May 2014

This Aquatic Invasive Species Management Plan is part of a multi-stakeholder collaborative effort to minimize the deleterious effects of nuisance and invasive aquatic species in the Lake Tahoe Region. The Tahoe Regional Planning Agency, as created by California, Nevada, and the U.S. Congress (P.L. 96-551, 94, Stat. 3235) provides oversight to the implementation of this plan, including acting as the fiscal agent, or pass through agency for funds associated with its implementation.



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State of Nevada

Jim Gibbons, Governor

Jim Gibbons 8/20/09
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State of Nevada

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Acknowledgements

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Lake Tahoe Aquatic Invasive Species Coordination Committee:

**California Tahoe Conservancy
California Department of Fish and Wildlife
California Department of Parks and Recreation
California State Lands Commission
Lahontan Regional Water Quality Control Board
Nevada Department of Wildlife
Nevada Division of State Lands
Tahoe Resource Conservation District
Tahoe Regional Planning Agency
Tahoe Science Consortium
U.S. Department of Agriculture (USDA) – Agricultural Research Service
USDA –U.S. Forest Service – Lake Tahoe Basin Management Unit
U.S. Fish and Wildlife Service**

Acronyms

AIS	Aquatic Invasive Species
AISCC	Aquatic Invasive Species Coordination Committee
ANSTF	Aquatic Nuisance Species Task Force
BLM	Bureau of Land Management
BPSs	Border Protection Stations
CADPR	California Department of Parks and Recreation
CAISMP	California Aquatic Invasive Species Management Plan
CDFA	California Department of Food and Agriculture
CDFW (CDFG)	California Department of Fish and Wildlife, formerly California Department of Fish and Game
CRWQCB	California Regional Water Quality Control Board
CTC	California Tahoe Conservancy
CWA	Clean Water Act
HACCP	Hazard Assessment and Critical Control Points Plans
IPM	Integrated Pest Management
ISAC	Invasive Species Advisory Committee
LRWQCB	Lahontan Regional Water Quality Control Board
LTAISCC	Lake Tahoe Aquatic Invasive Species Coordination Committee
LTAISP	Lake Tahoe Aquatic Invasive Species Plan
LTAISWG	Lake Tahoe Aquatic Invasive Species Working Group
NDA	Nevada Department of Agriculture
NDEP	Nevada Department of Environmental Protection
NDOW	Nevada Department of Wildlife
NDSL	Nevada Division of State Lands
NDSP	Nevada Division of State Parks
NISC	National Invasive Species Council
ONRW	Outstanding National Resource Water
TERC	Tahoe Environmental Research Center
TMDL	Total Maximum Daily Load
TRCD	Tahoe Resource Conservation District
TRPA	Tahoe Regional Planning Agency
UCD	University of California, Davis
USACE	United States Army Corps of Engineers
USBOR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USDOI	United States Department of Interior
USFS - LTBMU	United States Forest Service – Lake Tahoe Basin Management Unit
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

Glossary

Accidental introduction: An introduction of nonindigenous species that occurs as the result of activities other than the purposeful or intentional introduction of the species involved, such as the transport of nonindigenous species in ballast water or in water used to transport fish, mollusks or crustaceans for aquaculture or other purposes.

Adaptive Management: Refinement of an approach (and sometimes objectives) to an environmental implementation plan that is modified based on outcome of initial results. The plan may continually be refined so that positive environmental results are achieved.

Aquaculture: The farming of freshwater or saltwater organisms including mollusks, crustaceans, and aquatic plants.

Aquascape: Aesthetic gardening in an aquatic area with aquatic species.

Aquatic invasive species: A nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters).

Aquatic species: All animals and plants as well as pathogens or parasites of aquatic animals and plants totally dependent on aquatic ecosystems for at least a portion of their life cycle.

Ballast: An often water-filled device used on ships and submersibles to control buoyancy and stability.

Ballast water: Any water and associated sediments used onboard a ship to increase the draft, change the trim, regulate the stability or maintain the stress loads of the vessel.

Benthic (benthos): The ecological region located at the deepest level of a body of water; this includes the area around the interface between the sediment surface and water column.

Biocontrol: The use of living organisms, such as predators, parasites and pathogens, to control pest animals (e.g., insects), weeds or diseases.

Coldwater fish: Fish species that prefer and inhabit colder waters; examples are salmonid species such as trout and salmon.

Crustacean: A large group of mostly aquatic arthropods that includes various species such as crab, lobster, crayfish, shrimp, krill, and barnacle.

Dreissenid: A family of small, often invasive, freshwater mussels in the phylum Mollusca.

Biological integrity: is associated with how “pristine” an environment is and its function relative to the potential or original state of an ecosystem before human alterations were imposed. Biological integrity is built on the assumption that a decline in the values of an ecosystem's functions are primarily caused by human activity or alterations.

Eradicate: For the purpose of this Plan, eradication is the complete elimination of an invasive species from a specific part of the Lake Tahoe Region.

Established: An introduced organism with a permanent population(s) (i.e., one that has the ability to reproduce and is not likely to be eliminated by humans or natural causes).

Extirpation: Complete elimination of a localized population of an aquatic invasive species

Indigenous: An organism that is native or naturally evolved to a specific region in which it naturally occurs.

Integrated Pest Management: A decision-based process involving coordinated use of multiple tactics for optimizing the control of all classes of pests (insects, pathogens, weeds, vertebrates) in an ecologically and economically sound manner.

Intentional introduction: All or part of the process by which a nonindigenous species is purposefully introduced into a new area.

Introduction: The intentional or unintentional escape, release, dissemination or placement of a species into a California ecosystem as a result of human activity.

Invasive species: An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112 [Federal Register: Feb 8, 1999, Vol. 64, No. 25]). Species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy.

Native species: A species within its natural range or natural zone of dispersal (i.e., within the range it would or could occupy without direct or indirect introduction and/or care by humans).

Nearshore: The zone extending from the low water elevation of Lake Tahoe (6,223.0 feet Lake Tahoe Datum) to a lake bottom elevation of 6,193.0 Feet Lake Tahoe Datum, but in any case, a minimum lateral distance of 350 feet measured from the shoreline. In other lakes, the nearshore extends to a depth of 25 feet below the low water elevation.

Non-native or Nonindigenous species: A species that enters an ecosystem beyond its historic geographic range. Also known as exotic or alien species. Other taxa can be considered non-native or nonindigenous, such as families, genera, subspecies or varieties.

Noxious weed: Any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment (Plant Protection Act of 2000 [7 U.S.C. 7701 *et seq.*])

Nuisance species: For the purpose of this plan, the term is synonymous with invasive species.

Oligotrophic: A lake condition of low production associated with low phosphorus and nitrogen.

Pathogen: A microbe or other organism that causes disease.

Pathway: Mode by which a species establishes and continues to exist in a new environment; often synonymous with vector, dispersal mechanism, and mode. Natural and human connections that allow movement of species or their reproductive propagules from place to place.

Pelagic zone: The zone of a waterbody with only water being present as the media or in space; open water.

Phytoplankton: Free-floating microscopic plants (primary producers) that compose the autotrophic component of the plankton community.

Riparian: Situated or dwelling on the bank of a river or other water body.

Secchi disk: Circular disk used to measure water transparency in oceans and lakes. The disc is mounted on a pole or line, and lowered slowly down in the water. The depth at which the pattern on the disk is no longer visible is taken as a measure of the transparency of the water. This measure is known as the *Secchi depth* and is related to water turbidity.

Stakeholder: Relevant representatives from regional, state, or federal agencies, non-governmental organizations, or property owners.

Taxa: Groups used to classify organisms (e.g., kingdom, phylum, class, order, family, genus and species).
Taxa is the plural form of taxon.

Trophic: Pertaining to nutrition status, or nutritive processes.

Vector: The physical means or agent by which a species is transported (e.g., boat hulls, live wells, fishing gear); often synonymous with pathway, dispersal mechanism, and mode.

Warm water fish: Fish species that prefer and inhabit warmer waters; examples include smallmouth bass, crappie, and other sunfish (Centrarchidae).

Watershed: The geographic area that drains to a single waterbody or hydrographic unit such as a lake, stream reach or estuary.

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LAKE TAHOE REGION

AQUATIC INVASIVE SPECIES MANAGEMENT PLAN

CALIFORNIA AND NEVADA

Executive Summary

Lake Tahoe is designated an Outstanding National Resource Water (ONRW) under the Clean Water Act (CWA Section 106) due to its extraordinary clarity. Substantial changes to the Lake Tahoe Region's economy, pristine water quality, aesthetic value, and recreational pursuits are occurring, partly due to the harmful impacts of non-native aquatic plants, fish, invertebrates, and other invaders. These non-native aquatic organisms are considered 'invasive' (or *aquatic invasive species* [AIS] in water) when they threaten the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent upon such waters (NANPCA 1990). AIS are commonly spread by activities such as boating, fishing, hatchery releases, and aquarium dumping. The Lake Tahoe Region is not only threatened by new introductions of AIS to Lake Tahoe from other waterbodies, but also the expansion of existing populations within the lake and even as a source of AIS to nearby waterbodies.

Nearly 30 non-native species are established in the Lake Tahoe Region, including aquatic plants, fishes, invertebrates, and an amphibian. As examples, Eurasian watermilfoil (*Myriophyllum spicatum*; an aquatic plant) has been spreading around Lake Tahoe over the last 15-20 years, and curlyleaf pondweed (*Potamogeton crispus*; another aquatic plant) has begun to expand dramatically over the last seven years. Beds of Asian clams (*Corbicula fluminea*) are larger and more common than previously known, and populations of warm water fishes such as largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) are expanding. Moreover, global climate change has resulted in warmer water temperatures, likely facilitating the establishment of non-native plants in the nearshore environment and providing increased spawning areas for warm water fishes that compete with desirable species.

The potential economic impact to the Lake Tahoe Region caused by new AIS introductions, or expanding populations of existing AIS could be substantial. The combined economic impacts to recreation value, tourism spending, property values, and increased boat/pier maintenance, when evaluated over a 50-year period, is estimated at between \$417.5 million and \$3.9 billion, with an average annual equivalent value of between \$22.4 and \$78 million per year. The largest estimated impacts would be to property values and lost tourism spending. Spending on prevention and early eradication typically produces a higher benefit to cost ratio than post-infestation control programs such that maximum benefits are realized through early and preemptive action.

This is the first update of the original *Lake Tahoe Region AIS Management Plan* (the Plan) that was approved in 2009. This update to the Plan seeks to revise the Plan taking into account changes in the implementation of AIS efforts in the Tahoe Region that have occurred in the previous four years, and the accomplishments during that time. In addition to the content update, the primary focus of the update is on changes that were needed to make the Plan as useful as possible to inform management, policy and funding decisions related to AIS issues in the region. This has been accomplished by changing the format of the Plan to make the body of the Plan robust enough to guide the program, while the appendices were expanded and intended to be “living” documents.

The format changes were intended to lead to future revisions where changes to the body of the document would require major technical revisions, and the more frequent changes to appendices would require the simpler process of minor technical revisions.

These changes seek to enhance coordination of regional, bi-state, state, and federal programs and to guide implementation of AIS prevention, monitoring, control, education, and research in the Lake Tahoe Region.

The goals of the Plan are to:

- Prevent new introductions of AIS to the Lake Tahoe Region
- Limit the spread of existing AIS populations in the Lake Tahoe Region, by employing strategies that minimize threats to native species, and extirpate existing AIS populations when possible
- Abate harmful ecological, economic, social and public health impacts resulting from AIS

To achieve these goals, the Plan is structured around four objectives associated with:

- Oversight and internal coordination
- Prevention
- Monitoring, detection and response
- Long-term control

To meet these objectives, strategies are identified with respective action items detailing how that objective will be met. These strategies and actions will be frequently updated to illustrate program changes, accomplishments, and any emerging threats.

The intent of the Plan is to provide more localized guidance for prevention and long term control of AIS in the Lake Tahoe Region and will not be in conflict with the California AIS Management Plan (CAISMP), administered by the California Department and Fish and Wildlife (CDFW) or the anticipated plan from the state of Nevada.

Review of the Plan will be directed by the LTAISCC. The breadth of experience and representation on the LTAISCC allows for comprehensive guidance for subsequent Plan review.

A subcommittee has been formed to provide an annual review and determine whether a formal revision of the Plan appendices is required to meet the emerging prevention, monitoring, control, education, and research needs in the Region. In addition to the annual review, if needed, the subcommittee will revise the body of the Plan every five years.

Summarized in the Plan are the background of non-native species introductions to the Lake Tahoe Region, the pathways for existing and potential AIS introductions, the types of existing and potential AIS in the Lake Tahoe Region, and goals and objectives of the plan. Also included (as appendices) is an overview of regulations and programs, prevention plans, control and eradication plans, monitoring and response plans, finance planning including an estimate of potential economic impacts AIS on the Region, and an overview of existing and potential AIS life histories, environmental requirements, and distributions.

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1 Introduction

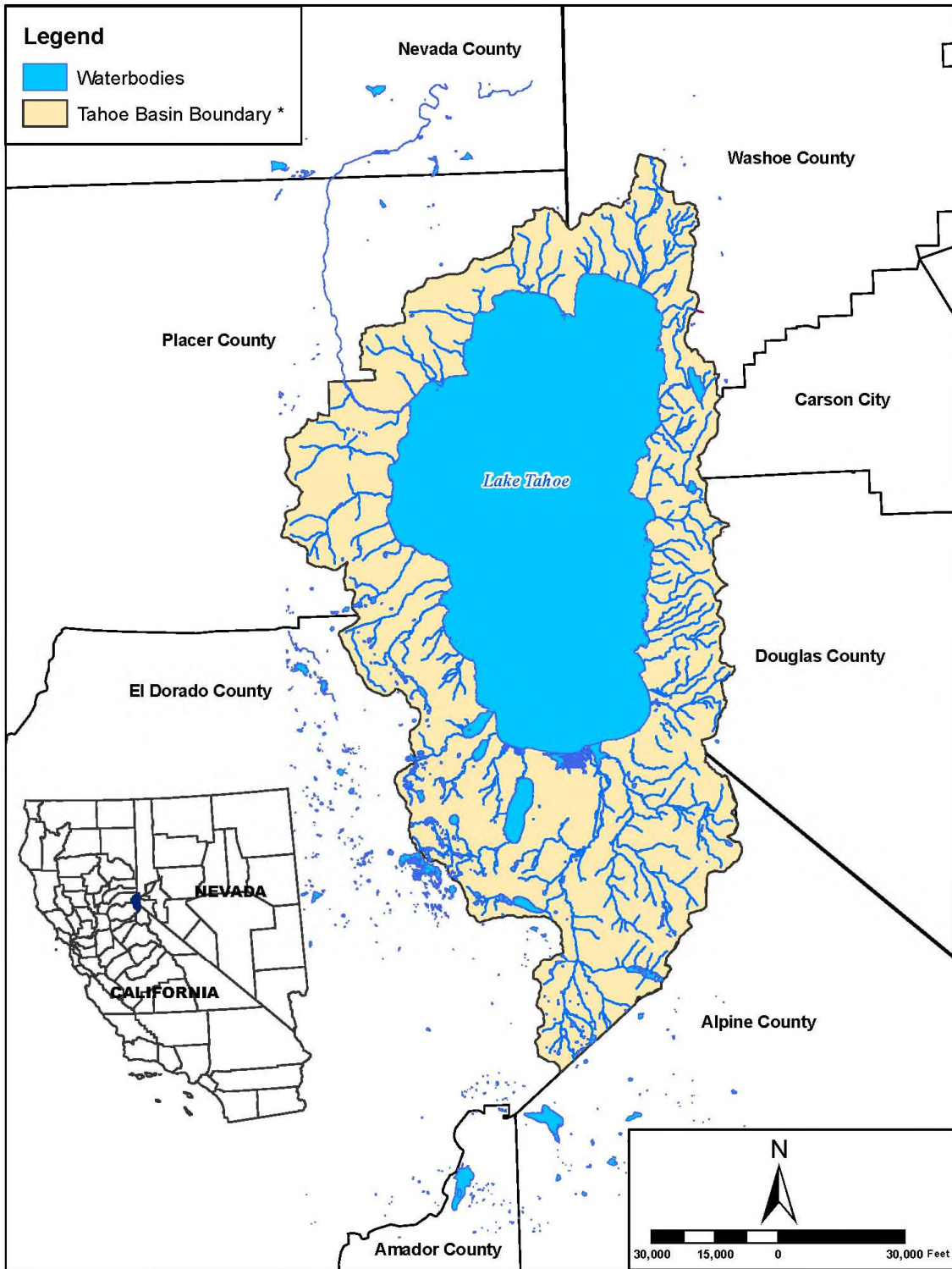
Numerous non-native species have been introduced worldwide intentionally (e.g., cultivars, pet trade, recreation, resource management) and accidentally (e.g., ballast water releases, hitchhikers, recreational pursuits). The nature of the relationship between non-native species and the local landscape is largely based on potential harmful impacts versus societal benefits. That is, society may deem the benefits of *intentional* introductions of non-native species outweigh potential or realized harmful impacts. Conversely, *accidental* introductions, or especially unauthorized intentional introductions, are generally viewed as undesirable and detrimental to the local landscape.

An invasive species is one “that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health” (NISC 2008; EO 13112). The terms ‘invasive’ and ‘nuisance’ are often interchangeable, and an aquatic nuisance species is defined as a “nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural or recreational activities dependent on such waters” (NANPCA 1990).

The purpose of the Plan is to facilitate coordination of regional, state, and federal programs and to prioritize and guide implementation of AIS prevention, monitoring, control, education, and research actions in the Lake Tahoe Region. Through region-wide stakeholder acceptance, the Plan is an attempt to coordinate and to set timelines for these actions to preserve and protect the environmental, economic, and human health in the Lake Tahoe Region. See Section 5 for Plan Goals and Objectives.

1.1 GEOGRAPHIC SCOPE: LAKE TAHOE REGION

The geographic scope of the Plan is the Lake Tahoe Region (the Region) (Figure 1). As defined by the Tahoe Regional Planning Agency (TRPA) Compact, the Region is located on the California-Nevada border and includes Lake Tahoe (and approximately 6 km of the Lower Truckee River below the lake), the adjacent parts of Douglas and Washoe Counties and Carson City in Nevada, and the adjacent parts of Placer and El Dorado Counties in California (TRPA Compact P.L 96-551). The Region drains 63 streams to Lake Tahoe with the Upper Truckee River being the largest. The lake’s only outflow, after passing the Lake Tahoe Dam, is the Lower Truckee River at Tahoe City. Beyond the Region boundaries, the Truckee River continues to flow approximately 140 miles to its terminus at Pyramid Lake (Murphy et al. 2000). In addition to Lake Tahoe, many smaller lakes and six larger recreation lakes (Fallen Leaf, Echo, and Cascade Lakes in California; Marlette, Spooner, and Incline Lakes in Nevada) are located in the Region.



Source: TRPA

Figure 1. Lake Tahoe Region

The majority of the land in the Region is owned and managed by public agencies. Approximately 80% of the public lands are managed by the U.S. Department of Agriculture - U.S. Forest Service – Lake Tahoe Basin Management Unit (USDA-USFS-LTBMU). There are nine state parks on the California side managed by California Department of Parks and Recreation (CADPR) and the Lake Tahoe Nevada State Park managed by Nevada Division of State Parks (NDSP) on the Nevada side. Also in the Region, the California Tahoe Conservancy (CTC) owns large and small land parcels and the Nevada Division of State Lands (NDSL) owns and manages approximately 500 urban parcels. Most of the private lands are commercially held with most development in the low-lying areas near the lake. The TRPA directs land use and development issues in the Region (see Appendix A for further information on agency jurisdiction).

South Lake Tahoe, the only incorporated city in the Tahoe Basin, occupies the south shore of the lake. With respect to AIS, of note is the Tahoe Keys, also on the south shore. The Keys, as it is commonly referred to, is a residential development that includes two marinas. The residential marina is in a western channel and the commercial marina is in an eastern channel, referred to as Tahoe Keys West and Tahoe Keys East, respectively. The Tahoe Keys were constructed within the Upper Truckee Marsh in the mid-1960s when water from the Upper Truckee River was channelized and diverted to prevent flooding. The result is that surface water exchange between the Tahoe Keys and the main body of Lake Tahoe is now limited to the two channels. Water in the Keys is shallow, turbid, and warm, providing habitat for numerous AIS (see Appendix B for a list of AIS of concern).

Lake Tahoe's water clarity (the depth of light penetration) is one of its most striking features. Lake Tahoe is designated an ONRW under the federal Clean Water Act (1972) as nominated by the California Regional Water Quality Control Board (CRWQCB). Likewise, Lake Tahoe is designated a "water of extraordinary ecological or aesthetic value" by the Nevada Division of Environmental Protection (NDEP). Lake Tahoe has a mean depth of 305 m (maximum 501 m), second only in the U.S. to the depth of Crater Lake (also designated an ONRW) in Oregon.

Secchi depths (a measurement of water clarity) have been regularly recorded in Lake Tahoe since 1968. Since that time, water clarity has declined up to 0.27 m year^{-1} (Jassby et al. 2003); however, progress has been made in lake clarity. Recent winter measurements have shown an improvement in water clarity (25.8 m in 2011) but declining trends continue during summer measurements (15.6 m in 2011) (TERC 2012). These declines suggest a shift in the lake's oligotrophic status (Goldman 1974, 1988). The decline in Lake Tahoe's water clarity is a result of light scatter from fine sediment particles (primarily particles less than 16 micrometers in diameter) and light absorption by phytoplankton, resulting in an increased shift in the lake's depth of maximum chlorophyll (LRWQCB and NDEP 2007). Stormwater runoff from the region's developed landscape and atmospheric deposition are the primary sources of elevated fine sediment and nutrient concentrations in the lake. The addition of nitrogen and phosphorus to Lake Tahoe contributes to phytoplankton growth. Fine sediment particles are the most dominant

pollutant contributing to the impairment of lake waters, accounting for an estimated two-thirds of the lake's impairment. The decline of Lake Tahoe's clarity resulted in the listing of Lake Tahoe as impaired for the transparency standard under Section 303(d) of the Clean Water Act. Lake Tahoe's 303(d) listing compelled California and Nevada to develop a Total Maximum Daily Load (TMDL) (under peer review).

Despite its relatively small watershed (812 km²), Lake Tahoe has a surface area of approximately 500 km². This low watershed-to-lake ratio (1.6:1) results in a substantial amount of precipitation falling directly on Lake Tahoe, contributing to its oligotrophic status. It is a subalpine lake (elevation 1,897 m) surrounded by mountains over 1,200 m above lake level (LRWQCB and NDEP 2007). Typical surface water temperatures range from 18 to 21°C during late summer and between 4.5 to 10°C during the winter. Evidence by Coats et al. (2006), however, strongly suggests increases in the thermal structure of Lake Tahoe, possibly facilitating further colonization and expansion of AIS (UCD 2008).

1.2 EXISTING AUTHORITIES AND PROGRAMS

Numerous federal, state, and regional regulations and programs are in place in the Region to limit the introduction and spread of AIS with no single agency or group responsible for all AIS issues. Table 2 lists the various agencies, regulations, and programs associated with AIS in the Region. As an interstate AIS management plan, management actions presented in this Plan consider the overlapping jurisdictions of the States of California and Nevada as well as the area-wide role of the TRPA. A comprehensive summary of regulations and programs currently in place can be found in Appendix A.

Federal

Federal authority to limit the interstate transport and importation to the U.S. of prohibited plant species is provided by the USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine (Plant Protection Act of 2000) and prohibited wildlife species authority is provided by the U.S. Fish and Wildlife Service (USFWS, Lacey Act) (Appendix A).

State of California

In California, the CDFW is responsible for prohibited fish and wildlife resources (CCR, Title 14) and is the lead agency for the California AIS Management Plan. The CAISMP defines invasive species as those:

“that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems,

invasive species may also negatively affect human health and/or the economy.”

The purpose of the CAISMP is “to coordinate state programs, create a statewide decision-making structure and provide a shared baseline of data and agreed-upon actions so that state agencies may work together more efficiently.” The CAISMP addresses numerous AIS presently established in or threatening introduction to aquatic ecosystems throughout the state. Waterbody types addressed include creeks, wetlands, rivers, bays, and coastal water habitats (CDFG 2008). The CAISMP describes vectors of concern on a statewide scale including: commercial shipping and fishing, recreational equipment and activities, trade in live organisms (e.g., aquarium trade), construction in aquatic environments, and water delivery and diversion systems (CDFG 2008).

California Fish and Game Code §2301 allows designated staff (and other authorized state authorities including CADPR peace officers and California Department of Food and Agriculture [CDFA]) to inspect, impound, or quarantine any conveyance (e.g., watercraft) that may carry dreissenid mussels (i.e., quagga and zebra mussels [*Dreissena bugensis* and *D. polymorpha*, respectively]). CDFA is the lead agency for regulatory activities associated with noxious weeds (CAC Title 3, Sec. 3400). Also in California, the Lahontan Region Water Quality Control Board (LRWQCB) is responsible for region-wide water quality objectives as outlined in the *Water Quality Control Plan for the Lahontan Region North and South Basins* (commonly referred to as the Basin Plan; CRWQCB 2005). With respect to managing AIS, the Basin Plan contains a prohibition on pesticides in waters. However, this prohibition provides exemption criteria so that project proponents may seek exemption from the prohibition and request that the LRWQCB grant permission for regulated use of aquatic pesticides. This amendment is currently awaiting approval by the Environmental Protection Agency (EPA; see Appendix A).

State of Nevada

In Nevada, the Nevada Department of Agriculture (NDA) is the lead agency for regulatory activities associated with noxious weeds and the Nevada Department of Wildlife (NDOW) is the lead agency for regulatory activities associated with prohibited wildlife. The state of Nevada defines and AIS as (NRS 503.597):

(a) “Aquatic invasive species” means an aquatic species which is exotic or not native to this State and which the Commission has determined to be detrimental to aquatic life, water resources or infrastructure for providing water in this State.

(b) “Injurious aquatic species” means an aquatic species which the Commission has determined to be a threat to sensitive, threatened or endangered aquatic species or game fish or to the habitat of sensitive, threatened or endangered aquatic species or game fish by any means, including, without limitation:

- (1) Predation;*
- (2) Parasitism;*
- (3) Interbreeding; or*
- (4) The transmission of disease.*

Under NRS Title 14 Chapter 171.123, any peace officer (e.g., NDOW Game Warden, county sheriff deputy, city police agencies) may detain a person who has committed, is committing, or is about to commit a crime (e.g., possession of state-listed prohibited wildlife [NAC 503.110] or plant [NAC 555.010] species). Additionally, NDOW Game Wardens (or other Nevada peace officers), as deputies of the USFWS have the authority to uphold provisions of the Lacey Act (Appendix A). Nevada is currently without a comprehensive AIS management plan and instead must rely on the disparate efforts of regional, state, and federal agencies. The state has, however, completed draft guidance to prevent and monitor for AIS, particularly quagga mussel. Nevada has a statewide AIS Coordinator and that position is involved with AIS efforts at Lake Tahoe.

The Nevada Legislature passed a law in 2011 that required all watercraft to have an AIS vessel decal. Revenue from the AIS decal program will fund the AIS Coordinator position and other state-wide efforts.

The Nevada Board of Wildlife Commissioners has set policy that clearly supports programs that would limit the introduction and impacts of undesirable aquatic species (P-33 Fisheries Management Program). The U.S. Department of Interior – Bureau of Land Management (USDOI-BLM) Nevada State Office maintains a website for its Invasive Species Initiative for reporting invasive species, but it is not specific to aquatic organisms. Likewise, efforts of the Nevada Invasive Species Council are not focused on aquatic invasive species. Quagga mussels have been found in Nevada lakes (e.g., Lake Mead) that are also popular destinations for Lake Tahoe visitors (Wittmann 2008). In 2012, quagga mussels were detected in Rye Patch and Lahontan Reservoirs. Since the initial discovery, continuing surveys have not shown additional detections. Presently, mandatory boat inspection and decontamination for boats leaving those waterbodies is in place and funded through 2014.

Tahoe Basin Region

Region-wide efforts include the designation of TRPA as an area-wide planning agency under Section 208 of the federal Clean Water Act to maintain water quality measures specified in the *Water Quality Management Plan for the Lake Tahoe Basin (208 Plan)* by limiting the impacts of tourism, ranching, logging, and development on the Lake Tahoe environment and enforcing environmental thresholds. TRPA and its Governing Board have taken an aggressive and proactive role in preventing the introduction of new AIS to Lake Tahoe. TRPA has the authority to inspect all boats entering Lake Tahoe for AIS or issue penalties starting at \$5,000 (TRPA Code of Ordinances Chapter 63.4.2). CADPR peace officers (or other state agencies with CDFW Director approval) have the authority to enforce California Fish and Game Code §2301 (related to dreissenid mussel inspections). As of November 1, 2008, all boat launches (public and private) without a trained inspector are closed (TRPA Code of Ordinances, Chapter 63.4.2.E).

TRPA defines an invasive species as:

“both aquatic and terrestrial, that establish and reproduce rapidly outside of their native range and may threaten the diversity or

abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat. Through their impacts on natural ecosystems, agricultural and other developed lands, water delivery and flood protection systems, invasive species may also negatively affect human health and/or the economy (TRPA Code of Ordinances, Chapter 90.2)."

Under the TRPA Compact, TRPA has the regulatory authority to set environmental quality standards that protect waters of the Region, as defined by the Compact (see section 1.1). This includes the authority to create and enforce rules that help prevent the spread and introduction of AIS in the Lake Tahoe Region. As a result of TRPA's regulatory authority in the Region, the management implications due to any differences from State laws or definitions are minimal.

Table 2. Federal, State, and Regional Agencies, Regulations and Programs in the Lake Tahoe Region and Associated AIS Activities

	Control	Coordination	Environmental Documentation	Education/ Outreach	Eradication	Exportation	Financial Assistance	Importation	Possession	Prevention	Quarantine	Research	Technical Assistance
Federal													
Endangered Species Act of 1973	x				x								
Executive Order 13057		x											
Executive Order 13112		x		x			x			x			x
Lacey Act of 1990 (amended 1998)								x	x				
Nonindigenous Aquatic Nuisance Prevention and Control Act (1990) and National Invasive Species Act (1996)	x	x		x			x			x		x	x
National Environmental Policy Act of 1970			x										
U.S. Army Corps of Engineers		x					x					x	x
U.S. Department of Agriculture	x	x		x	x		x			x		x	x
U.S. Department of Interior	x	x		x	x		x			x		x	x
State and Regional													
California Department of Parks and Recreation	x	x		x	x					x	x	x	x
California Department of Food and Agriculture	x	x	x	x	x	x		x	x	x			x
California Department of Fish and Wildlife	x	x		x	x	x		x	x	x	x	x	x
California Environmental Quality Act	x		x		x					x			
California State Lands Commission	x	x					x						
California Tahoe Conservancy				x			x			x			
Environmental Improvement Program		x					x					x	

Table 1. cont.

	Control	Coordination	Documentation	Education/ outreach	Eradication	Exportation	Financial Assistance	Importation	Possession	Prevention	Quarantine	Research	Technical Assistance
State and Regional cont.													
Lahontan Regional Water Quality Control Board	x	x		x			x			x			
Lake Tahoe Aquatic Invasive Species Coordination Committee	x	x	x	x	x					x		x	x
League to Save Lake Tahoe				x			x			x			
Nevada Department of Wildlife	x			x	x	x		x	x	x	x		x
Nevada Division of State Lands		x					x						
Nevada Division of State Parks		x		x						x			
Tahoe Area Sierra Club Group				x						x			
Tahoe Science Advisory Group		x											
Tahoe Keys Property Owners Association	x												
Tahoe Resource Conservation District	x	x		x	x		x			x			x
Tahoe Regional Planning Agency	x	x	x	x	x		x	x	x	x		x	x
Tahoe Science Consortium		x		x								x	x
University of California, Davis - Tahoe Environmental Research Center	x			x	x					x		x	x
University of Nevada, Reno	x				x					x		x	x

1.3 GAPS AND CHALLENGES

Aquatic Herbicides

The unique ecological and political landscape of the Lake Tahoe Region presents some policy challenges that could limit the ability of resource managers to achieve management goals. For example, the NDEP allows for the application of EPA-approved aquatic herbicides for the control of nuisance aquatic plants. On the California side of Lake Tahoe, however, the LRWQCB's region-wide water quality objectives for pesticides, at the adoption of this Plan, essentially preclude direct discharges of pesticides such as aquatic herbicides. The LRWQCB has updated the Lahontan Basin Plan so that pesticides in water are prohibited in the Lahontan Region. However, the amendment to the Basin Plan allows for an exemption to this prohibition at the discretion of the LRWQCB, so long as certain exemption criteria are satisfactorily met. The information needs of the exemption criteria are extensive and include the need for a California Environmental Quality Act-compliant environmental analysis document. At the time of this writing, the LRWQCB and the State Water Resources Control Board have adopted the Basin Plan amendment, which is currently awaiting EPA approval.

Watercraft Inspections

With respect to the state-wide inspection of AIS vectors (e.g., motorized watercraft, kayaks, waders), it is the responsibility of each boat launch facility to provide inspectors. CDFW staff may inspect, impound, or quarantine any watercraft that may carry dreissenid mussels (Fish and Game Code §2301). NDOW may seize as evidence any watercraft or other equipment *only if* probable cause exists to believe that a state-listed prohibited species is being imported into, transported through, or possessed in Nevada (NAC 503.110). TRPA-designated inspectors inspect all motorized vessels prior to launching at public and private boat ramps and all non-motorized watercraft and seaplanes in the Tahoe Basin are subject to inspection prior to launch (Appendix D). In addition, non-motorized watercraft users of day-use recreation facilities or water access points (e.g., campgrounds and beaches) are subject to an AIS screening process where such sites are managed and staffed by special use permittees. Appendix D summarizes the USFS-LTBMU's AIS screening process for small watercraft, which is part of operating plan direction for special use permits.

CDFW operates 16 Border Protection Stations (BPSs) statewide to reduce the number of pest introductions to the state. Two BPSs are location in the vicinity of Lake Tahoe: the Meyers Border Station, located in El Dorado County on U.S. Hwy 50 south of Lake Tahoe, and the Truckee Border Station, located in Nevada County on Interstate 80, 5 miles east of Truckee, California. Both stations inspect commercial and private vehicles. Unfortunately, the stations are of limited effectiveness in preventing AIS from entering Lake Tahoe. Both stations are only structured to inspect westbound traffic and the Truckee Station is located outside of the Region. The Truckee Station is located such that it inspects westbound vessels that arrive at Lake Tahoe

by way of Hwys 89 or 237; however, many westbound vessels arrive from the east by other routes (Hwys 50, 431, and 207). The result is boaters arriving to Lake Tahoe from any direction can easily bypass both BPSs. Conversely, westbound boaters leaving Lake Tahoe via Hwy 50 are likely inspected.

1.4 PLAN OVERSIGHT

Oversight for state AIS management plans is typically led by a respective state resource agency (e.g., CDFG for the CAISMP); however, in the case of bi-state or regional plans, oversight is best suited to an organization capable of regulation across state jurisdictions. The TRPA, as created by California, Nevada, and the U.S. Congress, has such regulatory authority (P.L. 96-551, 94, Stat. 3235). TRPA has successfully demonstrated the ability to cooperatively lead and manage the \$1.1 billion Environmental Improvement Program (EIP). Therefore, the TRPA will act as the fiscal agent, or pass-through agency, for funds associated with implementing this Plan.

Efforts to improve collaboration, leverage funding, and provide peer oversight in the Region are implemented by members of the LTAISCC. The mission of the LTAISCC is to protect the Lake Tahoe Region from aquatic invasive species by education, research, prevention, early detection, rapid response, and control. The LTAISCC provides direction for implementation of the Plan, and members ensure that the activities proposed in the Plan are either consistent with current agency policy or working in-house to expand or modify policies and management strategies to implement AIS activities (Appendix D, Attachment B). The LTAISCC is composed of leaders from state and federal agencies, researchers, and other groups responsible for management, regulatory, or cultural heritage activities in the Region. TRPA and USFWS staff currently co-chair the LTAISCC.

2 AIS Management Approach

The approach to managing AIS depends on a range of factors, including the species of concern, local and regional extent of infestation, likelihood of introduction, harmful impacts, and the cost and feasibility of control/eradication. The Aquatic Nuisance Species Task Force (ANSTF) recognizes eight AIS management approaches, implemented independently or in combination:

- Control/Eradication
- Coordination
- Education
- Funding
- Monitoring
- Prevention
- Research
- Restoration

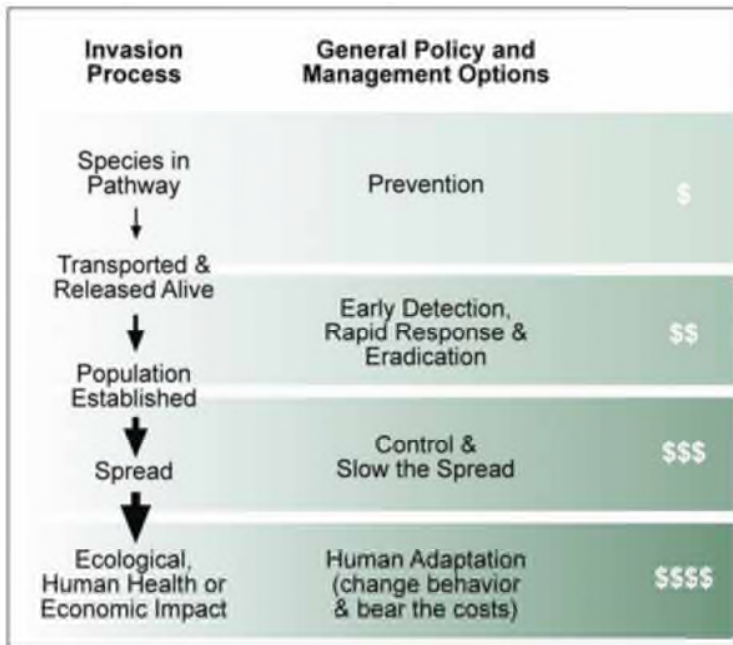
These eight AIS management approaches are organized to work in combination such that prevention, monitoring, and control/eradication each include specific education and research elements.

2.1 PREVENTION

Prevention measures are used to address AIS not yet present as well as to diminish harmful impacts by reducing further spread. Prevention measures include activities such as inspection, quarantine, and decontamination of watercraft, enforcement of legal authority, utilizing Hazard Assessment and Critical Control Points Plans (HACCP) where applicable (ANSTF 2014) and strengthening the code of conduct for businesses dealing with aquatic organisms (Lodge et al. 2006). HACCP planning provides a structured method to identify risks and focus procedures in natural resource pathway activities to avoid unintended spread of species (ANSTF 2014).

Inspection and decontamination of recreational equipment such as watercraft (including boats, rafts, kayaks, paddleboards, and float tubes), fishing gear, clothing, waders, rope, cooling tanks, and live wells prevent the spread of many AIS such as mollusks, aquatic plants, and other unwanted pests. AIS control projects develop HACCPs plans as part of the project planning process.

Preventing the introduction of AIS to new water bodies is most desirable and far more cost efficient compared to control efforts (Figure 2) (Leung et al. 2002; Lodge et al. 2006). Conversely, the likelihood of eradicating AIS is dramatically reduced once the population is established.



Source: From CDFG (2008) as adapted from Lodge et al. 2006

Figure 2. Model of Increasing Costs Based on Invasion Process and Management Response.

2.2 MONITORING

In addition to preventing the introduction of new AIS, surveying for new infestations and determining environmental thresholds improve success in control or eradication efforts. That is, early detection of new species allows for more effective rapid response outcomes such as quarantine and eradication; more information on species distribution and biology leads to improved management with reduced impacts to native species. In Lake Tahoe, biologists are monitoring the presence, movement, and spawning habits of warm water fishes to facilitate and improve control efforts and ameliorate their impacts to native species (Chandra et al. 2009); monitoring the distribution of aquatic plants every two years to determine their presence or absence and potential spread around Lake Tahoe; and conducting surveys of and research studies on Asian clam infestations to monitor the potential spread and to inform development of a lake-wide control strategy. Additional information on current early detection and monitoring efforts in the Tahoe Region is described in Appendix F.

2.3 CONTROL/ERADICATION

The identification of new infestations often sparks the most attention and commands immediate resources to control or eradicate the invaders. Control of AIS implies that populations are present and small enough to curtail further increases while eradication is defined as complete removal of the species from an area or waterbody. Factors to consider when evaluating the feasibility of control or eradication measures include:

- Size of infestation (i.e., small or new populations targeted for eradication with large infestations targeted for control)
- Demonstrated history of eradication elsewhere
- Knowledge of species life history
- Potential environmental impact
- Financial support for initial and follow-up management
- Likelihood of reintroduction
- Public comment
- Current policy restrictions

Well-coordinated efforts and the availability of approved control tools increase the likelihood of a successful eradication; however, this likelihood decreases substantially as the population spreads and becomes more abundant.

Numerous methods to manage AIS are briefly summarized in the Plan and are commonly presented as independent methods (e.g., physical removal of unwanted aquatic vegetation). Integrated Pest Management (IPM), however, combines a variety of management techniques utilizing an ecosystem-based approach in order to minimize impacts to human health, the environment, non-target species, and the economy. IPM efforts may include simultaneous management methods, monitoring, and research that in the end may result in reduced pesticide use and cost (Ehler 2006). An example of IPM might include the use of a biocontrol agent to reduce vegetation followed by mechanical or manual harvesting and a bottom/benthic barrier (described in Appendix E).

Efforts are currently underway in Lake Tahoe to control invasive aquatic plants (Eurasian watermilfoil and curlyleaf pondweed), warm water fishes, Asian clams, bullfrogs, and signal crayfish (*Pacifastacus leniusculus*). Research is being conducted to determine the most effective means of controlling each of these species. The control measures in use or being investigated are not presently aimed at eradication; however, extirpation of localized open-water AIS plant populations appears to be possible.

Limiting movement of AIS within Lake Tahoe can be addressed where possible. This may include efforts to inform boaters of the possibility of transporting aquatic invasive weeds on boat propellers or keels and preparing HACCP plans for all control efforts. When wrapped around propellers or fouled on keels, plants can be carried long distances from one part of the lake (or a marina) to other locations. When the vessel is stopped or put into reverse, plant fragments can drop off and potentially spawn a new infestation. Strategic locations for “Backup Stations” can help reduce the likelihood of such transport. HACCP plans identify and provide remedies for risks associated with various AIS control methods and projects.

2.4 EDUCATION

Education is key to any effective prevention program and is an important part of a successful control/eradication program as well. Programs to educate the public about the impacts of AIS,

methods to prevent introduction and further spread in the Region, and control efforts are actively underway by several organizations (Appendix I). Based on the USFWS's Stop Aquatic Hitchhikers! campaign, the message "Clean, Drain and Dry" is now common to visitors at Lake Tahoe. Since 2009, a Tahoe-specific campaign based on the "Clean, Drain and Dry" message has informed boaters and other sectors of the public on the need for prevention. The Tahoe Resource Conservation District (TRCD) delivers the Tahoe-specific campaign logo and slogan through flyers, regulatory boat launch signs, training materials, highway billboards, television advertisements, and brochures. Most importantly, the message is reinforced by watercraft inspectors at inspection stations and seal inspectors at boat launches (Appendix D). Other education/outreach activities that have been used in the Region have included television advertisements, newspaper articles, the Tahoe Aquatic Nuisance Species Hotline (1-888-TAHO-ANS), the USFWS hotline (877-STOP-ANS), watercraft inspection trainings, the Tahoe Keepers online training, the Eyes on the Lake volunteer monitoring program, and presentations to public interests groups (e.g., public utility districts, chambers of commerce, property owner associations).

2.5 RESEARCH

Research to enhance the understanding of AIS life histories, environmental thresholds, distributions, and interactions with native species is a critical component to the AIS management framework. Efforts to prevent, control/eradicate, and monitor AIS in the Tahoe Region all interact with the research community and utilize research in a continual improvement process. Key management questions that guide research efforts in the Region can be found in Appendix J.

2.6 CONTINUAL IMPROVEMENT

Application of these management approaches may occur singularly (e.g., control/eradication) or in combination (e.g., prevention and education). Either way, managers and researchers must continually refine their approaches, through a continual management improvement process, to improve effectiveness. That is, using an iterative process can reduce uncertainty, maximize resources, and improve the efficacy of the management approach.

Continual improvement strategies should be utilized for future Plan revisions. In particular, the effects of climate change on AIS should be considered as new information emerges from research and observations or monitoring (Bierwagen et al. 2008). Also, given the limited dollars that must be spread between all management approaches, it is important to evaluate the effectiveness of each. For example, researchers with the University of Minnesota Sea Grant Program found that reinforcing the Stop Aquatic Hitchhikers! campaign prevention message through a variety of media dramatically improved boater/angler AIS awareness in Minnesota, Wisconsin, and Iowa as did the likelihood of taking precautionary actions (D. Jensen, pers. comm., 2008). Overall, they found that information personally conveyed by watercraft inspectors at boat launches provided the most effective means of increasing AIS awareness and eliciting

changes in behavior (i.e., removing AIS from trailered watercraft). This was followed by billboards and signs targeted to non-residents in a timely manner (e.g., during holiday travel season).

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3 Problem Definition and AIS Types

Aquatic invasive species are one of the largest threats to the ecosystems and economies of the United States. Nearly half of the species on the threatened or endangered species lists are at risk primarily because of predation or competition with non-native or invasive species (Nature Conservancy 1996; Wilcove et al. 1998). In fact, impacts of invasive species are second only to habitat destruction as a cause of global biodiversity loss (Simberloff 2000). AIS such as largemouth bass, curlyleaf pondweed, and New Zealand mudsnail (*Potamopyrgus antipodarum*) may prey upon, displace, alter habitat, or otherwise harm native species. Other AIS, such as quagga mussel and Eurasian watermilfoil may reduce production of fisheries, decrease water availability to residential and commercial users, block transport routes, choke irrigation canals, foul industrial and public water supply pipelines, degrade water quality, accelerate filling of lakes and reservoirs, and decrease property values. The damages to human enterprises caused by AIS result in enormous economic costs. The United States incurs more than \$120 billion per year in damage and control costs to combat invasive species (Pimentel 2005). As the world trade network continues to grow, the number and frequency of introduced species are expected to increase. Additionally, climate change may also facilitate increased introductions.

3.1 BACKGROUND

Invasive species populations span geographic and jurisdictional boundaries, making coordination and collaboration critical to success. Efforts to prevent the continued spread and introduction of AIS are extremely varied across state, tribal, federal, and local jurisdictions. Success will be determined by consistency in coordination, cooperation, and effective programmatic outreach and concurrent management efforts. Prevention is the first line of defense. It can be the most cost-effective approach to protection against invasive species. Once a species becomes widespread, controlling the species may require significant and sustained expenditures. Therefore, public investment in prevention tools, resources, and infrastructure are indispensable in protecting human health, agriculture, and natural resources. For example, human activities such as logging, grazing, urban development, and dam construction have occurred since the mid-1850s and have resulted in profound ecological changes to the Region including loss of biological integrity, decreased water quality, and increased fire hazard (USDA 2000, LRWQCB and NDEP 2007, Chandra et al. 2009, Raumann and Cablk 2008). To address many of these concerns, numerous programs and policies are being developed or have been implemented, for example:

- Environmental Improvement Program (initiated in 1997; states of California and Nevada, the federal government, local governments, and private sector; TRPA 2014)
- *Regional Plan* (TRPA 2008)
- *Land and Resource Management Plan* (USFS)
- Draft TMDL regulations for Lake Tahoe (LRWQCB and NDEP)

- Shorezone Ordinances (TRPA)
- *Water Quality Management Plan for the Tahoe Region* (208 Plan; TRPA)

Prior to the 1800s, the trophic structure of Lake Tahoe was relatively simple and limited to one predatory fish population, the native Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*). The demise of the Lahontan cutthroat trout from the Tahoe Basin is largely attributed to predation by lake trout, or mackinaw (*Salvelinus namaycush*) (introduced to Lake Tahoe for sport fishing in 1888 [Cordone and Frantz 1966]), and by hybridization with non-native species of rainbow trout (*Oncorhynchus mykiss*). Other factors that have contributed to the decline include: overexploitation by humans, dam construction on the Truckee River, which prevented the migration of fish, and loss of spawning habitat (USFWS 1995 and summarized in Vander Zanden et al. 2003). Today, the historical trophic niche of the Lahontan cutthroat trout in Lake Tahoe is now largely occupied by lake trout (Vander Zanden et al. 2003); however, USFWS and NDOW have begun the recovery process for Lahontan cutthroat to Lake Tahoe.

The establishment of non-native lake trout and mysid shrimp (*Mysis relicta*) (intentionally introduced in 1963 for game fish forage) (Linn and Frantz 1965) also coincided with declines in native Lahontan redbreast (*Richardsonius egregius*) and speckled dace (*Rhinichthys osculus*) populations (Chandra et al. 2009) from the Tahoe Keys, an important rearing ground for native fishes (CDFG, unpublished data). Mysid shrimp have contributed to the shift in Lake Tahoe's trophic structure and composition. For example, predation by mysid shrimp has played a significant role in the loss or near elimination of three pelagic cladoceran (small crustaceans) species from Lake Tahoe with an occasional reappearance during years of increased productivity (Richards et al. 1975; Goldman et al. 1979; Byron et al. 1984). Furthermore, other fish species have shifted their feeding from benthic to pelagic fish production due to the influence of mysid shrimp (Vander Zanden et al. 2003).

More recent AIS introductions to Lake Tahoe include non-native warm water fish (largemouth bass and bluegill), aquatic plants (Eurasian watermilfoil and curlyleaf pondweed), and invertebrates (Asian clams). Many of these AIS are found within isolated areas of Lake Tahoe (e.g., marinas and embayments) and in the Tahoe Keys. In fact, the largest populations of AIS are found in or near the Tahoe Keys along the south shore; however, populations are present and rapidly expanding to other regions of Lake Tahoe. Several working groups including the Nearshore Aquatic Weed Working Group, the Asian Clam Working Group, and the Tahoe Keys Working Group with memberships from various basin agencies, researchers, and organizations are working collaboratively to monitor current populations, to identify new or expanding populations, and to control populations of AIS in the Tahoe Basin.

The January 2007 confirmation of quagga mussels in Lake Mead, Nevada marked the first population of dreissenid mussels west of the 100th Meridian and the Rocky Mountain Range. This discovery served as a wake-up call to resource managers, researchers, boaters, and marina operators about the potential for new AIS to be carried to the Region because boats are commonly transported by trailer between Lake Mead and Lake Tahoe (Wittmann 2008). This

realization also prompted resource managers to consider a number of different potentially harmful AIS when developing current and future management alternatives because boats are only one vector type and AIS transport is attributed to a diverse set of pathways and vectors.

3.2 PATHWAYS OF INTRODUCTION

Thousands of AIS have been dispersed or transplanted across the globe by humans. While AIS can be transported naturally, for example, seeds can be transported on currents and fish can move up and down streams, human activities are a common vector for transporting AIS. Much of the ongoing spread of AIS to inland waters throughout North America can be attributed to the overland movement of trailered watercraft. Thus, the potential for AIS colonization depends as much on suitable environmental conditions as the frequency the waterbody is exposed to human activities. Unwanted species hitchhike via a myriad of human-driven pathways including recreational activities, the aquarium trade, commercial shipping, intentional stocking, and resource management activities (Cooke et al. 2005; CDFG 2008). For example, these species can arrive in the ballast or on the hulls of boats, through the movement of shellfish and bait, by the opening of new channels or canals, through intentional release, and by way of fishing gear such as footwear, bait, and tackle equipment. The potential for new AIS introductions is especially worrisome as boats arrive to the Region from AIS-infected water bodies such as the Sacramento Delta, Clear Lake, Lake Havasu, Lake Mead, and the Colorado River Basin (Wittmann 2008).

Recreational Activities

Recreational activities involving watercraft (including motor boats, personal watercraft, kayaks, canoes, and float tubes) and/or fishing are the most likely vectors for the introduction of AIS to the Region (inter-Region) and among waterbodies within the Region (intra-Region). Currently, TRPA Code 63.4.2 states that “all motorized watercraft shall be inspected prior to launching into the waters of the Lake Tahoe Region to detect the presence, and prevent the introduction, of aquatic invasive species.” While the establishment of AIS is largely determined by factors such as environmental conditions, food availability, and the presence of predators, the movement of AIS between water bodies is determined by similarities in recreational pursuits, possibly even more than waterbody proximity. For example, the likelihood may be greater that New Zealand mudsnails would be introduced from one fly-fishing stream to another (from fishing gear such as float tubes and felt-soled waders) rather than a fly-angler introducing mudsnails to Lake Tahoe. Conversely, a power boat contaminated with quagga mussels would not be the most likely vector for mussels to a lake without a boat launch.

Inter-Region AIS Introductions

Most AIS exposure to Lake Tahoe is due to recreational boats that are more likely to move between waterbodies with similar recreational opportunities rather than smaller waterbodies that may be closer. During the summers of 2005 and 2006, Wittmann (2008) conducted recreational boater surveys at seven boat launches around Lake Tahoe. Boaters were asked about their boat use, visitation frequency, areas visited at Lake Tahoe, cleaning practices/habits, and AIS awareness. A visual inspection was also conducted. Of the 778 boaters surveyed, about 300 users had visited about 20 other waterbodies within a week (some of which are listed in Table 3). During the same survey, Wittmann found that 265 boats originated from waters with AIS and that three of those waterbodies contained quagga mussels (Lake Mead, Colorado River, and Lake Havasu). She also found that 117 boats that were leaving Lake Tahoe had aquatic plants (native and non-native) entrained on boating equipment when exiting the lake and that 82.1% of boaters surveyed “never” conduct as much as a visual inspection of their equipment for AIS after use.

Table 3. Inter-Region Recreational Waterbodies

Waterbody	Boat Launch	Fishing	Non-motorized	Rafting
Lake Berryessa, CA	x	x	x	
Boca Reservoir, CA	x	x	x	
Colorado River, NV	x	x	x	x
Donner Lake, CA	x	x	x	
Folsom Lake, CA	x	x	x	
Lake Havasu, AZ	x	x	x	
Lahontan Reservoir, NV	x	x	x	
Lake Mead, NV	x	x	x	
Pyramid Lake, NV	x	x	x	
Sacramento-San Joaquin Delta, CA*	x	x	x	
Lake Shasta, CA	x	x	x	
Stampede Reservoir, CA	x	x	x	
Topaz Lake, CA-NV	x	x	x	

* At least 84 non-native species are found in the freshwater portions of the San Francisco Bay and Delta ecosystem.

Source: Cohen and Carlton 1998.

Intra-Region AIS Introductions

In addition to Lake Tahoe, seven other important recreational waterbodies are located in the Region (Table 4). These waterbodies not only provide further opportunities for AIS introduction to Lake Tahoe but they risk invasion by Eurasian watermilfoil, curlyleaf pondweed, and Asian clams from Lake Tahoe.

Table 4. Intra-Region Recreational Waterbodies

Waterbody	Boat Launch	Fishing	Non-motorized	Rafting
Lake Tahoe, CA-NV	x	x	x	
Cascade Lake, CA		x	x	
Echo Lake, CA	x	x	x	
Fallen Leaf Lake, CA	x	x	x	
Lower Truckee River, CA*	x	x	x	x
Marlette Lake, NV		x	x	
Spooner Lake, NV		x	x	

*Only the first 6 km of the Lower Truckee River below the dam at Lake Tahoe is considered in the Lake Tahoe Region.

Cascade Lake lies south of Emerald Bay and has no public boat launch and much of the shoreline access is privately held. Echo Lake, southwest of South Lake Tahoe, has a public boat launch operated by Echo Lake Chalet under a USFS-LTBMU special use permit. The gated boat launch is closed when a trained inspector is not available. Game fishes present in Echo Lake include rainbow, brook, and Lahontan cutthroat trout. Fallen Leaf lake is located to the south of Lake Tahoe, southeast of Cascade Lake and Emerald Bay. Most of the shoreline at Fallen Leaf Lake is publicly held by the USFS-LTBMU. From the north shore of Fallen Leaf Lake, Taylor Creek runs directly to Lake Tahoe. Game fishes present in Fallen Leaf Lake include lake, rainbow, Lahontan cutthroat, brook and brown trout, and Kokanee. Many of the 63 streams that drain to Lake Tahoe are popular for recreational activities, including fishing and rafting. Only the upstream-most 6 km of the Lower Truckee River is in the Lake Tahoe Region; however, its popularity for rafting and fly-fishing leave it particularly vulnerable to New Zealand mudsnail introduction and establishment. Marlette Lake, located in the Lake Tahoe Nevada State Park northeast of Lake Tahoe, is closed to motorized watercraft. Game fishes in Marlette Lake include brook trout, Lahontan cutthroat trout, and rainbow trout. The lake is currently managed as a brood lake for rainbow and cutthroat trout, which provide eggs for NDOW hatcheries. Spooner Lake, south of Marlette Lake and also in the State Park, has no boat launch facilities but is open to catch and keep trout fishing with a five trout limit. Due to their limited or restricted boat access, Marlette and Spooner Lakes may be at greater risk of AIS introduction via contaminated waders and float tubes.

Aquascaping and the Aquarium Trade

The use of aquatic plants in outdoor water features is increasing in popularity. Many species associated with this industry are non-native to the U.S. and often problematic in natural environments. Increasing internet sales have facilitated the widespread distribution of many federal and state listed prohibited species (Kay and Hoyle 2001). Education and outreach efforts directed to the aquascaping and aquarium trades have increased. Programs such as the ANSTF's partnership program, Habitattitude™, and Sea Grant campaigns encourage the selection of non-

invasive or regionally native plants and the construction of water features away from natural waterways. Despite these efforts, the spread of invasive aquatic plants continues, most likely due to lack of enforcement or inadequate stewardship.

Dumping of non-native live bait is prohibited in Lake Tahoe, a measure that most likely prevents the further spread of unwanted fish species. The use of live bait in Lake Tahoe and its tributaries in Carson City and Douglas and Washoe Counties is only allowed for the following species: Lahontan redbreasted sunfish, tui chub (*Gila bicolor*), Tahoe sucker (*Catasomus tahoensis*), Lahontan mountain sucker (*Catostomus platyhynchus*), Paiute sculpin (*Cottus beldingii*), and Lahontan speckled dace (NDOW 2008). Fish used as live bait may only be taken from, and must be native to, Lake Tahoe and its tributaries.

Resource Management Activities

Many non-native species are intentionally introduced, but others are unintentionally introduced through resource management activities such as fish stocking or habitat enhancement projects. Hitchhikers in early development stages (i.e., egg, larvae, or seed) can easily be transported on equipment (e.g., water sampling devices, nets, waders, and shovels) or in water (e.g., fish enhancement projects and revegetation projects for riparian or submersed vegetation) by unknowing workers. Actions in recent years have been incorporated into project designs and land management planning documents in which treatment of equipment (see wildfire suppression section below) through such means as wash stations and use of various treatment formulas for both terrestrial and aquatic invasive species has been implemented to reduce and/or eliminate the spread of invasive species and pathogens.

Nearshore Construction Activities

Shoreline construction and maintenance activities such as the removal, replacement, or repair of docks, moorings, marinas, and other structures may result in the introduction of harmful AIS if contaminated equipment is used. Again, TRPA Code 63.4.2 requires that all motorized watercraft be inspected prior to launching into the waters of the Region. Thus, inspection and decontamination requirements are extended to construction equipment.

Wildfire Suppression Activities

Wildfires threaten not only the forest ecosystem of the Region, but homes and commercial structures. The Angora Fire, located in the southwestern portion of the Region, burned over 3,000 acres, nearly 300 homes and 67 commercial buildings in 2007. To control these fires, the USFS-LTBMU and other private and state firefighters commonly use aerial and ground-based drafting/dipping methods from nearby waterbodies. This involves the use of water conveyance equipment including: slings, buckets, suction hoses, and holding tanks to remove and transport water to fires. The USFS-LTBMU developed Resource Guidelines for Wildfire Suppression to help conserve natural resources, including reducing the likelihood of AIS transport from fire suppression activities. The AIS pertinent guidelines include:

- Decontaminate water conveyance equipment (slings, buckets, suction hoses, holding tanks) before and after use. Disinfect internal tanks by applying either a rinse of 5% solution of Quat 128 or Sparquat 256 or high pressure water applied at 140°F or hotter. Do not pump treated water into any stream or lake, or on areas where it can migrate into any waterbody.
- Remove water at least 1,000 feet from the shoreline in Lake Tahoe and 500 feet from the shoreline in Emerald Bay in order to avoid coming in contact with aquatic weeds (Eurasian watermilfoil and curlyleaf pondweed) from water withdrawal equipment (i.e., buckets and/or suction hoses).
- Only remove water out of one site once committed to a specific waterbody unless conveyance systems are decontaminated before removing water from an alternate site.

For management consistency, these AIS fire suppression guidelines are available for use by other state, county, and municipal agencies that have responsibility for wildfire suppression. The important consideration for wildfire suppression is, where possible, avoid removing water from areas with known AIS, such as Eurasian watermilfoil and curlyleaf pondweed.

3.3 AIS OF CONCERN AND TYPES

Nearly 30 known non-native aquatic species, including plants, fish, invertebrates, and an amphibian, are established in the Lake Tahoe Region (as defined by the TRPA Compact). Many of these non-native species were introduced via pathways described above. The states of California and Nevada further define the economic impacts, distribution, and level of establishment of many non-native species. Based on this and information provided by numerous researchers, resources managers, and published literature, a summary of AIS of concern to the Lake Tahoe Region was developed (Appendix B) that outlines the general biology, impacts, and control measures for AIS that are known to occur or threaten introduction to the Tahoe Region. This summary includes background information and control methods for a variety of AIS, including aquatic plants, warm water fishes, Asian clams, quagga and zebra mussels, crayfish, New Zealand mudsnail, and American bullfrog. Further, Appendix B provides details on non-native species “types” and the current management response (Table 5). Three of the six species management types include prevention as a management response. This focus on prevention is evident in the rigorous boat inspection program in place in and around Lake Tahoe.

Table 5. Non-Native Species Management Types

Species Management Type	Current Management Response
Type 1 Species not yet detected in the Lake Tahoe Region	Prevention Monitoring Education
Type 2 Species is limited in geographic extent with operational control* options available	Monitoring Control/Eradication
Type 3 Species is established in the Lake Tahoe Region with operational control* options available	Prevention Monitoring Control/Eradication Education Research
Type 4 Species is established in the Lake Tahoe Region but no operational control* options available	Monitoring Research
Type 5 Potential for invasion and establishment of the species in the Lake Tahoe Region is unknown	Prevention Research
Type 6 Legal introduction of a species (e.g., stocking by a state or federal agency for recreational purposes)	Education Research

*Operational control refers to legal and permitted control and eradication methods (e.g., hand-removal of aquatic plants, diver-assisted suction for Asian clam removal).

4 Plan Development

4.1 THE 2009 PLAN

The 2009 Plan was authorized pursuant to Section 108 of Division C of the Consolidated Appropriations Act of 2005, Public Law 108-447 and an interagency agreement between the U.S. Army Corps of Engineers and the California Tahoe Conservancy. It was prepared by Tetra Tech, Inc. staff and greatly facilitated by numerous stakeholders, researchers, and agency staff, particularly the LTAISCC and the former Lake Tahoe AIS Working Group (now several working groups that are taxa- or issue-specific).

The 2009 Plan is based on the ANSTF's *Guidance for State and Interstate Aquatic Nuisance Species Management Plans*. The Implementation Table (Appendix C) was developed by LTAISCC and Tetra Tech, Inc. staff in a daylong meeting on September 17, 2008, as a cooperative team effort. The timeline for plan development, stakeholder meetings, comments, and ANSTF presentation and approval is summarized in Figure 3.

Drafts of the 2009 Plan were submitted by Tetra Tech, Inc. to the LTAISCC on October 24, 2008, and on January 18, 2009, a second draft was submitted to the LTAISCC, the LTAISWG, and to Ronald Smith, AIS Coordinator for USFWS Region 8, for a cursory review. Comments were received from the CADPR, CDFW, California State Lands Commission, LRWQCB, NDOW, NDSL, TRCD, TRPA, Tahoe Science Consortium, University of California, Davis – Tahoe Environmental Research Center (UCD – TERC), University of Nevada, Reno, USDA-Agricultural Research Service, and the USFS – LTBMU. To facilitate Tetra Tech, Inc. in its response to comments, a LTAISCC review subcommittee was formed (identified in Appendix I) and met by conference call, email, and in person as needed. On March 24, 2009, a third draft of the 2009 Plan was posted to the TRPA website for a 30-day public comment period and simultaneously submitted to the ANSTF for a preliminary 45-day review. During the public comment period, additional comments were received by CADPR but no comments were received from the general public.

2/27/2008	Tetra Tech awarded contract for development of 2009 Plan
6/05/2008	LTAISWG meeting
9/17/2008	LTAISCC meeting
9/25/2008	LTAISWG meeting
10/24/2008	Plan to LTAISCC for review
11/21/2008	LTAISCC comments to Tetra Tech
12/03/2008	LTAISCC meeting to discuss comments
12/04/2008	LTAISWG meeting
01/18/2009	Plan to LTAISCC and ANSTF for preliminary technical review
01/15/2009	LTAISWG meeting
03/05/2009	Tetra Tech received comments from ANSTF
03/19/2009	LTAISWG meeting
03/24/2009	Begin public (30 day) and ANSTF (45 day) review
04/28/2009	Public comment period ends
05/21/2009	Plan presented to ANSTF
06/03/2009	Received comments from ANSTF
08/20/2009	Environmental Improvement Program (EIP) Summit
11/05/2009	2009 Lake Tahoe Region AIS Management Plan approved by ANSTF
01/01/2013	Tetra Tech awarded contract for revised 2014 Plan
12/18/2013	Plan to LTAISCC for preliminary review and section assignments
12/19/2013	LTAISCC meeting
07/18/2013	Plan to AISCC subcommittee for technical edits
Fall 2013	LTAISCC comments to Tetra Tech
01/07/2014	Plan to ANSTF for preliminary technical review
02/18/2014	Summary of changes to 2014 to ANSTF
04/21/2014	Received comments from ANSTF
04/30/2014	Final 2014 Plan to ANSTF
05/07/2014	2014 Lake Tahoe Region AIS Management Plan approved by ANSTF

Figure 3. Timeline for Development of the 2009 and 2014 Lake Tahoe Region AIS Management Plans

All comments and responses are presented in Appendix H and some common themes are summarized below:

- Does the geographic scope of the Plan cover the Lake Tahoe Basin or Lake Tahoe Region (as defined by TRPA Compact)?
- Clearly separate *desirable* non-native game fish from unwanted and invasive fish species. (e.g., largemouth bass).
- Define “invasive” species and distinguish invasive from non-native desirable or managed species (e.g., coldwater game fish).
- Identify species invasive to the Lake Tahoe Region, their estimated dates of introduction, and assumed pathway for introduction (i.e., develop the ranking systems).
- Rank or categorize non-native species to improve understanding of AIS issues.

- Request additional non-native species be added to Appendix B, including bullfrog (*Rana catesbeiana*), spiny waterflea (*Bythotrephes longimanus*), and smallmouth bass (*Micropterus dolomieu*).
- Explain why the life histories, invasive life strategies, and environmental requirements are identified for some species listed in Appendix B but not all.
- Suggest adding information on collaboration/coordination with the Western Regional Panel and the Quagga-Zebra Mussel Action Plan for Western U.S. Waters.

4.2 THE 2014 PLAN REVISION

The 2014 Plan revision was prepared by the LTAISCC revision subcommittee (Appendix I) in conjunction with Tetra Tech, Inc. staff.

The focus of the 2014 Plan revision was to revise and update the content of the Plan taking into account changes in the implementation of AIS efforts in the Tahoe Region that have occurred in the previous four years, and the accomplishments during that time. In addition to the content update, there was also a focus on changes that were needed to make the Plan as useful as possible to inform management, policy, and funding decisions related to AIS issues in the Region. This was accomplished by changing the format of the Plan to make the body robust enough to guide the program, while the appendices were expanded and intended to be “living” documents. With the format changes, future revisions to the body of the document will require major technical rewriting; the more frequent changes to appendices will require a simpler process of minor technical revisions.

As in the development of the original 2009 Plan, comments on revisions to the 2014 Plan are found in Appendix H. In general, comments addressed the following:

- Editorial comments and formatting to improve readability;
- Additions to the Literature Cited;
- Clarification of TRPA’s authority to create and enforce rules that help prevent the spread and introduction of AIS in the Region versus the authorities granted to the states of California and Nevada; and
- Clarified definitions for “invasive”, “nuisance”, and “aquatic invasive/nuisance species”.

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5 Management Plan Goals and Objectives

The goals of the Lake Tahoe AIS Management Plan are to:

- Prevent new introductions of AIS to the Region.
- Limit the spread of existing AIS populations in the Region by employing strategies that minimize threats to native species, and extirpate existing AIS populations when possible.
- Abate harmful ecological, economic, social, and public health impacts resulting from AIS.

These goals will be accomplished by continuing and revising education and prevention measures including but not limited to staffed boat inspections at launches, billboards, signage, and television commercials. These education and prevention measures must be adaptable and proactive to meet emerging issues. In addition, adoption of early detection monitoring protocols is paramount to this effort and the ability to rapidly respond is also needed. Control and eradication efforts must also continue to prevent in-lake spread of existing populations. The LTAISCC identified four objectives detailed below and summarized in Table 6. Lake Tahoe Region AIS Management Plan Objectives to meet the Plan's goals to limit AIS introductions, spread, and reduce their impacts. The strategies and actions used to meet these objectives, including the Implementation Table, are found in Appendix C.

5.1 OBJECTIVE A: OVERSIGHT AND INTERNAL COORDINATION

As an interstate management plan, strong oversight and coordination are necessary to ensure Plan objectives and action items continue to meet the goals of the Plan within the existing regulatory framework of both states and the Region. This requires identifying lead organizations to support Plan development, oversight, coordination, implementation, and adaptive review.

5.2 OBJECTIVE B: PREVENTION

Preventing the introduction of AIS to the Lake Tahoe Region (inter-Region) and further spread of existing AIS within the Lake Tahoe Region (intra-Region) requires adequate inspection and decontamination procedures coupled with effective and consistent education and outreach. Additionally, targeting prevention efforts to high risk introductory pathways will maximize limited resources.

5.3 OBJECTIVE C: MONITORING, DETECTION, AND RESPONSE

Following prevention, early detection, containment, and control/eradication of new AIS introductions are the second most cost-effective measures to reduce the impacts from AIS. This is accomplished through rigorous monitoring followed by the ability to respond efficiently and

aggressively. Response is facilitated by a collaborative effort between numerous agencies, non-governmental organizations, researchers, and other stakeholders.

5.4 OBJECTIVE D: LONG-TERM CONTROL

Control of AIS implies that populations are present and small enough to curtail further increases while eradication means complete removal of all life stages of a species (see Section 2 AIS Management Approach). Often the methods to control AIS are the same as those to eradicate it; however, the methods are applied differently or used in a fully-integrated eradication regime. That is, the intensity of management may vary greatly from control to eradication. Methods to control or eradicate may overlap between groups of AIS while other methods are specific to a particular AIS.

Controlling intra-lake spread of AIS can be accomplished by educating boaters of the possibility of transporting AIS from an infested location to other areas of the lake. Outreach and education of techniques to minimize this risk as well as specific locations for safe prop reversing can be provided.

Table 6. Lake Tahoe Region AIS Management Plan Objectives

Objective	Title	Description
A	Oversight and Internal Coordination	Continue plan oversight and coordination within the Region, and coordinate with other AIS plans and programs outside of the Region.
B	Prevention	Prevent the spread of existing AIS and the introduction of new AIS to the Tahoe Region
C	Monitoring, Detection, and Response	Develop and maintain programs that: <ul style="list-style-type: none"> • Ensure the early detection of new AIS introductions • Monitor existing AIS populations • Establish and manage systems to rapidly respond to new AIS introductions
D	Long-Term Control	Establish and maintain funding sources to support activities that minimize impacts of AIS to native species and protect water quality and environmental health

6 Plan Review

Review of the Plan will be directed by the LTAISCC. The breadth of experience and representation on the LTAISCC allows for comprehensive guidance for subsequent Plan review. A subcommittee has been formed to provide an annual review and determine whether a formal revision of the Plan appendices is required to meet the emerging prevention, monitoring, control, education, and research needs in the Region. In addition to the annual review, if needed, the subcommittee will revise the body of the Plan every five years. All revisions to the body and appendices of the Plan will follow the ANSTF's *Guidance for State and Interstate Aquatic Nuisance Species Management Plans* such that changes to the appendices would require minor technical revisions, while changes to the body of the Plan would follow the process for major technical revisions. Examples of minor technical revisions include: 1) typographical, grammatical, formatting/layout corrections, 2) updating or correcting scientific names, contact information, species distribution or abundance, regulatory amendments, glossary terms, and 3) minor changes to the Implementation Table in Appendix C (new actions, but not the addition of new objectives or strategies). Examples of major technical revisions include: 1) new information on species, impacts, laws, management techniques, integrated pest management strategies, new stakeholder partners, 2) previously identified problems and concerns that were not addressed in the original plan, and 3) new or revised objectives and strategies (not actions).

Considerations for annual reviews and revision should address:

- The effectiveness of prevention efforts, the efficacy of control methods
- The effectiveness of outreach associated with prevention and control.
- The number of new species introductions
- Allocation and availability of funds consistent with the objectives of the Plan
- New vector pathways
- Species list, management types, presence/absence, pathways of introduction, and applicable pest ratings
- Gaps and challenges in regional, state, and federal regulations related to AIS introduction, spread, and control
- Early detection and rapid response protocols
- Adaptive management approaches and their use during Plan revision
- Known or potential effects from climate change on AIS.

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