

# Chapter 5: River Values and Their Management

## Mandate to Protect and Enhance River Values

The Tuolumne River was added to the national wild and scenic rivers system based on three categories of values: (1) its free-flowing condition, (2) its water quality, and (3) its outstandingly remarkable values. Collectively and hereafter, these are referred to as *river values*. Section 10(a) of the Wild and Scenic Rivers Act (WSRA) provides the following broad direction related to river management:

*Each component of the national wild and scenic rivers system shall be administered in such manner as to protect and enhance the values which caused it to be included in said system without, insofar as is consistent therewith, limiting other uses that do not substantially interfere with public use and enjoyment of these values. In such administration primary emphasis shall be given to protecting its aesthetic, scenic, historic, archaeologic, and scientific features. Management plans for any such component may establish varying degrees of intensity for its protection and development, based on the special attributes of the area.*

Under the *Tuolumne River Plan*, protection and enhancement of river values will be achieved by (1) identifying and defining the river values; (2) establishing the baseline conditions of river values; (3) identifying management concerns about each river value; (4) listing the actions the National Park Service (NPS) will take to correct these concerns; and (5) establishing measurable indicators and standards, including the management standard for each river value, and a monitoring program to ensure that these values are fully protected and enhanced over time.

After presenting a brief overview of river values and introducing the concepts of *management standard*, *adverse impact*, and *degradation*, this chapter will present detailed discussions of the river's condition, management concerns, actions for addressing management concerns, and continuing monitoring and protective action for each river value. The actions presented in this chapter to ensure protection of river values are common to all alternatives. A range of further actions for enhancing the conditions of river values are presented in the alternatives in "Chapter 7: Alternatives for River Management."

## Overview of River Values

### Free-Flowing Condition

As discussed in "Chapter 1: The Tuolumne Wild and Scenic River," a river must be in a free-flowing state to be eligible for inclusion in the national wild and scenic rivers system. Preserving the free-flowing condition of rivers is central to the purpose of WSRA. Once a river is designated, the managing agency is required to preserve it in its free-flowing condition for the benefit and enjoyment of present and future generations.

### Water Quality

Another purpose of WSRA is to protect the water quality of designated rivers. Water quality in the Tuolumne River is exceptionally high, and far superior to federal and state standards.



*The Tuolumne River winds through Tuolumne Meadows (viewed from Medlicott Dome).*

## **Outstandingly Remarkable Values**

Outstandingly remarkable values were first considered for the Tuolumne River as part of the development of the 1979 *Tuolumne Final Study*, which established the eligibility of the Tuolumne River for inclusion in the national wild and scenic rivers system. Since the completion of that study, the Interagency Wild and Scenic Rivers Coordinating Council (Interagency Council, or IWSRCC) has issued specific guidance and criteria for identifying outstandingly remarkable values (IWSRCC 1999), which can be summarized as follows:

- The value must be river-related or river-dependent. To be considered river-related or river-dependent, a value must be located in the river or on its immediate shorelands (generally within 0.25 mile on either side of the river); contribute substantially to the functioning of the river ecosystem; and/ or owe its location or existence to the presence of the river.
- The value must be rare, unique, or exemplary in a regional or national context. To be considered rare, unique, or exemplary, a value should be a conspicuous example from among a number of similar values that are themselves uncommon or extraordinary.

The Interagency Council provides additional criteria for assessing each category of outstandingly remarkable values listed in WSRA, noting that these criteria may be modified to make them more meaningful to a particular river. The Interagency Council also notes that while no specific national evaluation guidelines have been developed for the “other similar values” mentioned in WSRA, agencies may assess additional river-related values, including but not limited to hydrology, paleontology, and botany resources, consistent with the guidance provided (IWSRCC 1999).

With input from other agencies, tribes, and members of the public, the Yosemite park staff used the best available science along with their best professional judgment to articulate river-related values, with the Sierra Nevada forming the primary region of comparison. Using these criteria, 10 outstandingly remarkable values have been identified for the Tuolumne Wild and Scenic River, as presented here in brief and discussed in



more detail later in this chapter. A discussion of how descriptions of river values evolved over the planning process is documented in appendix F.



NPS PHOTO BY RANDY FONG

*Meadow and riparian vegetation in Tuolumne Meadows.*



NPS PHOTO BY KRISTINA RYLANDS

*Wetlands in Poopenaut Valley.*

## Biological Values

**In Tuolumne Meadows, Dana Meadows, and along the Lyell Fork, the Tuolumne River sustains one of the most extensive Sierra complexes of subalpine meadows and riparian habitats with relatively high biological integrity.**

**Explanation:** The unusual extent and influence of glaciations in the Tuolumne River corridor created extensive areas of low relief that alternate with steep river reaches flowing over bedrock. The long, low-gradient reaches along the Lyell Fork, the lower Dana Fork, and below their confluence through Tuolumne Meadows were conducive to the accumulation of sand, silts, and organic debris. The resulting meadow/riparian complex is the largest in Yosemite National Park and one of the most extensive in the Sierra Nevada (see figure 5-1, following this overview of river values).

**Poopenaut Valley contains a type of low-elevation riparian and wetland habitat that is rarely found in the Sierra.**

**Explanation:** Poopenaut Valley, located about 3 miles below the Hetch Hetchy Reservoir and O'Shaughnessy Dam, is one of the few undeveloped and largely undisturbed low-elevation riparian/meadow/wetland complexes in the region. Aquatic/riparian systems are the most altered and impaired habitats of the Sierra Nevada (UC Davis 1996), and loss of these habitats may be the most important cause of population decline among land bird species in western North America (DeSante and George 1994). The wet meadow habitats at Poopenaut Valley are some of the most productive in the park.

## Geologic Value

**Between Tuolumne Meadows and Pate Valley, the Tuolumne River demonstrates classic stairstep river morphology, repeatedly transitioning from calm stretches to spectacular cascades.**

**Explanation:** The Tuolumne River corridor between Tuolumne Meadows and Pate Valley represents one of the finest examples of stairstep river morphology in the Sierra Nevada. This glacially carved morphology extends over an unusually long gradient. A series of broad basins interspersed with steep dropoffs help define the river's overall character. The spectacular cascades and waterfalls within this segment include Tuolumne Fall; White Cascade; and California, LeConte, and Waterwheel Falls.



NPS PHOTO BY RANDY FONG

*Stairstep river morphology along the trail to Glen Aulin.*



NPS PHOTO BY RANDY FONG

*Waterwheel Falls.*



## Cultural Values

**The rich archeological landscape along the Tuolumne River reflects thousands of years of travel, settlement, and trade.**

**Explanation:** The nearly continuous archeological landscape along the Tuolumne River contains dense concentrations of archeological resources reflecting thousands of years of travel, settlement, and trade. The record of cultural continuity at specific locations is longest along the Dana Fork, where it extends back at least



NPS PHOTO BY KRISTINA RYLANDS

*Obsidian flake.*

6,000 years (NPS 2007d and 2007s). Some of these sites individually hold exceptional data potential, and Dana and Tuolumne Meadows have the potential to provide data about how and why prehistoric people occupied these riparian/meadow areas and the relationships between ecological and cultural change over millennia. In addition to this regionally significant scientific and interpretive value, the sites have value to American Indian tribes and groups as a connection to their history and their ancestors.

**Parsons Memorial Lodge, a national historic landmark sited near the Tuolumne River, uniquely commemorates the significance of this free-flowing segment of the river in inspiring conservation activism and protection of the natural world on a national scale.**

**Explanation:** Beginning at the end of the 19th century, the Sierra Club played a major role in instilling appreciation of and support for the preservation of wild rivers and natural areas for the benefit of all Americans. The Soda Springs area was a historic center of activity for these efforts. Parsons Memorial Lodge continues to fulfill its historic role as a meeting place where people learn, share ideas, and champion a greater understanding and appreciation of rivers and other wild places (NPS 1975a, NPS 1985g, NPS 1987b, NPS 2007u).



NPS PHOTO BY MIKE YOCHIM

*Parsons Memorial Lodge.*

## Scenic Values

**Lyell Canyon offers remarkable and varied views of lush meadows, a meandering river, a U-shaped glacially carved canyon, and surrounding peaks.**

**Explanation.** The scenery throughout Lyell Canyon includes spectacular views of a U-shaped river valley, mountain peaks, ridgelines, and the largest glacier on the western flank of the Sierra Nevada. Specific views from the bed and banks of the Lyell Fork include Mount Lyell, Lyell Glacier, Lyell Canyon, Kuna Crest, the cascades at Kuna Creek, and the meandering Lyell Fork through extensive alpine and subalpine meadows.



NPS PHOTO BY MIKE YOCHIM

*Sweeping views of Lyell Canyon and a distant Mount Lyell.*

**Dana and Tuolumne Meadows offer dramatic views of a meandering river, adjacent meadows, glacially carved domes, and the Sierra Crest.**



NPS PHOTO BY RANDY FONG

*The scenic interface of meadow, river, forest, and granite peaks in Tuolumne Meadows.*

**Explanation.** Tuolumne Meadows offers scenic views of the large, low-lying river valley, adjacent meadows, glacially carved domes, rugged mountain peaks, and expansive skies. Specific views from the bed and banks of the river include Lumbert, Pothole, and Fairview Domes; the Kuna Crest; Mounts Dana and Gibbs; Cathedral and Unicorn Peaks; Juniper Ridge; and the river meandering through subalpine meadows. Dramatic views from the Dana Fork include glacially carved mountains and ridgelines, and alpine and subalpine meadows. Specific views from the bed and banks of the Dana Fork include the Kuna Crest, Mount Dana, Mount Gibbs, and the meandering Dana Fork through Dana Meadows.

**The Grand Canyon of the Tuolumne offers views of a deep, rugged canyon with vast escarpments of granite, hanging valleys, and long cascades of falling water.**

**Explanation.** Spectacular views from the trail leading from Tuolumne Meadows to Glen Aulin and through the Grand Canyon of the Tuolumne include steep canyon walls, the untrailed Muir Gorge, hanging valleys, and cascades of falling water.





FROM THE COLLECTION OF KRISTINA RYLANDS.

*The Tioga Road provides unusual access to the High Sierra, enabling people to take part in many recreational activities, like this family camping around 1925.*



NPS PHOTO BY KRISTINA RYLANDS

*Meadow along the John Muir Trail in Lyell Canyon.*

## Recreational Values

**The Tioga Road across the Sierra provides rare and easy access to high-elevation sections of the Tuolumne River through Tuolumne and Dana Meadows.**

**Explanation.** The Tioga Road is the highest continuous paved road in California and one of just a few trans-Sierra highways. As such, it provides ready access to Tuolumne Meadows, enabling visitors to easily connect with the Tuolumne River and engage in a variety of outdoor recreational activities. Such ready access is rare in California and the primary feature of this outstandingly remarkable recreational value of the Tuolumne River.

**Wilderness travelers along the Tuolumne River engage in a variety of activities in an iconic High Sierra landscape, where opportunities for primitive and unconfined recreation, self-reliance, and solitude shape the experience.**

**Explanation.** The Tuolumne River provides outstanding opportunities for visitors to engage in a variety of river-related recreational activities in a wilderness setting characterized by dramatic natural scenery. Remote areas in the Lyell Fork and Grand Canyon of the Tuolumne enable solitude; an intimacy with the river and natural sights and sounds shape the visitor experience.

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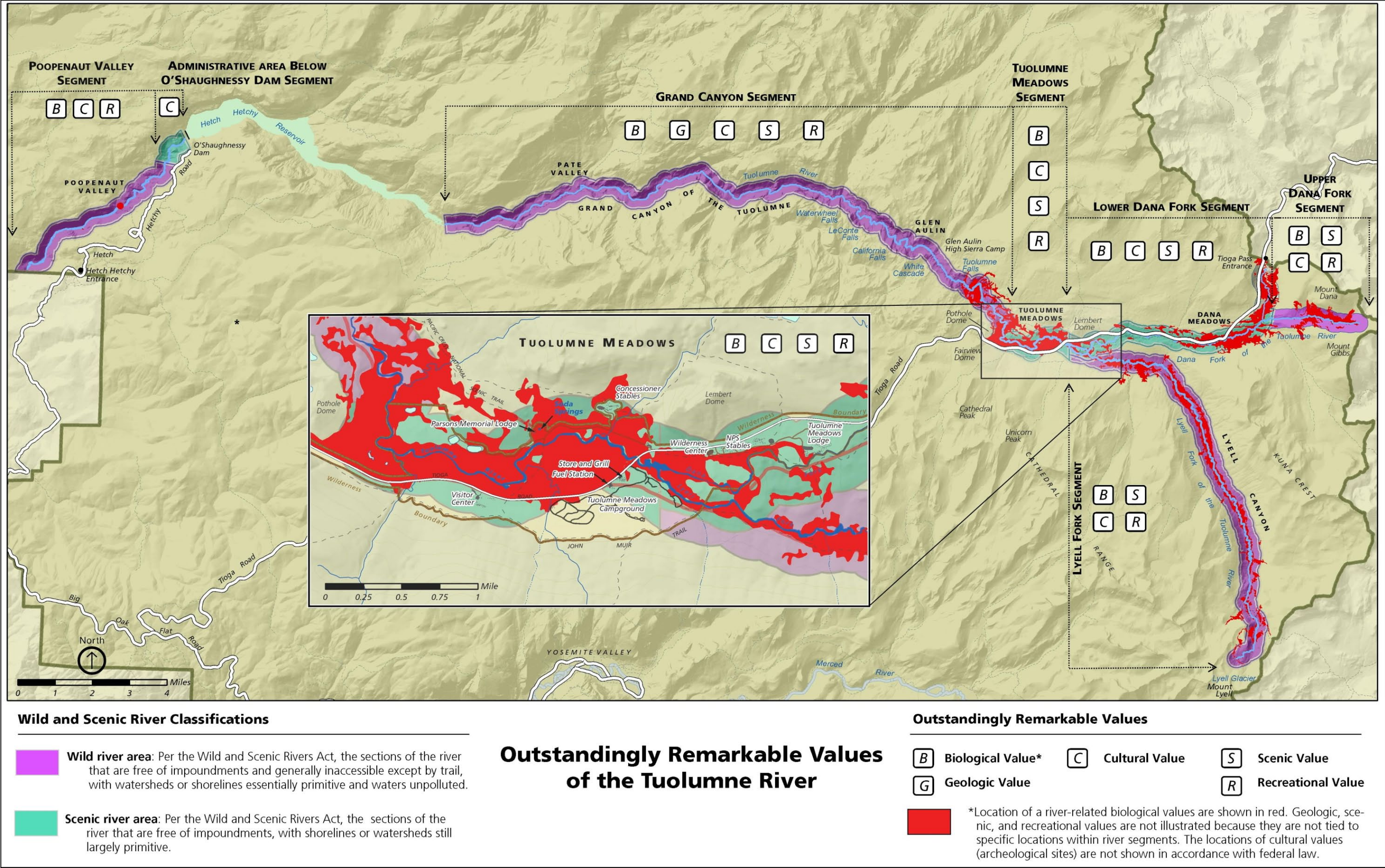


Figure 5-1. Outstandingly Remarkable Values of the Tuolumne River.



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## Concepts Applied in the Context of River Management

In 1968, Congress passed the Wild and Scenic Rivers Act to “preserve . . . selected rivers or sections thereof in their free-flowing condition[,] to protect the water quality of such rivers[,] and to fulfill other vital national conservation purposes.” Congress went on to direct that “Each component of the national wild and scenic rivers system shall be administered in such manner as to protect and enhance the values which caused it to be included in said system without, insofar as is consistent therewith, limiting other uses that do not substantially interfere with public use and enjoyment of these values.”<sup>1</sup>

In 1982, at the direction of the President, the Secretaries of Interior and Agriculture jointly promulgated regulations (hereafter referred to as the Secretaries’ Guidelines for River Areas, or the guidelines) implementing the WSRA.<sup>2</sup> The guidelines interpret the act as stating a “nondegradation and enhancement mandate for all designated river areas, regardless of classification.” Under the guidelines, rivers must be “managed to protect and enhance the values for which the river was designated, while providing for public recreation and resources uses which do not adversely impact or degrade those values.” The guidelines require agencies to address the kinds and amounts of public use that the river area can sustain without adverse impact to river values. The guidelines also place limits on major public use facilities in the river area, and require that any such developments have no adverse effect on river values.<sup>3</sup>

The U.S. Court of Appeals for the Ninth Circuit (the Ninth Circuit) has interpreted WSRA and its implementing guidelines to mean that a comprehensive river management plan must contain provisions designed to prevent any adverse impacts or degradation from occurring. Specific thresholds must be stated for mandatory management action that will occur ahead of any such impacts or degradation. In addition, a comprehensive river management must address “both past and ongoing degradation.”<sup>4</sup>

The Interagency Council was formed in 1995 to assist those federal and state agencies charged with administering designated wild and scenic rivers.<sup>5</sup> The Interagency Council’s mission is to make recommendations that will foster consistency in the interpretation and implementation of WSRA. In its technical report on managing wild and scenic rivers, the council recommends that managers should document and eliminate adverse impacts on outstandingly remarkable values, free flow, and water quality, “including activities that were occurring on the date of designation.”<sup>6</sup> According to the Interagency Council, any past degradation or adverse impacts in existence as of the date of designation should be carefully assessed, and the managing agency should establish “a positive trajectory for any value that was in a degraded condition.”<sup>7</sup>

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1 16 USC 28: 1271-1287.

2 National Wild and Scenic River System; Final Revised Guidelines for Eligibility, Classification and Management of River Areas, 47 *Federal Register* 39454 (1982).

3 Id. at 39458-9. In order to be located within the river area, major public use facilities such as visitor centers, administrative facilities, and developed campgrounds, must be (1) necessary for public use or resource protection; and (2) infeasible to move outside the river area; and (3) have no adverse effects on river values.

4 *Friends of Yosemite v. Kempthorne*, 520 F.3d 1024, 1035-36 (Ninth Circuit, 2008) [hereafter *FYVIII*].

5 See <http://rivers.gov/council.html>.

6 IWSRCC, “Wild and Scenic River Management Responsibilities,” page 26 (2002), available at <http://www.rivers.gov/publications/management.pdf>.

7 IWSRCC, “A Compendium of Questions and Answers Relating to Wild & Scenic Rivers,” page 69 (2011), available at <http://rivers.gov/publications/q-a.pdf>.

In order to assess the health of river values at the date of designation, and to ensure that no further degradation or adverse impact occurs, in 2002 the Interagency Council recommended that “the river administering agency should document baseline resource conditions and monitor changes to these conditions.”<sup>8</sup> According to the council, this baseline

*serves as the basis from which the degree/intensity of existing and future impacts can be measured. All future activities are to be measured from this baseline to ensure continued high quality conditions and to eliminate adverse impacts (protect) or improve conditions (enhance) within the river corridor. If a thorough resource assessment that includes a baseline description of the ORVs [outstandingly remarkable values] is not completed at the time of designation, this assessment should be included in the river management plan [for the Tuolumne, that assessment is included in this chapter]. The river management plan then establishes the baseline conditions at the time of designation—including a description of any degradation—and proposes management actions [presented in this chapter, along with additional actions presented in chapter 7] that will be taken to improve conditions until they meet the requirement to protect and enhance the river’s values.*

This chapter presents the following means by which the NPS will ensure future protection of river values:

- identification of river values<sup>9</sup>
- definitions of management standard, adverse impact, and degradation, as used in the assessment of conditions
- assessment of baseline conditions, both current and at the time of the 1984 designation
- identification of management concerns
- commitment to actions to correct management concerns, adverse impacts, and degradation and prevent them from recurring
- selection of one to three measurable indicators of condition for each river value, with specific metrics for the management standard, adverse impact, and degradation
- ongoing monitoring with trigger points for additional corrective actions that would be taken to protect or enhance river values over the life of the plan

By assessing baseline conditions, past adverse impacts or degradation can be identified and corrected.<sup>10</sup> In addition, any downward trends that could lead to adverse impacts or degradation can be identified and addressed at an early stage. The baseline condition assessment will guide future actions to ensure that river values are fully protected and enhanced. The monitoring program will fulfill the WSRG guideline requirement that “studies will be made during preparation of the management plan and periodically thereafter to determine the quantity and mixture of recreation and other public use which can be permitted without adverse impact on the resource values.”<sup>11</sup> The conditions assessments for each river value; the statements of management concerns; the corrective actions to be taken; the indicators; the definitions of management standards, adverse

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8 IWSRCC, “Wild and Scenic River Management Responsibilities,” page 22 (2002), available at <http://rivers.gov/publications/management.pdf>.

9 Statements of river values have been extensively reviewed and revised during the development of this *Tuolumne River Plan*. See Appendix F: Revisions to Outstandingly Remarkable Value Statements, 1984-2012,” which documents how the statements have evolved through this planning process and provides the rationale for the revisions.

10 According to the Interagency Council, adverse effects to river values “must be identified in development of the CRMP, with appropriate strategies detailed for their resolution.” IWSRCC, “Wild and Scenic River Management Responsibilities,” page 22 (2002), available at <http://rivers.gov/publications/management.pdf>.

11 National Wild and Scenic River System; Final Revised Guidelines for Eligibility, Classification and Management of River Areas, 47 *Federal Register* 39454, at 39459 (1982). In addition, by clearly stating the baseline conditions, management concerns, actions to correct those, indicators, standards, and triggers for corrective action, the plan “will state .... the specific management measures which will be used to implement the management objectives for each of the various river segments and protect aesthetic, scenic, historic, archeologic and scientific features” 47 FR 39454, at 39458 (1982).



impact, and degradation; and the triggers for future action are all based on the best professional judgment of subject matter experts. This judgment was informed by the best available science (e.g., existing scientific literature, scientific protocols for data collection and analysis, existing monitoring information, and peer review), which is cited throughout this chapter.

Before assessing the condition of each river value, it is important to set forth the definitions of management standard, management concern, adverse impact, and degradation as used in this plan.

As noted above, the definitions of protection and enhancement used in this plan are provided by the Interagency Council, which has defined protection as “elimination of adverse impacts” and has defined enhancement as “improvement in conditions.”<sup>12</sup> The definitions of adverse impact and degradation presented below have been developed within the context of this guidance and are not intended to be the same definitions of these terms that are used in the National Environmental Policy Act (NEPA) analysis presented in “Chapter 8: Affected Environment and Environmental Consequences.” The *Tuolumne River Plan* will be evaluated in terms of three legal requirements: (1) the WSRA requirement that it protect and enhance river values (addressed in volume 1); (2) the NEPA requirement that it fully consider the effects, including the intensity of beneficial and adverse impacts, on the human environment (addressed in volume 2); and (3) the National Historic Preservation Act (NHPA) requirement that it consider effects on historic properties (also addressed in volume 2). Guidelines that exist for each of these requirements describe the criteria to be used in defining terms and determining the effects of the plan. This chapter focuses directly on how the plan will meet the WSRA requirement to protect and enhance river values, and it defines terms based on the guidelines for implementing WSRA. Evaluations of whether or not a value is in a protected condition, the identification of specific management concerns, and determinations of adverse impact or degradation are described first in qualitative terms, then in terms of specific, measureable indicators and numeric standards.

## **Enhancement**

**Enhancement** is defined as actions taken to improve the condition of a river value. This definition is based upon guidance provided by the Interagency Council, which states “Enhance rivers by seeking opportunities to improve conditions.”<sup>13</sup> Such actions would improve the conditions of a river value to the point where the river value’s condition meets or exceeds the management standard (defined below). These actions would, where possible, correct past and present degradation. The state of enhancement is the best possible condition for a river value; in some cases, this state would be unattainable (perhaps due to past degradation that irreversibly alters a value’s condition); in other cases, a river value’s condition is already at the state of enhancement. In all cases, the management standard would be at the lower end of the enhanced state.

## **Management Standard**

**Management standard** is defined as the desired condition for a river value.

Under this plan, all river values will be protected and enhanced in accordance with WSRA and the Secretaries’ Guidelines for River Areas. The management standard is the desired condition of a river value attainable under current trends and influences beyond NPS control, given implementation of all the actions discussed in this chapter (which are actions common to all alternatives) and those additional actions identified in “Chapter 7: Alternatives for River Management.” For those river values that have management concerns present or are

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<sup>12</sup> IWSRCC, “Wild and Scenic River Management Responsibilities,” page 26 (2002), available at <http://rivers.gov/publications/management.pdf>.

<sup>13</sup> IWSRCC, “Wild and Scenic River Management Responsibilities,” page 26 (2002), available at <http://rivers.gov/publications/management.pdf>.

adversely affected or degraded, the management standard is an aspirational state, the condition to which park managers aspire to bring the value. If a river value is within its management standard, it is considered to be both protected and enhanced.

## **Management Concern**

**Management concern** is defined as an impact identified in the condition assessment discussions below, or in future monitoring, that may bring the condition of a value below that described by the management standard, but that does not bring it down to the adverse impact state.

Management concerns might be quite localized (such as erosion occurring in a 20-foot-long section of riverbank) or may be as large as segmentwide (such as informal trails fragmenting a meadow complex that dominates a river segment), but are correctable and do not bring the river value condition to the level of adverse impact or degradation. Another form of management concern is a downward trend in river condition that is occurring so slowly that the river condition has not yet been adversely affected but would if given adequate time and continued decline. With the *Tuolumne River Plan* being a 20–30 year plan, if a downward trend is visible for 10 years or more, the trend will be considered a management concern even if the river value condition has not yet fallen to the level of adverse impact. In such an instance, the NPS will take the actions identified for each river value (presented later in this chapter) when a management trigger occurs. A river value that has management concerns present is considered to be protected but with need for enhancement.

## **Adverse Impact**

**Adverse impact** is defined as a substantial reduction in the condition of a river value in relation to baseline conditions as a result of public use, development, and/or administrative use. An adverse impact is a segmentwide effect and requires immediate attention by the agency. It may be detected by periodic monitoring or by other means. When more than one indicator is monitored for any river value, an adverse impact associated with any one of the indicators constitutes an adverse impact on the value as a whole.

Under WSRA, the NPS must protect the river area against those impacts that “substantially interfere” with river values.<sup>14</sup> Like degradation, “adverse impact” is not defined in the act or guidelines. In this plan, the NPS has defined the term in accordance with its plain, ordinary meaning, and best professional judgment. An adverse impact is not simply a mere decline in the condition of a river value but is a substantial reduction in the condition of that value throughout a given river segment. Such an impact may be sudden and unforeseeable, or it may have been sustained over a specified period of time, as reflected through results from repeated condition assessments.<sup>15</sup> As shown in this chapter, each river value has a specific set of conditions that constitute an adverse impact to that value that has been established in reliance on the best available scientific information and expertise, and reasoned professional judgment.

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14 *Hell’s Canyon Alliance v. U.S. Forest Service (USFS)*, 227 F.3d 1170, at 1177-78 (Ninth Circuit 2000). As one court has observed, the act requires managers to exercise discretion and judgment in order to strike a balance between use and preservation. *Sierra Club v. Babbitt*, 69 F. Supp. 2d 1202, 1254 (E.D. Cal. 1999). (“If anything, the WSRA seems deliberately ambiguous as to how an agency is supposed to balance the recognized tension between use and preservation.”)

15 The requirement that in order to be an adverse impact, a decline must be substantial and sustained over time is intended to exclude limited, transitory, or natural fluctuations in condition from the definition. Many river values may experience temporary downward trends that are not indicative of any threat to the segmentwide condition of the river value as a whole. For example, a deer may drown while crossing the Tuolumne River, thereby temporarily increasing nearby coliform bacteria counts. In another example, some downward trends may be the result of natural variations in function over time. Drought years, for example, may negatively influence the diversity and productivity of grasses in Tuolumne Meadows for several years in a row. For these reasons, the trends leading to adverse impacts must be reflective of something more than inconsequential changes or short-term fluctuations. More rarely, sudden unforeseeable impacts may occur that require immediate action to mitigate. For example, a chemical or fuel spill into the meadow from a truck traveling over Tioga Road would create such an adverse impact.



## **Degradation**

**Degradation** is defined as the state in which a river value has been fundamentally altered by public use or development to the point that its value is lost for at least a decade. Degradation is a long-term, segmentwide condition. A river value has been degraded when recovery would only be possible through a sustained change in park management and a significant investment of financial and natural capital. Degradation may be detected by the baseline condition assessment, by periodic monitoring, or by other means.

The Ninth Circuit has held that under WSRA, a comprehensive management plan must “trigger management action before degradation occurs.”<sup>16</sup> Neither WSRA nor the Interagency Council guidelines interpreting the act specifically define degradation. The Ninth Circuit has held in the context of the WSRA that in the absence of guidance, such terms should be given their ordinary meaning.<sup>17</sup> This plan therefore relies on the common, ordinary meaning of the term. Merriam Webster’s *Collegiate Dictionary, Tenth Edition*, defines *degradation* as a “decline to a low, destitute, or demoralized state,” while *degrade* is defined as “to lower or impair in respect to some physical property,” or “to lower in grade, rank, or status.” Similarly, Webster’s *Third New International Dictionary Unabridged* uses both of the above definitions of degrade, as well as “to lower from a superior to an inferior level.” Thus, the common, ordinary meaning of degradation is consistent with that given above: a substantial reduction in the condition of a river value to a clearly defined, low state of functioning.

As presented in this chapter, each river value has a specific set of conditions constituting degradation. The NPS relied on the best available science and reasoned professional judgment in determining these conditions.

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<sup>16</sup> *FYVIII*, 520 *F.3d* 1024, 1034-35 (Ninth Circuit 2008).

<sup>17</sup> *Friends of Yosemite Valley v. Norton*, 348 *F.3d* 789, 796 (Ninth Circuit 2003) (citing *Hell’s Canyon Alliance v. USFS*, 227 *F.3d* 1170, at 1177 (Ninth Circuit 2000)). “Degradation” is not a term from the act, but from the Secretaries’ Guidelines for River Areas. The Supreme Court has recently reaffirmed that where an agency’s regulations construing a statute are ambiguous, the agency’s own interpretation of those terms are entitled to substantial weight. *Chase Bank USA, N.A. v. McCoy*, 131 S. Ct. 871, 880 (2011). In this case NPS has determined that the ordinary meaning of the term “degradation” is the most reasoned reading of the text of the guidelines because it will enable the agency to use the best available science to establish clear and specific thresholds for degradation of each outstandingly remarkable value, as well as a monitoring program that triggers action intended to prevent degradation prior to its incidence. See *FYVIII*, 348 *F.3d* at 1034.

## Biological Value: Subalpine Meadow and Riparian Complex

***Wild Segments: Lyell Fork, Upper Dana Fork***

***Scenic Segments: Lower Dana Fork, Tuolumne Meadows***

### **Condition Assessment**

#### **Condition at the Time of Designation**

At the time of the 1984 designation, the subalpine meadow and riparian complex in the Tuolumne River corridor was largely undeveloped and retained a relatively high level of biodiversity and productivity. The diversity of plants and animals currently present (see “Current Conditions,” below) was probably also present in 1984. Managers were generally unaware of any serious problems, and no major research or resource management initiatives were underway. However, historic activities along the river and other anthropogenic (human-induced) influences over the previous 100 years had probably disrupted biological and hydrologic processes, which were affecting meadow stability at Tuolumne Meadows, as described below. The primary sources for the following discussion are Cooper et al. 2006; NPS, Babalis et al. 2006k; and Smith 2009.

#### **Effects of Historic Sheep Grazing**

Significant and lasting vegetation changes, driven by the overgrazing of sheep, occurred in Tuolumne Meadows from the 1860s through to the early years of the 20th century (Dull 1999). The damage is cited by many sources. John Muir (1911), who first came to the Sierra Nevada as a shepherd, famously called sheep “hoofed locusts.” In the 1870s Joseph LeConte (1875) observed that “some twelve to fifteen thousand sheep are now pastured here (in Tuolumne Meadows). They are divided into flocks of about twenty-five hundred to three thousand.” Visitors to Tuolumne Meadows observed a variety of impacts resulting from overgrazing. Meadow plants were grazed to the ground or trampled, especially around bedding areas. Sheep hooves punched into the wet ground, cutting the soil and destroying the underground network of rhizomes that supports sod-forming plants. Bare earth was loosened and eroded by rain into gullies.

Long-lived clonal and densely tufted plant communities were replaced by communities dominated by annual species. Damage was especially severe along repeatedly used trails. Streambanks were denuded of protective willow and other plant cover, resulting in extensive erosion. Studies conducted in Tuolumne Meadows and other regions show that overgrazing along streams has been linked to channel downcutting or widening, which in turn leads to lowered water tables in adjacent meadows (Kaufman and Krueger 1984; Hall and Bryant 1995; Sierra Nevada Ecosystem Project 1996).

The restoration of natural hydrological conditions to Tuolumne Meadows, which is discussed in detail below, may help to protect meadows from conifer encroachment. The causes of conifer encroachment will be researched as part of the comprehensive program to restore subalpine meadow habitat. If this research indicates a need for the resumption of conifer removal, it will be incorporated into the ecological restoration program. The role of fire is managed according to the park’s Operational Fire Management Plan, which seeks to perpetuate as natural a role for fire in Yosemite wildland ecosystems as is possible. Fire management will also be informed by the research supporting ecological restoration at Tuolumne Meadows.

An 1897 National Academy of Sciences report on the impacts of grazing in the Oregon Cascades shows that, in the last years of the 19th century, the issue was receiving national attention. In 1889, John Muir and Robert Underwood Johnson, appalled by the damage done by overgrazing, lobbied for national park status for the Yosemite area. This was granted by Congress in 1890. The U.S. Army administered the park from 1891 to 1913. The army’s primary management challenge was protecting the park from illicit grazing, logging, and poaching. It took over a decade to bring these practices under control. An 1898 report from the park’s first acting

superintendent shows just how extensive grazing was in Yosemite: “From June 25 until September 1, we expelled from the park 189,550 head of sheep, 350 head of horses, 1,000 head of cattle, and captured 27 firearms” (USDI 1899: 85).

### Altered Fire Regimes and Conifer Encroachment

Natural and Native American fire regimes have been absent from Tuolumne Meadows since at least the early 1900s but may have been relatively frequent prior to the mid 1800s (Cooper et al. 2006). The relative effect of natural versus Native American fires is not well known. Fires may have historically promoted meadow stability by limiting conifer encroachment. However, it is not known if fires burned across Tuolumne Meadows or stopped at the forest-meadow margin. Periods of conifer encroachment into the meadows appear to be the result of a warmer, drier climate and lower moisture correlated with low interannual climate variability (Millar et al. 2004). Manual control of conifers in the meadows likely began with Native Americans; the practice was adopted by the Civilian Conservation Corps in the 1930s and continued until recently.

As discussed under “Actions NPS Will Take to Address Management Concerns,” below, the *Tuolumne River Plan* will address the effects of historic sheep grazing as part of a comprehensive ecological restoration program for subalpine meadow and riparian habitats (see appendix H). Two of the closely related objectives of this program are (1) to restore natural hydrologic function to the river and its floodplain and (2) to restore native riparian and meadow plant communities. The latter will include planting of riparian vegetation along riverbanks. Additional research is underway to identify feasible and appropriate techniques for restoring native meadow vegetation in areas where historic grazing has led to shifts in vegetative composition.

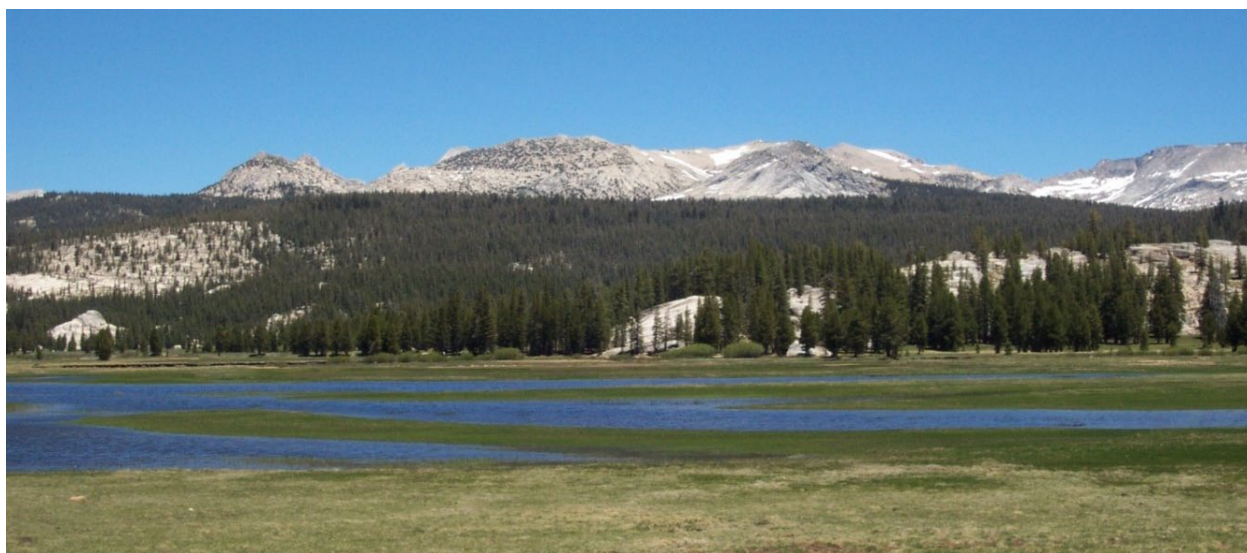
### Effects of Historic Trails, Roads, and Camping

The chronology described in this and the following paragraphs comes from the park’s historic resources study (NPS, Greene 1987a). Many of the travel routes through Tuolumne Meadows originated as Native American trails. In 1883 the Great Sierra Wagon Road was completed across the meadows to the silver mines on Mount Hoffman. This route was reopened to automobiles as the Tioga Road in 1915. The current trail system through the meadows was established between 1891 and 1913 during the period of U.S. Army administration. Portions of the Tioga Road were realigned in 1934. Some data suggest that the presence of the Great Sierra Wagon Road and Tioga Road has caused local damming of surface and subsurface flow along the roads (Cooper et al. 2006). Culverts have forced previously dispersed runoff into localized channels and resulted in downcutting and lower water tables in adjacent meadows.

The Sierra Club purchased the homestead at Soda Springs in 1912, and camping occurred there until 1974. Parsons Memorial Lodge was constructed at Soda Springs in 1915. Tuolumne Meadows Lodge was opened in 1916. Visitation flourished following the opening of the Tioga Road, and this in turn led to concerns about impacts on the meadows. Visitors drove automobiles through the meadows and camped where they liked. Soil compaction and resulting damage to park forests and meadows were documented by Meinicke in 1927, who recommended confining campers to designated sites (NPS 2006k). Rock barriers were placed and ditches dug along roads in 1927 to prevent people from driving autos onto the meadows. The NPS began restricting camping in the meadows in 1933, and the Tuolumne Meadows campground was completed in forest adjacent to the meadows in 1936.

Mitigating the effects of historic roads on meadow hydrology is a central component of the ecological restoration program for Tuolumne Meadows, as described under “Actions NPS Will Take to Address Management Concerns,” below.





NPS PHOTO BY KRISTINA RYLANDS

*Seasonal high water in the Tuolumne River, Tuolumne Meadows.*

### **Effects of Development and Management Practices in Place at the Time of Designation**

By 1984 most facilities, with the exception of roads and trails, were concentrated in upland areas around Tuolumne Meadows. Seasonal facilities (open May to October) that supported basic visitor services included a small store, a large campground, rustic tent lodging, employee tents and cabins, administrative and concessioner stables, a visitor contact station, a gas station, and water and wastewater treatment systems. The Tioga Road skirted the southern edge of Tuolumne Meadows and ran just north of Dana Meadows. Roadside ditches and culverts allowed movement of water from upland areas into the meadows. The ditches intercepted natural surface sheet flow and shallow groundwater, moving it rapidly to culverts, where the flow was passed under the road and released as channelized flow on the other side. From November to April, the roads were closed and visitor use was limited to hearty travelers who snowshoed or skied into the snow-covered meadows.

Impacts associated with foot traffic in areas of concentrated visitor use, such as Soda Springs, occurred at the time of designation, as evidenced by restoration projects conducted in the 1980s. Other historic actions that may have contributed to conditions at the time of designation in Tuolumne Meadows include adding oil to ponded areas for mosquito abatement, extensive aerial spraying of malathion/diesel mix in an effort to kill needle leaf miner, the free-form camping that allowed people to drive across the meadow to their campsites, and the installation and repair of sewer lines between the old Sierra Club campground and the current Tioga Road.

Lodgepole pine encroachment into subalpine meadows was ongoing in 1984.



NPS PHOTO BY KRISTINA RYLANDS

*Meadow and riparian vegetation along an ephemeral stream in Dana Meadows.*

## Current Condition

Since the 1984 designation, a wilderness center has been added; parking has been expanded at Dog Lake and the visitor center; the number of campsites in the campground has been reduced by about half; shower houses have been added or replaced in employee housing areas; and underground gas tanks have been removed. Facilities remain concentrated in uplands. Restoration projects to repair impacts on meadow/riparian areas have been implemented across Tioga Road from the store/grill, near the Cathedral Lakes trailhead, at Pothole Dome, at Soda Springs, at Lumbert Dome, along the trail to Glen Aulin, and along the lower Lyell Fork (NPS 2009f).

In spite of historical disruptions to biological and hydrologic processes, the meadow and riparian complex still provide habitat for a diversity of plant and animal species, including special status species such as slender lupine (*Lupinus gracilentis*), Yosemite bulrush (*Trichophorum clementis*), Yosemite toad (*Anaxyrus canorus*), and several species of bats and migratory birds (NPS, Buhler et al. 2010e). Meadow invertebrate assemblages at Tuolumne Meadows are also remarkably diverse, with relatively low dominance of any one form (Holmquist and Schmidt-Gengenbach 2003). These indicators suggest a relatively high degree of meadow and riparian health and functioning.

However, several recent studies have documented changes in meadow ecological integrity, exemplified by expanding areas of bare ground, atypical plant species, conifer encroachment, and diminished willow vegetation along riverbanks, summarized below (NPS, Buhler et al. 2010e; Cooper et al. 2006). Researchers suspect that the disruption of ecological processes resulting from historic sheep grazing, coupled with the emerging stress of global climate change and more frequent periods of low precipitation, is being exacerbated by heavy foot and stock traffic in sensitive meadow habitats, heavy browsing by deer of the few remaining willows, and a high level of ground disturbance by gophers and voles (Cooper et al. 2006; NPS, Ballenger et al. 2010j). While studies continue, currently there are no simple explanations for these findings of instability in particular meadows and riparian areas. However, the cumulative effects of these past, present, and emerging stresses have the potential to change the long-term productivity of the meadows. These management concerns are described in detail below, and are addressed by actions included in this chapter, in the alternatives in chapter 7, and in the restoration plan in appendix H.

## Management Concerns

### Meadow Fragmentation Due to Informal Trails

Areas of concentrated visitor use along the Dana and Lyell Forks and at Tuolumne Meadows are being disturbed by increasingly heavy foot traffic (NPS, Buhler et al. 2010e). These areas have been found to be highly susceptible to impacts on vegetation, soils, and soil organisms associated with foot traffic (Holmquist and Schmidt-Gengenbach 2008).

NPS monitored four areas from 2009 to 2011: (1) the main meadow at Tuolumne Meadows, (2) the small meadow near the ranger station, (3) the upper meadow in Lyell Canyon, and (4) Dana Meadows. The following maps (figures 5-2 through 5-8) and table 5-1 document locations and conditions of informal trails in Tuolumne and Dana Meadows and the upper Lyell meadows (NPS 2009k). Informal trails were classified, as illustrated on the maps, as having one of three levels of visible impact: (1) stunted vegetation (stunted by trampling), (2) some bare ground (areas of visible soil interspersed with trampled vegetation), or (3) barren (a linear path denuded of vegetation). The maps also show a 5-meter zone centered on the trails to graphically depict the associated disturbance to vegetation and soils that occurs from the presence of the trail and the use it receives.

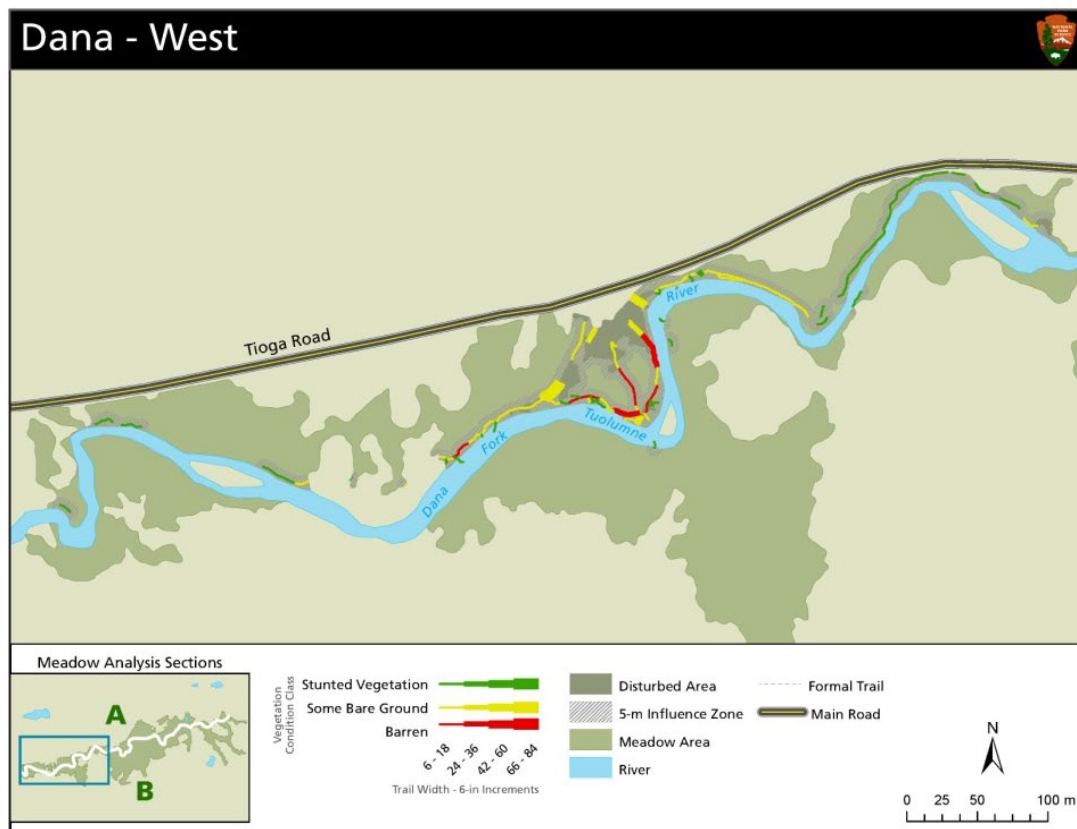


Figure 5-2. Location and Condition of Informal Trails, West Dana Fork.

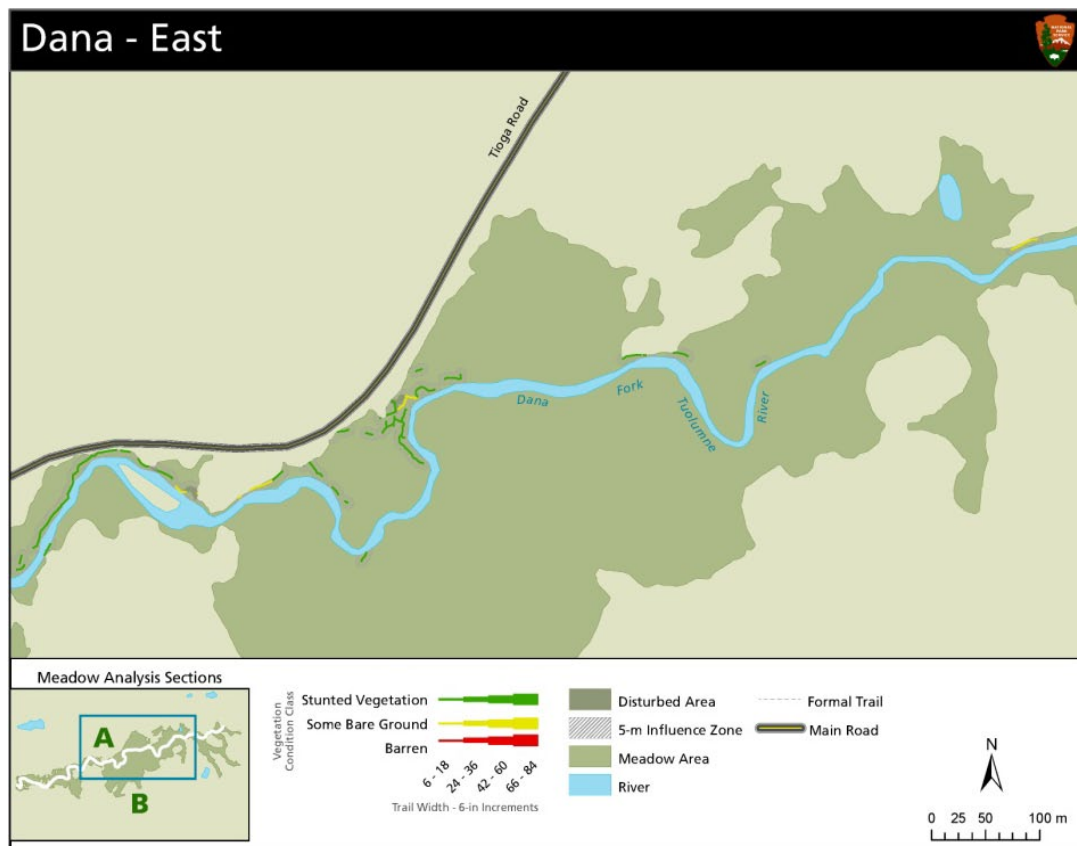


Figure 5-3. Location and Condition of Informal Trails, East Dana Fork.



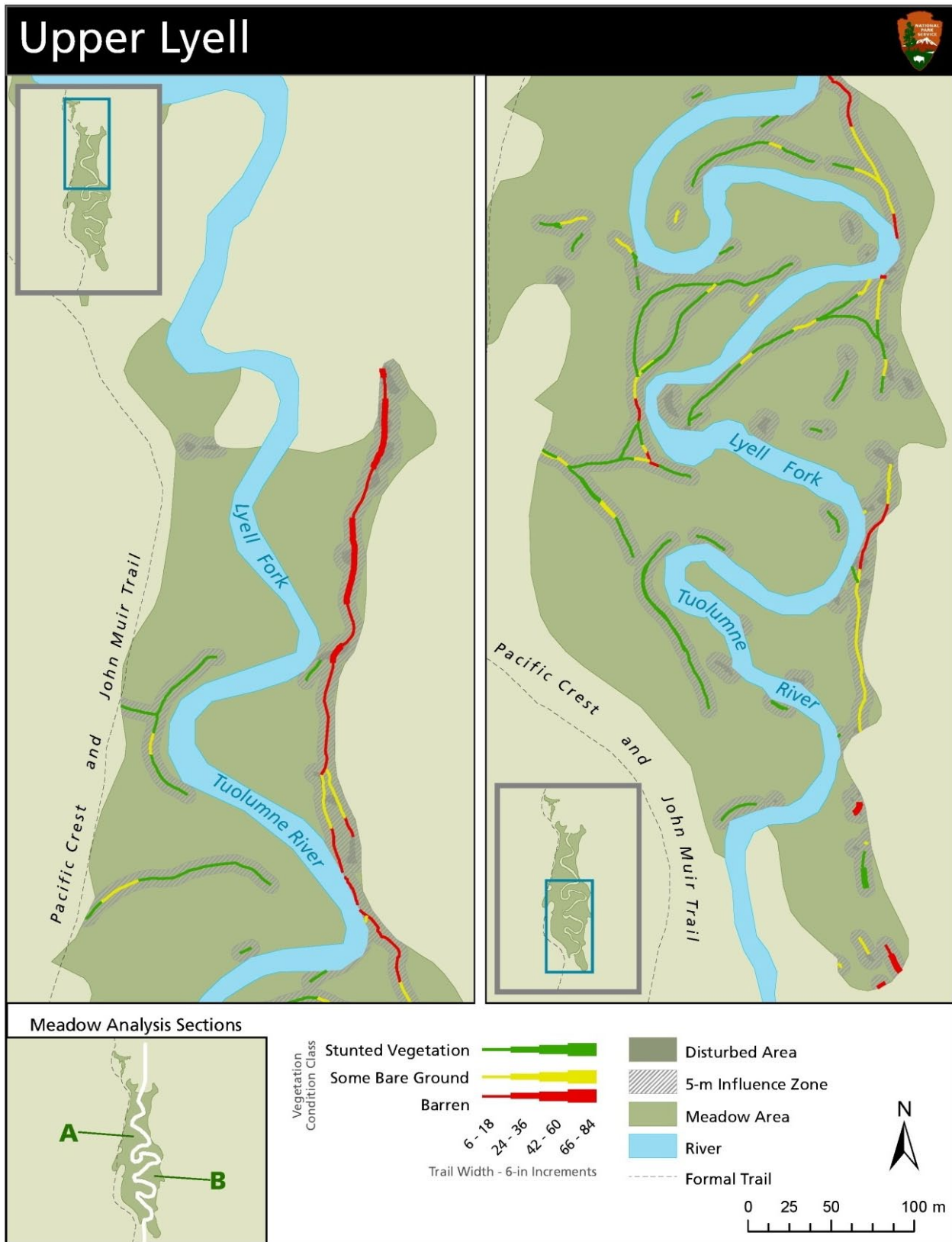


Figure 5-4. Location and Condition of Informal Trails, Upper Lyell Fork.

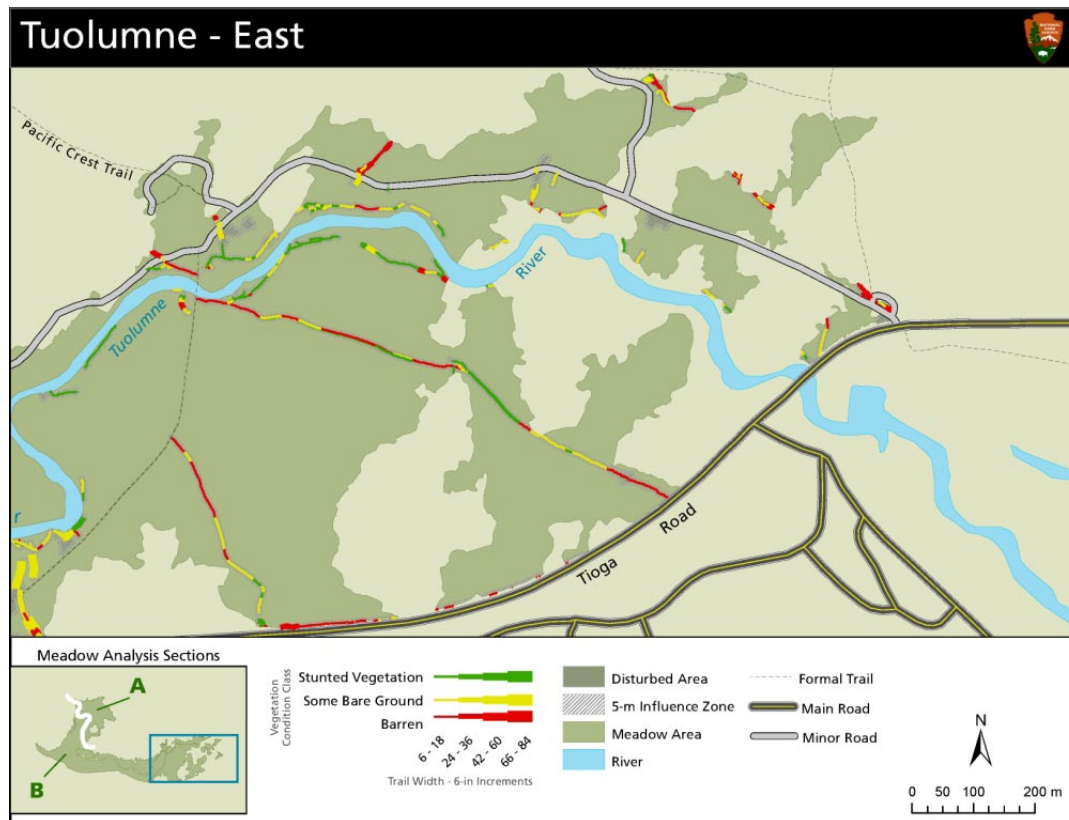


Figure 5-5. Location and Condition of Informal Trails, East Tuolumne Meadows.

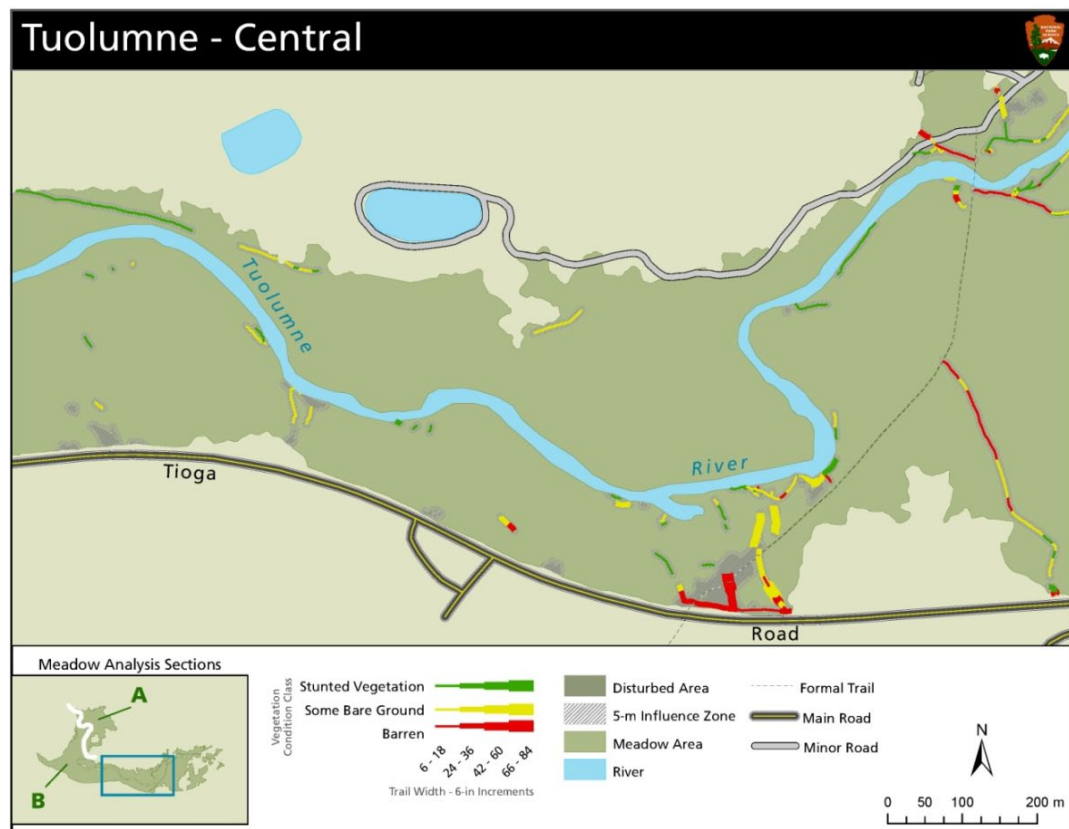


Figure 5-6. Location and Condition of Informal Trails, Central Tuolumne Meadows. The two visible ponds are the wastewater containment ponds.

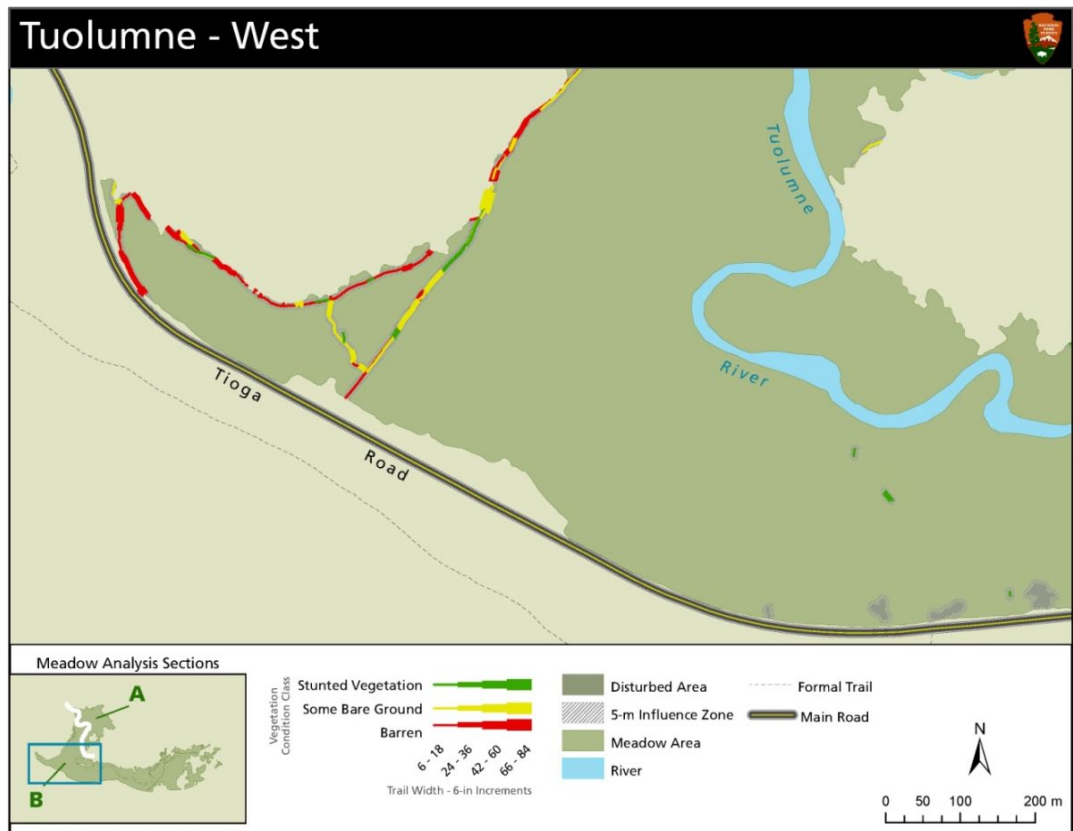


Figure 5-7. Location and Condition of Informal Trails, West Tuolumne Meadows.

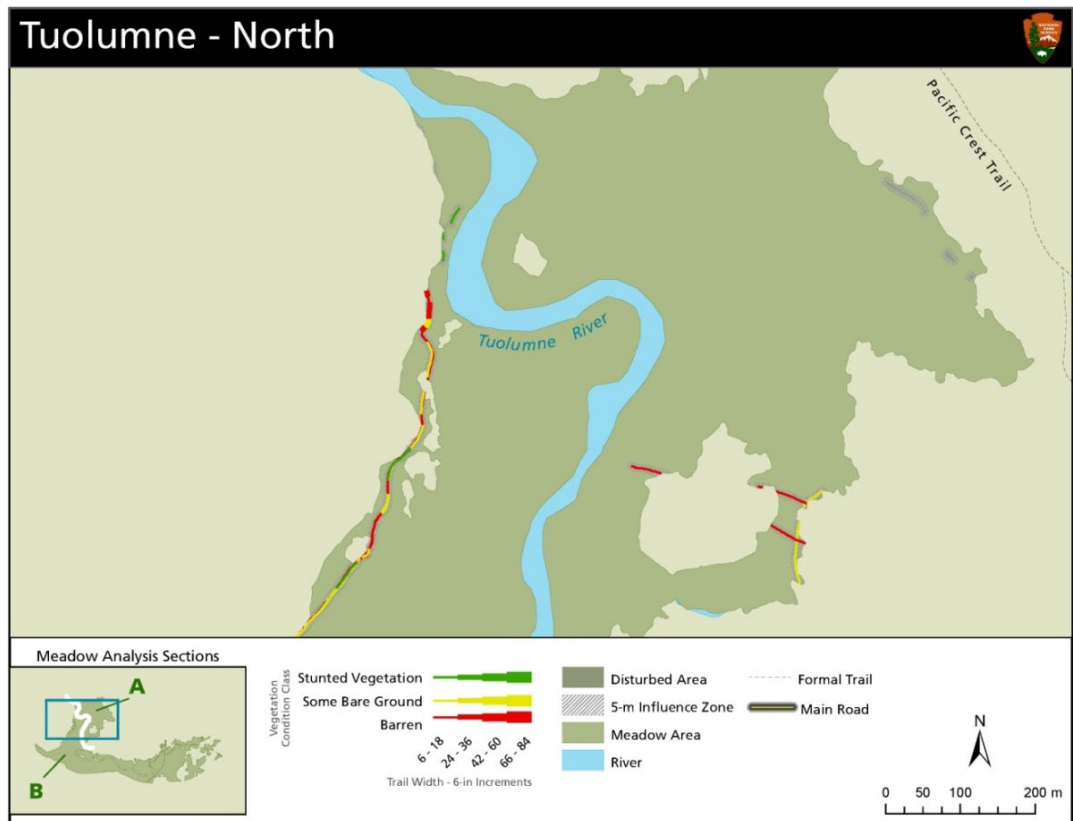


Figure 5-8. Location and Condition of Informal Trails, North Tuolumne Meadows.



## Diminished Streambank Stability and Channel Widening

Based on a preliminary condition assessment (developed by Pritchard et al. 1998) of the Tuolumne River in Tuolumne Meadows, a team of hydrologists and river managers determined that several reaches of the Tuolumne River appear to be “functioning at risk” with an undetermined trend. Cooper and others (2006) found that the banks of the Tuolumne River are eroding on outside meanders without accompanying riparian vegetation (primarily willow) recruitment on the complementary point bar, likely resulting in channel widening. Riverside willows, abundant along the river in Tuolumne Meadows in 1867 (Cooper et al. 2006), appear to have diminished greatly. As part of the assessment of historical and contemporary influences on vegetation, Cooper and others found that the decrease in willows might be associated with extensive sheep grazing during the late 1800s, exacerbated by deer heavily browsing the few remaining willows.



*An example of channel widening on an outer river bend in Tuolumne Meadows.*

The riverbanks on the Tuolumne River (particularly on the west end of Tuolumne Meadows) have little to no vegetation, particularly willows, and are characterized by extensive erosion and riverbank loss (NPS, Buhler et al. 2010e). Vegetation loss and the subsequent riverbank erosion could be exacerbated by human trampling (NPS, Buhler et al. 2010e). Certain reaches of the Tuolumne River that experience high levels of visitor use are devoid of riverbank vegetation.

Willows along the riverbank serve an important role in preventing river widening. The lack of willows on sandbars and riverbanks allows water to flow unimpeded, thus increasing the river flow velocity and altering scour and deposition relationships (NPS, Buhler et al. 2010e). Channel widening produces a shallower channel with a lower river stage for any given flow

volume and a concurrent drop of the water table associated with the river (Cooper et al. 2006, Loheide and Booth 2010). Because wet meadows form where a shallow water table during the summer fulfills the water requirements of this groundwater-dependent ecosystem (Loheide et al. 2009), a drop in the water table could adversely affect wet meadow vegetation. A wider, shallower channel also influences the magnitude and frequency of overbank flow and associated sheet flow processes (NPS, Buhler et al. 2010e).

## Changes in Meadow Hydrology at Tuolumne Meadows

Soil moisture and hydroperiod (length of time soil remains saturated) are the most important determinants of the presence and integrity of meadows (Heady and Zinke 1979, Allen-Diaz 1991). Stream channelization and straightening, drainage efforts, and culverts have lowered water tables in northern Sierra Nevada meadows, triggered a succession to xeric (drought-tolerant) plant species, and diminished ecosystem function (Loheide and Gorelick 2007).

Tioga Road runs east-west along the southern edge of Tuolumne Meadows. Direct precipitation runoff from roads and surface sheet flow from the adjacent slopes is collected in roadside ditches and then channeled through 35 culverts. Roadside ditches can act as drainage ditches by intercepting surface sheet flow and shallow soil water and moving it more quickly out of wetland systems than would normally occur (Repath 2011). Road culverts are intended to move water from one side of a road to the other; however, in 2006 Cooper and others observed that culverts were clogged with vegetation and sediment in 12 locations, and signs of ponding water south of the road were visible in 23 locations. Ponding is much more frequent near the eastern end of the



*Headcut associated with Budd Creek.*



*Partially blocked culvert.*



*Culvert set too low in meadow.*

meadow, where culverts are spaced farther apart. This is also where the campground, gas station, store, and other infrastructure, coupled with lower gradient surface slopes, further interrupt water flow.

Culverts force previously dispersed runoff into local channels, and downcutting of these channels has occurred on the downside of many culverts, particularly in the west end of the meadow. Headcuts (see Budd Creek photo above) occur when sheet flow is concentrated and channeled at higher than natural velocity, thus increasing scour and altering sedimentation dynamics. Like downcut channels, headcuts lower the adjacent water table and limit sheet flow across meadows (Cooper et al. 2006). Many Tioga Road culverts were installed lower or higher than the meadow surface, which exacerbates downcutting, headcutting, and ponding. These changes in meadow hydrology can result in changes to meadow community species composition (NPS, Buhler et al. 2010e).

The sections of the Great Sierra Wagon Road from the visitor center to Parsons Memorial Lodge (now a trail) and from Parsons Memorial Lodge to Lembert Dome (currently used by maintenance vehicles) include segments of raised roadbed edged with ditches that empty into culverts. The damming action of the roadbed, combined with headcuts, vegetation loss, and incised channels associated with the ditches and culverts, alters the natural near-surface and surface flow of water throughout the meadow (NPS, Buhler et al. 2010e).

The other stretch of the Great Sierra Wagon Road, between Tuolumne Meadows Lodge and Lembert Dome (now a trail), is deeply rutted, a situation that also affects the meadow hydrology. Its proximity to the Tioga Road and the Tuolumne River, combined with the sandy substrate, has led to deep channeling, heavy erosion, headcuts, and sediment transport into the river. Sheet flow coming off Lembert Dome is channeled through culverts and along the deeply rutted trail toward the river. This diverts water from the meadow and exacerbates erosion in the deep ruts (NPS, Buhler et al. 2010e). The lateral headcuts and informal trails leading to the main trail exacerbate and expand the channeling effects through the local terrain. Sections of the historic roadway are deep, sandy, and difficult to walk on. Visitors and pack stock walk on the edge of the trail, which leads to further vegetation loss and widening of the incised trail. If this condition was allowed to persist, continued erosion and alteration of the natural and cultural terrain would likely occur (NPS, Noon and Martin 2010d).

Enhancing river hydrology, while critical, may not be sufficient to reverse the disturbance to the meadow, as described below.

## **Bare Soil and Changes in Meadow Vegetation**

Existing studies show that Tuolumne Meadows has higher bare soil cover than would be expected for an intact wet meadow (NPS, Ballenger and Acree 2009m). The high organic content of Tuolumne Meadows soils and the currently low belowground plant production suggest that the existing vegetation could not have formed these soils (Cooper et al. 2006). Recent studies suggest several possible causes. As reported by Cooper and others (2006), historic grazing may have created an alternative stable state that would require more than just mitigating disruptions to hydrologic processes to reverse. Intense grazing and hoof punching can destroy the underground network of rhizomes that supports sod-forming plants, and their reestablishment is an extremely slow process. When a rhizomatous sod layer is broken apart, the loose, bare ground is susceptible to erosion and invasion by non-meadow plants. Shallow-rooted annuals dominate these disturbance patches, and lodgepole pine seedlings are common. The low density of belowground roots and rhizomes allows pocket gophers and voles to maintain plant communities in a perpetual state of disturbance. It also affects the water retention capacity of meadow soils, thus exacerbating the drying effects of the previously described impacts on hydrologic processes (Lowry and Loheide 2010).

Recent studies also show higher levels of bare ground in subalpine meadows with high levels of current pack stock use (such as meadows along the Lyell Fork), when compared with those with lower pack stock use (NPS, Ballenger et al. 2010j). Hoof punching was highest in meadows with more area dominated by wetland species, suggesting that meadows are receiving stock use while soils are still wet and more susceptible to impacts. Recent studies document lodgepole pine encroachment into subalpine meadows along the Lyell Fork (Cooper et al. 2006).

## **Actions NPS Will Take to Address Management Concerns**

The previous sections speak to the loss of ecological resistance of subalpine meadow ecosystems (the amount of disturbance that a system can take before key ecosystem elements change), and the capacity of these ecosystems to adapt (the ability to deal with unpredictable change). This section presents actions the NPS will take to protect and enhance the Tuolumne River's subalpine meadow and riparian system. Anthropogenic threats that can be managed by the NPS, such as residual effects of historic uses and effects of current visitor and administrative use, will be addressed. Some influences, such as global environmental change, which might result in long-term changes to the riparian and meadow system, cannot be prevented by the NPS. The meadows are being monitored for the effects of global environmental change in efforts unrelated to this plan, and management practices may be adjusted to protect and enhance river values in response to climate change.

Detailed restoration planning was originally conducted and documented in *Ecological Restoration Planning for the Tuolumne Wild and Scenic River Comprehensive Management Plan (Ecological Restoration Plan)*; NPS, Buhler et al. 2010e). Proposals from that report are summarized here, and the full report is attached as appendix H. Referenced locations are shown on the *Ecological Restoration Plan* map (figure 5-9). Unless noted otherwise, all actions discussed herein are actions common to all alternatives.



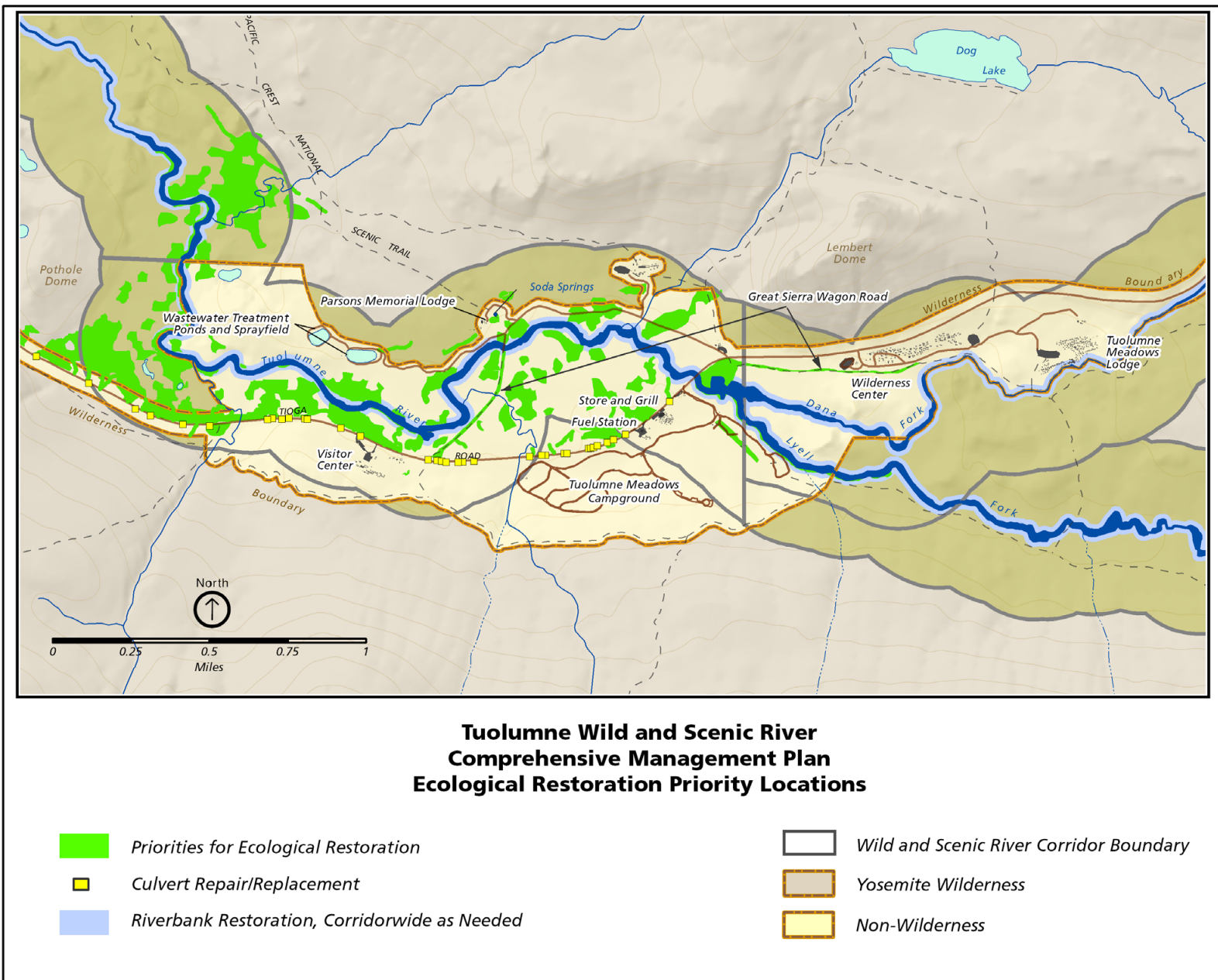


Figure 5-9. Tuolumne Meadows Ecological Restoration Priority Locations.

The *Ecological Restoration Plan* focuses on protecting or restoring primary hydrologic and biological processes. The goals and objectives of the plan are as follows:

- Protect, maintain, and restore natural hydrologic function of the Tuolumne River and tributaries.
  - Protect, maintain, and restore the hydrologic connectivity between the main river channel and the floodplain (which includes meadows, ponds, wetlands, cutoff channels, oxbows) during regular high water flows.
  - Protect, maintain, and restore naturally high groundwater levels and sheet flow processes to support biotic communities in riparian and meadow plant communities.
  - Protect, maintain, and restore the ability for the Tuolumne River channel to migrate and change course.
  - Improve and protect the ecological integrity of Soda Springs.
- Protect, maintain, and restore the function, structure, diversity and productivity of native riparian and meadow plant communities and wildlife habitat.
- Restore areas impacted by the removal or relocation of facilities to natural conditions.

The above goals and objectives will be achieved through the actions described below. The *Ecological Restoration Plan* is intended to address all the management concerns identified above (meadow fragmentation, streambank stability, changes in meadow hydrology, bare soil, and changes in vegetation). These issues cannot be addressed in isolation; management action to address one issue will often also address others.

### **Eliminate Roadside Parking and Associated Informal Trails**

Roadside parking is a major cause of informal trails across the meadow. To eliminate such informal trails, roadside parking will be eliminated along Tioga Road and the road to Tuolumne Meadows Lodge by installing curbing or naturalistic barriers and by directing visitors to formal parking areas and trailheads. The locations and sizes of the new parking areas would vary by alternative. Informal trails will be removed throughout Tuolumne Meadows. Actions to remove informal trails will include decompacting soils, recontouring unnatural landforms, and revegetation (through seeding and transplanting with native seeds/plants), all of which will contribute to the restoration of more natural conditions in the meadows. Priority areas identified for restoration are listed below:

- roadsides, particularly near the Cathedral Lakes and Parsons Memorial Lodge trailheads
- along the Dana Fork from the former Tuolumne Meadows Lodge to the campground
- along riverbanks
- at Soda Springs
- at Pothole and Lumbert Domes

### **Remove Structures Inappropriately Sited Near the Riverbank or in Wet Areas**

Abandoned utility lines will be removed, crushed, filled, or plugged to prevent their altering underground water transport. For example, old sewer lines likely exist along the Great Sierra Wagon Road between Tioga Road and Parsons Memorial Lodge. The method of pipe removal will depend on the habitat type; those in meadows may be filled with slurry, while in other areas it may be more appropriate to remove the pipe.

The following facilities that are inappropriately sited near the riverbank or in wet areas will be removed under all alternatives:

- the concessioner employee housing in a wet area behind the store and grill
- the concessioner employee tents nearest the river at the Tuolumne Meadows Lodge
- three visitor tent cabins near the river at the Tuolumne Meadows Lodge
- the A-loop campsites closest to the river

Additional facilities not in meadow and riparian areas may also be removed and restored, depending on the alternative and associated site development. They are identified in the site planning sections of each alternative in chapter 7.

The following actions will be taken to restore previously disturbed sites:

- Decompect, mulch, and revegetate impacted areas.
- Recontour unnatural landforms.
- Restore primary ecosystem processes (primarily hydrologic).
- Protect restoration areas from further impacts with fencing or appropriate deterrents.
- Remove above- and belowground infrastructure that affect hydrologic conditions (such as pipes, asphalt, and water diversion).
- Salvage any soil or vegetation impacted by removal for replanting/reuse.

### **Restore Riparian Vegetation along Riverbanks**

Channel widening is believed to be associated with loss of riparian vegetation along riverbanks. Such widening affects the hydrologic connectivity between the river and the adjacent meadow/riparian complex. It also lowers the river stage for any given flow volume, decreases the magnitude and frequency of overbank flow during flood periods, and drops the groundwater table associated with the river. The primary action to address channel widening will be the reestablishment of this riparian vegetation. The following actions are included in every alternative to restore riparian vegetation along riverbanks where vegetation loss can be attributed to past and current human activities:

- Apply brush-layering techniques (see appendix H) to stabilize riverbanks, promote sediment accretion, and minimize further riverbank loss.
- Establish willows (using hydrodrilling techniques) along riverbanks.
- Protect affected riverbanks from further trampling by temporary fencing or other deterrents so that vegetation can establish.
- Install temporary exclosures to protect willow regeneration from deer browsing.
- Decompect, seed, mulch, and plant to encourage vegetation establishment on denuded riverbanks.

### **Mitigate Effects of Tioga Road Culverts**

To enhance meadows and hydrologic function, culverts along Tioga Road will be improved to facilitate water flow to the river and adjacent meadows. Existing culverts will be repaired or replaced with larger, better-placed culverts. Additional larger culverts are needed in some locations, such as Budd Creek and Unicorn Creek, to accommodate peak spring runoff, some channel migration, and flash floods from summer thunderstorms. A section 7 determination (see appendix I) showed that this work will not unreasonably diminish river values. That determination has been guided by the process described in “Chapter 4: Section 7 Determination Process for Water Resources Projects.”

Culverts will be aligned with the surface level of the adjacent meadows to minimize downcutting, headcutting, ponding, and clogging. Tioga Road is a historic property listed on the National Register of Historic Places, and the historic culverts contributing to the eligibility of that property to the national register will require special treatment to address impacts on the cultural landscape.



When culverts are replaced and enhanced, the following actions will be taken to restore the contours adjacent to existing culverts to help reduce further impacts to natural hydrologic processes:

- Fill ditches associated with culverts with native soil.
- Apply woody debris and plant material to divert and disperse runoff, promote deposition, and limit scour.
- Recontour slope and landform to natural condition to encourage sheet flow.
- Revegetate areas downslope of culverts with native species to slow velocity of water flowing into the meadow and encourage sheet flow and sediment deposition.

## **Mitigate Effects of the Great Sierra Wagon Road**

The hydrologic effects of the section of the Great Sierra Wagon Road from Tuolumne Meadows Lodge to Lambert Dome will be mitigated through the following actions:

- Bring trail ruts up to the same elevation as the adjacent meadow (fill with native soil, rocks, and/or gravel).
- Apply woody debris, plant material, and erosion control structures, such as wattles or blankets, to divert and disperse runoff, promote deposition, and limit scour.
- Establish vegetation (seeding, planting, mulching) to slow water velocity.
- Improve culverts that convey runoff from Lambert Dome (north of the road) to reduce channeling, downcutting, and velocity, thus encouraging sheet flow.
- Stabilize existing headcuts and encourage sediment accumulation by filling and planting or by installing check-dam structures.
- Where the trail diverges from the historic road in front of the ranger station, relocate the trail at the edge of the road and restore the meadow to natural conditions.

The effects of the sections of the Great Sierra Wagon Road from Lambert Dome to Parsons Memorial Lodge and from the lodge to the visitor center will be mitigated through the following actions:

- Lower trail sections that act as dams.
- Fill ditches on either side of the trail section from Parsons Memorial Lodge to the visitor center.
- Apply woody debris, plant material, and erosion control structures, such as wattles or blankets, to divert and disperse runoff, promote deposition, and limit scour.
- Narrow the roadbed to a width that retains its historic character.
- Remove nonnative fill.
- Install additional and larger culverts to accommodate flows from Unicorn Creek.
- Install sections of boardwalk or other surface types through wet and saturated areas to maintain sheet flow and protect vegetation from trampling.

The historic character of the Great Sierra Wagon Road and the John Muir Trail (which follows the historic roadbed in this location) will be protected by the following mitigating measures:

- Maintain the current alignment and a minimum width of 10 feet in order to convey the historic use as a wagon road.
- If modifications are necessary to historic culverts and their associated headwalls, ensure that the modifications match their historic character; similarly, ensure that any new culverts match the historic character of the culverts.

## Mitigate Impacts From Stock Use in Lyell Canyon

Actions to mitigate stock-related impacts in Lyell Canyon would vary by alternative and involve either eliminating all commercial and some administrative stock use or increasing its regulation. When an alternative has been selected in a formal record of decision, it will be incorporated here as part of the final *Tuolumne River Plan*. All alternatives call for the following regulation of stock use (which at a minimum would include administrative stock use):

- Campsites and access routes will be specified. Factors such as avoidance of rare plants and other resources of special concern will be considered in designating these areas.
- Pack stock opening dates (or “range readiness” dates for mountain meadows) will be set by managers. Researchers and park staff are collecting data to develop models that predict range readiness dates for meadows frequently used by pack stock. These data will include extent of saturated soil for each meadow as well as soil drying and plant maturation rates for key meadow communities. Data from multiple years over a range of early season conditions will be correlated with snowpack and/or runoff rates to develop a model to predict meadow opening dates prior to stock use season. In areas of stock use, conditions will be monitored to provide feedback for adjusting opening dates. This information will allow managers to determine the best dates for early season stock use while protecting meadow soils and vegetation.
- A grazing capacity for meadows in the Lyell Fork has been identified based on recent meadow condition assessments and past research (Cole et al. 2004). The grazing capacity is an estimate of the grazing level that could be sustained without undesirable effects on meadow habitat (NPS, Ballenger 2010h). Meadows receiving high use will be monitored annually to ensure that the grazing capacity was protective of river values (NPS, Ballenger et al. 2010j).

Localized areas previously disturbed by stock use or other human activities in Lyell Canyon will be restored using techniques that meet the minimum-requirement criteria established under the Wilderness Act.

## Conduct Additional Research

More research is necessary to examine evidence of the historic vegetation communities in areas of concern, the most efficient and effective techniques for restoration, and the feasibility, as well as the appropriateness, of potential ecological restoration activities. Research into the composition of historic vegetation is likely to entail analyses of soil seed banks, plant macrofossils, and phytoliths (microscopic pieces of plants that are resistant to decay and can identify historic plant species). Analyses of organic matter content, soil carbon, and plant productivity may also be included. Ecological restoration techniques, if determined feasible and appropriate, would likely involve planting, seeding, and mulching, with temporary closure to foot traffic as vegetation reestablished. Research might also provide information on the relationship between past land uses, such as intensive grazing, and the rate and extent of conifer seedling establishment. All of these studies will address the potential influence of climatic conditions and consider those interactions.

Cooper and others (2006) recommended a detailed study of willows to understand the factors that limit willow establishment and persistence in the area and the relationship between willow growth and bank stability. This research was initiated in 2011 and is ongoing. Research into the effects of pocket gophers, voles, and deer on the establishment and growth of perennial plants typical of wet meadows also began in 2011. The effects of deer browsing is being studied by placing small enclosures around individual willows to protect them from grazing, then assessing any changes in willow height, productivity, and catkin/seed production. These research plots are located outside of designated wilderness.

Fire also played a role in shaping the vegetation communities and landscape of Tuolumne Meadows, but the frequency and types of ignition (lightning or anthropogenic) of fire are largely unknown. Ongoing studies of fire history in subalpine forests may shed some light on the role that fire may have played in shaping Tuolumne Meadows and point to using fire as an additional restoration tool.

## **Management Indicators and Monitoring Program**

The NPS has developed a suite of three indicators to protect and enhance the subalpine meadow and riparian complex: (1) fragmentation of meadow habitats by visitor-created informal trails; (2) physical streambank stability; and (3) the amount of bare soil in meadows. This combination of metrics represents the most efficient method available for representing the scope of this value and the complexities of the system protected. Each indicator reflects a different aspect of the meadow and riparian complex and different potential impacts on the greater biological value. All meadows within the three segments in which portions of the subalpine meadow and riparian complex occur will be evaluated every three to five years for evidence of use, and all meadows with high potential for visitor-created impacts will be monitored, also every three to five years.

The three indicators are discussed individually below.

### **Indicator #1: Meadow Fragmentation from Informal Trails**

#### **Indicator Description**

Informal trails are defined as visitor-created tracks that are noticeable to observers and generally not managed directly by park staff, as opposed to formal trails, which are mapped, periodically assessed, and maintained (Leung et al. 2002; Leung et al. 2011b). Various informal trail metrics have been commonly used as indicators of visitor-caused impacts by federal land management agencies and selected as indicators in other national parks, such as Mount Rainier and Acadia (Kim and Daigle 2011; Rochefort and Swinney 2000) because of their representation of impacts on both social and ecological conditions (Leung et al. 2011b; Monz and Leung 2006).

Informal trail management has been found to be more difficult in subalpine environments, where recovery rates are slow (Eagan et al. 2004; Kim and Daigle 2011). The NPS selected habitat fragmentation from visitor-created trails in meadows as an indicator because of its sensitivity in detecting spatial changes and thus protecting the pristine quality of large areas of intact meadow. In studies of trail impacts outside of meadow environments, researchers have identified disturbance to vegetation and soils within 1 to 3 meters of the trail's edge (Dawson et al. 1974; Dale and Weaver 1974; Leung et al. 2011c). Research within meadow environments has demonstrated that impacts from trails can extend beyond the direct impacts on trails and can have significant impacts radiating from the trail's edge into the meadow (Holmquist and Schmidt-Gengenbach 2004). The degree of fragmentation reflects the potential for impacts on meadow hydrology, habitat quality, soil moisture, and the introduction of nonnative species (Forman 1995; Leung et al. 2011c; Lindenmayer and Fischer 2006). Trail corridors have also been shown to pose barriers for small mammals and other wildlife (Knight 2000; Gaines et al. 2003). Investigations of trampling impacts in Tuolumne Meadows demonstrate that meadow condition is poorer in heavily used areas; larger areas are more prone to recovery than smaller areas; and visitor-created trampling has a significantly negative impact on vegetation and macroinvertebrate structure and diversity (Holmquist and Schmidt-Gengenbach 2004 and 2008; Leung et al. 2011a; Foin et al. 1977).

To measure meadow fragmentation, a Largest Patches Index – Five (LPI<sub>5</sub>) has been adapted from the concept of Largest Patch Index (McGarigal and Marks 1995). This index is derived from the sum of areas of the five largest patches without informal trails divided by total landscape (meadow) area and then multiplied by 100. The resulting percentage indicates the extent to which the meadow area is divided (fragmented) due to the existence of visitor-created trails. If zero trails were present, the total index value would be 100%. The main



purpose of including the largest patches as a group of five, rather than merely the single largest patch, is to reduce the index's oversensitivity to changes in one single patch. Although parks such as Mount Rainier have found variations of this metric best suited to their meadow system (Moskal and Halabisky 2010), Yosemite park staff and collaborators also considered the three largest and ten largest patches (LPI<sub>3</sub>, LPI<sub>10</sub>), ultimately determining that five best achieved a balance between simplicity and representativeness for Yosemite's meadows (Leung et al. 2011b).

## **Definitions of Management Standard, Adverse Impact, and Degradation**

### ***Management Standard***

The fragmentation management standard for the subalpine meadow complex within the Tuolumne River corridor is an LPI<sub>5</sub> (sum of the five largest intact patches as a percentage of the total meadow area) of 90%. This is interpreted to mean that the LPI<sub>5</sub> for all the selected meadows within any given segment must be greater than or equal to 90%, calculated as a weighted mean of the indexes for each of the selected individual meadows in the segment. The weighted mean value for each segment factors in the relative size of each of the selected meadows in the segment when calculating the index for the segment as a whole. As the overall size of the meadow complex is a key component of the meadow value, this ensures protection of the integrity and overall extent of individual meadows and the full meadow complex within each segment. Although the standard applies to a river segment as a whole, meadows will be monitored individually, and action will be taken if the standard is exceeded at the meadow level (see "Management Triggers and Responses," below).

The fragmentation standard adopted for the *Tuolumne River Plan* was developed using several years of data showing the recent levels of impacts at individual meadows within the main Tuolumne River corridor. Data from several meadows within Yosemite Valley in the Merced River corridor were also considered in selecting numerical standards. A group of subject matter experts determined this threshold based on data from meadows that experienced elevated visitation levels, reduced vegetation cover, and an increased occurrence of invasive species. To select an appropriate standard, all meadow values were considered, and an appropriate value selected from a range of meadow condition over several years. Managers have used best professional judgment in selecting a weighted mean to evaluate the management standard at the segment level. In making this consideration, a suite of other informal trail metrics were considered to ensure that the chosen indicator accurately reflects the degree of trampling-related impacts.

### ***Adverse Impact***

An adverse impact will occur if the weighted mean of all meadows within a given segment has dropped below an LPI<sub>5</sub> threshold of 81% for three consecutive years of annual assessments despite management actions to improve the connectivity and overall health of the meadow. Specific precipitation patterns will be evaluated to ensure that the sampling interval reflects impacts caused by visitors as opposed to other natural causes.

Patch size in some meadows has been shown to be associated with reduced total vegetation, increased bare ground cover, and an increased presence of nonnative plants (Leung et al. 2011b). The value chosen to represent adverse impacts reflects conditions found in individual meadows identified by park staff, managers, and subject matter experts as needing significant restoration actions. This value relates to low values for the main meadow in Tuolumne and meadows within Yosemite Valley, both of which have been identified for comprehensive restoration action. These meadows should demonstrate accelerated recovery rates and good response to restoration after actions are taken. A conservative number has been chosen from existing data, with 2 percentage points added for increased sensitivity to impacts (NPS 2009k).

If the LPI is between 89% and 81% for the weighted mean of all meadows within a river segment, management concerns will trigger management actions to ensure that adverse impacts are avoided (see the monitoring program for this indicator, below).

### Degradation

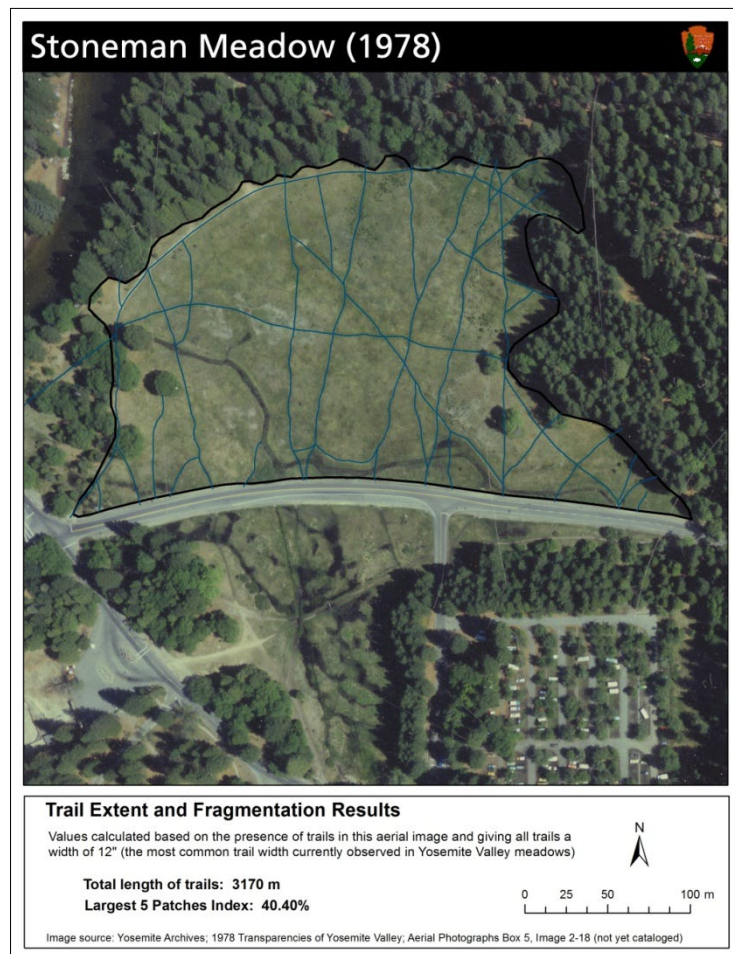
The degradation standard for individual meadows monitored for fragmentation resulting from informal trails is a weighted mean LPI<sub>5</sub> value of 40% for meadows within the subalpine meadow complex in the Tuolumne corridor.

Archival aerial photographs make it possible to simulate the fragmentation that previously existed in certain Yosemite Valley meadows. Through spatial analysis using a 1978 image of Stoneman Meadow, park staff determined that an LPI<sub>5</sub> of 40% existed prior to intensive restoration efforts in that meadow (see figure 5-10). The 1978 depiction of this meadow and its associated impacts represents what Yosemite meadow ecologists point to consistently as an example of a meadow in a degraded state. Although this meadow has shown evidence of recovery in recent years, it was made possible through intensive restoration efforts involving several years of planning and significant financial investment.

### Current Findings Regarding Management Standard, Adverse Impact, and Degradation

The fragmentation indicator has been monitored by Yosemite biologists at highly visited meadows within the Tuolumne River corridor since 2008. All meadows selected for monitoring are evaluated for a complete set of measures reflecting extent, proliferation, and condition of trails and disturbed areas (Leung et al. 2011b). Meadows of concern are identified for increased monitoring based on other trends found in other metrics that are collected alongside fragmentation data.

Table 5-1 displays current LPI values for the meadows in all three river segments in which portions of the subalpine meadow and riparian complex occur.



**Figure 5-10. 1978 Aerial Image of Stoneman Meadow with LPI Calculations.** (Today a boardwalk crosses the meadow north-to-south and the northern edge of the meadow is fenced. Due to these actions, no informal trails are present.)

**Table 5-1.**  
**Current Condition of Meadow and Riparian Complex Based on Monitoring of Largest Patches Index (LPI)**

Standards	River Segment /Meadows	Current Conditions by Year <sup>a</sup>			
		2008	2009	2010	2011
<b>Management Standard:</b> LPI is greater than 90% of weighted mean value of the meadows in a river segment	<b>Lyell Fork Segment</b>				
	Ranger Station A		99.49		
	Ranger Station B		99.94		
	Upper Lyell A (see figure 5-4)	99.7	99.3		99.3
	Upper Lyell B (see figure 5-4)	98.9	93.9		96.9
	<i>Weighted mean</i>				98.71
	<b>Lower Dana Fork Segment</b>				
	Dana A (see figure 5-2)	96.3	95.6		
	Dana B (see figure 5-3)	100.0	100.0		
	Twin Bridges	98.6			
	<i>Weighted mean</i>				98.4
<b>Management Concern:</b> LPI is between 81% and 89% of weighted mean value of the meadows in a river segment	<b>Tuolumne Meadows Segment</b>				
	Tuolumne A (see figure 5-8)	100	99.9	99.8	100.0
	Tuolumne B (see figures 5-5, 5-6, and 5-7)	80.0	78.4	78.2	78.7
	<i>Weighted mean</i>				82.3
<b>Adverse Impact:</b> LPI is below 81% of weighted mean value of the meadows in a river segment					
<b>Degradation:</b> LPI is below 40% of weighted mean value of the meadows in a river segment					

a LPIs as a percentage of the weighted mean value of all the meadows in a river segment.

Table 5-1 shows that three years of consecutive data have not yet been collected for the Lyell Fork and Lower Dana Fork segments. Based on the available data, if current trends continue, both segments will be within the management standard. The meadows in the Tuolumne Meadows segment do not meet the management standard, as the weighted average falls within the management concern range. This concern will be addressed by actions included in the *Ecological Restoration Plan*, described above, and through long-term monitoring to ensure the proposed management is effective, as described below.

### Monitoring Program

As required by the guidelines implementing WSRA, the NPS will conduct a program of monitoring and ongoing study during and following the implementation of the *Tuolumne River Plan* to ensure that river values are protected and enhanced throughout the life of the plan. A key part of this program will be “management triggers” intended to ensure that any substantial downward trend in conditions will be identified and arrested well before any adverse impact occurs. These triggers will identify management concerns prior to the occurrence of any adverse impact or degradation and will require that specific kinds of management action be taken. Management actions will become more comprehensive if the value continues to decline despite intervention.

### Monitoring Protocols

Monitoring of informal trails in meadows within the Tuolumne River corridor will occur during the growing season before plant senescence (final stage in the life cycle of a plant). Meadows with high potential for visitor-created impacts will be monitored every three to five years. Meadows with specific management concerns will be monitored annually. Meadows without evidence of visitor impacts, as reflected in the baseline conditions report, will be periodically evaluated until evidence suggests more intensive monitoring is necessary.

### Triggers and Management Responses

To ensure that a downward trend in conditions can be arrested well before an adverse impact occurs, trigger levels for management actions have been developed to address increasing departures from the management standard (an LPI greater than or equal to 90% as a weighted average of the meadows in a particular river segment). Management actions will be triggered when the LPI falls below this level for an individual meadow and become more comprehensive and intensive at lower LPIs, as described in table 5-2.

**Table 5-2.**  
**Triggers and Management Responses for Preventing Meadow Fragmentation**

Trigger	Management Response	Rationale
Decrease in LPI <sub>5</sub> threshold below 90% for an individual meadow (as opposed to the weighted mean for all the meadows in the segment).	<p>Increase meadow monitoring assessments to one-year interval at each individual meadow that surpasses this value. Largest patches in meadow will be analyzed for trail condition and emergence of new trails.</p> <p>Increase enforcement and education of best management practices in meadows.</p> <p>Manage visitor use through visitor messaging, restoration signs, delineation of trails determined to be less disturbing to meadow ecology, and closure of selected informal trails.</p>	This action allows increased sensitivity to changes in trails, and would allow managers better opportunities to identify meadows of concern and take actions well before adverse impacts are incurred. With more frequent assessment, emerging trails and particularly problematic trails will be identified and restoration actions taken.
Data analyses from annual monitoring of fragmentation yields results less than or equal to LPI <sub>5</sub> value of 90% for three consecutive years for an individual meadow (as opposed to the weighted mean for all the meadows in the segment).	<p>Remove informal trails and restore disturbed areas in specific meadows that exceed the threshold. Restoration activities could include the following:</p> <ul style="list-style-type: none"> <li>▪ Decomact soils.</li> <li>▪ Salvage any plants growing in the ruts or on the edges of the trail/ruts for later replanting.</li> <li>▪ Recontour topography.</li> <li>▪ Scatter locally gathered seed and organic materials to facilitate new plant growth.</li> <li>▪ Fill (with native soil) any deep headcuts caused by informal trails and recontour to more natural meadow topography.</li> </ul> <p>Management of visitor use could include the following:</p> <ul style="list-style-type: none"> <li>▪ Install boardwalks or hardened surfaces to allow access to sensitive areas.</li> <li>▪ Temporarily close sites to use to facilitate restoration.</li> <li>▪ Fence meadow perimeters.</li> <li>▪ Institute “hard closures” of specific affected meadows, which involves law enforcement and increased visitor education about the rationale for closures as a means of protecting meadows. Meadow closure regulations would be included within the superintendent’s compendium in order to allow law enforcement.</li> <li>▪ Reduce or redirect use.</li> </ul> <p>Any management action in designated wilderness would require a minimum-requirement analysis.</p>	This value represents the level at which a group of subject matter experts determined that the effects of visitor use would threaten resource protection and quality of the visitor experience.

## Indicator #2: Physical Streambank Stability Rating

### Indicator Description

Streambank stability ratings consist of a combination of vegetative cover and the presence/absence of erosion features (Frazier et al. 2005; Burton et al. 2011). Results of quality control tests conducted by Archer and others (2004) demonstrated that streambank stability ratings had generally low coefficients of variation, were repeatable, and were consistent among different observers (especially when ratings were dichotomous—either stable or unstable). Streambank stability has been widely identified as a factor affecting the geomorphic function of stream channels (Kondolf et al. 1996; Kattelman and Embury 1996; Madej et al. 1994; Kauffman et al. 1997).



Impacts on streambank stability can result from multiple causal mechanisms, including both anthropogenic (human-related) and natural sources that alter sediment-discharge balance (Kondolf et al. 1996) or cumulative impacts from both source types (Allen-Diaz et al. 1999). Examples of anthropogenic activities and their impacts that contribute to destabilization of streambanks (hereafter, streambank alteration) include the following:

- human foot traffic (bank shear, compaction, vegetation trampling)
- stock use (hoofpunching, bank shear, soil compaction, vegetation trampling, vegetation removal from grazing)
- road/trail construction and/or informal trailing (soil compaction, decreased sheet flow, reduced infiltration/percolation, increased surface routing and flow velocities, vegetation composition changes)

Streambank stability is a long-term indicator of system function over time; therefore, monitoring data on stability conditions can be used to verify whether and how well objectives are being achieved. Low ratings for streambank stability could be indicative of reduced system function and diminished biological integrity of riparian areas.

### **Definitions of Management Standard, Adverse Impact, and Degradation**

Standards for streambank stability have been reported in published literature from various survey protocols, including the Pfankuch-Rosgen *channel stability assessment* (Rosgen 2001), the *stream condition inventory* (Frazier et al. 2005), and *multiple indicator monitoring* (Burton et al. 2011). Each protocol and corresponding optimal value for streambank stability ratings was considered in determining the management standard, adverse impact, and degradation standard for this indicator.

The following delineations are described hierarchically—in terms of increasing spatial and/or temporal scale. The management standard is determined at the monitoring site (or designated monitoring area) scale. Adverse impact and degradation are determined at the scale of each river segment. This hierarchical distinction is consistent with the river discontinuum and continuum concepts, which infer that each river segment is comprised of individual components (Poole 2002) that collectively function as an interconnected riverine system (Vannote et al. 1980; Rosgen 1996). In addition, the degradation standard incorporates temporal scale, where this standard is met if streambank stability conditions have not recovered to above the management standard over two monitoring years.

### **Management Standard**

The management standard for the maintenance of stable streambanks is a streambank stability rating of 50% or greater for the mean observed value at any individual monitoring site. Monitoring sites are specific, established places, chosen according to accepted criteria, within the three river segments in which portions of the subalpine meadow and riparian complex occur. The monitoring sites are regularly monitored pursuant to the schedule specified in the “Monitoring Protocols” section below, which also lists the specific sites in the Tuolumne River corridor.

Preliminary assessment of multiple indicator monitoring data from sites categorically separated by use levels, indicated a mean percent of stable plots as 55 percent for the highest use sites without adjustment for statistical confidence ( $n = 3$ ; all are located within the upper Lyell Fork of the Tuolumne River and surveyed between 2009 and 2011). This value is consistent with the findings for nonreference (managed) sites by Frazier and others (2005). Furthermore, this management standard allows for a portion of streambank instability due to either anthropogenic causes and/or dynamic processes (channel migration, erosion, and deposition) fundamental to hydrologic function of fluvial river systems.

Despite a reportedly low coefficient of variation (Archer et al. 2004), an inherent level of uncertainty exists in efforts to quantifiably measure changes in streambank stability conditions, based on variability in observers, as well as variation within, and between, sites. Confidence limits developed from monitoring data would facilitate a given level of certainty (i.e., 95% or 90% confidence) for comparison of the mean of the observed values with the management standard. Burton and others (2011) reported the width of confidence intervals as 5.2 percent at 95% confidence from repeat surveys of streambank stability at 89 sites. Therefore, breach of the management standard will be determined by comparing the management standard to the value of the upper confidence limit for the mean of the observed data.<sup>18</sup>

### ***Adverse Impact***

Based on available scientific knowledge and professional judgment, an adverse impact would occur when streambank stability ratings are less than 50% stable averaged across all monitoring plots within a river segment for any single monitoring year, after restoration or use restrictions have been implemented. Potential adverse impacts may also be realized when a statistical trend is observed where streambank stability ratings less than 50% stable are likely to occur in subsequent monitoring years without intervening management action.

As with the management standard, the decline of streambank stability conditions below adverse impact will be determined by comparing the adverse impact to the value of the upper confidence limit for the mean of the observed data across the river segment.

### ***Degradation***

Based on available scientific knowledge and professional judgment, degradation would occur when streambank stability ratings are less than 50% stable averaged across all monitoring plots within a river segment for at least two consecutive monitoring years, after restoration or use restrictions have been implemented.

Degradation of riparian zones and stream channels diminishes their capacity to provide critical functions, including chemical and nutrient cycling, water purification, flood attenuation, maintenance of stream flows and temperatures, groundwater recharge, and habitats for fish and wildlife (Kauffman et al. 1997). Ultimately, adverse consequences of channel instability (or disequilibrium) would be associated with land productivity change, land loss, aquatic habitat deterioration, changes in both short- and long-term channel evolution, and loss of physical and biological function (Rosgen 2001). Extensive or severely degraded streambank stability conditions, manifested from either anthropogenic or natural sources, would likely propagate the loss of functional integrity of the stream channel on site and downstream. Realization of the degradation standard would be indicative of the need for substantial restoration investment.

### **Current Findings Regarding Management Standard, Adverse Impact, and Degradation**

Current conditions for streambank stability in the Tuolumne Meadows and Lower Dana Fork segments are currently unknown. As noted below under “Monitoring Protocols,” baseline conditions will be established through data collection the first year of plan implementation.

The upper Lyell Canyon north site is within the management standard; however, the upper Lyell Canyon south site falls slightly below the standard (see table 5-3). Management concerns will be addressed by actions to restore riparian vegetation along riverbanks, described above, and through long-term monitoring to ensure the proposed management is effective, as described below.

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<sup>18</sup> The upper confidence limit is the upper value for a given mean's confidence interval (i.e., if the confidence interval is 45 to 55, then it's compared to 55).

**Table 5-3.**  
**Streambank Stability Ratings by Monitoring Site and Segment Averages**

Standards	River Segment	Current Conditions, 2011
<b>Management Standard:</b> Average streambank stability rating greater than 50% at any individual monitoring site	<b>Lyell Fork Segment (average stability rating of all plots at the monitoring site)</b>	
	Upper Lyell Canyon, north	63
	Upper Lyell Canyon, south	49
	Segment Average	56
<b>Management Concerns Present</b> (condition does not meet management standard but is better than adverse impact):	<b>Lyell Fork Segment</b>	
	Upper Lyell Canyon, south A stability rating at the south upper Lyell Canyon site of 49% does not meet the management standard and will trigger a management response (see "Actions to Be Taken to Avoid Adverse Impacts or Degradation," below).	49
<b>Adverse Impact:</b> Average streambank stability rating below 50% averaged across all monitoring sites within a river segment for any single monitoring year		
<b>Degradation:</b> Average streambank stability rating below 50% across all river segments for at least two consecutive monitoring years		

## Monitoring Program

As required by the guidelines implementing WSRA, the NPS will conduct a program of monitoring and ongoing study during and following the implementation of the plan to ensure that river values are enhanced where necessary and protected throughout the life of the plan. A key part of this program will be management triggers intended to ensure that any downward trend in conditions can be identified and arrested well before adverse impact occurs. For streambank stability, action will be triggered when the condition is still within the management standard (if the stability rating falls below 75% at any monitoring site, see table 5-4).

## Monitoring Protocols

Streambank stability monitoring is a long-term indicator and can be effectively monitored on a three- to five-year interval (see Kershner et al. 2004; Burton et al. 2011); whereas, streambank alteration is a short-term indicator that should be monitored annually (see Burton et al. 2011). Streambank stability and streambank alteration will be assessed by trained personnel after the majority of use has occurred for that year, typically September or October. Monitoring locations will be selected according to the site selection criteria of the chosen protocol. Monitoring sites have been established within the Lyell Fork of the Tuolumne River segment and include middle Lyell; upper Lyell, north; and upper Lyell, south. In addition, one or more monitoring sites will be established within the Lower Dana Fork and Tuolumne river segments in accordance with site selection criteria of the protocol.

Baseline conditions for streambank stability will be established through data collection the first year of plan implementation; subsequent evaluation of streambank stability conditions will be conducted on a three- to five-year monitoring interval, thereafter. If less than 75% of plots at a given monitoring site are rated as stable, the NPS will undertake detailed annual assessments to evaluate the level of streambank alteration at that site. Annual assessments of alteration will provide data on the level, location, and distribution of use, and will facilitate inference on the degree to which use is affecting streambank stability. Concurrently, the NPS will assess hydrologic conditions within the contributing source area for that monitoring site to identify potential anomalies (i.e., excessive alteration at areas upstream of the monitoring site, or the occurrence of natural

events, such as landslides or wildfires) as sources of site instability. In combination, these two management actions will help prioritize subsequent actions necessary for site recovery.

### **Triggers and Management Responses**

Management actions to facilitate site recovery could restrict the use of riparian habitats by a combination of exclusions (access restriction), rest (temporary restriction of specific use types), and/or site restoration. The duration of use-restriction will be dependent on the rates of recovery of streambank stability and could be short or long term. Effectiveness monitoring will be initiated if management actions to restrict use levels are implemented.

**Table 5-4.**  
**Triggers and Management Responses for Protecting Streambank Stability**

Trigger	Management Response	Rationale
<p>The percent of stable plots observed at any monitoring site declines to less than 75%.</p> <p>OR</p> <p>A statistical trend indicating the likelihood for a monitoring site to have less than 75% stable plots in subsequent monitoring years, without intervening management action, is observed.</p>	<p>Assess streambank alteration at impacted sites.</p> <p>Conduct hydrologic assessments of the contributing source area for that site.</p> <p>Implement actions to facilitate site recovery through restoration and/or use restriction (i.e., resource exclusions, site rest, and so on).</p> <p>Implement use-restriction actions if streambank alteration or other anthropogenic activities are identified as causal mechanisms of instability.</p> <p>Increase monitoring frequency to evaluate effectiveness and recovery to the management standard, and compare to reference site conditions as available.</p>	<p>Assessments will refine understanding of baseline conditions and the causes (streambank alteration, natural processes, or cumulative effects) affecting streambank stability, on-site and within the greater contributing source area for that monitoring site. Identifying land use practices that are the most damaging to ecosystems or that prevent recovery is essential for restoration (National Research Council 1992). Comparison of site conditions to reference sites will validate observed conditions and recovery.</p>

## **Indicator #3: Meadow Bare Soil**

### **Indicator Description**

The amount and distribution of bare soil is considered an important indicator of meadow integrity because it directly relates to site stability and susceptibility to wind and water erosion (Smith and Wischmeier 1962; Morgan 1986; Benkobi et al. 1993; Blackburn and Pierson 1994). Grazing activities have been linked to increases in bare soil as well as decreased plant cover, decreased primary productivity, and shifts in species composition (Miller and Donart 1981; Trimble and Mendel 1995; Olson-Rutz et al. 1996; Fahnestock and Detling 2000; Cole et al. 2004). Trampling, by either humans or stock, can produce similar results (Cole 1995; Liddle 1975, 1991) with the added effect of soil compaction that compromises root growth and water infiltration (Gilman et al. 1987; Unger and Kaspar 1994; Pietola et al. 2005).

Candidate metrics for monitoring ecological conditions in meadows subject to grazing and/or trampling pressures include vegetative cover, bare soil, species composition, and meadow productivity. Bare soil and basal vegetative cover are more sensitive indicators of meadow condition than species composition (Cole et al. 2004). For instance, bare soil increases at lower levels of disturbance compared with shifts in species composition in a variety of montane vegetation types of North America (including alpine meadow) (Cole 1993). Plant productivity may be more sensitive to grazing pressure than bare soil (Cole et al. 2004), but it may be impractical to monitor in wilderness meadow settings. Furthermore, plant productivity is subject to high interannual variability due to climatic factors such as precipitation (Walker et al. 1994), snowpack, or snowmelt (Walker et al. 1995). In addition to its relevance for monitoring meadow condition, bare soil measured from point data is efficient, objective, easily obtained, and repeatable across time and observers. Therefore, bare soil may be one of the most robust indicators of changes in meadow ecological condition.



The adopted standards for bare soil are based on monitoring data from Sierra Nevada meadows (Weixelman and Zamudio 2003). Additional data may be collected from meadows where there is no human use to further refine these standards and provide reference plots to discern changes in condition unrelated to human use or management actions. The monitoring approach may also include collecting additional information on meadow characteristics and human use to have an empirical basis for assessing the causes of bare soil. The specific approach will be determined during monitoring design.

## Definitions of Management Standard, Adverse Impact, and Degradation

### Management Standard

The management standard for the meadow bare soil indicator is that at least 75% of monitoring plots in a river segment have bare soil amounts within the range of high ecological condition, and no more than 15% of plots have bare soil amounts with the range of low ecological condition (Weixelman and Zamudio 2003). The numeric standard for bare soil will vary according to meadow type and elevation (table 5-5). For example, a moist meadow within the range of high ecological condition will not have bare soil cover exceeding 6%, and a wet montane meadow (at an elevation of 5,000–8,000 feet) will not have bare soil exceeding 4%. Temporarily flooded meadows may have greater variability in bare soil cover than other wet meadows (NPS unpublished data). This variability may necessitate the development of bare soil standards for temporarily flooded meadows during the early portion of the monitoring program.

No standards for bare soil are reported in published literature. The management standard is based on data and recommendations from the U.S. Forest Service (USFS) Region 5 (California) Range Monitoring Project. This project has been monitoring bare soil in Sierra Nevada meadows for 12 years in relation to livestock use (Weixelman 2009). Ecological condition classes for bare soil values are based on point-intercept data collected from 363 meadows across a broad disturbance gradient (Weixelman and Zamudio 2003). Based on point-intercept data collected from these meadows, the USFS derived ecological condition classes for bare soil values.

**Table 5-5.**  
**Bare Soil Cover Values for Ecological Condition Classes among Sierra Nevada Meadow Types**

Meadow Type /Elevation Zone	High Condition	Moderate Condition	Low Condition
Wet meadow/ subalpine <sup>a</sup>	0–4%	5–8%	>8%
Wet meadow/ montane <sup>b</sup>	0–4%	5–9%	>9%
Moist meadow/all zones	0–6%	7–13%	>13%
Dry meadow/ subalpine	TBD <sup>c</sup>	TBD	TBD
Dry meadow/ montane	0–8%	9–13%	>13%
Temporarily flooded/all zones	TBD	TBD	TBD

Source: Data from Weixelman et al. 2003.

a The subalpine zone is 8,000 – 9,500 feet in elevation.

b The montane zone is 4,000 – 8,000 feet in elevation.

c Cover values for condition classes within the dry subalpine meadow requested from the USFS on 12/15/2011.

TBD = to be determined.

### Adverse Impact

An adverse impact on meadow condition will occur if more than 20% of monitoring plots in a river segment have bare soil amounts within the range of low ecological condition as described by Weixelman and Zamudio (2003). For example, if the river segment has 100% wet subalpine meadow, an adverse impact will occur if more than 20% of the plots have 8% or greater bare soil cover.

The condition ratings in Weixelman and Zamudio (2003) provide ecologically meaningful ranges for bare soil values that were derived from analyzing meadow data from the Sierra Nevada. This condition class approach provides a way to distinguish adverse impact from minor fluctuations in the amount of bare soil. Increases in

bare soil that result in a low ecological condition rating for more than 20% of meadow plots in a river segment would signify a more significant decline than a minor, short-term fluctuation in one meadow.

### ***Degradation***

Degradation will occur if at least 80% of monitoring plots in a river segment have twice the bare soil value for the low ecological condition as defined by Weixelman and Zamudio (2003). For example, if the river segment has 100 percent wet subalpine meadow, degradation will occur if 80% of the plots have 16% or greater bare soil cover.

The ecological processes that sustain meadows are integrally tied to plant composition, vegetative structure, and soil stability. A meadow in low ecological condition would have a predominance of shallow- and tap-rooted species, lower vegetative cover, and a greater extent of bare soil. High amounts of bare soil indicate low meadow productivity and greater susceptibility to erosion. Bare soil amounts of the magnitude described above, widespread across meadows in a river segment, would likely indicate that the processes sustaining meadow function were in jeopardy within that segment of the Tuolumne River corridor.

### **Current Findings Regarding Management Standard, Adverse Impact, and Degradation**

Detailed monitoring of the meadows in Dana, Lyell, and Tuolumne Meadows has not been done for bare soil. Consequently, a definitive finding of adverse impacts or degradation is currently impossible. As noted above, though, Tuolumne Meadows has higher bare soil cover than would be expected for an intact wet meadow (NPS, Ballenger and Acree 2009m). More monitoring is needed before the bare soil condition of the meadows in Dana, Lyell, and Tuolumne Meadows can be determined. However, existing studies show that management concerns are clearly present. These concerns will be addressed by actions included in the ecological restoration plan, described above, and through long-term monitoring to ensure the proposed management is effective, as described below.

### **Monitoring Program to Prevent Future Adverse Impacts or Degradation**

As required by the guidelines implementing WSRA, the NPS will conduct a program of monitoring and ongoing study during and following the implementation of the plan to ensure that river values are enhanced where necessary and protected throughout the life of the plan. A key part of this program will be management triggers intended to ensure that any downward trend in conditions can be identified and arrested well before an adverse impact occurs. These triggers will identify management concerns prior to the occurrence of any adverse impact or degradation. Triggers will require that specific kinds of management action be taken. Management actions will become more comprehensive if the value continues to decline despite intervention.

### ***Monitoring Protocols***

Monitoring will be conducted in subalpine meadows with grazing and/or trampling concerns. These currently include two meadows in upper Lyell Canyon and one meadow at Tuolumne Meadows. The frequency and timing of such monitoring will be every five years unless the amount of bare soil exceeds the management standard. If that occurs, a subset of sites may receive annual monitoring to obtain estimates of interannual variation. Monitoring may occur any time between meadow flowering and first snowfall.

### ***Triggers and Management Responses***

The NPS has developed two triggers for management action to ensure that a downward trend in conditions can be reversed well before an adverse impact occurs (see table 5-6). Both triggers would require additional management action if a downward trend was detected even though the condition was still within the management standard. For meadows with pack stock or human use, management responses will include

reducing the intensity or timing of use. In addition, when a trigger point is reached, there will be additional assessments to help identify factors associated with decline and to assess the meadow complex as a whole.

**Table 5-6.**  
**Triggers and Management Responses for Preventing Bare Soil**

Trigger	Management Response	Rationale
<p>Trigger point 1: There is a statistically significant increase in bare soil at any monitoring site over one monitoring period.</p> <p>OR</p> <p>Fewer than 90% of monitoring plots within a river segment are rated as having a high ecological condition for bare soil.</p>	Apply a meadowwide rapid assessment method (e.g., California Rapid Assessment Method [CRAM, CWMW 2009]) for a qualitative evaluation of meadow condition.	Rapid assessments are diagnostic tools that provide standardized, rapid, field-based assessments of the overall condition or functional capacity of wetlands. Assessing meadow condition at a greater scale than the monitoring plot will aid in identifying key stressors that may be affecting meadow condition. Assessment results will assist with interpretation of monitoring results. CRAM, for example, has undergone extensive peer review, and it performs well when compared with fine-scale quantitative condition assessments (Stein et al. 2009). A version of CRAM tailored to wet meadows is in development; it is best used in combination with quantitative measures.
	Increase education in best management practices for meadows.	Education in maintaining meadow condition will help prevent further increases in bare soil associated with human use.
	Develop strategies for reducing use and/or the timing of use to minimize impacts.	Determining effective strategies for managing meadow use is a necessary step in the process to protect and enhance meadow condition, positioning the park for rapid response in the advent of additional increases in bare soil.
	Implement actions such as placing signage, placing naturalistic barriers (such as rocks and logs), slightly rerouting trails to discourage off-trail travel, increasing ranger patrols, and other actions to encourage the public to tread where they will not do undue resource damage but at the same time, can enjoy the resource.	Physical barriers will prevent further increases in bare soil by preventing trampling of protected areas.
<p>Trigger point 2: Fewer than 80% of monitoring plots within a river segment are rated as having high ecological condition.</p>	Apply a meadowwide rapid assessment method (e.g., CRAM [CWMW 2009]) for a qualitative evaluation of meadow condition.	Rationale above for rapid assessment also applies at this trigger point.
	Implement strategies to reduce intensity of use and /or modify timing of use (i.e., move use to later in the season) by pack stock or people. Evaluate the possibility of meadow rest.	Reducing stresses from herbivory (animals eating plants) and/or trampling effects (either total for the entire season or when meadow soils are wet) will help facilitate meadow recovery. Effects of trampling that are expected to decline with reduced use or avoidance of early-season use include soil compaction, bare ground exposure, and plant disturbance.
	Increase monitoring frequency.	Frequent monitoring will help facilitate more rapid detection of, and management response to, changes in ecological condition. It will be useful in evaluating the effectiveness of changes in the intensity and/or timing of use on meadow condition.

## **Conclusions: Protecting and Enhancing the Subalpine Meadow and Riparian Complex**

At the time of designation, the portion of the subalpine meadow and riparian complex in the Tuolumne Meadows segment was likely experiencing a shift in vegetation associated with historic grazing and disruptions to meadow hydrology caused by historic roadbuilding and drainage projects. Stresses on meadow processes are now being increased by visitor foot traffic, which is creating informal trails across the meadow and causing habitat fragmentation. These management concerns will be addressed under the *Tuolumne River Plan* by a comprehensive program of ecological restoration and management of visitor use and development. Ecological restoration will include actions to restore riparian vegetation along riverbanks, restore more natural meadow hydrology, and continue research into possible additional restoration of historic vegetation communities. Management of visitor use and development will include the elimination of roadside parking to reduce informal trailing and removal of facilities from riverbanks and wet areas. These actions will be expected to enhance the meadow and riparian complex and allow for its long-term management in a condition equal to or better than the management standards. (Additional management of visitor use and development to further enhance this value is explored through alternative proposals to reduce use levels, reduce development, and/or confine use to resilient areas; these alternatives are explored in chapter 7).

At the time of designation, the portions of the subalpine meadow and riparian complex in the Lyell Fork and Lower Dana Fork segments were in good condition, and they remain in that condition today. Stock use has been identified as a management concern for meadow and riparian areas in Lyell Canyon. Streambank stability is a management concern in at least one location on the Lyell Fork. This concern will be addressed under the plan either by eliminating or regulating commercial stock use (both alternatives are under consideration in this Draft EIS).

The NPS will implement an ongoing program of monitoring and continuing study to ensure that the subalpine meadow and riparian complex is returned to good condition and remains in good condition over the life of the plan. A suite of three indicators will be used to track the health and potential for impact on this complex river value. An important part of the monitoring program will be the management triggers used to identify any decline from good condition under any of the three indicators well before an adverse impact occurs. Any of these triggers would require additional action to protect the subalpine meadow and riparian complex.



# Biological Value: Low-Elevation Riparian and Meadow Habitat

## *Wild Segment: Poopenaut Valley*



NPS PHOTO BY KRISTINA RYLANDS

*Poopenaut Valley, meadow, river, and seasonal pond.*

## **Condition Assessment**

### **Condition at the Time of Designation**

The ecological health of the Poopenaut Valley's unique, low-elevation meadow, wetland, and riparian habitats, which provide important habitat for many wildlife species, depends upon a river whose flows have been controlled since 1923. No condition assessments were conducted at or near the time of designation. However, no major changes in development or use have occurred in this area since designation, making it likely that conditions then were similar to current conditions. Research conducted since designation (NPS, Stock et al. 2007k)(discussed below) indicates that, despite alterations to the hydrologic regime caused by dam operations, a diverse mix of low-elevation, riparian, wetland, meadow upland, and forested communities continues to provide essential habitat for wildlife.

### **Current Condition**

In the Tuolumne River corridor below Hetch Hetchy Reservoir, the O'Shaughnessy Dam has influenced the magnitude, timing, duration, and frequency of river flow. However, Poopenaut Valley and its ecosystems have largely been spared the severe impacts seen downstream of other dams. This is because of several factors unique to this setting, such as a low overall gradient and a downstream bedrock constriction that promotes floodplain inundation at Poopenaut Valley (NPS, Stock et al. 2007k). Despite a reduction in available water

during the growing season, a diverse mix of riparian, wetland, and upland plant communities remain in Poopenaut Valley. These are some of the most diverse communities in the park.

Wetland and upland meadows cover most of the Poopenaut Valley floor. Riparian vegetation adjacent to the river and tributary streams is relatively extensive as compared to other riverbank areas below the dam. Several Poopenaut Valley wetlands contain an unusual assemblage of plants, and hydric soils and hydrophytic vegetation are present in some upland areas. This suggests that valley wetlands were more extensive in the past (NPS, Stock et al. 2007k). A 2007 wetland delineation in the valley indicates that there may be riparian encroachment associated with low, regulated flows (NPS, Buhler and Santina 2007n). Some conifer encroachment has occurred in these meadows, similar to conditions seen in Tuolumne Meadows.

## **Management Concerns**

Research conducted by Stock and others suggests that some areas of wetland below O'Shaughnessy Dam might be transitioning to drier upland habitat, the result of lowering groundwater levels. Riparian areas below the dam appear to have expanded. The degree to which these changes have been influenced by dam operations is being studied (NPS, Stock et al. 2007k).

## **Actions NPS Will Take to Address these Concerns**

The Raker Act authorizes the San Francisco Public Utilities Commission (SFPUC) to manage water releases according to its needs and mission. The NPS will continue to work with the SFPUC regarding recommended science-based release rates from the dam. The overall goals of this collaboration are to better understand the complex ecology of Poopenaut Valley and to design water release strategies to protect meadows, wetlands, and riparian zones in Poopenaut Valley; a specific goal is to mimic a natural snowmelt. While the SFPUC attempts to cooperate with the NPS, it can be limited in its ability to provide the recommended flows. For example, naturally occurring drought years may not produce adequate runoff to simulate a spring flood. Given these constraints, low-elevation riparian and meadow habitat in Poopenaut Valley will continue to be sustained by natural ecological processes to the maximum extent possible, supplemented when possible by scientifically informed releases from O'Shaughnessy Dam that would provide maximum ecological benefits to the river-dependent ecosystems below the dam.

## **Management Indicator and Monitoring Program**

### **Indicator Description**

### **Definitions of Management Standard, Adverse Impact, and Degradation**

### **Current Findings Regarding Management Standard, Adverse Impact, and Degradation**

These terms are not defined for the Poopenaut Valley because the river flows that sustain this river value are subject to the provisions of the Raker Act and beyond NPS control.

### **Monitoring Program**

Collaborative ecological studies conducted since 2006 by the NPS and SFPUC have focused on connections between the hydrology, geomorphology, and plant and wildlife ecology of the Poopenaut Valley. Extensive monitoring protocols, including river and groundwater levels, surveys of plant communities, and surveys of birds and aquatic invertebrates, have been established to evaluate the effects of water release strategies. A baseline conditions report was developed in 2007. Annual monitoring is expected to continue into the foreseeable future, and every five years a periodic condition assessment will be conducted and compared to

baseline conditions to ensure that, within the bounds of the Raker Act and NPS authority, public use and management actions do not adversely affect this outstandingly remarkable biological value.

## **Conclusions: Protecting and Enhancing Low-Elevation Riparian and Meadow Habitat**

Since 1923 O'Shaughnessy Dam has influenced the magnitude, timing, duration, and frequency of river flows below the dam. Because of favorable site conditions, Poopenaut Valley continues to experience seasonal flooding and retains a rare mix of diverse riparian, wetland, and upland meadow plant communities. For reasons that are still the subject of ongoing research, some wetlands appear to be transitioning to drier upland habitat, while riparian areas appear to be expanding. The NPS is working collaboratively with the SFPUC to scientifically inform dam releases to mitigate the impacts on natural ecological processes in Poopenaut Valley to the maximum extent possible; however, this management is constrained by the legal mandates of the SFPUC to deliver water and power. Monitoring is ongoing to support this collaborative effort; however, because the NPS does not have jurisdiction over the extent to which dam releases affect the ecology in Poopenaut Valley, no management standards or determinations of adverse effect or degradation have been established for this value.

## **Geologic Value: Stairstep River Morphology**

### ***Wild Segment: Grand Canyon***

#### **Condition Assessment**

##### **Condition at the Time of Designation**

The unique landforms comprising this outstandingly remarkable geologic value are predominantly the result of geologic uplift and glacial erosion that occurred over millions of years. Since retreat of the most recent glaciers about 15,000 years ago, these landforms have changed remarkably little because of the very strong granitic rock of which they are composed. At the time the Tuolumne River was included in the wild and scenic river system, the extensive stairstep river morphology was unaltered by human intervention.

##### **Current Condition**

No natural event or human intervention has perceptibly changed the morphology of the Tuolumne River corridor since the time of designation. Low-impact recreational uses, such as hiking and camping, have had negligible impacts on these durable landforms.

#### **Management Concerns**

Natural processes will continue to shape the landscape and the geologic value of the Tuolumne River corridor. No present or foreseeable management concern exists regarding the condition of stairstep river morphology in the river corridor.

#### **Actions NPS Will Take to Manage this Value**

Because there are no concerns regarding the condition of this value, no actions other than continued protection under the Wild and Scenic Rivers Act are necessary.

## **Management Indicator and Monitoring Program**

### **Indicator Description**

#### **Definitions of Management Standard, Adverse Impact, and Degradation**

#### **Current Findings Regarding Management Standard, Adverse Impact, and Degradation**

These terms are not defined for stairstep river morphology because this geologic value is essentially impervious to intended human activities.

### **Monitoring Program**

No existing or future human uses allowed in this segment are expected to have adverse impacts on these landforms. Therefore, active monitoring is not required to ensure that actions taken to manage public use, and other management actions, protect and enhance this outstandingly remarkable geologic value.

## **Conclusions: Protecting and Enhancing Stairstep River Morphology**

Stairstep river morphology is considered impervious to the intended human uses in this wild river segment. No management or monitoring is needed to protect this river value.

## **Cultural Value: Archeological Landscape**

### ***All Wild and All Scenic Segments***

#### **Condition Assessment**

##### **Condition at the Time of Designation**

Information about the extent and significance of the archeological landscape was limited in 1984. Archeological surveys along the Lyell Fork (up to Ireland Creek), Tuolumne Meadows, Dana Meadows, and Upper Dana Fork in the 1950s (Bennyhoff 1956) noted numerous sites with significant research potential. Some prehistoric archeological sites along the Dana Fork were affected by road and trail construction prior to enactment of legislation protecting archeological resources. Impacts on sites in less developed locations were limited to visitor use and natural processes.

Of the known sites on the Dana Fork, only nine (along Tioga Road where it follows the Dana Fork) had been formally evaluated for their eligibility for listing on the National Register of Historic Places (NRHP or national register). Seven of these sites were found eligible and two were found ineligible. One of the eligible sites had undergone data recovery excavation, which was conducted to mitigate the impacts of highway construction. None of the sites along the Lyell Fork (with the exception of those near the confluence with the Dana Fork, which were included in the NRHP-nominated Tuolumne Meadows Archeological District, see below) had been evaluated for eligibility. Based on studies conducted in the 1950s and 1970s (Bennyhoff 1956; Napton and Greathouse 1976b), the Tuolumne Meadows Archeological District was nominated for inclusion on the NRHP in 1978. At that time, the Tuolumne Meadows Archeological District was altered but considered to be in fair condition overall (NPS, Anderson and Hammack 1977b).



While there were additional recorded archeological sites in the Grand Canyon, none had been evaluated for eligibility on the NRHP at the time of designation. One site that has since been determined to be eligible for listing on the NRHP had been affected by flooding, erosion, illegal collection of artifacts, and scientific study.

The Hetch Hetchy Archeological District (NPS 1979), like the Tuolumne Meadows Archeological District, had been determined eligible for the NRHP based on surveys conducted in the 1950s and 1970s (Bennyhoff 1956; Napton and Greathouse 1976b). Two sites comprised the Hetch Hetchy Archeological District at that time, one of which was located within the wild and scenic river corridor in the Below O'Shaughnessy Dam segment (NPS, Montague 2006n). This site was in fair condition.

## **Current Condition**

Documentation, condition assessments, and the few evaluation projects since designation (NPS, various authors 1985a–f; NPS, Montague 1996; NPS, Montague 2000 a–f; NPS, Gavette 2004b and 2005d; NPS, Shive 2007d; and others) have expanded the body of knowledge about the archeological importance of the river corridor. Many sites have been documented, and previously unknown sites continue to be discovered. Sites that have not yet been evaluated are considered potentially contributing resources to the outstandingly remarkable archeological values of the Tuolumne River until determined otherwise through formal evaluation (NPS, Montague 2006n).

Although few of the sites along the Lyell and Dana Forks have been formally evaluated for their NRHP eligibility, many of the sites along both forks appear to have important research potential that might make them significant (NPS, DePascale and Curtis 2006e, among others). Almost all the sites along these forks are affected indirectly by informal trails that bring visitors to the site area (NPS, Shive 2007d). Other commonly observed impacts were caused by erosion, camping, informal trails, and park operations (NPS 2009k).

The Tuolumne Meadows Archeological District contains a significant concentration of sites with a diversity of materials and important research potential. A few of these sites (located in the campground, at the wastewater containment ponds, and along road or trail corridors) are severely disturbed. The most common impact on the integrity of archeological sites is from the displacement of artifacts or archeological features, caused either by natural forces (evident at 78% of the sites visited in 2009) and/or visitor use (evident at 42% of the sites visited in 2009) (NPS 2009k).

Sites located in the Grand Canyon of the Tuolumne provide distinct evidence of trade and travel routes, tool caching, food and medicine procurement and processing, and related settlement. These sites may also contribute to the understanding of human demography and cultural occupation in recent prehistory. Three sites that are located in the Grand Canyon and also within the Tuolumne Meadows Archeological District have been evaluated for their NHRP eligibility. The condition of other prehistoric sites in this river segment is, in general, fair to good. The most common causes of site disturbance in the river corridor below Tuolumne Meadows are erosion and use by hikers and/or pack stock. Less common sources of disturbance include camping, trail construction, unauthorized collecting or looting, rodent activity, fire, and grazing or trampling.

At Glen Aulin High Sierra Camp specifically, the large site in the camp's immediate vicinity has been affected by development, use, and ongoing utilities work at the camp (NPS, Montague 2006b).

Sites in the lower elevations of the Sierra Nevada (2,000–4,000 feet) had the potential to be occupied year-round, and could provide substantial data about settlement and subsistence to the archeological record. These sites are more likely to have architectural features, such as house pits and dance houses, to be associated with burial areas, and to have food storage and cooking features, in contrast to the higher-elevation sites.

Furthermore, obsidian obtained from Bodie Hills may signify certain cultural affiliation and trade networks, particularly in the most recent prehistoric past.

Because many archeological sites in the Tuolumne River corridor are estimated to contain subsurface materials, their scientific data potential and the integrity of the deposits cannot be fully documented and evaluated without some form of excavation or scientific analysis. Few of the sites in the Tuolumne River corridor have had such excavation or analysis, so the data potential and condition of the majority of sites in these segments is interpreted from surface observations only (NPS, Montague 2006b).

## **Management Concerns**

Management concerns are largely due to one of two causes: (1) visitor use or (2) construction-related impacts (including impacts of facility maintenance and repair). Almost all the sites in the meadows and along the river are affected by informal trails, many of which emanate from roadside parking and bring visitors close to sensitive sites. Several sites have evidence of camping and campfires. Many sites in Dana and Tuolumne Meadows are at risk of losing some of their integrity from ongoing visitor use impacts associated with informal trails near the sites (NPS, Montague 2006b and 2007s; NPS, Shive 2007d). Many locations of archeological sites in the greater Tuolumne Meadows area, especially adjacent to the Tuolumne River, receive high levels of use in the summer.

The potential for future development, repair, and maintenance of facilities and underground utilities to support visitor use is also a management concern at both Tuolumne Meadows and Glen Aulin. A 2005 site evaluation at Glen Aulin concluded that continued use of the High Sierra Camp and backpacker camp has the potential to further affect the integrity of the site, and that consideration should be given to limiting future ground-disturbing activities within the boundaries of the camp, particularly within the high lithic (stone tool) concentration area (NPS, Kreshak 2006s).

## **Actions NPS Will Take to Address these Concerns**

### **Wild Segments (Lyll Fork, Upper Dana Fork, Grand Canyon of the Tuolumne, Poopenaut Valley)**

Prehistoric archeological sites will continue to be documented and monitored through the NPS Archeological Sites Management Information System (ASMIS) adopted in 2007 to support improved archeological resource protection by tracking the visitor use impacts on archeological sites. Sites will be protected by managing use levels, using natural features to conceal and divert foot traffic around sites, mitigating potential impacts of ecological restoration practices by using noninvasive techniques wherever possible, evaluating sites where appropriate, and undertaking site-specific treatment actions, such as data recovery, where necessary to avoid resource loss through park actions or natural forces.

### **Scenic Segments (Tuolumne Meadows, Lower Dana Fork, Below O'Shaughnessy Dam)**

All the management actions described for archeological resources in wild segments, above, will also apply to archeological resources in scenic segments. In addition, many of the actions related to ecological restoration at Tuolumne Meadows, such as eliminating roadside parking and removing informal trails, will also help protect archeological sites in the Tuolumne Meadows and Lower Dana Fork segments by diverting foot traffic away from sites and into less sensitive areas.

Management concerns about potential impacts on archeological sites caused by ground disturbance associated with future development, repair, and maintenance of facilities and underground utilities will be addressed by

confining actions to nonsensitive areas wherever feasible and by mitigating unavoidable effects in compliance with section 106 of NHPA. Specific actions related to use levels, ecological restoration, and site development would vary among the alternatives and are presented in chapter 7 and evaluated against the NHPA criteria of effect in chapter 8.

Associated American Indian tribes and groups will be consulted to ensure that management of archeological sites considers their concerns, issues, and perspectives.

## **Management Indicator and Monitoring Program**

### **Indicator Description: Aggregate Condition of Archeological Sites**

Within the Tuolumne River corridor, individual prehistoric sites combine to form the collective character and significance of the archeological landscape. The indicator is the aggregate condition of the collection of archeological sites within the landscape. The condition of individual sites includes the general physical state of the site and associated material remains. Other key components of site condition are site stability (the potential for physical deterioration over time) and site integrity (of location, design, setting, materials, workmanship, feeling, and association).

Archeological site condition was chosen as an indicator because this characteristic is sensitive to human disturbance (an observable harmful effect on the integrity or data potential of a site resulting from human activity). There is a direct relationship between the degree of site disturbance and the current site condition (NPS 2007e). Site disturbances, or impacts, can lead to the irretrievable loss of archeological resources at the individual site level (NPS 2007f). The cumulative loss of individual site resources within an archeological district can ultimately result in degradation of the district as a whole, because “the majority of components that add to the district’s historic character...must possess integrity, as must the district as a whole” (NPS 1997a).

The site monitoring protocol uses the NPS ASMIS format (NPS 2007e, 2007f), supplemented with data collection specific to human impacts. ASMIS, which is a management database developed by the NPS, tracks a broad range of information about documented archeological sites: site components, disturbances, current condition, cumulative disturbance effects, and management actions. ASMIS functions as a “tool to support improved archeological resources preservation, protection, planning, and decision-making by parks, regional offices, and the national program offices” (NPS 2007f). Archeological site condition has been assessed in Yosemite National Park for several decades, but prior data collection does not always meet current professional standards. The site monitoring protocol was designed to assess site condition and impacts using a systematic, consistent methodology.

ASMIS quantifies impacts (disturbances) in two ways: (1) the effect on site condition and (2) site damage severity levels. Condition effects are ranked on an ascending scale: negligible, partial loss repairable, partial loss irretrievable, and total loss irretrievable. Impacts with negligible effects can cause minor damage to the physical condition of the site, with little to no loss of data potential or site integrity. Partial loss repairable effects result in minor damage to the site that can be reversed or ameliorated through treatment or repair, such as careful removal of campfire rings or hand removal of fire fuel buildup. Partial loss irretrievable effects result in more serious damages that are not repairable, such as the partial collapse of a prehistoric rock feature from human alteration, or artifact movement from its original context. Total loss irretrievable effects result in complete loss of the resource, as in site destruction from major earthmoving associated with construction (NPS 2007e).

Site damage from a disturbance is measured as low, moderate, or severe, based on areal extent or the amount of site integrity compromised (NPS 2007e; NPS, Bane 2011b). These measurements take into consideration site type, data potential, and impact on site integrity. Destruction of a pictograph, for example, is highly damaging

to site data potential even if the pictograph represents only a small physical area of site. Loss of the densest portion of a lithic scatter may be small in areal extent, but critically large for research potential if temporally diagnostic tools had been present in that locus (place). Previous data recovery at the site may mean some impacts are less damaging for data potential at the excavated locations.

ASMIS includes fields that assign causes of disturbances: natural, park operations, visitor, or unknown. Both park operation and visitor disturbances are included in total site counts of human impacts. Typical park operation disturbances include road construction and maintenance, trail construction and use, utilities installation, building construction, controlled fire, or scientific research. Unlike natural and visitor impacts, many park operation impacts are considered “undertakings,” and are addressed before or during disturbance through a regulated process (NHPA, section 106, and NEPA) involving consultation with tribal partners, evaluation, and treatment. The most common types of visitor disturbances include camping impacts, informal trails, climbing, and use by hikers and/or horses. Other, less common visitor disturbances include vegetation damage, structure modification, stock use (picketing or corralling), soil compaction, dumping, off-road vehicle use, vandalism, and unauthorized collection of artifacts (looting or collection piles).

## **Definition of Management Standard, Adverse Impact, and Degradation**

### **Management Standard**

For the Tuolumne River archeological landscape, the management standard is at least 85% of sites free from serious unmitigated human impacts for sites with high data potential, and at least 80% for sites with low data potential. *Serious unmitigated human impacts* are single disturbances with partial or total loss irretrievable disturbance effects at moderate to severe site damage levels, or a series of three or more disturbances with partial or total loss irretrievable disturbance effects at low site damage levels. Unmitigated impacts are disturbances uncorrected by management action under a regulatory context such as section 106 of NHPA. Sites with low data potential are valuable and justifiable inclusions into the management standard: While they may individually be considered less important for their individual information potential, they are tangible elements on the landscape that contribute to understanding of the settlement patterns, land use, and other aspects of the prehistory; they are also important in terms of their cultural value to contemporary traditionally associated peoples.

In balancing visitor use and site preservation, some disturbances to resources can be acceptable if the site retains context and integrity (NRHP 1990). For archeological sites with estimated low data potential (i.e., small sites with few materials and no diagnostic artifacts; sites with a single feature, such as a bedrock mortar; sparse lithic scatters; or heavily deteriorated sites), some amount of irretrievable damage may be allowable. This is particularly true for common site types in the river corridor, such as small lithic scatters. The management standard allowance for numbers of low data sites with human impacts (20%, or 80% of sites free of serious unmitigated human impacts) represents a realistic management threshold for protection of the largest portion of sites (Donnermeyer 2005).

For sites with estimated high data potential (i.e., sites with multiple features, sites with diagnostic artifacts or dense artifact concentrations, documented historical sites, or sites with uncommon or unique attributes), the potential resource loss is greater, as is the impact to an archeological district. A serious human impact or series of minor impacts resulting in irretrievable damage and loss at high data sites is less acceptable (Donnermeyer 2005). The management standard allowance for numbers of high data sites with human impacts for these effects (15%, or 85% of sites free of serious unmitigated human impacts) is therefore less.

### **Adverse Impact**

Adverse impact occurs when the number of sites free from serious unmitigated human impacts falls to 60% or fewer for sites with low data potential, and 70% or fewer for sites with high data potential in a 10-year monitoring interval.

The adverse impact represents a higher level of serious impact for both low and high data potential sites over a 10-year interval of representative site sampling within an archeological district. The 20% increase serves as a warning of long-term downward trends in site condition, thus requiring stronger protective management actions before widespread individual site damages threaten the essential character of the aggregate archeological district (Donnermeyer 2005).

### **Degradation**

Degradation occurs when the majority of sites ( $\geq 50\%$ ) comprising the archeological landscape exhibit severe disturbance severity levels and poor site conditions as a result of human impacts.

Severe disturbance severity levels indicate a prior history of disturbances that caused major site damage. Sites or major portions of sites will likely be lost if actions to protect and/or preserve are not taken within two years (NPS 2007f). Poor site conditions indicate current loss of site features or key areas that define primary site function and are critical to site data potential for historical or scientific research. Such losses make it difficult to use any remaining site data (NPS 2007f). The combination of prior and current damage causes a near total loss of site significance (data potential) and integrity.

The archeological landscape value for the Tuolumne River corridor is comparable to an archeological district as defined by the National Register of Historic Places as “a grouping of sites, buildings, structures, or objects that are linked historically by function, theme, or physical development or aesthetically by plan” (Little et al. 2000). When the majority of sites within the aggregate landscape lose significance and integrity, as indicated by severe disturbance levels and poor site conditions, the significance and integrity of the archeological landscape as a whole degrades (NPS 1991).

### **Current Findings Regarding Management Standard, Adverse Impact, and Degradation**

Current human impact values for a sample of relevant Tuolumne River corridor sites are shown in table 5-7. Results are drawn from site monitoring conducted in 2007–2011 of a sample set of 128 sites (54%) from a total of 235 sites in the archeological landscape of the Tuolumne River corridor as of May 2011. Over that five-year interval (2007–2011), 98% of high data potential sites and 96% of low data potential sites in the sample were considered free of serious human impacts, thus meeting the management standards for the indicator. Based on recent site condition assessments, the archeological landscape is well within the management standard.



**Table 5-7.**  
**Current Condition of Archeological Sites Based on Monitoring of Aggregate Condition of Sites**

Standards	Current Conditions, 2007–11		
	Sites free of current serious unmitigated human impacts <sup>a</sup>	High data potential sites	Low data potential sites
<b>Management Standard:</b> Sites with low data potential: 80% of sites free from serious unmitigated human impacts <sup>a</sup> Sites with high data potential: 85% of sites free from serious unmitigated human impacts	Sample set of 128 sites (54% of 235 sites relevant to the Tuolumne River archeological value)	98%	96%
<b>Management Concern:</b> Sites with low data potential: 61–84% of sites free from serious unmitigated human impacts Sites with high data potential: 71–84% of sites free from serious unmitigated human impacts			
<b>Adverse Impact:</b> Sites with low data potential: 60% of sites free from serious unmitigated human impacts Sites with high data potential: 70% of sites free from serious unmitigated human impacts			
<b>Degradation:</b> All sites: The majority of sites (≥ 50%) exhibit severe disturbance severity levels and poor site conditions due to human impacts			

a Impacts with partial loss irretrievable effects with moderate to severe damage levels or multiple (≥3) impacts with low damage levels.

## Monitoring Program to Prevent Future Adverse Impacts or Degradation

As required by the guidelines implementing WSRA, the NPS will conduct a program of monitoring and ongoing study during and following the implementation of the *Tuolumne River Plan* to ensure that the archeological river value is protected throughout the life of the plan. Impacts on archeological resources are irreversible, and their condition can never be enhanced. Even if all human impacts could be eliminated, a downward trend in the condition of archeological resources over time would be inevitable due to the effects of natural weathering. The management triggers for protecting archeological resources are considerably higher than the management standard so that downward trends can be identified and arrested to the extent possible while the resources are still in a protected state and well before any adverse impacts occur (see “Triggers and Management Responses,” below).

### Monitoring Protocols

The NPS will assess site conditions for a representative sample of archeological sites within the landscape at 5–15 year monitoring intervals, following the assigned ASMIS site inspection schedule (NPS 2007f). The following criteria generally guide the frequency of site condition assessments:

- assessment every 5 years: sites likely to be affected by humans, animals, or natural forces or sites with structural components covered by the Park Facilities Management Software System
- assessment every 10 years: sites with a currently good or fair condition that are not likely to be affected and already have good or fair documentation or have low data potential
- assessment every 15 years or longer: sites that would meet the criteria for assessment every 10 years except that they are very remote and/or logistically expensive to access

The key source of feedback for adaptive archeological site management is the periodic, systematic analysis of collected site data, focused on management objectives (Kintigh et al. 2007). To support management, site monitoring results will be compiled and analyzed at 5-year intervals (for the individual sites that were assessed over the past five years) and aggregated and analyzed at 30-year intervals (for the entire archeological landscape). (The 5-year interval for summary reporting and analysis of site data is the minimum reporting

period necessary for accurate capture of human impacts over longer time spans [NPS, Bane 2011b]; a 30-year interval for aggregate summary reporting for the entire landscape is necessitated by the large number of archeological sites within the corridor.) Analysis of these data, which may report on 10–50 sites at every 5-year interval and approximately 250 sites at the 30-year interval, will identify trigger points for management actions to ensure that this value remains within the management standard.

### Triggers and Management Responses

For the archeological landscape, a management response will be triggered if the number of individual sites free from serious unmitigated human impacts is 90% for sites with low data potential, and 95% for sites with high data potential in a monitoring interval. At this level of impact, the landscape is still within the management standard, but management concerns are present. Management actions will become more comprehensive and intensive if the condition moves farther from the management standard, as described in table 5-8.

**Table 5-8.**  
**Triggers and Management Responses to Protect the Archeological Landscape**

Trigger	Management Response	Rationale
The number of individual sites free from serious unmitigated human impacts falls to 90% or less for sites with low data potential, and falls to 95% or less for sites with high data potential in a monitoring interval.	<p>Increased monitoring frequency for affected sites.</p> <p>Increased management protection designed to counteract or minimize impacts, crafted to individual site specifications. Examples include:</p> <ul style="list-style-type: none"> <li>▪ consultation with tribal partners.</li> <li>▪ site documentation, research, testing, or NRHP evaluation.</li> <li>▪ site stabilization, revegetation, trail reroutes, or trail removal.</li> <li>▪ increased public interpretation and education.</li> <li>▪ increased education for local user communities, such as backpackers and climbers.</li> <li>▪ NRHP reevaluations and/or data recovery at affected sites.</li> <li>▪ development of comprehensive site management plans for large, complex sites in developed areas.</li> <li>▪ hard closures of individual affected sites, using law enforcement monitoring and increased visitor education about human impacts and the necessity for closures. Site closure regulations will be represented within the superintendent's compendium in order to allow legal enforcement.</li> </ul>	The trigger range is set at 10% above the management standard, thus allowing identification of individual problem sites and localized areas and timely prescriptive actions before the management standard levels are violated. The trigger range was selected from sampling results for five years of site impact monitoring within the district, and is based on best professional judgment of thresholds necessary to retain the desired management standard.

NRHP = National Register of Historic Places

## **Conclusions: Protecting and Enhancing the Archeological Landscape**

At the time of designation, the known archeological resources in the river corridor were characterized as being in a generally fair condition. Since then, ongoing documentation, condition assessments, and evaluation projects have expanded the body of knowledge about the importance and condition of this outstandingly remarkable cultural value. Several decades of site condition assessments have found that archeological sites occurring in every river segment either have or appear to have important research potential. Almost all the archeological sites along the river and in meadows have been affected by informal trails, and many of these sites are at risk of losing some of their integrity.

Since the time of designation, the NPS adopted the ASMIS to support improved archeological resource protection by providing a systematic, consistent methodology for assessing archeological site condition and impacts. Based on ASMIS evaluation criteria and standards, the collective character and significance of the archeological landscape remains well within the management standard of being fully protected. However, concerns about disturbances to sites caused by foot traffic and/or potential future facility development and maintenance remain.

Under the plan, sites will continue to be monitored through the ASMIS. The potential for effects associated with visitor foot traffic will be greatly reduced by eliminating roadside parking and removing informal trails. The potential for effects associated with future facility development, repair, and maintenance will be addressed by confining actions to nonsensitive areas wherever feasible and by mitigating unavoidable effects in compliance with section 106 of NHPA. Any future downward trend in site conditions associated with human use will trigger a required management response to counteract or minimize the effect before an adverse impact occurs.

## **Cultural Value: Parsons Memorial Lodge**

### ***Scenic Segment: Tuolumne Meadows***

#### **Condition Assessment**

##### **Conditions at the Time of Designation**

Parsons Memorial Lodge, a national historic landmark, was designed in the office of the renowned Berkeley architect Bernard Maybeck with a thorough understanding of the harsh environmental conditions encountered at its location at 8,640 feet. The national historic landmark nomination for Parsons Memorial Lodge, prepared in 1985, states that the building had undergone a few minor changes over the years but none that marred its historic integrity. Its condition at that time was rated as good (NPS, Harrison 1985g). It is assumed that the building was in the same condition at the time of designation in 1984.

##### **Current Condition**

The lodge receives scheduled preservation and maintenance treatment, as defined by the Secretary of Interior's Standards for the Treatment of Historic Properties (Secretary's Standards for Historic Properties), and is in good condition (NPS 2007u). The structure continues to be used as a gathering place, as it was historically.

#### **Management Concerns**

Parsons Memorial Lodge is in good condition, with no management concerns present.

#### **Actions NPS Will Take to Manage this Value**

The Parsons Memorial Lodge will continue to be preserved in accordance with the Secretary's Guidelines for Historic Properties, NPS cultural resource management guidelines, and the park's programmatic agreement with the Advisory Council on Historic Preservation (ACHP) and the California state historic preservation officer (SHPO) (see appendix D).

The Yosemite National Park Maintenance Division has a trained and experienced historic preservation crew that performs regular annual maintenance on Parsons Memorial Lodge, such as applying preservative to exposed logs. The crew also inspects the condition of the structure each year during annual maintenance. The rangers who staff Parsons Memorial Lodge also inspect the lodge each year at the beginning of the season. They submit work orders to have small and large problems fixed as problems arise so that the condition of the structure never falls below good.

## **Management Indicator and Monitoring Program**

### **Indicator Description: List of Classified Structures Condition Assessment**

The NPS List of Classified Structures is the primary computerized database for registration and long-term management of park historic and prehistoric structures. The NPS is required by NPS Director's Order (DO) 28 and the Secretary's Guidelines for Historic Properties to preserve and protect the Parsons Memorial Lodge in good condition as defined in the List of Classified Structures guidance. This standard will also ensure protection required by the Wild and Scenic Rivers Act.

List of Classified Structures conditions are defined as follows:

- *Good*: The structure and significant features are intact, structurally sound, and performing their intended purpose. The structure and significant features need no repair or rehabilitation but only routine or preventative maintenance.
- *Fair*: The structure is generally structurally sound and performing its intended purpose; however, one of the following conditions is present:
  - There are early signs of wear, failure, or deterioration affecting 15% to 25% of the structure.
  - There is failure of a significant feature of the structure.
- *Poor*: The structure is in poor condition if any of the following conditions is present:
  - The significant features are no longer performing their intended purpose.
  - Significant features are missing.
  - Deterioration or damage affects more than 25% of the structure.
  - The structure or significant features show signs of imminent failure or breakdown.

### **Definitions of Management Standard, Adverse Impact, and Degradation**

#### **Management Standard**

The management standard is to protect Parsons Memorial Lodge in good condition as defined in the List of Classified Structures guidance.

#### **Adverse Impact**

Parsons Memorial Lodge will be considered adversely impacted if the condition of the building is diminished from good to fair as defined in the List of Classified Structures guidance.

#### **Degradation**

Parsons Memorial Lodge will be considered degraded if the condition of the building is diminished from good to poor as defined in the List of Classified Structures guidance, or if critical building failures are allowed to continue without repair for a period of longer than six months.

### **Current Findings Regarding Management Standard, Adverse Impact, and Degradation**

Parsons Memorial Lodge is within the management standard of good condition based on the most current List of Classified Structures assessment, conducted in 2007 (see table 5-9).

**Table 5-9.**  
**Current Condition of Parsons Memorial Lodge**

Standards	Current Conditions, 2012
<b>Management Standard:</b> Parsons Memorial Lodge is protected in good condition as defined in the List of Classified Structures guidance.	According to the 2007 assessment, Parsons Memorial Lodge is in good condition.
<b>Adverse Impact:</b> The condition of the lodge is downgraded to fair as defined in the List of Classified Structures guidance.	
<b>Degradation:</b> The condition of the lodge is downgraded to poor as defined in the List of Classified Structures guidance.	

## Monitoring Program to Prevent Future Adverse Impacts or Degradation

As required by the guidelines implementing WSRA, the NPS will conduct a program of monitoring and ongoing study during and following the implementation of the *Tuolumne River Plan* to ensure that river values are enhanced where necessary and protected throughout the life of the plan. A key part of this program will be management triggers intended to ensure that any downward trend in conditions can be identified and arrested well before adverse impact occurs.

### Monitoring Protocols

The Yosemite National Park historical architect, in concert with the park historic preservation specialist, will assess the condition of Parsons Memorial Lodge at least once every five years and identify any critical building system failures or weather impacts. Preservation and cultural resource specialists who assess the structure must meet the qualifications outlined within NPS DO 28. Additionally, in the performance of routine patrols of the Parsons Memorial Lodge area, the district ranger will report any observed threats or changes in condition.

The following are specific components of the structure that will be monitored by park preservation and cultural resource specialists responsible for ensuring that the Parsons Memorial Lodge remains in good condition:

- failing fasteners of the corrugated metal roofing
- damaged or missing corrugated metal roofing
- failing chimney to roof flashing
- failing mortar joints of the stone masonry: interior walls, exterior walls, and chimney
- loose or missing stones of the stone masonry: interior walls, exterior walls, and chimney
- damaged or deteriorated log roof structure, mainly the exposed log rafter tails and braces
- damaged or deteriorated wood sash windows, jambs, hardware, or wooden shutters
- damaged or deteriorated front door, jamb, or hardware

### Triggers and Management Responses

Because 15% or more damage to, or deterioration of, the structure would place the lodge into fair condition, the need for repairs will be triggered if 10% of the structure is experiencing damage or deterioration, as shown in table 5-10. The rationale for taking action at this threshold is to ensure that repairs needed to mitigate damage or deterioration are made while the condition of the structure is still good.

**Table 5-10.**  
**Trigger and Management Responses to Protect Parsons Memorial Lodge**

Trigger	Management Response	Rationale
Detection of deterioration or damage affecting 10% of the structure	Increase monitoring. Increase frequency of condition assessment. Make repairs to mitigate damage or deterioration.	Repairs are made to mitigate damage or deterioration while the structure is still in good condition.



## **Conclusions: Protecting and Enhancing Parsons Memorial Lodge**

Parson Memorial Lodge was in good condition at the time of designation and remains in good condition, with no management concerns identified. The lodge will continue to be preserved in accordance with all applicable standards, guidelines, and agreements. If future monitoring under the List of Classified Structures assessment program detects deterioration or damage, repairs will be undertaken to correct the deficiency while the structure is still in an overall good condition.

## **Scenic Values: Scenery through Lyell Canyon, Dana and Tuolumne Meadows, and the Grand Canyon of the Tuolumne**

***Wild Segments: Lyell Fork, Grand Canyon of the Tuolumne***

***Scenic Segments: Tuolumne Meadows, Lower Dana Fork***

The three outstandingly remarkable scenic values of the corridor are addressed collectively because the same management indicators and monitoring program will be used for each.

## **Condition Assessment**

### **Condition at the Time of Designation**

#### **Wild Segments: Lyell Canyon and Grand Canyon of the Tuolumne**

The *Tuolumne Final Study* (USFS and NPS 1979b) found that the area's unspoiled condition, its variety of landscape types, its vegetation, and its backcountry values ranked that portion of the river at least as high as the national forest portion (which had been studied and given a high aesthetic rating compared with other rivers).

#### **Scenic Segments: Dana and Tuolumne Meadows**

Expansive views were afforded by the natural vegetation patterns at Tuolumne Meadows. Views into and away from the meadows were maintained and occasionally expanded by the mechanical removal of encroaching lodgepole pines. After 1930, the siting of all development was guided by the principle of not obstructing or competing with the naturally occurring views and vistas. Reducing human visual impacts was a key reason for realigning the Tioga Road and eliminating all camping inside the meadow. Building locations and circulation patterns were designed to take advantage of the scenic opportunities of this landscape, while remaining as unobtrusive as possible (NPS 2007t).

### **Current Condition**

#### **Wild Segments: Lyell Canyon and Grand Canyon of the Tuolumne**

Views from the river and trails in Lyell Canyon continue to have high aesthetic value. The Glen Aulin High Sierra Camp is the only developed structure within these segments. Infrastructure associated with the camp is visible from a few locations in the river corridor. Visible facilities include about a dozen off-white-colored tents, a dining hall, two restroom buildings, several sheds, a large fire ring, a utility shed with a small solar panel and water pipes, and other camp equipment and structures. The camp is fairly well screened from most parts of the trail in its vicinity and has a very limited geographic extent.

**Scenic Segments: Dana and Tuolumne Meadows**

Views from trails and vista points through Dana and Tuolumne Meadows continue to have high aesthetic value. The predominantly open meadows provide for a remarkable variety of visual experiences, including unobstructed views of the craggy Sierra Nevada and dramatic, changing weather formations. Even from the periphery of the meadows, where denser vegetation obstructs the panoramic views, a sense of openness is provided by glimpses of the meadows and distant peaks between the trees.

The built environment at Tuolumne Meadows has remained relatively unchanged since the river was designated. Most development remains sited just within the surrounding forest to take advantage of views into and across the meadows while avoiding any obstructions to views (NPS 2007t). Most existing structures are in low- to moderate-visibility zones. Sources of artificial light at Tuolumne Meadows are minimal (NPS, Duriscoe 2005c), and outdoor lighting guidelines are being developed to protect nighttime views (NPS 2008k). The important visual relationships between the natural features of Tuolumne Meadows and its adjacent developed areas remain largely intact (NPS 2007t).

**Management Concerns****Wild Segments: Lyell Fork and Grand Canyon of the Tuolumne**

Scenic values in these two wild segments will generally continue to be shaped by natural processes. The only exception will be at Glen Aulin, where structures are visible from short segments of the trails through this area. At Glen Aulin any new structures will be subject to the Visual Resource Management (VRM) contrast analysis explained below (under the “Management Indicators and Monitoring Program” discussion for this value).

**Scenic Segments: Lower Dana Fork and Tuolumne Meadows**

Views into and away from Tuolumne Meadows are being affected by roadside parking, which has increased since the 1997 flood destroyed the Cathedral Lakes parking area. Conifers are also encroaching into views. This encroachment may be a response to changes in average precipitation and other factors (see “Subalpine Meadow and Riparian Complex,” above).

**Actions NPS Will Take to Address Management Concerns****Wild Segments: Lyell Canyon and Grand Canyon of the Tuolumne**

With no concerns present in Lyell Canyon, no actions are necessary. At Glen Aulin, the NPS will continue to ensure that the High Sierra Camp is kept in an overall clean and tidy condition. When the tents are next replaced, the NPS will seek replacement fabric colors that blend with the landscape, thereby reducing their contrast. Other actions to enhance the scenic value in the vicinity of the camp would vary among the alternatives and are presented in chapter 7.

**Scenic Segments: Lower Dana Fork and Tuolumne Meadows**

Views into and away from Tuolumne Meadows will be enhanced under all the action alternatives by eliminating roadside parking, which currently affects those views, and by requiring visitors to park in formal parking areas, which will be located away from highly visible areas (shown in figure 5-12). Roadside curbing or naturalistic barriers and signs to prevent roadside parking will intrude into views, but they will be considerably less obtrusive than parked vehicles. The removal of informal trails and the revegetation of riverbanks will also enhance views in the Tuolumne Meadows area under all alternatives. These actions are described in detail earlier in this chapter under “Subalpine Meadow and Riparian Complex.” When the canvas siding on the

structure housing the store and grill needs replacing, NPS will consider using tan, green, or gray fabric if a contrast analysis indicates such a color would blend more harmoniously with the surrounding landscape.

The outstandingly remarkable scenic values throughout Tuolumne and Dana Meadows will continue to evolve in response to natural ecological processes. The mechanical removal of conifers from meadows was discontinued in 2010, pending further study as part of the ecological restoration program. If conifer removal proves to be beneficial for restoring meadow and riparian habitats, it could be included in that program. However, mechanical removal of conifers for the purpose of enhancing scenery is not included in any of the alternatives of this *Tuolumne River Plan/Draft EIS*, with the exception of managing the eight scenic vista points identified below. Management of scenic vista points would vary among the alternatives and is addressed in chapter 7.

The eight scenic vista points in or near the Tuolumne River corridor that would be maintained under some alternatives are listed below. All these vista points are in or near scenic segments and outside designated wilderness; no vista management would occur in designated wilderness. Appendix J contains work plans for each of the viewpoints that would be consistent with protecting and enhancing the scenic values of the Tuolumne Meadows and Lower Dana Fork segments, if vista management was adopted under the selected alternative.

- Tioga Road: Mount Dana and Mount Gibbs view facing east, overlooking a pond and meandering Tuolumne River. (This viewpoint is outside of the Tuolumne River corridor.)
- Tioga Road, Mount Dana viewpoint: view looking east at the river meandering through Dana Meadows, with the Sierra Nevada crest in the background
- Tioga Road, Dana Fork interpretive viewpoint: view looking west down through the glaciated river valley along the Dana Fork, with distant views of the granite peaks
- Tioga Road, near the “little blue slide” road cut: view overlooking Lyell Canyon and the Kuna Crest
- Lumbert Dome, near the parking area: view looking west toward Unicorn Peak
- Tioga Road, Parsons Memorial Lodge trailhead: view looking west toward Pothole Dome and the river, with Fairview Dome in the background
- Tioga Road, near the Pothole Dome parking area: view looking east over Tuolumne Meadows to Lumbert Dome. (This viewpoint is outside of the Tuolumne River corridor.)
- Parsons Memorial Lodge doorway: view looking south across the meadow and river toward Unicorn Peak

These vista points differ from the vista points identified for the Tuolumne River area in the 2010 environmental assessment for the park’s *Scenic Vista Management Plan* (NPS 2010k). The Finding of No Significant Impact (FONSI) for that plan stipulates that the identification of vista points for the Tuolumne and Merced river corridors will be deferred to the comprehensive river management plans.

Actions included in the parkwide Yosemite Exterior Lighting Guidelines (NPS 2008k) are protective of the outstandingly remarkable skyward views through Dana and Tuolumne Meadows. Exterior lighting in the river corridor will comply with the most current guidelines.

When the NPS selects an alternative in a formal record of decision, the management actions included in that alternative will be incorporated into this chapter of the *Tuolumne River Plan* to guide the future management of scenic values in the Tuolumne River corridor. This guidance will also amend the park’s *Scenic Vista Management Plan*.

## Management Indicators and Monitoring Program

### Indicator Description: Visual Resource Management Classification

The definitions of management standard, adverse impact, and degradation for the scenic values are based on application of the VRM system within the Tuolumne River corridor. Developed by the USFS (1995) and further refined by the Bureau of Land Management (BLM 2007a-c), the VRM system is a widely accepted system for assessing the scenic character of a landscape and of predicting the effects of a management action upon that landscape. The VRM system has been in use for over three decades and has proven to be a process that can consistently document what people consider to be incongruous with a predominately natural environment (Galliano 2000). Under this system, landscapes are classified into one of four classes, with class I being most protective/most wild and class IV being most accommodating to a variety of human change.

There are typically two steps for the VRM system: an inventory of the existing landscape and a contrast analysis. The inventory is done to ensure that existing conditions are acceptable and to develop a baseline for future comparison. In the contrast analysis, the degree of contrast of a management action as compared to the native landscape is quantitatively assessed (the contrast analysis is part of the monitoring program for this indicator and is described more fully in that section, below).<sup>19</sup>

## Definitions of Management Standard, Adverse Impact, and Degradation

### Management Standard

Segments classified as wild shall meet the definitions of VRM class I areas, with scenic segments meeting the definitions of VRM class II areas. As presented in table 5-11, there is a natural parallel between wild and scenic river classifications and VRM classes.

**Table 5-11.**  
**WSRA Classification Definitions and VRM Class Definitions**

WSRA Classification Definitions	VRM Class Definitions <sup>a</sup>
<b>Wild</b> segments: Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.	<b>Class I</b> objectives: Preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention (BLM 2007b).
<b>Scenic</b> segments: Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.	<b>Class II</b> objectives: Retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape (BLM 2007b).
<b>Recreational</b> segments (no designated segments in the Tuolumne Wild and Scenic River corridor): Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.	<b>Class III</b> objectives: Partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape (BLM 2007b).

<sup>a</sup> Class IV is not included in this table because it would accommodate more human change in a landscape than is acceptable in the Tuolumne River wild and scenic river corridor.

<sup>19</sup> While scores have some subjectivity, variations in scoring between scorers decline with user training and experience (NPS 2009). For example, in the Blue Ridge Parkway the NPS has used this system using large numbers of volunteers to assess scenic value and monitor change over time. Using those results, park managers have been able to successfully communicate the need of adjacent land owners to modify developments to reduce the possible contrasts with the native landscape. Results were also introduced in a 2008 lawsuit case against the Tennessee Valley Authority and cited by the judge in the ruling to justify requirements for three coal plants to operate above Clean Air Act standards (NPS 2009).

## Adverse Impact

Wild river segments managed as VRM class I would be adversely affected if they fell into the VRM class II management class evaluation. Scenic river segments managed as VRM class II would be adversely affected if they fell into VRM class III management class evaluation.

## Degradation

Wild river segments managed as VRM class I would be degraded if they fell into the VRM class III management class evaluation. The scenic segments managed as VRM class II would be considered degraded if they fell into the class IV management class evaluation (which is not included in table 5-11 because it would accommodate more human change in a landscape than is acceptable in the Tuolumne River corridor).

## Current Findings Regarding Management Standard, Adverse Impact, and Degradation

The scenic values in the Lyell Fork and Lower Dana Fork segments are within the management standards for wild and scenic segments, respectively. However, the scenic values in the Grand Canyon and the Tuolumne Meadows segments have management concerns present (see table 5-12). These concerns will be addressed by actions to eliminate intrusions into views, as described above, and through long-term monitoring to ensure the proposed management is effective, described below.

**Table 5-12.**  
**Current Condition of Scenic Values Based on Visual Resource Management System**

Standards	Current Conditions, 2010	
	Wild Segments	Scenic Segments
<b>Management Standard:</b> Wild Segments shall fit within VRM class I. Scenic Segments shall fit within VRM class II.	The Lyell Fork segment meets the VRM objectives for class I areas.	The Lower Dana Fork segment meets the VRM objectives for class II areas
<b>Management Concerns:</b>	Grand Canyon (due to views being affected by structures at Glen Aulin)	Tuolumne Meadows (due to views being affected by roadside parking and conifers encroaching into the meadows)
<b>Adverse Impact:</b> Wild segments would be adversely impacted if they fell into VRM class II. Scenic segments would be adversely impacted if they fell into VRM class III.		
<b>Degradation:</b> Wild Segments would be degraded if they fell into VRM class III. Scenic segments would be degraded if they fell into VRM class IV		

## Monitoring Program to Prevent Future Adverse Impacts or Degradation

Using the VRM system described above, the monitoring program will consist of (1) a contrast analysis for any new proposed structures and/or modifications of existing structures, (2) periodic on-the-ground monitoring, and (3) actions taken when specific management triggers are reached. These components are explained in more detail below.

### Contrast Analysis

“Contrast” refers to the difference between the 12 key components of a landscape (form, line, texture, and color of the landscape’s vegetation, of its land and water, and of its existing structures) and the same components of the proposed structure. The lower the contrast between the existing landscape and a proposed structure, the more the structure can be said to blend into (not distract from) and therefore preserve the surrounding landscape and its VRM landscape class rating.

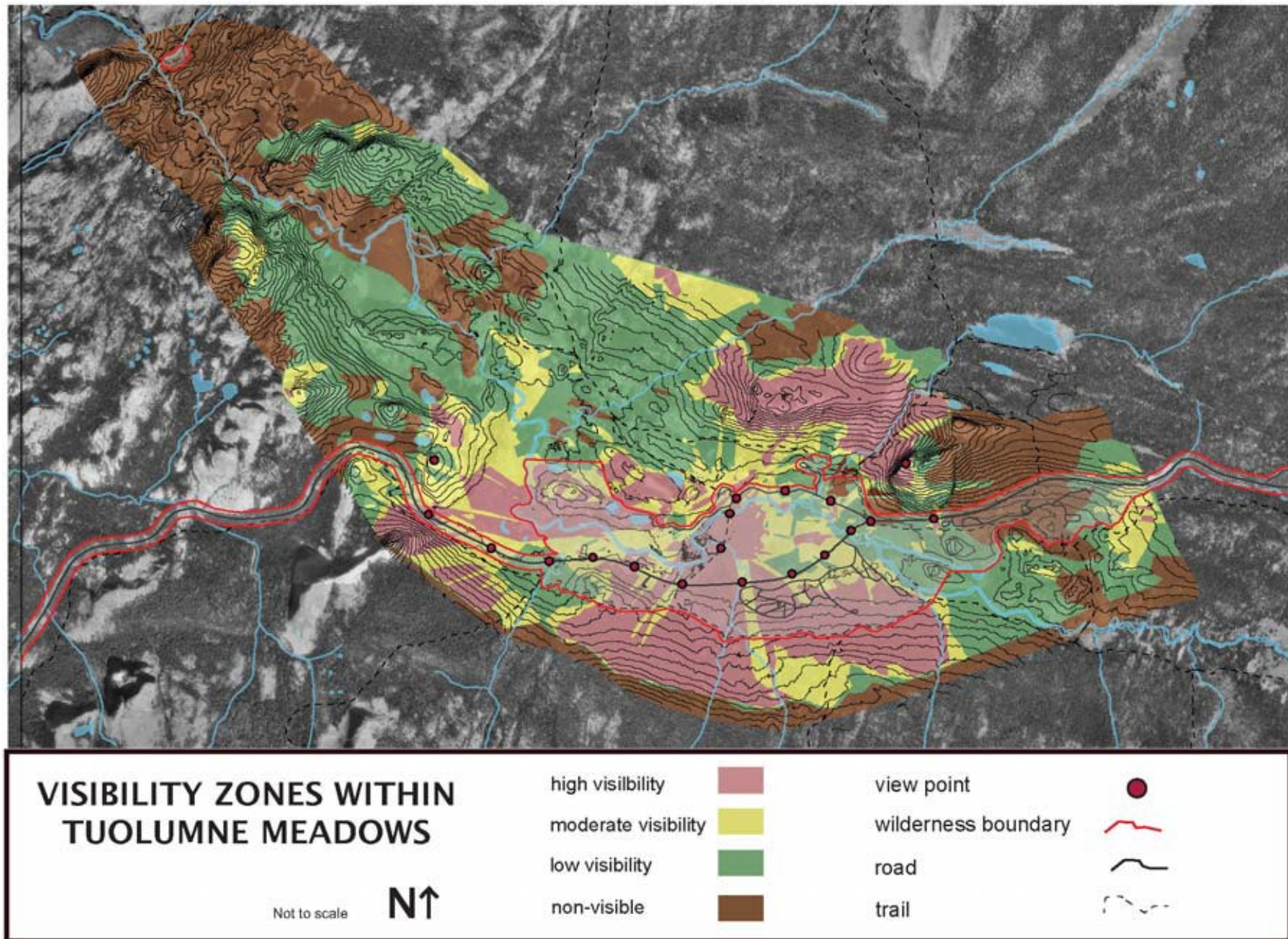


The NPS will perform a contrast analysis for all new structures and/or modifications of existing structures proposed for the Tuolumne River corridor (see figure 5-11, below). The contrast analysis will analyze whether the proposed structure or modification will harmonize with the class I or class II landscapes in which they will be located. For each of the 12 key components, contrast will be rated from high (3 points) to none (0 points). This could result in a contrast rating as high as 36, if the structure is rated as having a strong contrast in all categories. Within the wild segments (Lyell Fork and Grand Canyon), contrast ratings must not exceed a total value of 4, with no strong contrasts evident. For scenic segments (Lower Dana Fork and Tuolumne Meadows), contrast ratings must not exceed a total value of 12, again with no strong contrasts evident. If a structure with an excessive contrast rating was constructed, it would cause the VRM class rating for that segment to fall to the next lower level (i.e., from class II to class III), representing an adverse impact. To prevent this from occurring, if a proposed structure is found to exceed the specified contrast rating for that segment, it will be revised to fall within that contrast rating.

		FEATURES		
		Land and Water Body	Vegetation	Other Structures
		Strong (3 pt.) Moderate (2 pt.) Weak (1 pt.) None (0 pt.)	Strong (3 pt.) Moderate (2 pt.) Weak (1 pt.) None (0 pt.)	Strong (3 pt.) Moderate (2 pt.) Weak (1 pt.) None (0 pt.)
ELEMENTS	Form			
	Line			
	Color			
	Texture			

**Figure 5-11. Sample Contrast Analysis Rating Sheet.** The 12 cells at the bottom would all be completed, providing a comprehensive and quantitative analysis of the proposed structure's contrast with the existing landscape.

The contrast rating for proposed structures or structure modifications within the landscape units that contribute to the outstandingly remarkable scenic values of the river corridor would be assessed from a randomized selection of the eight scenic vista points and other vista points commonly used by park visitors today. Additional considerations for protecting scenic values in the Tuolumne Meadows area are included in the *Scenic Analysis of Tuolumne Meadows* (NPS, Torgerson and Schaible 2007o). This analysis was conducted to support the *Tuolumne River Plan* by identifying visually sensitive areas within the Tuolumne Meadows landscape and to recommend planning and design guidelines for the potential addition of new development to the meadows in the future. This information will be used in conjunction with the contrast analysis (explained above) and has informed the site planning component of the plan, as described in chapter 7. The analysis is summarized below as figure 5-12.



Source: NPS, Torgerson and Schaible 2007m

Figure 5-12. Visibility Zones within Tuolumne Meadows.

## Monitoring Protocols

Monitoring of scenic segments will take place every four years to ensure that any recommended mitigations and actions are within the management class rating. Monitoring will include site visits to a random selection of the eight scenic vista points and five other notable scenic views. The monitoring will assess the landscape using the VRM initial inventory. Monitoring of wild segments will occur only when needed. Impacts in these segments are unlikely because of Wilderness Act restrictions on facility construction.

## Triggers and Management Responses

Table 5-13 shows actions that will be taken to avoid adverse impacts or degradation on outstandingly remarkable scenic values.

**Table 5-13.**  
**Triggers and Management Responses for Protecting Scenic Values**

Trigger	Management Response	Rationale
Planned construction of any new structure or exterior modifications to any existing structure	Contrast analysis.	The contrast analysis is intended to reveal effects on the outstandingly remarkable scenic value before a new structure is built.
Within a wild river segment, a contrast rating of moderate in any category.	Mitigation such as changing color of structures to blend with native landscapes.	Actions or structures within this segment should attempt to minimize the contrast to the surrounding landscape to the extent possible.
Within a scenic river segment, an overall contrast rating greater than 12, or a strong contrast in any category	Mitigations to reduce the contrast rating to 12 or below, or to avoid any strong contrast rating. (If such mitigation is not practical, an alternative location must be found.)	A contrast rating above a 12 would attract more attention than is acceptable from the casual observer.
Within the scenic river segment, an overall contrast rating greater than 21, or a strong contrast in any two categories	Mitigations to reduce the contrast rating to 21 or below, or to avoid two strong contrast ratings. (If such mitigation is not practical, an alternative location must be found.)	A contrast rating above a 21 is beginning to dominate the surrounding landscape.

## Conclusions: Protecting and Enhancing the Scenic Values of the River Corridor

The outstandingly remarkable scenic values across all segments are found to be within the management standard, although management concerns are present at Glen Aulin (due to the visibility, if limited, of High Sierra Camp structures from the surrounding wilderness) and in Tuolumne Meadows (due to the roadside parking and lodgepole pine encroachment into the meadows). To remedy these concerns, a variety of actions are proposed, such as replacing the Glen Aulin tents to match the surrounding landscape more harmoniously, and eliminating roadside parking. The NPS will manage lodgepole encroachment according to the restoration program discussed under “Subalpine Meadow and Riparian Complex,” above. To prevent concerns from redeveloping, the monitoring program will subject all new proposed structures to a contrast analysis, complemented by periodic monitoring and a suite of actions to be taken if new concerns are identified.



## Recreational Value: Tioga Road Access to the River through Tuolumne and Dana Meadows

### *Scenic Segment: Tuolumne Meadows and Lower Dana Fork*



NPS PHOTO BY KRISTINA RYLANDS

*Tioga Road bridge on Tioga Road in Tuolumne Meadows.*

### **Condition Assessment**

#### **Conditions at the Time of Designation**

At the time of designation, visitors traveling the Tioga Road within the Tuolumne Wild and Scenic River corridor could travel across the Sierra Nevada and enjoy recreational opportunities such as auto touring, sightseeing, trailhead access, and car-based camping. The *Tuolumne Final Study* (USFS and NPS 1979b) noted that Tuolumne Meadows contained one of the largest campgrounds in the national park system and served as a major point of access to the Yosemite backcountry. The study also noted that the number of visitors in the Tuolumne Meadows area reached 3,000 per day during the peak summer season (which included both day and overnight visitors).

#### **Current Conditions**

The Tioga Road continues to provide access to a diversity of recreational and educational opportunities in the Tuolumne River corridor that are easily accessible to people of various ages and abilities. These opportunities have not changed since the time of designation, with the exception that the number of campsites in the Tuolumne Meadows campground has been reduced from about 600 (USFWS and NPS 1979a) to 304 regular sites plus 7 group campsites, as part of redesign to accommodate larger modern recreational vehicles, provide better site separation, and better protect natural features. The most popular activities in the Tuolumne area are

sightseeing/scenic driving, visiting the visitor center, nature study, and day hiking (Littlejohn et al. 2005). In 2009, 64% of summer park visitors reported taking a scenic drive as an activity in which they participated and 11% considered it their primary activity while in the park (Littlejohn et al. 2010).

Access to the meadows and river within the Tuolumne Meadows area remains largely unrestricted. Visitors park wherever they can (often along the shoulders of Tioga Road and other access roads) and walk out into the meadows and along the river shoreline at will, thus creating many informal trails. Although visitors are satisfied with this level of accessibility (see below), the cumulative impacts of current patterns and levels of use are contributing to changes in meadow habitats, as described under “Subalpine Meadows and Riparian Complex,” earlier in this chapter. According to comments received throughout the Tuolumne River planning process, visitors have easy access to important park attractions and vistas, they connect with the natural environment, they experience a sense of freedom, they find it easy to access scenic overlooks/vistas, and they can go “where they want, when they want” (NPS 2006m; White 2011).

The NPS estimates that 4,072 people visit Tuolumne Meadows during peak hours on peak days (see maximum amount of use for the no-action alternative in chapter 7). No comparative data for maximum people at one time are available from the time of designation; however, visitation parkwide has increased by 44% since the Tuolumne was designated (2.74 million in 1984 compared with 3.95 million in 2011 [NPS Public Use Statistics Office]).

Length of stay data from the 2010 visitor surveys in Tuolumne Meadows indicate that approximately 60% of visitors stay more than 24 hours and 40% of visitors stay less than 24 hours. For visitors staying more than 24 hours, the average length of stay was 3.9 days, with a median stay of 3 days. For visitors staying less than 24 hours, the average length of stay was 7.4 hours, with a median stay of 8 hours.

## **Management Concerns**

Internal, tribal, and public scoping produced more comments about the nature of the visitor experience than any other general topic (NPS 2006m). Most of the concerns related to recreational values focus on the Tuolumne Meadows area. As the popularity of the area has increased, crowding and congestion—particularly vehicle congestion and crowding at popular spots along the river and in the meadows—have begun to change the quality of the visitor experience and to adversely affect resources. Many respondents expressed some dissatisfaction with vehicle congestion and crowding at popular spots along the river and in the meadow (NPS 2006m; White 2011). More than a third of all visitors now park in undesignated locations along road shoulders or around the edges of designated parking areas. Parking data collected in 2011 indicate that, of the 870 vehicles found parked in the Tuolumne Meadows area during peak use periods (including both day and overnight parking), only 533 of these vehicles were parked in designated spaces. Parking is essentially unmanaged at Tuolumne Meadows, in that visitors park wherever they can (all visitors do keep their cars on road shoulders, however). Roadside parking creates traffic congestion as cars slow or wait for a parking space to open up, creates safety hazards associated with erratic traffic and pedestrians on the road, and allows the intrusion of parked cars into the views of people taking a scenic drive along Tioga Road. If management action is not taken to protect the visitor experience, future increases in visitation can be expected to increase visitor dissatisfaction and traffic safety hazards, as well as impacts on resources.

## **Actions NPS Will Take to Address these Concerns**

All the action alternatives would eliminate roadside parking along Tioga Road, thereby reducing traffic congestion, safety hazards, and the intrusion of parked cars into the viewing experience of people traveling Tioga Road. With the exception of alternative 1 (which would reduce visitor use to a level that would allow



visitors to have a self-reliant experience), the action alternatives would increase the amount of designated parking, thus making it possible for more visitors to find a space in a designated parking area. All designated parking would be in locations that were protective of all the outstandingly remarkable river values. Formal trail connectors and shuttle bus stops would provide easy access from the designated parking to trailheads and other visitor facilities. Thus, people wishing to park and get out of their cars would have easier access to these destinations than is currently available, up until the time that the designated parking became full. Because the amount of designated day parking would be used to manage the day visitor capacity (established for each alternative), whenever the designated parking was full during peak times, some visitors wishing to park and get out of their cars would no longer be able to do so.

Traffic management would seek to balance the potential for adverse impacts on the visitor experience associated with the frustrations of trying to find a parking space in relatively heavy traffic, with the potential for adverse impacts associated with more intrusive traffic control techniques, such as requiring a parking permit and issuing tickets for illegally parked vehicles (see the discussions of the monitoring program for this value, below, and also the direction provided for management of user capacity under all the action alternatives, in chapter 7). In exchange for these unavoidable adverse effects (which are analyzed in chapter 8), enforcing the user capacity would improve the recreational experience for those visitors who were able to park and get out of their cars by decreasing congestion on trails and at other destinations and by protecting other river values from visitor use-related impacts (as described in the discussions specific to those values).

## **Management Indicator and Monitoring Program**

### **Indicator Description: Vehicles Parked Compared to Designated Parking Supply**

The number of vehicles parked at any one time in the Tuolumne Meadows area can now be extrapolated from data produced by vehicle volume counters, using a coefficient derived from comparing vehicle volumes to actual counts of parked cars conducted in 2006 and 2011. Through these extrapolations and direct observation, the total vehicles parked at one time in the Tuolumne Meadows area can be compared to the designated parking supply to evaluate compliance with designated parking regulations.

The indicator will document any parking shortages during the busiest days of the year and guide management in determining the most appropriate traffic management actions for minimizing impacts on the experience of visitors accessing the river corridor via Tioga Road. Because the availability of day parking will be used to enforce the day visitor capacity, some visitors will unavoidably be displaced to other locations; the intent of this indicator will be to help managers manage traffic to minimize the adverse impact on all visitors.

### **Definitions of Management Standard, Adverse Impact, and Degradation**

The definitions of management standard, adverse impact, and degradation compare cars parked with the number of designated parking spaces. Peak volumes between Tuolumne Meadows and Tioga Pass vary from 140 to 150 vehicles per hour for westbound traffic, and 155 to 170 vehicles per hour for eastbound traffic. Travel patterns could change, resulting in consistent peak hourly volumes but increased daily volumes. During the 2006 data collection, peak daily volumes were 1,450 vehicles westbound and 1,715 eastbound (DEA 2007). The NPS 2011 study collected parking data on eight days, capturing both early morning (overnight parking) and peak hour parking data. Excluding the campgrounds, peak hour parking counts in the 2011 study ranged from 589 to 870 at Tuolumne Meadows.

### **Management Standard**

Parking design has typically sought to accommodate parking demand on the seventh to tenth busiest day of the year (NPS 2008b). Adapting this practice to this standard and translating the tenth busiest day to a percent (10%), the management standard is defined as vehicles parked do not exceed parking supply more than 10% of the time at peak hour.

### **Adverse Impact**

An adverse impact is defined as parked vehicles exceeding the parking supply 50% of the time at peak hour, or an increase of 30% or more in exceeding parking supply within a three-year sample.

### **Degradation**

Degradation is defined as parked vehicles exceeding the parking supply 80% of the time at peak hour.

## **Current Findings Regarding Management Standard, Adverse Impact, and Degradation**

Parking supply is currently elastic, in that the lack of restrictions allows visitors to seek and use additional undesignated parking during periods of high demand; however, if parking supply is defined as designated parking (as it needs to be to protect river values), then parked cars exceed the parking supply by 39% at peak hour. This impact will be addressed by actions to manage the visitor user capacity, described above, and through long-term monitoring to ensure the proposed management is effective, as described below.

## **Monitoring Program to Prevent Future Adverse Impacts or Degradation**

As required by the guidelines implementing WSRA, the NPS will conduct a program of monitoring and ongoing study during and following the implementation of the *Tuolumne River Plan* to ensure that river values are enhanced where necessary and protected throughout the life of the plan. For this outstandingly remarkable recreational value (Tioga Road access to the river through Tuolumne and Dana Meadows), monitoring will be conducted to ensure that management of day parking is effectively protecting river values, including the quality of the visitor experience. A key part of this program will be management triggers intended to identify and address management problems before adverse impact occurs.

### **Monitoring Protocols**

NPS will use automated counters to monitor inbound and outbound travel in the Lower Dana Fork and Tuolumne Meadows segments to determine whether relationships across use levels remain similar over time. Parking in unauthorized locations (where parked vehicles and associated informal trails could affect vegetation and soil, cause traffic congestion and visitor safety issues, and affect scenic values) will be monitored by direct observation.

Baseline monitoring will occur annually for the first three years of implementation to account for the change in infrastructure resulting from implementation of the selected *Tuolumne Wild and Scenic River Plan/Draft EIS* alternative. Thereafter, monitoring to detect change is expected to take place one out of every three years. This monitoring schedule will ensure that both segmentwide and site-specific information is understood.

Unauthorized parking locations that are curbed or barricaded with natural features will be evaluated for their effectiveness in protecting river values, particularly during busier times of the peak visitor season.

### **Triggers and Management Responses**

Table 5-14 shows triggers at which action will be taken to address management concerns that arise.

**Table 5-14.**  
**Triggers and Management Responses to Protect River Values by Managing Tioga Road Access to the River through Tuolumne and Dana Meadows**

Trigger	Management Response	Rationale
Parked vehicles exceed parking supply 10% of the time for three consecutive years.	Increase monitoring of vehicle volumes, parking, and travel time conditions. Increase educational efforts within the park. Increase pre-trip planning educational efforts for prospective visitors. Redouble efforts to enforce parking restrictions. Escalate parking enforcement.	Exceeding the management standard routinely warrants further identification of the issue. Exceeding the management standard routinely warrants assurances that visitors are not parking in locations not specifically designated for day or overnight parking.
<b>Approaching Adverse Impact:</b> Parked vehicles exceed parking supply 40% of the time during peak hour, or a change of 25% or more in exceeding parking supply over a three-year sample.	Implement parking reservation system; provide alternative transportation on shuttle system subject to that system's limitations.	Given the legal ramifications of reaching adverse impacts in accordance with the WSRA, aggressive visitor use management measures will be put in place to reduce parking demand on the finite supply of parking in the Tuolumne River corridor.

WSRA = Wild and Scenic Rivers Act

## **Conclusions: Protecting and Enhancing Tioga Road Access to the River through Tuolumne and Dana Meadows**

The Tioga Road continues to provide access to a diversity of recreational and educational opportunities in the Tuolumne River corridor that are little changed since the time of designation. Access to the meadows and river within the Tuolumne Meadows area remains largely unrestricted, and visitors report satisfaction with their ability to go “where they want, when they want.” However, visitors also report dissatisfaction with vehicle congestion and with crowding at popular spots along the river and in the meadows. Unrestricted access also contributes to impacts on other outstandingly remarkable river values, as more than a third of all visitors currently park along the road shoulder and create informal trails across the meadows and along the riverbanks to reach popular attractions.

Under the *Tuolumne River Plan*, the roadside parking along Tioga Road will be eliminated, thus reducing the traffic congestion, safety hazards, and intrusion of parked cars into the viewing experience of people traveling on Tioga Road. Under most alternatives presented in chapter 7, the amount of designated parking would be increased to make it possible for more visitors to find a space in designated parking areas. Also, under all the action alternatives, a visitor capacity will be enforced to protect the quality of the visitor experience from increasing congestion and to protect other river values from visitor use-related impacts. The day use capacity will be managed through the availability of day parking and the capacity of the buses that serve the Tuolumne River corridor, while the overnight capacity will be managed by the number of lodging units, campsites, and wilderness permits.

The effectiveness of using the day parking supply at Tuolumne Meadows to manage the day use capacity in all the river segments above Hetch Hetchy Reservoir will be monitored through an indicator that compares the number of vehicles actually parking in the Tuolumne Meadows area with the supply of designated parking provided under the plan. Additional management actions to identify issues and enforce the designated user capacity will be triggered by the exceedance of standards developed for this indicator.

## Recreational Value: Wilderness Experience along the River

***Wild Segments: Lyell Fork, Upper Dana Fork, Grand Canyon of the Tuolumne, and Poopenaut Valley***



NPS PHOTO BY KRISTINA RYLANDS

*Backpackers along the Grand Canyon of the Tuolumne.*

### **Condition Assessment**

#### **Condition at the Time of Designation**

Wilderness along the Tuolumne River offered outstanding opportunities for recreation characterized by self-reliance and solitude. This experience was being protected by an overnight zone capacity and associated trailhead quota system, which had been implemented in response to concerns about increasing visitor use in the Yosemite backcountry, as described below.

As the popularity of backpacking increased in the late 1960s and 1970s, campsites proliferated throughout Yosemite's backcountry. Some areas had hundreds of campsites, and documented impacts included vegetation loss, soil compaction, firewood depletion, and informal trail formation. In response, the Yosemite wilderness zoning and trailhead quota system was developed in the 1970s (van Wagtendonk and Coho 1980 and 1986). The backcountry was divided into travel zones. The capacity within each zone was based on its size, miles of trails, and desired sociological densities for campsites and trails. These values were then adjusted downward to account for ecological factors. Capacities were reduced in zones that contained rare or vulnerable ecosystems (such as the subalpine meadows in the Tuolumne River corridor) or ecosystems that had a low potential for

recuperation and repair (such as alpine meadows). While this research took place more than 30 years ago, the ecological and social factors that the capacities are based on are little changed (NPS, Fincher 2010m).

By the time the river was designated (the same time that the Yosemite Wilderness was designated), the zone capacities and associated trailhead quotas were limiting the number of overnight visitors in the wilderness, thus limiting the number of campsites and encounters with other parties. Requiring a wilderness permit also allowed NPS staff to have a face-to-face educational contact with every party spending the night in the wilderness. Leave-No-Trace education and low-impact camping practices helped protect wilderness and river values. Campers learned how to minimize or avoid impacts on water quality, sensitive resources, and wildlife by, for example, camping in existing sites, minimizing trips to water to avoid using or forming informal trails, properly disposing of human waste and dishwater, leaving artifacts where found, and storing food to prevent feeding wildlife.

The zoning and quota system was not designed to work by itself in limiting these impacts. Monitoring and restoration of backcountry campsites started in the 1960s. Campsites close to water were restored to natural conditions, and camping was encouraged in more resilient locations already used for camping. By the time of the Tuolumne River's designation, these efforts had started to improve ecological conditions in the backcountry and the associated wilderness experience.

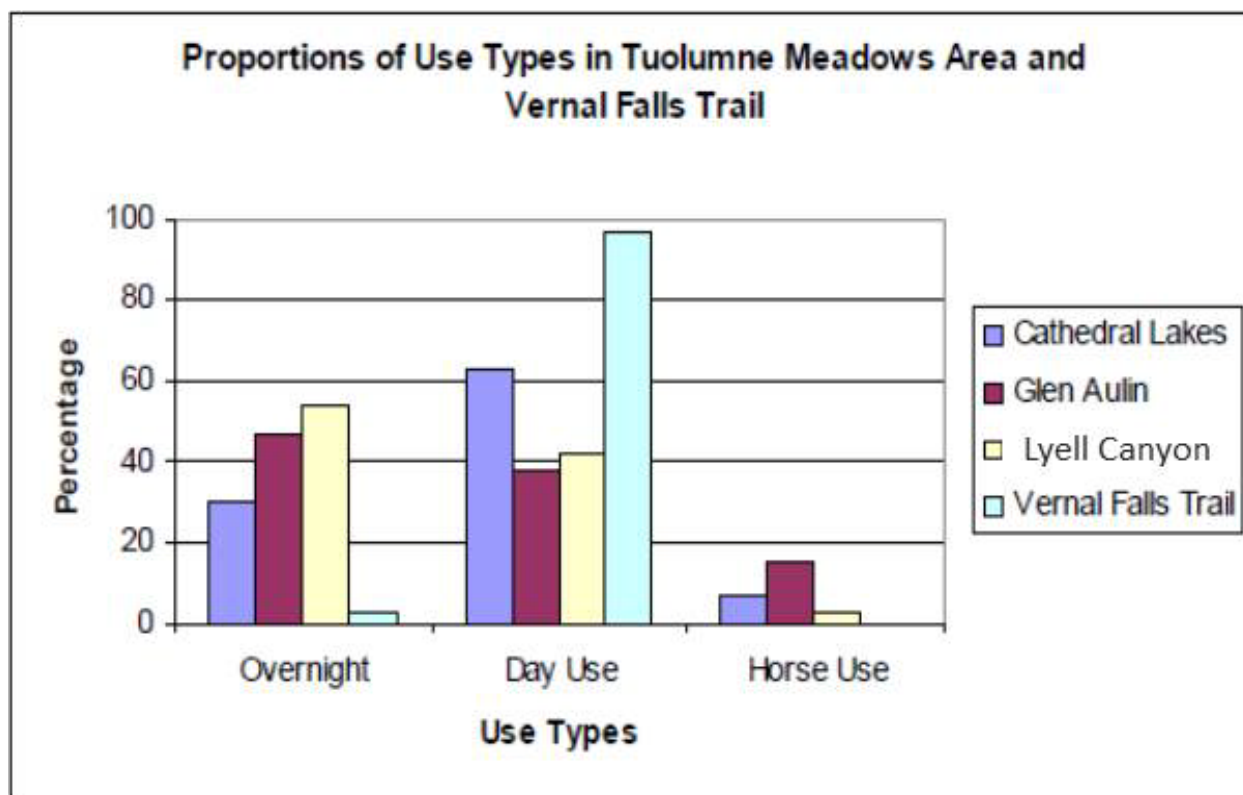
## **Current Conditions**

The wild segments of the Tuolumne River corridor continue to offer a variety of opportunities for solitude and self-sufficient recreation, with visitors enjoying the same activities they did in 1984. Use in designated wilderness remains largely unconfined. River values are protected by the wilderness zoning and overnight trailhead quota system, restrictions on camping in sensitive areas, and group size limitations.

Variables monitored to determine the effectiveness of the zone capacities and trailhead quotas include water quality, meadow health, formal trail conditions, informal trails, day use levels, encounters with others on trails, and campsite numbers and condition. Monitoring of wilderness campsites provides a good example of observed trends. Campsite numbers and conditions were inventoried in 1972 (NPS, Holmes 1972) and then in the 1980s (this time using the Wilderness Inventory and Monitoring System (WIMS) (NPS, Sydoriak 1986b). In the 1990s and again in the 2000s, NPS assessed a representative sample of wilderness campsites (WIMS 2 and WIMS 3). Analysis of these four data sets (spread over 35 years) shows a positive trend and steady improvement over time. The total number of campsites is decreasing, sites with large impacts are being restored, and overall impacts continue to show a significant decrease with each round of monitoring. As an example of this trend at a specific location, when Pate Valley was surveyed in 1984 (the year the Tuolumne Wild and Scenic River was designated), 18 campsites were recorded, while a 2006 survey recorded only 9 campsites. In 1984, five of the sites were within 25 feet of water; in 2006 only one site was that close (NPS, Fincher 2010m).

Monitoring of resource conditions has led to adjustments in the wilderness trailhead quotas, and by extension, the zone capacities themselves. In 1984, for example, the trailhead quota for Lyell Canyon was 50 people per day. The quota has since been lowered to 40 people per day to further enhance the wilderness recreational experience. In contrast, at Glen Aulin, the management response was to establish a designated backpacker campground. As a result, more people could be accommodated with less physical impact, and the trailhead quota was raised from 25 to 35 people per day. Other management responses to undesirable impacts discovered through this monitoring have included site-specific regulations (such as prohibiting fires), increased ranger patrols, and major restoration efforts. Lyell Canyon, in particular, has seen extensive restoration of campsites since 1984 (NPS, Fincher 2010m).

The monitoring data indicate that with the quota system in place, visitors' overnight wilderness experiences are protected from crowding and perceptions of human disturbance. However, this quota system can temporarily deny some individuals access to a particular location on a particular date if the quota is already filled. Overnight wilderness visitors' attitudes about their wilderness experience were studied from 2001–2002 (Newman 2002). Respondents were asked to trace their daily route of travel and make evaluative judgments concerning qualities that contributed to a positive wilderness experience. Factors found to be important included (1) signs of human use at camping sites, (2) numbers of people encountered per day when hiking, (3) encountering stock or signs of stock use, (4) regulation of camping, (5) the chance of obtaining a wilderness permit, and (6) the opportunity to camp out of sight and sound of other groups. The study suggested that Yosemite Wilderness visitors are willing to trade some freedoms, such as camping regulation and some degree of access, in order to obtain a high quality recreational experience (Newman 2002).



Source: Pettebone et al. 2008. Vernal Falls, which is not in the Tuolumne River corridor, is included for comparison.

**Figure 5-13. Mean Hourly Visitation at Three Primary Tuolumne Meadows Trailheads.**

While overnight visitation to the Yosemite Wilderness has decreased substantially since the zone capacity and trailhead quota system was instituted, demand for wilderness permits in the Tuolumne River corridor remains well above the quotas. Thus the quota system is still vital in protecting river values from the potential threats listed above.

By 2008, one-third to over one-half of use on the three major trailheads originating in Tuolumne Meadows (Glen Aulin, Cathedral Lakes, and Twin Bridges along the Lyell Fork) was day use (see figure 5-13) (Pettebone et al. 2008). Increasing day use levels have contributed to increased perceptions of crowding on trails within a day hike of Tuolumne Meadows trailheads, particularly on the trail following the river from Tuolumne Meadows to Glen Aulin.



## **Management Concerns**

The number of people encountered per day when hiking in the Yosemite Wilderness was identified as a concern of overnight wilderness users in the Newman study (2002). Increasing day use on wilderness trails within the first few miles of Tuolumne Meadows trailheads is not addressed by the wilderness overnight zone capacities and associated trailhead quota system. Another identified concern was encountering stock or signs of stock use. Wilderness overnight users also identified concerns about signs of human use at camping sites, regulation of camping, the chance of obtaining a wilderness permit, and the opportunity to camp out of sight and sound of other groups.

## **Actions NPS Will Take to Address these Concerns**

Designated wilderness within the wild segments of the Tuolumne River corridor will continue to be managed in accordance with the Wilderness Act and its implementing regulations and NPS policies. The impacts of the *Tuolumne River Plan* on wilderness character are addressed in chapter 8.

In addition to the guidance provided by the current *Wilderness Management Plan* and the upcoming *Wilderness Stewardship Plan*, the *Tuolumne River Plan* will guide management of wild segments within the river corridor to protect and enhance river values. Specifically, the *Tuolumne River Plan* will address concerns about encounters with other groups and potential conflicts between hikers/backpackers and stock users. The plan will establish an indicator and management standard for wilderness trails that are within a day's hike of Tuolumne Meadows to protect the river-related wilderness experience in wild segments of the Tuolumne River corridor. For any trail segment on which the management standard is not being met, the NPS will increase monitoring, inform visitors about alternative trails within the corridor, and encourage visitors to hike during days and times of day at which lower encounter rates occur. If encounter rates increase despite these efforts, the NPS will establish a day use permitting system and make necessary changes in the backcountry quota system to better manage for opportunities for solitude.

Stock use will be reduced under all the alternatives to enhance the opportunity for a wilderness experience along the river with a reduced potential for conflicts between hikers/backpackers and stock users. Commercial stock use would be eliminated under some, but not all, the alternatives.

The NPS has found the wilderness overnight zone capacities to be an effective tool for keeping use within the standards to be adopted under the *Tuolumne River Plan*. Monitoring of impacts on river values from wilderness camping under the existing capacities will be sufficient to ensure that river values are being protected and enhanced.

## **Management Indicator and Monitoring Program**

### **Indicator Description: Number of Encounters with Other Hiking Parties per Hour**

One of the components of this outstandingly remarkable recreational value (wilderness experience along the river) of the Tuolumne River is the opportunity for solitude, which is an enduring characteristic of a wilderness experience (Lucas 1964). Expectations for solitude and actual numbers and types of groups encountered have been shown to have a significant effect on the quality of visitor experiences (Newman and Manning, 2002; Patterson and Hammitt 1990; Vaske et al. 1986). Although some studies have shown a weak relationship between encounters and visitor perceptions of solitude and crowding (Graefe et al. 1984; Lee 1977; Stewart and Cole 2001), there exists a substantial body of literature to support the use of encounters as an indicator of solitude opportunities in wilderness (Broom and Hall 2009; Graefe et al. 1984; Lee 1977; Manning et al. 2000; Stewart and Cole 2001; Vaske and Donnelly 2002).

The number of encounters has been chosen by many wilderness managers as an indicator for the social setting, not only because encounters among groups have an effect on solitude but also because field measurements are easy to accomplish (Watson et al. 1998). Researchers and managers have at times chosen to monitor the number of individuals encountered, rather than the number of groups, due to difficulties distinguishing individuals' affiliations to others, especially in busy areas (Shelby and Heberlein 1986). However, where possible, documenting each group encountered as well as the number of people in the group will provide the most flexibility for subsequent analysis (Broom and Hall 2010).

Encounters are also an excellent way to assess use levels and density, which can affect other outstandingly remarkable values, such as the biological and cultural values identified for the Tuolumne River Wild and Scenic River.

## **Definitions of Management Standard, Adverse Impact, and Degradation**

### **Management Standard**

The management standard is defined as a mean encounter rate (across all designated trail sections sampled within a river segment) of no more than 10 encounters with other groups per hour, 80% of the sampled time (or more), exceeded no more than two out of three consecutive years.

The standard has been derived from several years of data collection on trails located throughout Yosemite National Park and representing varying levels of use (Broom and Hall 2010; Pettebone et al. 2010). Several studies have examined visitor preferences toward encounters in wilderness areas that support the chosen thresholds (Broom and Hall 2009; Cole and Hall 2008). The numerical threshold takes into account a sampling strategy that includes a high-use destination and a low- to moderate-use destination in each segment.

### **Adverse Impact**

Adverse impact is defined as a mean encounter rate (across all designated trail sections sampled within a river segment) exceeding 12 encounters with other groups per hour more than 20% of the sampled time, in both the Lyell Fork and Grand Canyon segments, for three consecutive years.

Monitoring for a downward trend toward the adverse impacts threshold of 12 encounters with other parties per hour 80% of the time allows for fluctuation in visitor use and offers management the ability to take measures to reduce the impact in a timely manner. This threshold is also consistent with management guidelines at Mount Rainier National Park for the standard for high- use climbing zones (Lah 2000). The level of adverse impact in the Tuolumne River corridor was determined through multiple years of indirect and direct sampling, looking at use in other areas of the park, the high use of adjacent trails (Pettebone et al. 2010), and visitor preferences expressed in studies of high-use destinations in wilderness (Cole and Hall 2008).

### **Degradation**

Degradation is defined as a mean encounter rate (across all designated trail sections in a river segment) exceeding 20 encounters with other groups per hour more than 20% of the sampled time, in both the Lyell Fork and Grand Canyon segments combined, for three consecutive years.

Degradation for wilderness encounters is defined at the level at which visitors perceive crowding is beyond an acceptable level. Encounter rates above this level cause displacement of visitors and detract from the visitor's experience (Cole and Hall 2008). This standard is based on observations from several years of encounter data in the Tuolumne River corridor as well as preferences from hikers in studies of wilderness use in the Pacific Northwest (Broom and Hall 2010; Cole et al. 1997). Although the literature offers insight into visitor

preferences regarding encounter rates and there are sufficient data on Yosemite trail encounters, managers must consider management objectives to set standards (Cole et al. 1997).

## Current Findings Regarding Management Standard, Adverse Impacts, and Degradation

The encounter rate on the trail to Glen Aulin occasionally reached 8 encounters with other groups per hour in 2010 (Broom and Hall 2010). Encounter rates on other trails were below that number. For all wild segments, the management standard for this recreational value was being met in 2010 (see table 5-15). Data from 2011 are still being analyzed.

**Table 5-15.**  
**Current Condition of Wilderness Experience Based on Mean Encounter Rate**

Standards	Current Conditions, 2010 (All Wilderness Trail Segments)
<b>Management Standard:</b> Mean encounter rate $\leq 10$ per hour, 80% of sampled time	All trails have a mean encounter rate of less than 8 per hour, with the trail to Glen Aulin approaching this rate.
<b>Management Concern</b> Mean encounter rate 10–12 per hour, 80% of sampled time	
<b>Adverse Impact:</b> Mean encounter rate $> 12$ per hour, 80% of sampled time	
<b>Degradation:</b> Mean encounter rate 20 per hour $> 20\%$ of sampled time	

## Monitoring Program to Prevent Future Adverse Impacts or Degradation

As required by the guidelines implementing WSRA, the NPS will conduct a program of monitoring and ongoing study during and following the implementation of the *Tuolumne River Plan* to ensure that river values are enhanced where necessary and protected throughout the life of the plan. A key part of this program will be management triggers intended to ensure that any downward trend in conditions can be identified and arrested well before adverse impact occurs.

### Monitoring Protocols

Automated counts of visitor trail use will occur annually along high-use trail segments. A recent study demonstrated that when based on direct counts, accurate encounter rates can be generated using automated trail counters (Pettebone et al. 2010). Prior sampling showed a relationship between indirect and direct counts (Broom and Hall 2010). Monitoring annually by indirect counts will reduce the burden on managers and provide reliable data on encounter levels on the trail segments. An annual analysis of these counts will provide management the best available data to make decisions.

Four locations have been selected to represent varying levels of use along trails within the Tuolumne Wild and Scenic River corridor: (1) the section of the Glen Aulin trail from the Young Lakes junction to Glen Aulin, (2) the trail from Glen Aulin to Waterwheel Falls, (3) the Grand Canyon of the Tuolumne trail from Pate Valley to the Rogers Creek bridge, and (4) the section of the Lyell Canyon trail from Rafferty Creek to the Ireland Lake junction. High-use trail sections will be monitored annually during the high-use season using automated counters. Actual encounters or direct counts will be collected at low-use and moderate-use sites every five years. Monitoring may occur with more frequency, depending on trends or trigger points being reached. Direct counts will be conducted along high-use trails as necessary to ensure that there is no significant downward trend towards an adverse impact. The status of this outstandingly remarkable recreational value will be evaluated by examining the mean encounter rates for all designated trail sections in the Tuolumne River corridor, as well as encounter rates for each individual sampling location. Mean encounter rates along individual trails and across the corridor will be used to inform management actions.

## Triggers and Management Responses

Table 5-16 summarizes the management triggers and responses to protect a wilderness experience along the Tuolumne River.

**Table 5-16.**  
**Triggers and Management Responses to Protect a Wilderness Experience along the River**

Trigger	Management Response	Rationale
Encounter rate exceeds 10 encounters with other groups per hour more than 20% of the time on an individual trail section in a single monitoring year. (This trigger would require action while the condition was still within the standard because the standard would not be exceeded until encounter rates reached this level across all the trail sections sampled within the river segment and for two of three consecutive years.)	Increase sampling intervals at low-use and moderate-use sites for direct observation. Increase direct observation sampling interval at high-use trail sections. Disseminate information to visitors regarding alternative trails within corridor. Encourage visitors to hike during days and times of day at which lower encounter rates occur.	Additional information is needed to determine that conditions are not trending toward adverse impacts.
Encounter rate exceeds 10 encounters with other groups per hour more than 20% of the time for three consecutive years on an individual trail section.	Make necessary changes in the overnight trailhead quota system to better manage for opportunities for solitude. Establish day use parking permits and institute changes to shuttle system to manage the number of people arriving at trailheads feeding trail sections that have exceeded the trigger point.	Trailhead quotas control the amount of overnight use in the wilderness segments of the Tuolumne River corridor. This standard will assist in determining whether the existing quotas and associated zone capacities sufficiently provide opportunities for solitude.
Encounter rate exceeds 10 encounters with other groups per hour more than 20% of the time for three consecutive years across all trail sections within the segment.	Establish a trailhead day use quota and permit system for trail sections that have exceeded the trigger point. Make necessary changes in backcountry quota system to better manage for opportunities for solitude. Institute hard closures of trailheads or parking as necessary to regulate use of wilderness corridor.	If the management standard is exceeded for the segment level, and an opportunity for solitude is not provided, aggressive actions are necessary to regulate the flow of individuals into wilderness.

## Conclusions: Protecting and Enhancing the Wilderness Experience along the River

At the time of designation, the wild segments of the Tuolumne River offered outstanding opportunities for river-related recreation characterized by self-reliance and solitude, and those opportunities continue today. Since the 1970s, an overnight zone capacity and trailhead quota system has helped protect this river value, particularly in more remote portions of the corridor. However, increasing day use on wilderness trails within the first few miles of the Tuolumne Meadows trailheads now threatens to diminish opportunities for solitude on certain trail segments. The *Tuolumne River Plan* will address this management concern by managing day use levels in the river corridor and by monitoring the indicator of encounters with other groups on trails, which is a widely used indicator for a quality wilderness experience. Use on wilderness trails will be managed to remain within the management standard established for this indicator through actions that could include changes to the overnight trailhead quota system and/or the implementation of a day use trailhead quota system if determined necessary.

# Water Quality

## Condition Assessment

### Conditions at the Time of Designation

At the time of designation, the Tuolumne River corridor was characterized as having generally high-quality water that was low in dissolved nutrients, had low conductance, adequate dissolved oxygen, and pH in the range expected for granitic watersheds. In 1979, prior to designation, a portion of the river at Tuolumne Meadows had elevated coliform and biological oxygen demand levels that were associated with large numbers of recreational users and the proximity of a wastewater treatment plant to the river (USFS and NPS 1979b). Shortly thereafter, the NPS rebuilt the wastewater treatment plant, thus solving the elevated coliform and associated problems.

Previous impacts on water quality at Glen Aulin were addressed in 1983, prior to designation, by replacing the septic tank and leach mound at the High Sierra Camp and by installing a composting toilet facility at the backpacker camp. Manure at the stock corral, which was relatively close to the river at that time, may have affected water quality.

### Current Conditions

Water quality in the Tuolumne River is exceptionally high and superior to state standards (NPS 2009k; SFPUC 2009; NPS 2011d). Levels of coliform and biological oxygen demand, which had been elevated in Tuolumne Meadows prior to designation, are now within established NPS standards throughout the river corridor. No samples collected between 2006 and 2010 fell below NPS water quality standards. Data from several of these years were used to establish the management standard, which requires water quality far superior to existing state and U.S. Environmental Protection Agency (USEPA) standards.

Because water quality in the Hetch Hetchy Reservoir is critical to the water supply for the City of San Francisco, the 1913 Raker Act grants the city the authority to protect the Hetch Hetchy watershed. The city has implemented requirements for the treatment or disposal of sewage and garbage, and restrictions on bathing, washing clothes or cooking utensils, watering stock, or any other activity that could pollute the watershed (SFPUC 2008). Water quality data collected by the NPS and the SFPUC in 2006–2009 show that the water quality of the Hetch Hetchy water supply remains exceptional.

Numerous actions have been taken over the past two decades to reduce risks to water quality. In the Tuolumne Meadows area, actions have included relining wastewater containment ponds, removing underground tanks at the public fuel station, repairing and installing new sewer lines, and removing manure from stables and trails. At the Glen Aulin High Sierra Camp, actions have included enforcing water use restrictions, moving the corral for the concessioners' stock farther from the river, and removing manure. In 1993, the NPS constructed a backpacker campground with about 32 sites to relocate campers and their associated potential effects on water quality (such as soil erosion and human waste) away from Conness Creek. Regulations protective of water quality and other river values are enforced by rangers hired specifically for that purpose.

The “little blue slide” is a road cut along the Tioga Road just east of Tuolumne Meadows and immediately adjacent to the Dana Fork. Continuous sloughing of material including silt and sand from the cut affects water turbidity, as described in greater detail immediately below.

## **Management Concerns**

The primary concern for water quality in the Tuolumne River corridor is caused by the “little blue slide.”

Impacts on river values from this road cut include reduced water quality and impacts on river habitat. Under-snow winter runoff, spring runoff, summer storms, and emerging groundwater are continually depositing silt into the Dana Fork at this location and undermining larger boulders that fall onto Tioga Road. Silt washed from the fill slope below the road sinks to the bottom of the river. According to NPS specialists in Yosemite and in the agency’s Water Resources Division in Fort Collins, Colorado, the cut has destabilized the slope both above and below the road and it will not stabilize without intervention (NPS, Noon and Martin 2010d). While sediments do indeed enter the Dana Fork, water quality in the fork remains excellent, and state turbidity standards are not exceeded.



NPS PHOTO BY KRISTINA RYLANDS

*Fine soils along a portion of Tioga Road can contribute to river turbidity during storm events.*

Other management concerns regarding water quality are present in the corridor. While the NPS operates in compliance with Central Valley Regional Water Quality Control Board permits, changes to the wastewater treatment facilities at Tuolumne Meadows would require upgrades to meet current standards. Potential wastewater leaks from the containment ponds in Tuolumne Meadows pose a risk to water quality, as does the potential for saturation of the sprayfield (SFPUC 2009). Past impacts associated with leakage from the wastewater line that runs beneath the river and meadow from the wastewater treatment plant to the wastewater ponds have been corrected by the installation of a new line. However, the risk of future impacts cannot be totally eliminated so long as the line remains in place.

Impacts from the fuel facilities at Tuolumne Meadows have been corrected and were mitigated between 1997 and 2005 (SFPUC 2009). However, the potential for future impacts cannot be totally eliminated as long as fuel facilities remain. Two vapor-extraction cleanup projects associated with older buried tanks are ongoing. In addition, the fuel station is required to operate according to all applicable state laws and best management practices, including having a spill prevention plan. The concern that water quality could be affected remains, even though water quality is excellent.

The leach mound associated with the High Sierra Camp septic system at Glen Aulin was found to be over capacity in 1997. The system was unable to adequately treat previous levels of wastewater, prompting restrictions in 2002 that capped water use at a maximum 700 gallons per day to protect water quality. In 2010 water use was further restricted to 600 gallons per day. Because of these measures, leach mound failure has been avoided. However, the risk to water quality from failure of the minimally sized leach mound remains.



A microbial water quality study in the Tuolumne River watershed considered the potential risk of surface water contamination by pack stock (Atwill et al. 2008). This study focused on *giardia* and *cryptosporidium* shedding by pack stock. While the study suggests that pack stock-associated waterborne contamination was of low concern, the study's authors made several recommendations to protect water quality. For example, since most manure occurs within the first 0.25 mile of trails from stable operations, the study authors recommended that trails be patrolled and manure removed from watercourses in these areas. These management practices are now ongoing.

## **Actions NPS Will Take to Address these Concerns**

Under all alternatives, the “little blue slide” east of Tuolumne Meadows along Tioga Road will be stabilized to reduce the erosion of silt into the Dana Fork. Stabilization of the site will require development of an engineering and revegetation strategy, followed by extensive manipulation of the cut slope above the road and the fill slope below the road. The stabilization strategy will be protective of the scenic values within the lower Dana Fork and Lyell Fork segments of the river.

All alternatives call for the Tuolumne Meadows wastewater treatment plant to be upgraded at its current location (the possibility of relocating the plant was considered but dismissed for reasons discussed at the end of chapter 7 under “Alternatives Dismissed from Further Consideration”). The design capacity of the new plant will depend on the visitor use alternative selected. The wastewater containment ponds and sprayfield on the north side of Tioga Road will either be improved to mitigate risks to water quality or replaced with facilities on the south side of Tioga Road. Site-specific planning for the plant, the containment ponds, and the sprayfield will be conducted after the NPS selects an alternative in a formal record of decision. This site-specific planning must ensure that risks to water quality are reduced and that meadow/riparian and scenic values remain protected.

The risk to water quality associated with stable operations will continue to be mitigated by best management practices, including manure removal from corrals and water courses within the first 0.25 mile of trails leading from stable operations. These practices have been successful in protecting water quality. The sizes and specific locations of the NPS and concessioner stable operations vary among the alternatives.

Risks from fuel storage tanks have been mitigated by secondary containment and periodic testing, as required by California regulations. The retention or removal of commercial fuel storage tanks, and the location of administrative fuel storage tanks, vary among the alternatives. After the NPS has selected an alternative in a formal record of decision, any additional implementing actions for protecting river values will be incorporated into the final *Tuolumne River Plan*.

The risk to water quality at the Glen Aulin High Sierra Camp would be addressed differently among the various alternatives (see chapter 7). After the NPS has selected an alternative in a formal record of decision, it will be incorporated here as part of the final *Tuolumne River Plan*.

## **Management Indicators and Monitoring Program**

### **Indicator Description: Nutrient Levels, *E. Coli*, and Hydrocarbons**

Nutrient levels (total dissolved nitrogen, total phosphorus, nitrate plus nitrite, and total dissolved phosphorous), *Escherichia coli* (*E. coli*), and hydrocarbons are appropriate indicators for monitoring water quality because their levels can be tied to human activities and human contact with water. The State of California has proposed replacing the more general fecal coliform indicator with *E. coli* as a more direct indicator of human disease potential. Adoption of this indicator is on hold until the USEPA finishes a court-

mandated review of bacteriological criteria, due in October 2012. Given the likelihood that state standards will change, coupled with the need to establish baseline conditions, the NPS herein is adopting *E. coli* rather than fecal coliform as an indicator of water quality, along with nutrient levels and hydrocarbons.

## Definitions of Management Standard, Adverse Impact, and Degradation

### Management Standard

The management standard for water quality is defined as the baseline established in the 2005–2008 period, with nutrients, *E. coli*, and petroleum hydrocarbons all measured. The management standard for nutrients is exceeded when the 75th percentile of annual sampling exceeds the 95% upper confidence limit of the baseline condition in more than one in five years at any sample location. The management standard for *E. coli* is exceeded when the 50th percentile of annual sampling exceeds the 95% upper confidence limit of the baseline condition in more than one in five years at any sampling location. The standard for petroleum hydrocarbons is exceeded when they are detected (at current detection limits) in more than one in five years.

Water quality criteria for the Tuolumne River above Lake Don Pedro were established by the California Water Control Board through the *Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins*. The *Basin Plan* adheres to the Federal Anti-degradation Policy (40 *Code of Federal Regulations* [CFR] 131.12) as follows:

*Chief among the State Water policies for water quality control is State Water Board Resolution No. 68-16 (Statement of Policy with Respect to Maintaining High Quality of Waters in California). It requires that wherever the existing quality of surface or ground waters is better than the objectives established for those waters in a basin plan, the existing quality will be maintained unless as otherwise provided by Resolution No. 68-16 or any revisions thereto.*

### Adverse Impact

Adverse impacts on water quality are defined as the occurrence of either or both of the following: (1) exceedance of the draft USEPA bacteriological criteria for water contact recreation *E. coli* one-day standard of 235 most probable number of bacterial colonies (MPN, the standard unit used to measure *E. coli* bacteria in water) per 100 milliliter (ml) and subsequent exceedance of the 90-day geometric mean standard of 126 MPN/100ml, or (2) exceedance of USEPA maximum contamination level for nitrate+nitrite of 10 milligrams per liter (milligrams of nitrate and nitrite expressed as the weight of elemental nitrogen). Exceedance of this bacteriological standard indicates a persistent contamination problem beyond normal flushing summer or fall rainstorms and would likely result in a violation of state water quality standards (protecting the designated beneficial use of Tuolumne River waters for recreational contact) when they are established after October 2012. Exceeding the nitrate+nitrite criteria would violate state water quality standards as they are applied to municipal water sources. The *Basin Plan* specifies that waters designated for municipal use must also adhere to California drinking water regulations (title 22), which include the USEPA maximum contaminant limit for nitrate+nitrite. It should be noted that current levels of nitrate+nitrite are only 1% to 10% of this maximum contaminant limit.

## Degradation

The degradation standard is defined as the inclusion of any Tuolumne River segment on the state listing under section 303d of the Clean Water Act of waters not attaining minimum water quality objectives. For the Tuolumne River and the chosen water quality indicators, this would occur when there were 10 or more violations (exceedances) of the USEPA water quality standards over the course of the 303d reporting period of three years. States are mandated by section 303(d)(1) of the Clean Water Act [40 CFR 130.7(b)] “to identify waters that do not meet applicable water quality standards with technology-based controls alone and prioritize such waters for the purposes of developing Total Maximum Daily Loads (TMDLs)” (CWRCB 2004).

## Current Findings Regarding Management Standard, Adverse Impact, and Degradation

In the summer of 2010, the NPS sampled water monthly in five locations on the Tuolumne River. All sites were sampled for total dissolved nitrogen, nitrate+nitrite, total phosphorous, and total dissolved phosphorous. *E. coli* was only sampled at frontcountry sites because of the maximum six-hour hold time for these samples. The river was also sampled for total petroleum hydrocarbons at four locations downstream of developed areas. Field staff also measured water temperature, specific conductivity, pH, and dissolved oxygen at all sites, and noted river stage where possible (NPS 2009k). Nutrient and *E. coli* concentrations were not significantly different (at the 95% confidence level) from conditions during 2005–2008, the period of baseline data used to establish the management standard (NPS 2009k). Samples were of very high quality and had low levels of dissolved nutrients, low conductance, adequate dissolved oxygen, and pH in the range expected for granitic watersheds. The current condition of water quality in the Tuolumne River corridor is presented in table 5-17.

**Table 5-17.**  
**Current Condition of Water Quality**

Standards	Current Conditions
<b>Management Standard:</b> The management standard for water quality is defined as the baseline established in 2005-2008, with nutrients, <i>E. coli</i> , and petroleum hydrocarbons all measured. <sup>a</sup>	Samples taken between 2005 and 2010 were of very high quality, and within the management standard.
<b>Management Concern:</b>	The primary concern for water quality in the Tuolumne River is caused by the “little blue slide” (though no violations of state turbidity standards are present), potential wastewater leaks from the containment ponds, and the leach mound at Glen Aulin.
<b>Adverse Impact:</b> Exceedance of USEPA bacteriological criteria for water contact recreation: <i>E.coli</i> and nitrates. <sup>b</sup>	
<b>Degradation:</b> The degradation standard is defined as the inclusion of any Tuolumne River segment on the state listing under section 303d of the Clean Water Act of waters not attaining minimum water quality objectives. <sup>c</sup>	

a The management standard for nutrients is exceeded when the 75th percentile of annual sampling exceeds the 95% upper confidence limit of the baseline condition in more than one in five years at any sample location. The management standard for *E. coli* is exceeded when the 50th percentile of annual sampling exceeds the 95% upper confidence limit of the baseline condition in more than one in five years at any sampling location. The standard for petroleum hydrocarbons is exceeded when they are detected (at current detection limits) in more than one in five years.

b (1) *E.coli* exceeds one-day standard of 235 MPN/100 ml and subsequent exceedance of the 90-day geometric mean standard of 126 MPN/100 ml for water contact recreation, or (2) exceedance of USEPA maximum contamination level for nitrate + nitrate of 10 milligrams per liter.

c For the Tuolumne River and the chosen water quality indicators, this would occur when there were 10 or more violations (exceedances) of the USEPA water quality standards over the course of the 303d reporting period of three years.

Abbreviations: *E. coli* = *Escherichia coli*; ml = milliliter; MPN = most probable number of bacterial colonies; USEPA = U.S. Environmental Protection Agency

The primary exception to Yosemite's generally outstanding water quality parkwide occurs during the first fall storms following the long dry season. In three out of seven years of intense monitoring of the Merced River, the proposed state single day *E. coli* standard of 235 MPN/100 ml has been exceeded. High values are common in all locations, both upstream and downstream of developed areas, indicating that natural sources of contamination may be dominating the signal during these storms. This is thought to result from the accumulation of animal waste across the entire watershed during the prior four to seven months, when few or no storms occur. Fall storms may have less impact on water quality in the Tuolumne Meadows area. Storms at that elevation are generally colder, with less rain and more snow, thus resulting in a smaller watershed response. Episodic summer thunderstorms may produce more of an impact. Capturing the effects of these storms is challenging, given their limited spatial and temporal nature and the logistical challenges of responding to these less predictable events.

### **Monitoring Program to Prevent Future Adverse Impacts or Degradation**

As required by the guidelines implementing WSRA, the NPS will conduct a program of monitoring and ongoing study during and following the implementation of the plan to ensure that river values are enhanced where necessary and protected throughout the life of the plan.

#### **Monitoring Protocols**

Water quality monitoring is ongoing. The monitoring protocol is available as a part of the overall *Visitor Use and Impacts Monitoring Program* field guide (NPS, 2011d). The initial sampling regime has been designed to inventory spatial and temporal water quality conditions on the Tuolumne River, with an emphasis on areas of the river adjacent to the heaviest development. Sampling sites were selected based on location, co-location with other sampling efforts, and existing water quality data. In general, locations were selected to be upstream and downstream of developed areas in order to better isolate impacts. To understand seasonal variations in water quality, monthly sampling is conducted on the Tuolumne River during the summer at all sites and bimonthly during the winter.

For Poopenaut Valley, water quality monitoring will be done as part of the ongoing program of continuous USEPA-mandated water quality monitoring in Hetch Hetchy Reservoir by the SFPUC. The SFPUC monitoring indicates that water quality at the dam is very good. Water quality sampling at Poopenaut Valley (only three miles downstream of the dam) by the NPS in 2007 indicates that water quality there is also very good. Given the proximity of Poopenaut Valley to the dam and the fact that SFPUC water quality monitoring is ongoing, the SFPUC's monitoring is an excellent proxy for water quality in Poopenaut Valley. Additionally, new water release strategies being implemented by the SFPUC at O'Shaughnessy Dam include reduced ramping rates (rates at which flows are increased and decreased) that are similar to unregulated river flow fluctuations. This action will reduce the potential for excessive erosion potential to background rates.

#### **Actions to Be Taken to Avoid Adverse Impacts or Degradation**

A key part of the monitoring program will be management triggers intended to ensure that any downward trend in conditions can be identified and arrested well before adverse impact occurs. These triggers will identify departures from the management standard and require that specific kinds of management action be taken, as shown in table 5-18.

**Table 5-18.**  
**Actions Identified by the NPS to Prevent Adverse Impacts on or Degradation of Water Quality**

Trigger	Action <sup>a</sup>	Rationale for Using this Action at this Threshold
Statistically significant trend toward decreasing water quality condition in any of the indicators at any one monitoring site. or Exceedance of any of the management standards. (In the case of water quality, the NPS standards are so far above the state standards that it is not feasible to strengthen this trigger.)	Initiate investigation of water quality conditions in the area of concern to identify potential point source.	These standards indicate possible deterioration of water quality. Steps taken based on these triggers are focused on determining the persistence and source of the problem and whether more serious investigation and action are required to resolve the issue.
Approaching Adverse Impact: Exceedance of proposed USEPA bacteriological criteria for water contact recreation ( <i>E. coli</i> one-day standard of 235 MPN/100 ml at any one monitoring site) in two consecutive monthly samples or Exceedance of a maximum contamination level for nitrate+nitrite of 8 mg/l (as N) or Detection of petroleum hydrocarbons	Initiate weekly sampling of <i>E. coli</i> at sites exceeding the limit until sample concentration falls below single sample limit (235 MPN/100 ml). Ensure at least five samples are taken over the course of the 90 days following the first exceedance to determine 90-day geometric mean, which determines adherence to proposed <i>E. coli</i> standard.  Establish a coordinated investigation of water quality, including more frequent sampling at more sites, inspection of sewage systems and stock operations, and closing the river to all contact recreation until issue is resolved.	This threshold indicates potential violation of a state (and USEPA) water quality standard. Subsequent prescribed sampling would determine whether the event was one time only or more persistent (more serious) in nature. Also, approaching these state and federal standards may indicate serious water quality problems that are likely the direct result of human use. Immediate and substantial action is required to resolve these issues to minimize impacts on river and human health and prevent an adverse impact from occurring.

a Depending on findings at each level above, NPS could also take the following management actions:

- Increase educational messaging regarding water quality.
- If impacts are related to human waste (and where allowed by management objectives), provide toilet facilities.
- If impacts are due to erosion, improve conditions through restoration, trail rerouting, etc.
- If impacts are due to stock use, redirect/reduce/limit stock use in certain areas.
- If hydrocarbons are detected, test the integrity of the fuel storage tanks and try to determine the source.
- Increase enforcement of permit requirements.
- Increase ranger patrols and visitor education efforts.
- Close some areas temporarily or permanently.

Abbreviations: ml = milliliter; MPN = most probable number of bacterial colonies; USEPA = U.S. Environmental Protection Agency

## **Conclusions: Protecting and Enhancing Water Quality**

The Tuolumne River has exceptionally high water quality. All the measured indicators are within the NPS standards, which are considerably more protective than other federal or state standards. Although water quality is fully protected, a few risks are present within the river corridor, including an unstable road cut along Tioga Road, wastewater treatment facilities at Tuolumne Meadows and Glen Aulin, fuel storage tanks at Tuolumne Meadows, and pack stock use. The plan includes actions to stabilize the road cut, to upgrade wastewater treatment facilities at Tuolumne Meadows, and to upgrade or eliminate wastewater treatment facilities at Glen Aulin. The risks to water quality associated with the public fuel station and pack stock use will either be eliminated or reduced and mitigated, depending on the alternative selected.

An ongoing monitoring program will continue to test for nutrients, *E. coli*, and petroleum hydrocarbons to ensure that the exceptional baseline water quality is sustained over time. Decreasing water quality for any of these indicators will trigger studies to identify the source of the concern. Depending on the source, appropriate action will be taken to address the concern prior to an adverse impact. If the concern is related to visitor use, use will be managed as needed to protect this river value.

## Free-Flowing Condition

### *All Segments*



NPS PHOTO BY KRISTINA RYLANDS

*Dana Fork water intake.*

### **Condition Assessment**

#### **Condition at the Time of Designation**

At the time of the 1984 designation, the Tuolumne River above the Hetch Hetchy Reservoir was largely free of structures that impeded flow or otherwise altered the free-flowing condition of the river. Flows varied seasonally. Snowmelt runoff caused high-velocity, high-volume flows during spring and early summer, while much lower flows occurred at most other times of the year. The natural flow regime below O'Shaughnessy Dam was altered by the dam.

Between late May and late October, water was taken from the Dana Fork by a low cement diversion to support seasonal visitor and operational uses in Tuolumne Meadows. The quantity of the water that was withdrawn is unknown. An intake hose was used to take water from the river at the Glen Aulin High Sierra Camp to serve the needs of guests and staff.

One vehicle bridge crossed the river at Tuolumne Meadows, and approximately seven footbridges crossed the river at various locations. The vehicle bridge and the footbridge near Parsons Memorial Lodge both contained abutments that may have caused the river channel to back up during periods of high flows.



## Current Condition

Flow levels remains largely the same as they were at the time of designation. Stream flows are typically between 25.3 million and 110 million gallons per day on the Lyell Fork and between 9.7 million and 57 million gallons per day on the Dana Fork, with the highest stream flows occurring during early summer snowmelt. In early summer, the Lyell and Dana Forks contribute about 60 percent and 40 percent, respectively, of the flow beneath the Tioga Road bridge in Tuolumne Meadows, proportions comparable to their relative drainage areas. The contribution of snowmelt to stream flow decreases by mid-summer. Then, the Lyell Fork contributes a greater percentage (66–75%) of the total flow into Tuolumne Meadows (Lundquist et al. 2005).

Data that record Tuolumne River flows into Hetch Hetchy Reservoir from the fall of 1982 to 2002 show considerable variability from one year to the next. During the 1982–2002 period, the greatest water year (in California, a “water year” extends from July 1 to June 30 of the following year) annual discharge into Hetch Hetchy was about 539 billion gallons in 1983 (the water year ending on June 30, 1983), while the least annual discharge was about 108 billion gallons in 1987. The periods from 1983–86 and 1995–98 were relatively wet (averaging 354 billion and 379 billion gallons), while the periods of 1987–94 and 2000–02 were relatively dry (averaging 160 and 187 billion gallons). These data indicate that wet and dry conditions can occur over multiyear spells (Lundquist et al. 2005).

Several attempts in the mid-1990s to develop a groundwater source as a viable water supply for the Tuolumne Meadows area were not successful (HRS Water Consultants 1994). Water continues to be taken from the Dana Fork of the Tuolumne River to support seasonal visitor and operational uses in Tuolumne Meadows. The Dana Fork water intake extends across a portion of the river. During high flows, water moves around and over the cement structure. However, during periods of lower flows in the fall, the structure impounds a portion of the river. Because the structure is on a steep and rocky section of the river, it does not affect riparian integrity.

Water withdrawals from the Dana Fork from late May to late October average about 65,000 gallons per day. As is typical for surface water diversions in the Sierra Nevada, maximum withdrawal coincides with annual minimum flows. Waddle and Holmquist (2011) found that flows of less than 3 cubic feet per second occurred on 47 or more days in at least 25% of years, flows of less than 1 cubic foot per second occurred on 9 or more days in at least 25% of years, and flows less than 1 cubic foot per second occurred for one day or more per year in 48 of the past 95 years. The study also showed that when flows are less than 3 cubic feet per second, wetted habitat losses are substantial and invertebrate production decreases. At the current withdrawal rates, when the amount of water withdrawn for use at Tuolumne Meadows amounts to less than 10% of the lowest flow rates, wetted habitat is considered to be only minimally affected by these withdrawals (Waddle and Holmquist 2011). Withdrawals of 65,000 gallons per day would approximate 10% of flow at 1 cubic foot per second, and average demands of no more than 60,000–70,000 gallons per day would fall within the margin of error of meeting a standard of no more than 10% of low flow when low flow equals 1 cubic foot per second. However, an increase in the abstraction rate could increase the number of days when flows reach extreme low levels, which would further decrease aquatic habitat during periods of low flow. For example, increasing domestic water withdrawals by 50% would decrease aquatic habitat by 44%, a decrease that could jeopardize the microorganisms (*ephemeroptera*, *plecoptera*, *trichopterta*) dependent on that habitat (Waddle and Holmquist 2011). Furthermore, if climate change results in an increase in the duration of summer low flows, current rates of water withdrawal could exceed 10% of future low flows.

An unknown amount of the water withdrawn from the river leaks from underground pipes (part of the aging water delivery system in Tuolumne Meadows) before it can be used. These losses will be assessed as part of future utilities improvement work and water conservation planning.

At Glen Aulin High Sierra Camp, water diversion from the main stem of the river has been limited to 600 gallons per day to address concerns about the leach mound capacity (see “Water Quality,” earlier in this chapter). Since designation, the NPS has made upgrades and improvements to the water purification system, and the water intake hose has been moved to a deeper collection pool located within designated wilderness.

The bridges crossing the Tuolumne River that existed in 1984 remain. They include the Tioga Road bridge at Tuolumne Meadows, a single-vehicle bridge below O’Shaughnessy Dam, and seven footbridges: one crossing the upper Lyell Fork near the middle base camp, Twin Bridges near Tuolumne Meadows, a Dana Fork bridge, a footbridge at Parsons Memorial Lodge, another “twin bridges” above Glen Aulin, a footbridge at Glen Aulin, and two bridges in Pate Valley. Three tributary bridges are very near the river corridor on Rafferty Creek just outside of Tuolumne Meadows, and along Conness and Return Creeks in the Grand Canyon reach. With the exception of the footbridge at Parsons Memorial Lodge, the trail bridges have very minor impacts on free flow, if any, generally because the river flows around them at high flows. The Tioga Road bridge in Tuolumne Meadows and the historic footbridge at Parsons Memorial Lodge have abutments that might cause the river channel to back up during periods of high flows and might contribute to accelerated flows downstream (NPS, Noon and Martin 2010d).

After the 1997 flood (a 90-year flood event, which included high flows on the Tuolumne River), a short section of boulder riprap was placed along the Lyell Fork to harden the riverbank and protect the campground A-loop road (NPS, Buhler et al. 2010e).

## **Management Concerns**

The need to withdraw water for domestic use from the Tuolumne River is among the factors that limit overall use and development at Tuolumne Meadows. An aging water supply system that lacks adequate storage capacity, loses water through leaking supply lines, and does not take full advantage of available water conservation technologies poses a management concern because it makes water use less efficient than it could be.

Ongoing periods of drought and the resulting effect on water availability is another growing management concern. The Waddle and Holmquist study (2011) concluded that withdrawals at or less than current levels and durations are likely to have a minimal impact on downstream habitat. However, the study notes that climate change might lead to longer low-flow periods that begin earlier in the summer. Continuous river flow monitoring is warranted to determine whether reevaluation of withdrawal levels might become necessary in the future. Currently, water withdrawals are maintained at a level that preserves sufficient flows in the Dana Fork to protect aquatic habitat.

While the Lyell Glacier itself is not a part of the Tuolumne River corridor, it is an important hydrologic feature contributing to flows in the Tuolumne River. Yosemite’s remaining glaciers are rapidly retreating, with consequences for ecosystem health and visitor experience. As with other glacial systems around the world, the retreat of the Lyell Glacier and probable loss of meltwater flows in the upper Lyell Fork poses a challenge for land managers. Due to forces external to the park, there is little direct action that can be taken aside from monitoring changes and trying to predict the downstream impacts of declining glaciers. The monitoring program detailed below is intended to assess the effects of the gradual reduction and probable elimination of the glacier.

The abutments for the bridge along the Tioga Road in Tuolumne Meadows and the historic footbridge at Parsons Memorial Lodge may cause the river channel to back up during periods of high flows and may contribute to accelerated flows downstream (NPS, Noon and Martin 2010d).

The short section of boulder riprap along the Lyell Fork near the campground A-loop road interferes with the free flow of the river.

The natural flow regime below O'Shaughnessy Dam is altered by the dam. The NPS, in collaboration with the SFPUC and others, is conducting research below the dam to inform the timing, duration, and magnitude of flows that will reduce the effects of dam operations on downstream habitats. This was discussed in greater detail under "Low-Elevation Riparian and Wetland Habitat at Poopenaut Valley," earlier in this chapter. Ultimately, the Raker Act is the controlling authority for the river below Hetch Hetchy Reservoir. Flows in the river are subject to the needs of the SFPUC, which does its best to consider NPS needs.

## **Actions NPS Will Take to Address these Concerns**

To avoid any future action that would adversely affect the free-flowing character of the Tuolumne River, the NPS has specified a process, required by section 7 of WSR, that it will use to evaluate all potential water resource projects within the bed and banks of the river (see chapter 4). Before it could be approved and implemented, any proposed project would have to be evaluated using the process outlined in chapter 4 and found to have no potential for direct or adverse effect on the values for which the river was added to the wild and scenic rivers system.

Existing facilities with the potential to affect river flows have been identified and will be mitigated. The Tioga Road bridge in Tuolumne Meadows and the historic footbridge at Parsons Memorial Lodge will both be improved under whichever of the action alternatives is selected to mitigate the ponding effect that these bridges' abutments cause on the river during high flows. Improvements to both bridges will be compatible with their historic character and will require additional site-specific planning and compliance. Both projects will be subject to section 7 determinations as part of future planning and assessment. Under all the action alternatives, the riprap at the Tuolumne Meadows campground will be removed and the riverbank will be restored to natural conditions.

Regarding river flows in the Poopenaut Valley segment, the NPS will continue to work cooperatively with a consortium of individuals, including scientists from Yosemite National Park, the SFPUC, Stanislaus National Forest, and contractors, to inform releases from O'Shaughnessy Dam intended to more closely mimic natural flows for the benefit of river-dependent ecosystems below the dam.

Regarding the effect of water withdrawals at Tuolumne Meadows, the Waddle and Holmquist study (2011) found that current abstraction (withdrawal) rates only minimally affect aquatic habitat but that an increase in the abstraction rate could increase the number of days when flows reach extreme low levels, which would further decrease aquatic habitat during periods of low flow. Based on this study, the NPS developed all alternatives in this plan such that water use would not comprise more than 10% of the Dana Fork's flows when such flows reach their critical low of 1 cubic foot per second. If climate change results in longer periods of low flow that begin earlier in the summer, current and proposed rates of water withdrawals could exceed 10% of future low flows. To avoid future potential impacts on downstream habitats, water conservation measures are part of all the action alternatives presented in chapter 7.

The NPS will update the water supply system in its current location to meet existing standards and to ensure that storage is adequate for demand. The current water treatment facility site is suitable for protecting river values (see the facilities analysis in appendix A). Water supply lines will be repaired or replaced to eliminate leakage. Additional planning will identify opportunities for conserving water in the Tuolumne Meadows area. In the interim, water meters will be installed and known conservation measures will be further improved,

including use of low-flow fixtures and the education of visitors and employees about the importance of water conservation and how they can contribute.

Additional reductions in water use based on user capacity would vary among the alternatives. When the NPS selects an alternative in a formal record of decision, it will be incorporated into this volume as part of the final *Tuolumne River Plan*. A program of long-term monitoring and protective action could trigger yet additional reductions in water use, as described under “Monitoring Program to Prevent Future Adverse Impacts or Degradation,” below.

## **Management Indicator and Monitoring Program**

### **Indicator: Water Withdrawals as a Percentage of Low Flow**

As described above, the domestic water supply for the Tuolumne Meadows facilities is taken from the Dana Fork. In late summer, the Dana Fork drops to very low flows, a common occurrence on Sierra Nevada rivers, given California’s Mediterranean climate. Withdrawals for domestic water often reach their peak at this same time, a situation that can be particularly problematic in drought years. This indicator will ensure that water withdrawals do not reduce low flows to the extent that they would result in a reduction in downstream aquatic habitat.

### **Definitions of Management Standard, Adverse Impact, and Degradation**

The NPS will monitor streamflows and withdrawals to ensure that withdrawals never exceed 10% of low flows.

Because all alternatives were developed to stay within the abstraction limits and because the water monitoring and conservation program would be mandatory under all alternatives (even no action), definitions of management standard, adverse impact, and degradation were not developed.

Water withdrawals at Glen Aulin are limited to 600 gallons per day, an amount that is negligible in comparison to the river’s flow at this location. No other water withdrawals are present on the river, nor would any withdrawals be permitted. Consequently, the discussion of low flows focuses on the Dana Fork withdrawals.

### **Monitoring Program to Prevent Future Adverse Impacts or Degradation**

As required by the guidelines implementing WSRA, the NPS will conduct a program of monitoring and ongoing study during and following the implementation of the *Tuolumne River Plan* to ensure that river values are enhanced where necessary and protected throughout the life of the plan. A key part of this program will be management triggers intended to ensure that any downward trend in conditions can be identified and arrested well before adverse impact occurs.

### **Monitoring Protocols**

River flow monitoring will occur on the Dana Fork at and downstream of the diversion structure. Flow monitoring will be sufficient to determine the daily average flow magnitude and annual low-flow frequency (return interval) for flow less than 10 cubic feet per second, as well as the amount of water being withdrawn from the river.

### **Triggers and Management Responses**

As shown in table 5-19, additional mandatory water conservation measures will be triggered when water withdrawals exceed 10% of flow whenever flow drops below 3 cubic feet per second, similar to those implemented at Wawona, where critically low flows also occur in drought years. Such additional conservation

measures at Tuolumne would begin with mandatory closure of shower facilities and use of paper plates in the lodge, and proceed to partial or complete closures of the lodge or campground, depending on the severity of the drought and the average water consumption of the different facilities.

**Table 5-19.**  
**Actions Identified by the NPS to Prevent Adverse Impacts on or Degradation of Free-Flowing Condition**

Trigger	Management Response	Rationale
Water withdrawals exceed 10% of the river's flow for one day when total flow drops below 3 cubic feet per second	Additional water conservation measures, such as shower restrictions and use of paper plates, go into effect at Tuolumne Meadows.	Water conservation measures would reduce human water withdrawals from the Dana Fork.
Approaching 1 cubic foot per second total river volume	Parts or all of Tuolumne Meadows Lodge and/or the campground are closed to protect water flows.	Water withdrawals when low flow drops to 1 cubic foot per second have greater potential to adversely affect aquatic habitat; therefore, emergency measures would be implemented to reduce water use during these periods.

## **Conclusions: Protecting and Enhancing the River's Free-Flowing Condition**

The Tuolumne River above the Hetch Hetchy Reservoir is free flowing, and the NPS will protect its free-flowing condition by implementing a process under section 7 of WSRA to ensure that no potential water resource project within the bed and banks of the river could have a direct and adverse effect on this river value. The natural flow regime below O'Shaughnessy Dam is altered by the dam, as it was at the time of designation. The NPS will continue to work cooperatively with the SFPUC to inform the timing, duration, and magnitude of flows that will reduce the effects of dam operations on downstream habitats. However, the Raker Act is the controlling authority over water releases from the dam. The NPS will apply the section 7 process to evaluate any potential water resource project below the dam.

Management concerns include the abutments of one vehicle bridge and one footbridge at Tuolumne Meadows, and a short section of boulder riprap placed along the Lyell Fork to protect the campground A-loop road from flooding. The *Tuolumne River Plan* calls for removal of the riprap and mitigation of the effects of these two bridges.

The amount of water withdrawn from the Dana Fork for domestic use in the Tuolumne Meadows area currently amounts to less than 10% of lowest flow. According to recent research, withdrawing this amount of water has a minimal effect on downstream aquatic habitat; however, any increase in water withdrawals could decrease wetted habitat. Management is also concerned about the potential for future reductions in low flows associated with climate change, in which case withdrawals at the current rate could decrease habitat. The plan calls for long-term monitoring of river flows and caps water withdrawals at no more than 10% of lowest flows. Water conservation measures, such as replacement of leaking water lines and installation of low-flow fixtures, are included in all the plan alternatives, and some alternatives would achieve additional decreases in water consumption through decreases in user capacity. If long-term monitoring detects a future decrease in river flows associated with natural cycles or climate change, those findings will trigger further decreases in water withdrawals for domestic use at Tuolumne Meadows, including reductions in the types and levels of visitor services, if necessary. The rapid retreat of the Lyell Glacier indicates that a probable loss of meltwater flows in the upper Lyell Fork will pose a challenge for river managers in the foreseeable future.

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