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 in acknowledgement of the river's (1) free-flowing condition, (2) water quality, and (3) outstandingly remarkable values. Collectively, these qualities 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) describing the baseline conditions of river values; (3) 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, and (4) identifying management concerns and the actions needed to protect and enhance each river value.

After presenting a brief overview of river values and introducing the concepts of *management standard*, *adverse impact*, and *degradation,* this chapter presents detailed discussions of the baseline conditions, management standards, and management concerns and protective actions for each river value. The actions presented in this chapter are common to all the action alternatives and will ensure the protection of river values regardless of alternative. In addition, the action alternatives presented in chapter 8 include a number of site-specific actions directed toward the general improvement of conditions in the river corridor, which may vary by alternative.

The River Values of the Tuolumne Wild and Scenic River

This section describes the river values of the Tuolumne Wild and Scenic River. The first two values are the river's free-flowing condition and water quality, and the remainder are the river's 10 outstandingly remarkable values (ORVs). The WSRA stipulates that all these values must be protected.

Free-Flowing Condition

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. When 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.

NPS PHOTO BY GREG LAWLER

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:

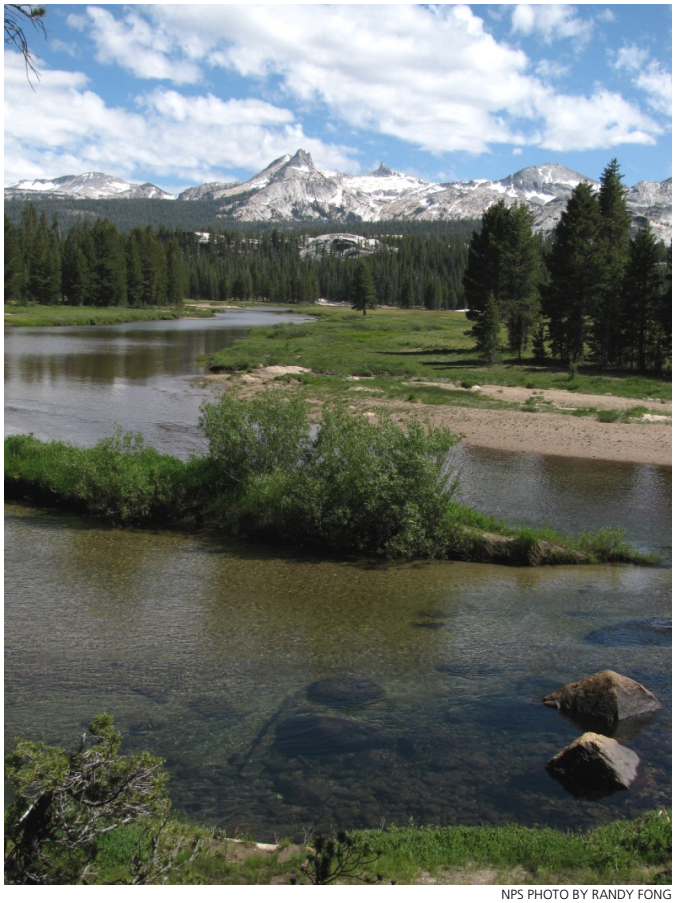
- The value must be river-related or river-dependent. To be considered river-related or river-dependent, a value must be located in the river or on its immediate shorelands (generally within 0.25 mile on either side of the river); contribute substantially to the functioning of the river ecosystem; and/or 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 G.

Biological Values



NPS PHOTO BY RANDY FONG

Meadow and riparian vegetation in Tuolumne Meadows.

NPS PHOTO BY KRISTINA RYLANDS

Wetlands in Poopenaut Valley.

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

Explanation: The nearly continuous prehistoric archeological landscape along the Tuolumne River contains dense concentrations of 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 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.

NPS PHOTO BY KRISTINA RYLANDS

Obsidian flake.

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 Lembert, 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 High Sierra Camp and through the Grand Canyon of the Tuolumne include steep canyon walls, the untrailed Muir Gorge, hanging valleys, and cascades of falling water.

Recreational Values

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.

Rare and easy access to high-elevation sections of the Tuolumne River through Tuolumne and Dana Meadows is provided by the Tioga Road across the Sierra.

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.

NPS PHOTO BY KRISTINA RYLANDS

Meadow along the John Muir Trail in Lyell Canyon.

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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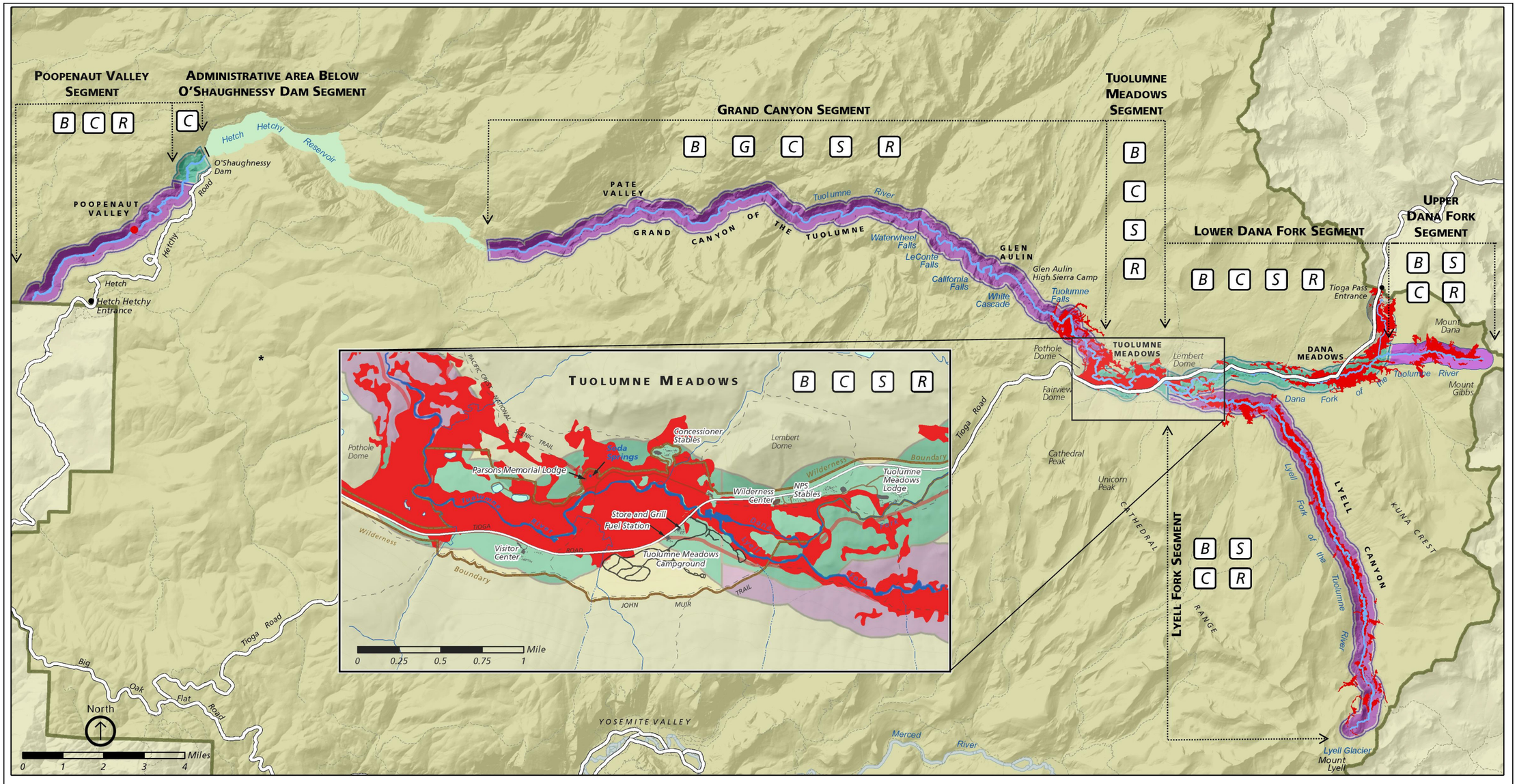

Wild and Scenic River Classifications

Wild river area: Per the Wild and Scenic Rivers Act, the sections of the river that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted.

Scenic river area: Per the Wild and Scenic Rivers Act, the sections of the river that are free of impoundments, with shorelines or watersheds still largely primitive.

Outstandingly Remarkable Values of the Tuolumne River

Outstandingly Remarkable Values

B **Biological Value***
C **Cultural Value**
S **Scenic Value**
G **Geologic Value**
R **Recreational Value**

*Location of a river-related biological values are shown in red. Geologic, scenic, and recreational values are not illustrated because they are not tied to specific locations within river segments. The locations of cultural values (archeological sites) are not shown in accordance with federal law.

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

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Protecting and Enhancing River Values

In 1968 Congress passed the WSRA 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."[1]

In 1982, at the direction of the President, the Secretary of the Interior and the Secretary of Agriculture jointly promulgated regulations (hereafter referred to as the Secretarial Guidelines, or the guidelines) implementing WSRA.[2] 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 impacts to river values. Guidance is also provided on the location of major public-use facilities with regard to the river corridor, and agencies are instructed to ensure that any such development does not adversely impact river values.[3]

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, comprehensive river management must address "both past and ongoing degradation."[4]

The Interagency Council was formed in 1995 to assist those federal and state agencies charged with administering designated wild and scenic rivers.[5] 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."[6] 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."[7]

1 16 United States Code (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, (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 (2011a), 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."[8] 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 8] *that will be taken to improve conditions until they meet the requirement to protect and enhance the river's values.*

The WSRA program embodied in the *Final Tuolumne River Plan/EIS* includes the following steps, each of which is important in carrying out the act's mandate:

(1) Identify and define river values.
(2) Define the terms 'adverse impact,' 'degradation,' 'enhancement,' 'management standard,' 'management concern,' and 'localized concern' as they are used to describe the condition of river values.
(3) Assess the baseline condition of all river values, including both the current state and, to the extent possible, the condition at the time of wild and scenic river designation in 1984.
(4) Select measurable indicators for each river value, and set metrics for the associated management standard and triggers for management concerns, as well as thresholds for adverse impact and degradation.
(5) Assess each river value for the presence of adverse impacts, degradation and/or management concerns, as defined in steps 2 and 4.
(6) Describe and commit to management actions needed to mitigate or eliminate adverse impacts, degradation, and management concerns.
(7) Implement a monitoring program for each indicator, with predetermined conditions that will trigger specific management actions needed to ensure that river values remain protected and enhanced over time.

By assessing baseline conditions, any past adverse impacts or degradation can be identified and corrected.[9] 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 WSRA guideline requirement that "studies will be made during preparation of the management plan and periodically thereafter to determine

8 IWSRCC, "Wild and Scenic River Management Responsibilities," page 22 (2002), available at *http://rivers.gov/publications/management.pdf*.
9 According to the Interagency Council, adverse impacts to river values "must be identified in development of the CRMP [comprehensive river management plan], with appropriate strategies detailed for their resolution." IWSRCC, "Wild and Scenic River Management Responsibilities," page 22 (2002), available at *http://www.rivers.gov/documents/management.pdf*.

the quantity and mixture of recreation and other public use which can be permitted without adverse impact on the resource values."[10]

Key Concepts for River Management under WSRA

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.

The following sections provide definitions of 'adverse impact' and 'degradation' in the context of WSRA requirements, which are not to be confused with similar terminology used for the National Environmental Policy Act (NEPA) analysis or the analysis completed in accordance with the National Historic Preservation Act (NHPA), both of which are included in chapter 9 of this EIS, "Affected Environment and Environmental Consequences." For purposes of WSRA, an *adverse impact* to a river value is not synonymous with an *adverse impact* under NEPA or an *adverse effect* to a historical property under NHPA. In this chapter, adverse impacts under WSRA pertain specifically to river values and are defined according to measurable thresholds determined at a segmentwide scale. Adverse impacts under NEPA and adverse effects under NHPA are resource-specific and may be observed at a smaller scale. Thus, the adverse impacts/effects reported in chapter 9 do not necessarily equate to adverse impacts (under WSRA) identified in this chapter.

Just as clarity is needed when defining the river's outstandingly remarkable values, it is necessary to define a number of terms to be able to translate the protection and enhancement mandate of WSRA into management activities.

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: "Enhance rivers by seeking opportunities to improve conditions."[11] Such actions 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 where possible correct past and present degradation. The state of enhancement is the best possible condition for a river value. Both chapters 5 and 8 address opportunities to enhance river values.

Management Standard

Management standard is defined as the desired condition for a river value attainable given current trends and influences beyond NPS control. Under this plan, all river values will be protected and enhanced in accordance with WSRA and the Secretarial Guidelines. As discussed in more detail below, most river values are currently in a condition that is better than the management standard and within desired conditions. Enhancement actions included in the plan will serve to increase this margin of quality. In all cases, the management standard is at the lower end of the enhanced state.

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10 "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 *Federal Register* 39454, at 39458).

11 IWSRCC, "Wild and Scenic River Management Responsibilities," page 26 (2002), available at *http://www.rivers.gov/documents/management.pdf*.

Protection

Recent guidance by the Interagency Council (IWSRCC 2011) equates protection under WSRA with the elimination and/or avoidance of adverse impacts. It is, therefore, important to define adverse impact in order to know what constitutes a "protected" state.

Adverse Impact (WSRA)

Adverse impact is defined as a substantial reduction in the condition of a river value in relation to the management standard as a result of public use or development. An adverse impact is a segmentwide condition and requires immediate attention by the agency. Such an impact could be sudden and unforeseeable, or it could develop over a specified period of time, as reflected through the findings of periodic assessments.[12] 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.[13] Like "degradation" (defined below), "adverse impact" is not defined in WSRA or the Secretarial Guidelines. In cases of this nature, the Ninth Circuit has held that, absent further guidance, such terms should be given their ordinary meaning.[14] Therefore, the NPS has defined this term in accordance with its plain, ordinary meaning. As discussed in this chapter, the specific conditions that constitute an adverse impact have been defined for each river value. These metrics were established using the best available scientific information, including research conducted specifically for this planning effort, and reasoned professional judgment.

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."[15] Like adverse impact, degradation is not defined in either the act or the guidelines. This plan therefore relies on the common, ordinary meaning of the term.[16] Merriam Webster's

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12 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.

13 *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.")

14 *Friends of Yosemite Valley v. Norton*, 348 F.3d 789, 796 (9thCircuit 2003) (citing *Hell's Canyon Alliance v. USFS*, 227 F.3d 1170, at 1177 (9th Cir. 2000).

15 *FYVIII*, 520 *F.3d*1024,1034-35 (Ninth Circuit 2008).

16 *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 Secretarial Guidelines. 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.

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.

Management Concern

The goal of this river plan is to maintain all river values in a condition that meets or exceeds the associated management standard. However, in a dynamic natural setting, fluctuations in resource conditions can be expected to occur over time. The key to successful management is to provide a series of checkpoints in the monitoring framework that will be used to trigger actions to arrest downward trends before conditions drop to the level of, and then perhaps below, the management standard. Therefore, for each river value, a series of "trigger points" have been established at incremental levels above the management standard. When monitoring indicates that the condition of the river value has reached a trigger point, the situation is described as a management concern. Management concerns are to be immediately addressed through corrective measures that have been pre-identified and included in the management framework described for each river value later in this chapter.

Management concerns are correctable and do not necessarily bring the river value condition to the level of adverse impact or degradation. They may be indicative of a downward trend in river condition that is occurring so slowly that the river condition has not fallen below the management standard but might do so if the downward trend is not arrested and reversed. The NPS will take the actions identified for each river value when a trigger point is reached. A river value that has documented management concerns is still considered to be protected but requires management action to remain so.

Localized Concern

Localized concerns are localized areas of impact to components of a river value whose overall condition is within the management standard. Management actions can be taken that will improve (enhance) conditions in the river corridor. Localized concerns may also be addressed by actions such as long-term monitoring programs, an example of which is water quality monitoring to identify any localized changes in water quality. Because of their limited extent, localized concerns can be corrected with relatively simple actions that help to ensure the associated river value remains at or above the management standard.

Baseline Conditions Assessment

To assess the health of river values and ensure that no degradation or adverse impact occurs, the Interagency Council recommends that managing agencies "document baseline resource conditions and monitor changes to these conditions."[17] According to the council, the baseline resource condition

> *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 effects (protect) or improve conditions (enhance) within the*

[17] IWSRCC, *Wild and Scenic River Management Responsibilities*, page 22 (2002), available at http://rivers.gov/publications/management.pdf.

> *river corridor. If a thorough resource assessment that includes a baseline description of the ORVs is not completed at the time of designation, this assessment should be included in the river management plan. The river management plan then establishes the baseline conditions at the time of designation—including a description of any degradation—and proposes management actions that will be taken to improve conditions until they meet the requirement to protect and enhance the river's values.*[18]

By assessing baseline conditions, managing agencies can identify and correct past degradation.[19] Downward trends that could lead to adverse impacts and 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.

Monitoring Program

The monitoring program in the *Final Tuolumne River Plan/EIS* fulfills the Secretarial Guidelines to ensure "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 effect on the resource values."[20] This plan defines a set of measureable indicators to monitor the condition of each river value through time as described in this chapter. Yosemite National Park staff selected indicators for their ability to provide insight into the integrity of the river value and to provide early warnings of change. Park staff also required indicators to be derived from objective and easily obtained data collection that is repeatable across time and across observers. The monitoring program for an individual river value may be refined through time, if necessary, as more information becomes available.

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18 IWSRCC, *A Compendium of Questions & Answers Relating to Wild & Scenic Rivers*, page 70 (2011), available at www.rivers.gov/publications/q-a.pdf. Note that although the IWSRCC uses the term "adverse effects," the NPS uses the term "adverse impacts" within this document and the *Tuolumne River Plan*, in accordance with the terminology used in the 1982 *Federal Register* regulations for wild and scenic rivers ("National Wild and Scenic River System; Final Revised Guidelines for Eligibility, Classification and Management of River Areas," 47 *Federal Register* 39454 (1982)).

19 According to the IWSRCC, adverse impacts to river values "must be identified in development of the comprehensive management plan, 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.

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

Overview of Management of River Values

The following sections describe the management to protect and enhance each river value as proposed in the *Final Tuolumne River Plan/EIS*. A major component of that management is the identification of management standards and an ongoing program of monitoring and specific actions that might be taken in the future to ensure that the river values remain protected and enhanced over the life of the plan. Table 5-1 provides an overview summary of (1) each river value, (2) the river segment(s) in which it is located, and (3) the indicator(s) that will be used to monitor the condition of the value over time. This overview is followed by an in-depth discussion of each value and how it will be managed.

Table 5-1.
River Values and Associated Indicators

River Value	Segment(s)	Indicator(s) to be Monitored through Time
Biological Values		
Subalpine meadow and riparian complex	Wild segments: Lyell Fork, Upper Dana Fork Scenic segments: Lower Dana Fork, Tuolumne Meadows	Meadow fragmentation due to proliferation of informal trails Physical streambank stability rating Meadow bare soil
Low-elevation riparian and meadow habitat	Wild segment: Poopenaut Valley	NA (No indicator is defined because management of the valued habitat is constrained by the Raker Act and its location downstream of the Hetch Hetchy Reservoir.)
Geologic Value		
Stairstep river morphology	Wild segment: Grand Canyon of the Tuolumne	NA (No indicator is defined because the condition of this value is governed by large-scale influences beyond human control.)
Cultural Values		
Prehistoric archeological Landscape	All segments	Aggregate condition of prehistoric archeological sites
Parsons Memorial Lodge	Scenic Segment: Tuolumne Meadows	Condition of Parsons Memorial Lodge
Scenic Values		
Scenery through Lyell Canyon	Wild segment: Lyell Fork	Visual resource management classification
Scenery through Dana and Tuolumne Meadows	Scenic segments: Tuolumne Meadows and Lower Dana Fork	Visual resource management classification
Scenery through Grand Canyon of the Tuolumne	Wild segment: Grand Canyon of the Tuolumne	Visual resource management classification
Recreational Values		
Rare and easy access to the river through Tuolumne and Dana Meadows	Scenic segments: Tuolumne Meadows and Lower Dana Fork	NA (No indicator for a management standard is needed because parking supply is the means by which the plan's user capacity will be enforced.)
Wilderness experience along the river	Wild segments: Lyell Fork, Upper Dana Fork, Grand Canyon of the Tuolumne, and Poopenaut Valley	Number of encounters with other hiking parties per hour
Water Quality	All segments	Nutrient levels *E. coli* Hydrocarbons
Free-Flowing Condition	All segments	Water withdrawals as a percentage of low flow

NA = not applicable

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, similar to the conditions of today. 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 (Cooper et al. 2006; NPS, Babalis et al. 2006k; 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, including John Muir (1911), who famously called sheep "hoofed locusts" (perhaps observing the damage caused by the flocks he himself was shepherding). 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." Explorers and early 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).

Management Response to Effects of Historic Sheep Grazing

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.

A 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, a request granted by Congress in 1890. The U.S. Army, administrator of the park from 1891 to 1913, found its primary management challenge to be 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, [and]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.

Management Response to Conifer Encroachment

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.

Effects of Historic Trails, Roads, and Camping

Many of the travel routes through Tuolumne Meadows originated as Native American trails (NPS, Greene 1987a). In 1883 the Great Sierra Wagon Road was completed across the meadows to the silver mines near Tioga Pass. 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 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.

Management Response to Effects of Historic Trails

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.

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 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.

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 in the heavily used areas across Tioga Road from the store/grill, near the Cathedral Lakes trailhead, at Pothole Dome, at Soda Springs, at Lembert 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, 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 and in the alternatives in chapter 8.

Meadow Fragmentation Due to Informal Trails

Areas of concentrated visitor use along the Dana and Lyell Forks and at Tuolumne Meadows are disturbed by 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).

The NPS monitored the condition of four areas in relation to informal trails 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) 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 (16.4-foot) zone centered on the trails to graphically depict the associated disturbance to vegetation and soils that occurs from trail presence and associated use.

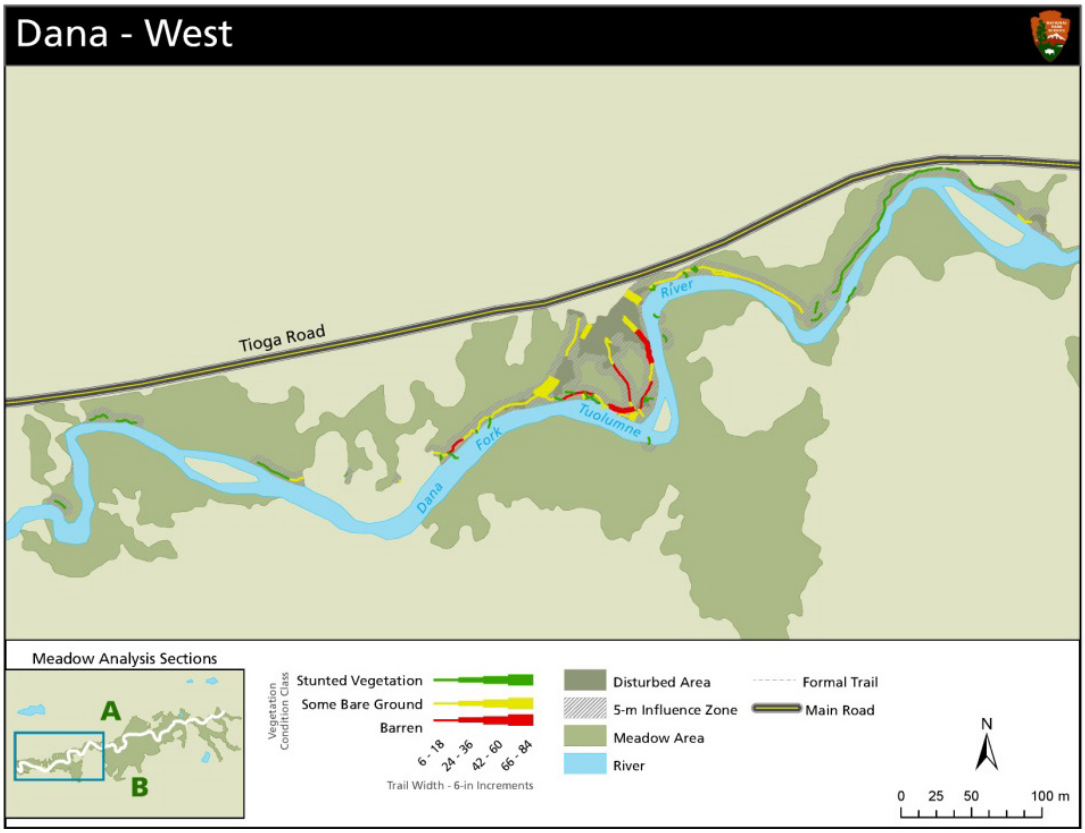

Figure 5-2. Location and Condition of Informal Trails, West Dana Fork.

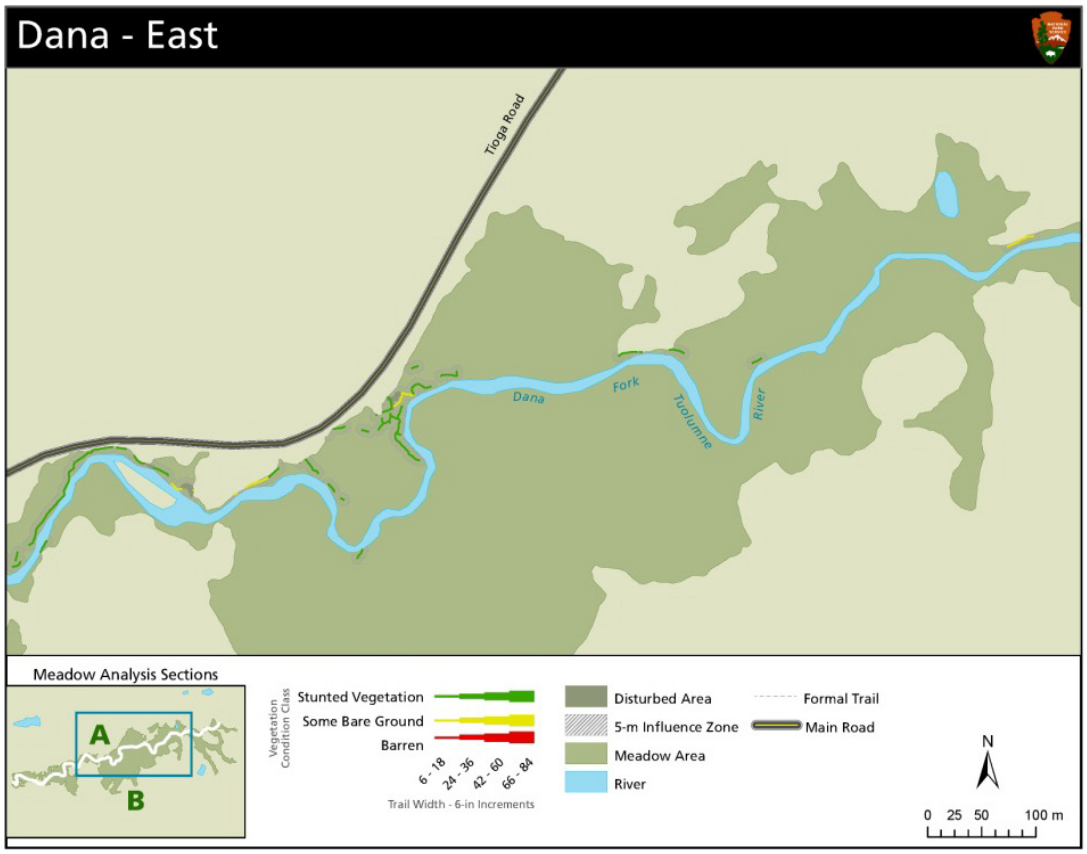

Figure 5-3. Location and Condition of Informal Trails, East Dana Fork.

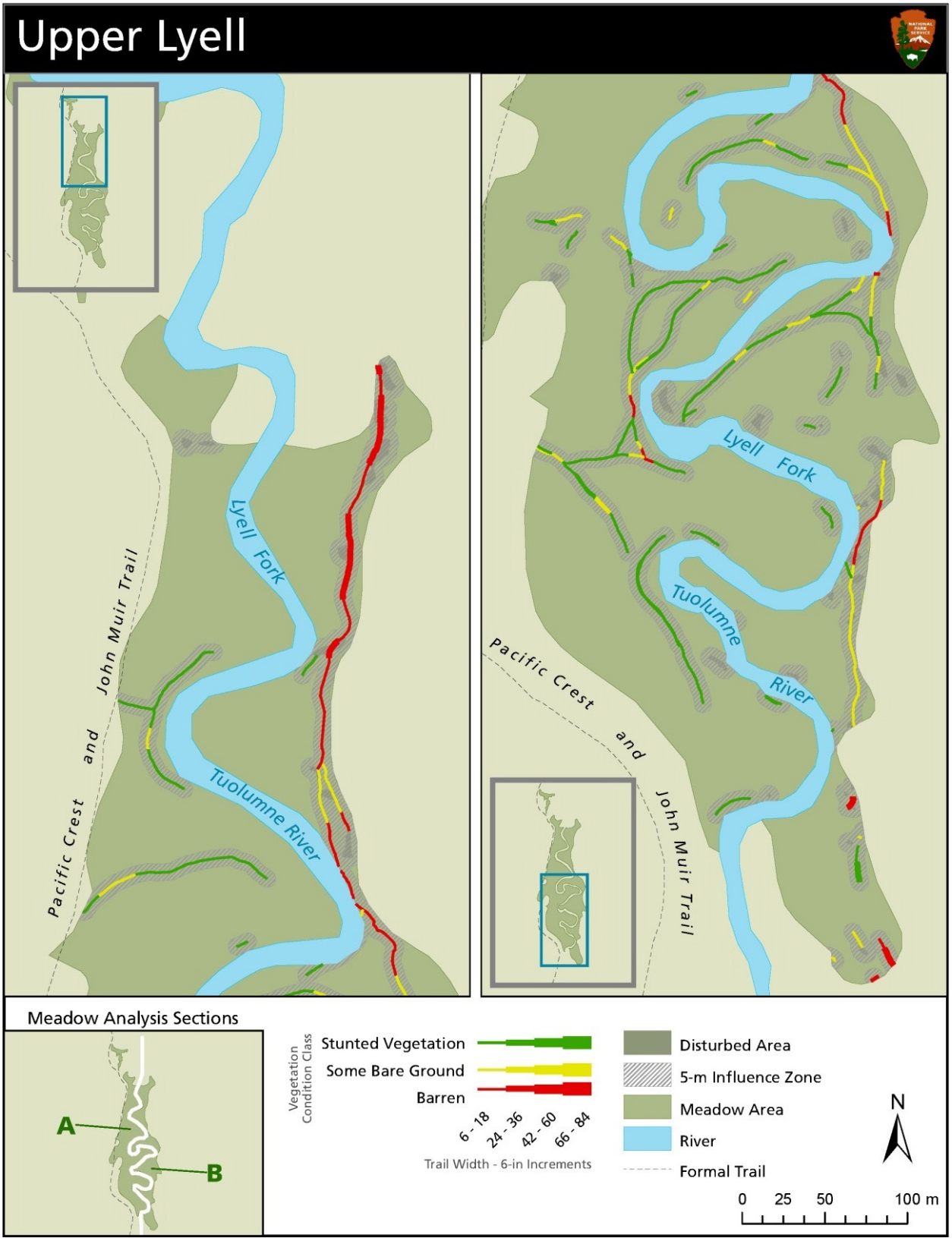

Figure 5-4. Location and Condition of Informal Trails, Upper Lyell Fork.

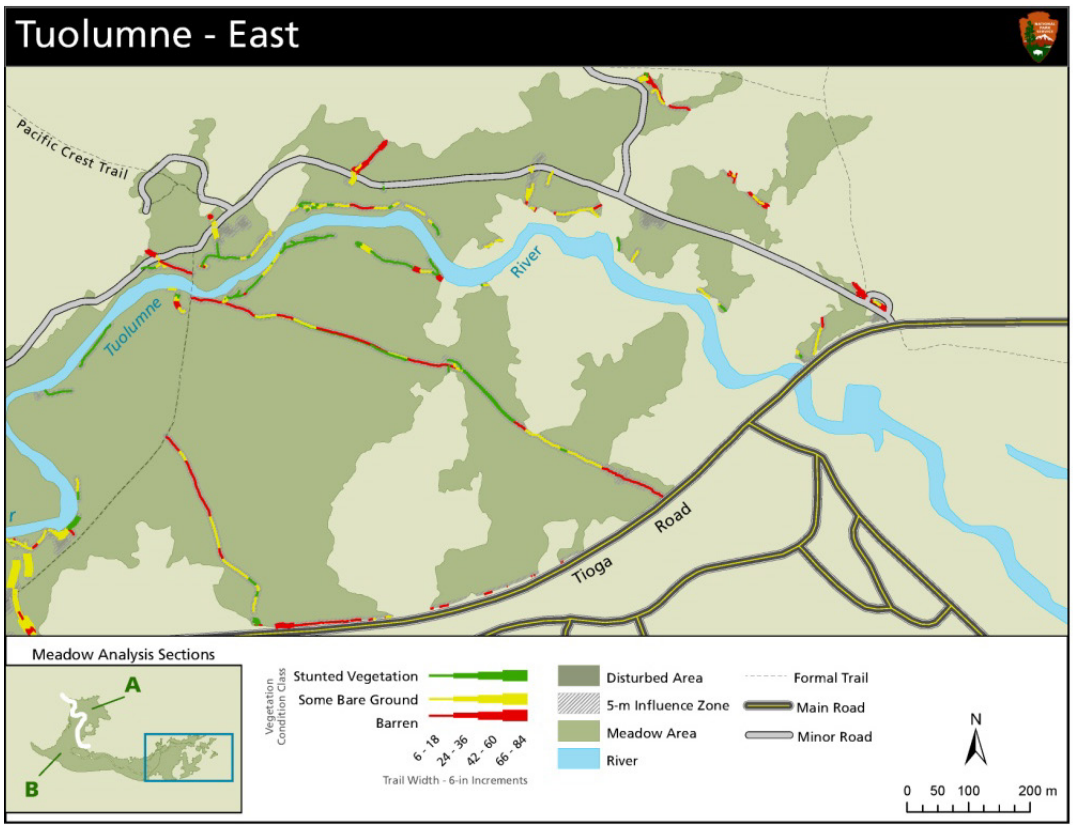

Figure 5-5. Location and Condition of Informal Trails, East Tuolumne Meadows.

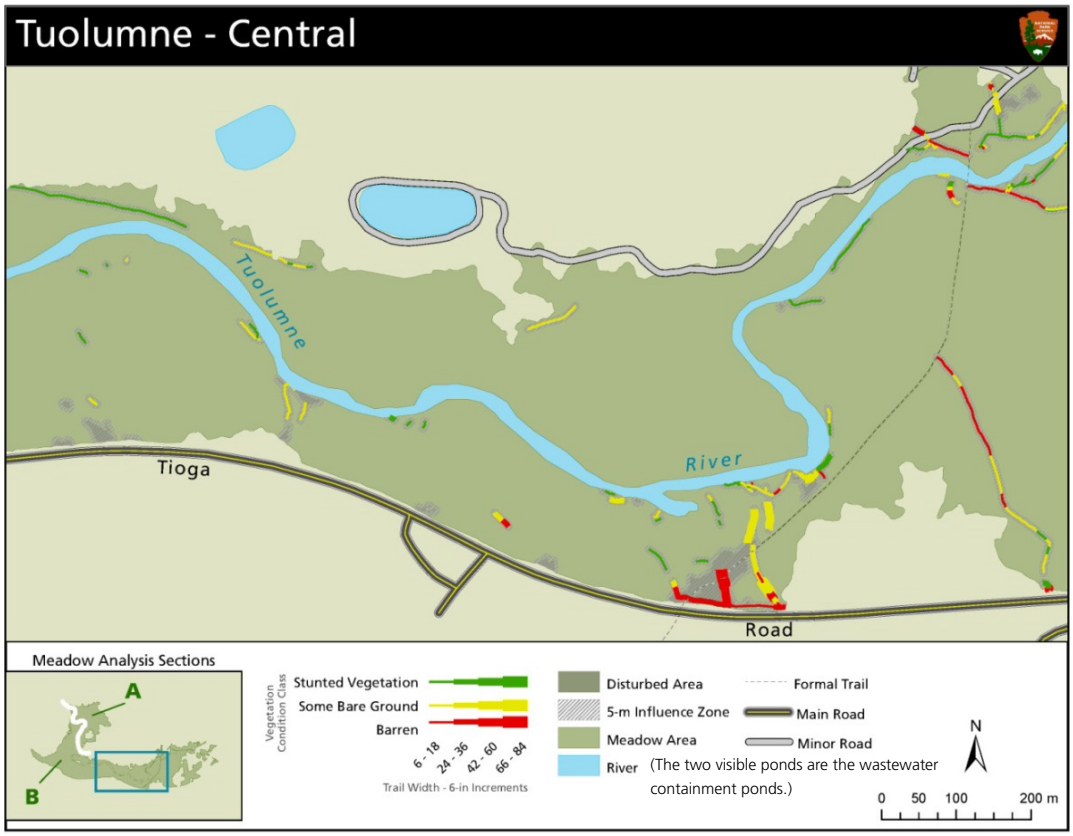

Figure 5-6. Location and Condition of Informal Trails, Central Tuolumne Meadows.

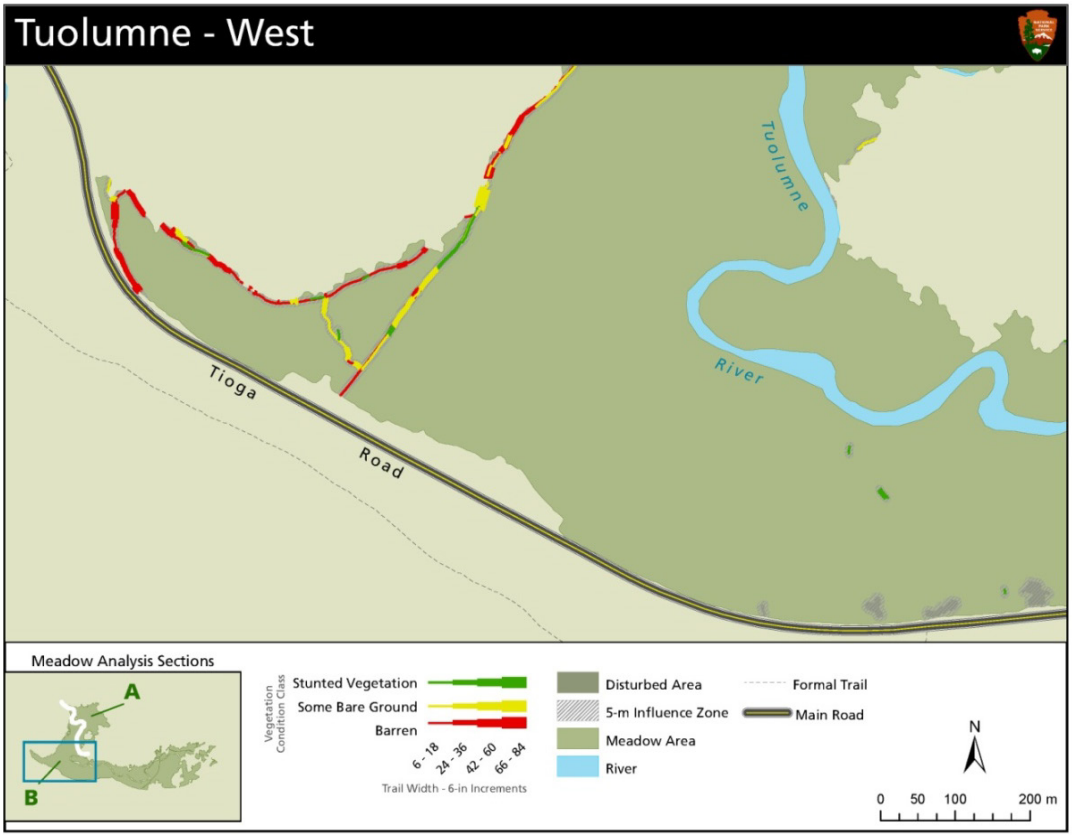

Figure 5-7. Location and Condition of Informal Trails, West Tuolumne Meadows.

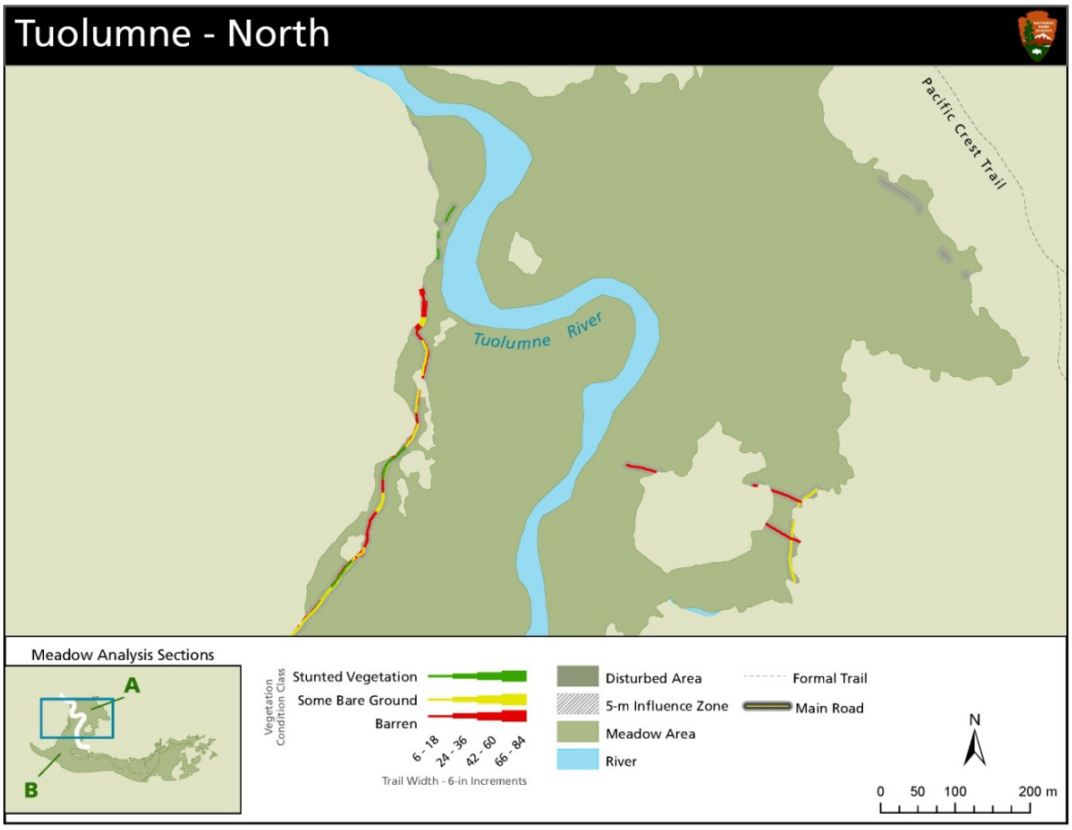

Figure 5-8. Location and Condition of Informal Trails, North Tuolumne Meadows.

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 were 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.

NPS PHOTO

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

NPS PHOTO

Headcut associated with Budd Creek.

NPS PHOTO

Partially blocked culvert.

NPS PHOTO

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 Old Tioga Road from the visitor center to Parsons Memorial Lodge (now a trail) and the Old Tioga Road/Great Sierra Wagon Road 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 persists, 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 nonmeadow 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). Hoofpunching 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 also document lodgepole pine encroachment into subalpine meadows along the Lyell Fork (Cooper et al. 2006).

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 due to proliferation of 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 four segments in which portions of the subalpine meadow and riparian complex occur will be evaluated every three to five years for evidence of use. The combination of these three indicators will provide park managers with a comprehensive and ongoing assessment of meadow health in the Tuolumne Meadows area and will enable the NPS to effectively protect the high-elevation meadows from the variety of use-associated impacts in Yosemite National Park.

The three indicators are discussed individually below. The comparison of the current condition of the meadows to these indicators and their definitions is presented after all three indicators are discussed, as the three indicators represent a comprehensive monitoring approach.

Indicator #1: Meadow Fragmentation due to Proliferation of Informal Trails

Indicator Description

Informal trails (sometimes also called social 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 the metrics provide good insight as to 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 meadow fragmentation caused by visitor-created trails because it is a highly sensitive indicator of changethat will allow Yosemite park staff to take steps to protect 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 (3.2 to 9.8 feet) of the trail's edge (Dawson et al. 1974, Dale and Weaver 1974, Leung et al. 2011c).

Research within high-elevation 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 2008). 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 able to recover 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).

As fragmentation exists as a proxy for the aforementioned impacts, a fragmentation measure known as the largest patches index-5 (LPI_5) will be used to measure the level of fragmentation. Adapted from the concept of a largest patch index (McGarigal and Marks 1995), this index is derived from the sum of the areas of the five largest patches without informal trails in a given meadow, divided by the total landscape (meadow) area and then multiplied by 100. The resulting number (a percentage) indicates the extent to which the meadow area is divided (fragmented) owing to the existence of visitor-created trails. If no trails are present, the total index value is 100%. The main purpose of grouping the five largest patches, instead of evaluating the single largest patch, is to reduce the index's oversensitivity to changes in one single patch. Just as parks like 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 3 largest and 10 largest patches (LPI_3, LPI_{10}), 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

To meet the fragmentation management standard, the weighted average of the LPI_5 indexes for all selected meadows within the given segment must be at least 93% (LPI_5) for each segment, with no individual meadow less than 90%. The segment would need to be out of compliance for three consecutive years for the management standard to be exceeded. The weighted mean values are calculated based on each individual meadow size relative to the total meadow area within each segment. Because the extensiveness of the meadow complex is a key component of this outstandingly remarkable river value, a weighted mean was adopted to ensure protection for the overall extent of the complex within each segment, as well as elements of individual meadow integrity. The fragmentation standard adopted for the *Final Tuolumne River Plan/EIS* 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 conditions over several years. Managers used their best professional judgment in selecting a weighted mean to evaluate the management standard at the segment level.

If the LPI_5 is for any individual meadow falls below 90% for one year or below 93% for three consecutive years, a management concern will be present, thus triggering management actions to ensure that adverse impacts are avoided (see the monitoring program for this indicator, below).

Adverse Impact

An adverse impact would occur if the weighted average of all meadows within a given segment dropped below an LPI_5 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, in both the Tuolumne River and Merced River corridors. This value specifically relates to low values collected for the main meadow in Tuolumne Meadows that has been identified for comprehensive restoration action. Similar values have been found in Yosemite Valley meadows in locations that 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 two percentage points added for increased sensitivity to impacts (NPS 2009k).

Degradation

The Tuolumne subalpine meadows will be considered degraded if the weighted average LPI_5 value drops to 40% or below. This value is based upon meadow conditions found in certain Yosemite Valley meadows in the past. Archival aerial photographs make it possible to simulate the fragmentation that previously existed in those meadows. Through spatial analysis using a 1978 image of Stoneman Meadow, park staff determined that an LPI_5 of 40% existed prior to intensive restoration efforts in that meadow (see figure 5-9). 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 only made possible through intensive restoration efforts involving several years of planning and significant financial investment.

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 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 (identified below) 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 (the final stage in the life cycle of a plant). All meadows within a segment will be evaluated for potential monitoring: a suite of variables will be collected, and all informal trails will be mapped and measured. Meadows will also be classified by impact type, using specific condition classes to identify the degree of visitor impact. Meadows with specific management concerns will be monitored annually, and meadows with high potential for visitor-created impacts will be monitored every three to five years, all by trained biological technicians. Meadows without evidence of visitor impacts will be periodically evaluated until evidence suggests more intensive monitoring is necessary. The *Visitor Use and Impact Monitoring Field Guide* (NPS 2010l) outlines the specific details for data collection, identification of informal trails, and a training program for technicians to ensure data is collected effectively and consistently for the life of the program.

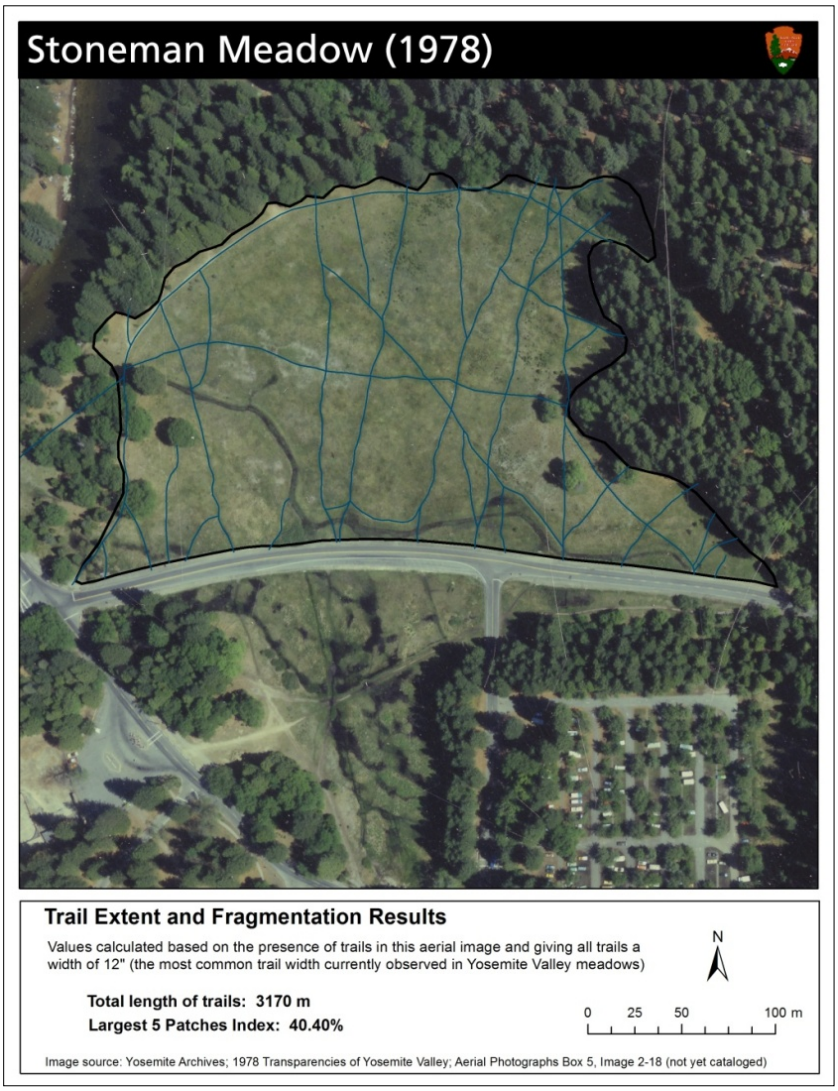

Figure 5-9. 1978 Aerial Image of Stoneman Meadow with LPI Calculations. (Today a boardwalk crosses the meadow north-to-south and the northern edge of the meadow is fenced. Due to these actions, no informal trails are present.)

Triggers and Management Responses

To ensure that a downward trend in conditions can be arrested before the river value condition falls below the management standard, and well before an adverse impact occurs, additional management actions will be triggered if the LPI_5 falls below 93% for an individual meadow and will become increasingly comprehensive and intense if the trend does not improve, as described in table 5-2.

Table 5-2.
Management Actions and Trigger Points to Maintain Desired Conditions for the Subalpine Meadow and Riparian Complex, related to Meadow Fragmentation

Trigger	Required Management Response (at least one action specified for each trigger will be taken)	Rationale
LPI_5 threshold decreases below 93% for an individual meadow (as opposed to the weighted mean for all the meadows in the segment).	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. Increase enforcement and education of best management practices in meadows. Implement restoration practices, including visitor messaging, restoration signs, delineation of trails determined to be less disturbing to meadow ecology, and closure of informal trails. Any management action in designated wilderness would require a minimum-requirement analysis.	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 an LPI_5 value of 93% for three consecutive years for an individual meadow (as opposed to the weighted mean for all the meadows in the segment).	Remove informal trails and restore disturbed areas in specific meadows that exceed the threshold. Restoration activities could include the following: ▪ Decompact soils. ▪ Salvage any plants growing in the ruts or on the edges of the trail/ruts for later replanting. ▪ Recontour topography. ▪ Scatter locally gathered seed and organic materials to facilitate new plant growth. ▪ Fill (with native soil) any deep headcuts caused by informal trails and recontour to more natural meadow topography. Management of visitor use could include the following: ▪ Install boardwalks or other hardened surfaces that allow access to sensitive areas. ▪ Temporarily close sites to facilitate restoration. ▪ Fence meadow perimeters. ▪ 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. ▪ Reduce or redirect use. Any management action in designated Wilderness would require a minimum-requirement analysis.	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

Riparian streambanks have been described as transitional areas between aquatic and terrestrial systems (Bohn 1986, Gregory et al. 1991), where the interchange among ground and surface water hydrologic processes are evident. In meadow systems, streambank conditions exhibit the balance between the hydraulic forces of fluvial surface water, subsurface pore pressure (i.e., lateral flow of groundwater input to the channel, infiltration, etc.), soil particle cohesion, and binding properties associated with roots of riparian vegetation (Micheli and Kirchner 2002). Streambank stability has been widely identified as a factor affecting the geomorphic function of stream channels (Kondolf et al. 1996, Kattelmann 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, loss of vegetative roots, or loss of woody riparian vegetation)

- 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)

Natural processes associated with channel migration or evolution to a new dynamic equilibrium can also manifest instability. Examples of these processes are substantial flood events or other large-scale disturbances, such as wildfires and/or landslides, within the contributing watershed.

For this component of the subalpine meadow and riparian complex, the indicator is streambank stability ratings. The management standard, adverse impact, degradation, and trigger points are determined by the percent of plots determined as 'stable' at the scale of the monitoring location or river segment (see detailed descriptions for each value, below). Streambank stability ratings involve a trained technician assessing three factors at a number of plots at one location, then averaging those rankings for the location. The three factors are habitat type (erosional or depositional [i.e., outside or inside of meanders], vegetation cover (covered or uncovered), and evidence of erosional features (block, slump, slough, active, or absent) (Frazier et al. 2005, Burton et al. 2011). Plots are ranked as either stable or unstable, with stable plots being those that have the specified combination of these three factors that signify stability. 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 is a fundamental component of riparian and meadow condition and function over time. Low ratings for streambank stability can be indicative of reduced system function and diminished biological integrity of riparian areas, and they suggest a need for focused monitoring and possible management actions. Long-term monitoring data on streambank stability conditions can be used to indicate whether, and how well, management objectives are being achieved. Follow-up focused monitoring at sites with low stability ratings includes intensive hydrologic assessments of the site and contributing watershed, such that the principal causes of instability can be discerned. Beyond focused monitoring, additional management actions can be taken to restore or mitigate low stability due to levels of streambank alteration.

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). Yosemite resource experts considered each protocol and corresponding optimal value for streambank stability ratings in determining the management standard, adverse impact, and degradation standard for this indicator. Ultimately, the NPS approach to determining values for these standards is blended from two protocols, stream condition inventory (SCI) (Frazier et al. 2005) and multiple indicator monitoring (MIM)(Burton et al. 2011). Both protocols assess streambank stability similarly, though some differences are apparent. For our purposes, the MIM protocol provides estimates of sample variance (i.e., confidence intervals) but does not currently provide recommended values for standards; the SCI protocol provides recommended standards for reference and managed reaches. The other published protocol for assessing streambank stability, the Pfankuck-Rosgen (Rosgen 2001), is not currently feasible given fiscal and staffing constraints for long-term monitoring, but may be appropriate as a hydrologic assessment tool for follow-up monitoring for sites that breach the trigger point value.

The values described below accommodate a given level of instability due to natural processes but are consistent with mean values reported by Frazier et al. (2005) for reference streams (75% stable, n = 18) and managed streams (50% stable, n = 25) in the Sierra Nevada. The following delineations are described hierarchically—in

terms of increasing spatial and/or temporal scale. The management standard is determined at the scale of the monitoring location (a designated monitoring area), while 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 value incorporates a temporal scale, occurring only if streambank stability conditions have not recovered to above the management standard over two monitoring years.

Monitoring locations 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 locations will be regularly monitored according to the schedule specified in the "Monitoring Protocols" section below, which also lists the specific locations in the Tuolumne River corridor.

Management Standard

The management standard for the maintenance of stable streambanks is that at least half (50%) of all streambank stability rankings at each individual monitoring location are stable in any given year.[21] This management standard allows for some streambank instability due to either anthropogenic causes and/or dynamic processes (channel migration, erosion, and deposition) fundamental to hydrologic function of fluvial river systems (as explained above), while still requiring at least half of all streambanks—amounts similar to those commonly found on unaltered streambanks—to be stable. Monitoring locations 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.

Adverse Impact

Based on available scientific knowledge and professional judgment, an adverse impact occurs when less than half (<50%) of all streambank stability rankings are stable, averaged across all monitoring locations within a river segment for any single monitoring year, after restoration or use restrictions have been implemented.[22] Potential adverse impacts may also be realized when a statistical trend is observed, where the percent of stable streambank stability ratings in a segment is likely to drop below 50% in subsequent monitoring years without intervening management action.

Degradation

Based on available scientific knowledge and professional judgment, degradation occurs when less than half (<50%) of all streambank stability rankings are stable, averaged across all monitoring locations within a river segment, for at least two consecutive monitoring years after restoration or use restrictions have been implemented.[23]

Ultimately, adverse consequences of channel instability (or disequilibrium) are 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). Extensively 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.

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[21] Breach of the management standard is determined by comparing the management standard to the upper confidence limit for the average of the observed data. For example, a location with an average of 46% of its plots as stable would have a 95% confidence interval of 41% to 51%. The upper confidence limit (51%) is used for comparison; because it exceeds 50%, this location is within the management standard.

[22] Again, the streambank stability rankings are determined using the upper confidence limit; for example, a location whose plots averaged 44% stable would be classified as having an adverse impact, because the upper confidence limit [49%] would be less than 50%.

[23] Again, the upper confidence limit is used.

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 defining management triggers intended to ensure that any downward trend in conditions can be identified and arrested well before adverse impact occurs. The triggers for protecting streambank stability are identified below in table 5-3.

Table 5-3.
Management Actions and Trigger Points to Maintain Desired Conditions for the Subalpine Meadow and Riparian Complex, related to Streambank Stability

Trigger	Required Management Response (at least one action will be taken)	Rationale
The percent of plots at any monitoring location rated as stable declines to less than 75%. OR A statistical trend is observed indicating that the percent of plots at a monitoring location rated as stable is likely to drop below 75% in subsequent monitoring years, without intervening management action.	Assess streambank alteration at impacted sites. Conduct hydrologic assessments of the contributing source area for that site. Implement actions to facilitate site recovery through restoration and/or use restriction (i.e., resource exclosures, site rest, and so on). Implement use-restriction actions if streambank alteration or other anthropogenic activities are identified as causal mechanisms of instability. Increase monitoring frequency to evaluate effectiveness and recovery to the management standard, and compare to reference site conditions as available.	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.

Monitoring Protocols

Streambank stability monitoring is a long-term indicator and can be effectively monitored on a three- to five-year interval (Kershner et al. 2004, Burton et al. 2011), whereas streambank alteration is a short-term indicator that should be monitored annually (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 all three reaches of the Tuolumne River that contain portions of the subalpine meadow and riparian complex (the Lyell Fork, the Dana Fork, and Tuolumne Meadows).

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 a trigger is tripped, 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. Results from a wide suite of metrics—stream monitoring data (i.e., the comprehensive MIM protocol, including streambank stability), follow-up hydrologic assessments, and available data from additional sources such as visitor use data—will be used to inform and help prioritize subsequent actions necessary for site recovery.

Triggers and Management Responses

For streambank stability, action will be triggered when less than 75% of plots at any monitoring location are ranked as stable (see table 5-3). Action will also be triggered when a statistical trend is observed indicating that the percent of plots at a monitoring location rated as stable is likely to drop below 75% in subsequent monitoring years without intervening management action. Management actions to facilitate site recovery of riparian habitats may include use restrictions (either exclosures or temporary restriction of specific use types),

and/or site restoration. The duration of use restrictions 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.

Indicator #3: Meadow Bare Soil

Indicator Description

The purpose of the bare soil indicator is to monitor meadow integrity in relation to pack stock grazing and trampling by people or pack stock. 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, Gutierrez and Hernandez 1996, Cerda 1999). Researchers have linked grazing activities 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.

Weixelman and Zamudio (2001) generated low, moderate, and high ecological condition classes for bare soil cover values based on monitoring data from a comprehensive multiyear study in U.S. Forest Service meadows in the Sierra Nevada. In their report, ecological condition classes for bare soil values were based on point-intercept data collected from 363 meadows across a broad disturbance gradient (Weixelman and Zamudio 2001). These values were used as a starting point to inform condition class development in Yosemite and are shown here as an example. However, the park will revise these condition class values based on monitoring data collected in Yosemite (protocol in development). These data will be collected from meadows with visitor and pack stock use as well as meadows with no to low use levels (reference sites) to detect changes in condition unrelated to direct human use or management actions. Exposed bare soil also occurs due to natural phenomena, such as wildlife activity, drought, and/or flooding, and therefore, some background level of bare soil may be expected. The monitoring approach may also include collecting information on meadow characteristics and human use to have an empirical basis for assessing bare soil causal factors. A specific approach will be determined during monitoring design.

Definitions of Management Standard, Adverse Impact, and Degradation

Management Standard

To meet the management standard for meadow bare soil, at least 75% of sites monitored in the river segment should have bare soil cover values within the range of high ecological condition, and no more than 15% of sites in low ecological condition occurring at the individual meadow level for three consecutive years. By including

multiple years in this standard, variability due to such nonhuman influences as drought or increased rodent burrowing can be ruled out for low ecological condition.

Values for bare soil cover that define ecological condition classes vary according to meadow type and elevation, as shown in table 5-4. To be in a high condition class, a moist meadow cannot have bare soil exceeding 6%, and a wet montane meadow (5,000–8,000 feet in elevation) cannot have bare soil exceeding 4%. Exact ranges of values for condition classes will be set and adaptively revised for Yosemite based on values obtained through additional data collection. One meadow may contain up to three meadow types (wet, moist, and dry), each of which would be sampled as an independent unit (a "site") and its values for condition class applied respectively. To determine whether the standard is met at the segmentwide level, a percentage of sites in low, moderate, and high condition classes will be calculated.

The NPS based these management standards on data and recommendations from the U.S. Forest Service Region 5 (California) Range Monitoring Project. This project has been monitoring bare soil in relation to livestock use in Sierra Nevada meadows for 12 years (Weixelman 2009).[24]

Table 5-4.
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[a]	0–4%	5–8%	>8%
Wet meadow/ montane[b]	0–4%	5–9%	>9%
Moist meadow/all zones	0–6%	7–13%	>13%
Dry meadow/ subalpine	TBD	TBD	TBD
Dry meadow/ montane	0–8%	9–13%	>13%
Temporarily flooded/all zones	TBD	TBD	TBD

Source: Data from Weixelman and Zamudio 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.
TBD = to be determined.

Adverse Impact

An adverse impact on meadow condition would occur if bare soil cover values are at least twice the bare soil cover value for low ecological condition (regardless of meadow type) in at least 40% of the sites in a river segment. Based on the values in table 5-4, a subalpine wet meadow with double the bare soil cover value for low ecological condition (as measured by point-intercept data) would have >16% bare soil cover. Exact ranges of values for condition classes would be set and adaptively revised for Yosemite based on values obtained through additional data collection. If a river segment contained 50 monitored sites, an adverse effect would be present if there were more than 20 sites with such a doubling of their respective bare ground cover values.

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 twice the value for low ecological condition rating for more than 40% of meadow plots in a river segment signify a more significant decline than a minor, short-term fluctuation in one meadow.

Degradation

Degradation would be indicated when bare soil cover values are twice (or more) the bare soil cover value for low ecological condition (regardless of meadow type) in at least 80% of the sites in a river segment. For example, a subalpine wet meadow with double the bare soil cover value (as measured by point-intercept data)

[24] There are no known standards for bare soil in published academic literature.

would have >16% bare soil cover. Exact ranges of values for condition classes would be set and adaptively revised for Yosemite based on values obtained through additional data collection. If a river segment contained 50 monitored sites, degradation would be present if there were more than 40 sites with such a doubling of their respective bare soil cover values.

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.

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 (identified below) 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

The NPS is collaborating with the University of California-Berkeley and the University of Arizona to develop a protocol to monitor meadow bare soil cover. Together they completed a draft monitoring protocol and collected pilot data from representative meadow types in the summer of 2012. They further refined the protocol based on pilot data results and began implementing the protocol in meadows of concern and reference meadows in the summer of 2013. Data collected will be used to adapt the ecological condition classes of Weixelman and Zamudio (2003) to Yosemite National Park.

Monitoring will occur in subalpine meadows with grazing and/or trampling concerns, which currently include two meadows in upper Lyell Canyon and one meadow at Tuolumne Meadows. The NPS will evaluate meadows of concern as well as reference meadows within the corridor. As the protocol develops, additional specific meadows of concern may be identified for monitoring. Reference sites (meadows with little to no visitor or stock use) will also be monitored as needed to provide a comparison with meadows of concern. Every five years, NPS staff will reevaluate which meadows in the corridor are in need of monitoring. The recommended monitoring interval for bare soil is three to five years unless the amount of bare soil reaches a management trigger, prompting an increase in monitoring frequency. 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. The NPS will evaluate the effectiveness of the indicators on a regular basis to ensure that the combination of these metrics fully protects this river value.

As noted earlier, bare soil amounts vary among meadow vegetation types and elevation zones. This variability is addressed by different values to define ecological condition for dry, moist, and wet meadows (Weixelman and Zamudio 2003). Temporarily flooded meadow types may also contribute to 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.

Triggers and Management Responses

The NPS has developed multiple triggers for management action to ensure that a downward trend in conditions can be reversed well before the river value condition falls below the management standard or an adverse impact occurs (see table 5-5). These triggers require additional management action if a downward trend is detected, even though the condition is 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 5-5.
Management Actions and Trigger Points to Maintain Desired Conditions for the Subalpine Meadow and Riparian Complex, related to Bare Soil

Trigger	Required Management Response (at least one action specified for each trigger will be taken)	Rationale
Trigger point 1: Monitoring indicates "low ecological condition" bare soil cover value at any monitored site.	Apply a secondary assessment 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 meadows. Assessing meadow condition aids in identifying key stressors that may be affecting meadow condition. Assessment results assist with interpretation of monitoring results.
	Increase education in best management practices in meadows for Yosemite Wilderness visitors, park staff, and park partners.	Education in maintaining meadow condition will help prevent further increases in bare soil associated with human use.
Trigger point 2: Monitoring indicates "low ecological condition" bare soil cover value at any monitored site for two monitoring periods. AND Secondary assessment indicates use is a stressor for both monitoring periods. OR Fewer than 80% of monitoring sites within a river segment are rated in high condition or greater than 10% of sites in low ecological condition for bare soil.	Increase education about best management practices in meadows for Yosemite Wilderness visitors, park staff, and park partners.	Education in maintaining meadow condition will help prevent further increases in bare soil associated with human use.
	Work with stakeholders to develop strategies for timing of use, then reduce use if needed to minimize impacts. Work with stakeholders to adjust use levels annually.	Determining effective strategies with stakeholders for managing meadow use is a necessary step in the process to protect and enhance meadow condition.
	Monitor annually for 5 years.	Frequent monitoring will facilitate more rapid detection of, and management response to, changes in ecological condition. Its utility is to evaluate the effectiveness of changes in the intensity and/or timing of use on meadow condition.
	Rest the meadow if necessary: temporarily discontinue grazing until conditions improve based on secondary assessment results. Establish a preliminary grazing capacity or adjust grazing capacity.	Allowing a period of meadow "rest" (removing stresses from grazing and/or trampling) has been shown to facilitate meadow recovery. Effects of trampling and grazing that are expected to decline with reduced use or avoidance of early-season use include soil compaction, bare ground exposure, and plant disturbance. Grazing capacities are estimates of use levels that can be sustained in a meadow based on available forage cover, productivity, and site condition, which can guide in setting an appropriate level of use.
Trigger point 3: Bare soil is double the value of low ecological condition class at a site. OR Previous management actions (such as reduction in use) have been ineffective. OR Assessments for five years have not shown improvement in ecological condition.	Discontinue grazing until conditions improve based on bare soil monitoring.	Allowing a period of meadow "rest" (removing stresses from grazing and/or trampling) has been shown to facilitate meadow recovery. Effects of trampling and grazing that are expected to decline with reduced use or avoidance of early-season use include soil compaction, bare ground exposure, and plant disturbance. Grazing capacities are estimates of use levels that can be sustained in a meadow based on available forage cover, productivity, and site condition, which can guide in setting an appropriate level of use.

Management to Protect and Enhance the Subalpine Meadow and Riparian Complex

Current Findings Regarding Management Standards, Adverse Impact, and Degradation

Building on the definition of the key terms defined (management standard, adverse impact, and degradation) for each of the three indicators for this river value, and on the assessment of the past and current conditions of the meadow and riparian complex, this section presents the most current monitoring data about the meadow and riparian complex in terms of the three indicators described above, and identifies where management concerns or localized concerns are present. The next section describes the actions the NPS will take to address these concerns. In brief, management concerns are present regarding both meadow fragmentation and streambank stability, but not enough information is yet known to assess bare soil conditions (although it appears that localized concerns are present). For all these concerns, a comprehensive restoration program is included; a summary of the program is provided in this section, and the full restoration plan included as appendix H.

Management concerns for meadow fragmentation occur when the condition of a resource has reached one of the trigger points identified in table 5-2; for streambank stability, one of the trigger points in table 5-3; and for bare soil, one of the trigger points in table 5-5. Management concerns associated with the subalpine meadow and riparian complex value are present with both meadow fragmentation and streambank stability. Table 5-6 compares the current condition of the meadow and riparian complex to the definitions of management standard, management concern, adverse impact, and degradation using the indicator for fragmentation. Table 5-7 compares the current condition of the complex to the definitions of management standard, management concern, adverse impact, and degradation using the indicator for streambank stability.

Table 5-6.
Current Condition of Meadow and Riparian Complex Based on Monitoring of Largest Patches Index-5 (LPI_5)

Metric	River Segment /Meadows	LPI_5 by Year[a] 2008	2009	2010	2011	2012
Meets management standard: LPI_5 is greater than 93% of weighted mean value of the meadows in a river segment, with no individual meadow less than 90%.	Lyell Fork Segment					
	Ranger Station A		99.49			98.96
	Ranger Station B		99.94			99.88
	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	
	Weighted mean for 2012					**98.18**
	Lower Dana Fork Segment					
	Dana A (see figure 5-2)	96.3	95.6			
	Dana B (see figure 5-3)	100.0	100.0			
	Twin Bridges	98.6				97.46
	Weighted mean for 2012					**98.7**
Management concern present: LPI_5 is below 93% for any individual meadow (trigger 1) or the annual LPI_5 index is below 90%, or below 93% for three consecutive years, again for an individual meadow (trigger 2).	Tuolumne Meadows Segment					
	Tuolumne A (see figure 5-8)	100	99.9	99.8	100.0	99.98
	Tuolumne B (see figures 5-5, 5-6, and 5-7)	80.0	78.4	78.2	78.7	82.02
	Weighted mean for 2012					**85.07**
Adverse impact: The weighted average LPI_5 value is below 81% for all the meadows in a river segment for three consecutive years.	None present.					
Degradation: The weighted average LPI_5 value is 40% or less for all the meadows in a river segment.						

a LPI_5 as a percentage of the weighted mean value of all the meadows in a river segment.

In terms of meadow fragmentation, a management concern is present in the Tuolumne Meadows river segment, where Tuolumne Meadow B has a fragmentation score of 82.02%, which is considerably below both trigger points, so additional management action is required for this meadow. No management concerns are present along the Lyell Fork or the Dana Fork segments. All other meadows that have been monitored have fragmentation scores above 93%, so their condition does not fall below a trigger point.

Table 5-7.
Streambank Stability Ratings by Monitoring Site and Segment Averages

Metric	River Segment	Stability Rating, 2012[a]
Meets management standard: At least half (50%) of all streambank stability rankings at each individual monitoring location are stable.	Dana Fork Segment (average stability rating of all plots at each monitoring site, with the upper bound of the confidence interval shown)	
	Dana Meadow	91 (+5) = 96
	Dana Fork Meadow	87 (+5) = 92
	Segment Average	**89 (+5) = 94**
Management concern present: Less than 75% of all streambank stability rankings at an individual monitoring location are stable.	Lyell Fork Segment (average stability rating of all plots at each monitoring site with the upper bound of the confidence interval shown)	
	Upper Lyell Canyon, north	63 (+5) = 68
	Upper Lyell Canyon, south	49 (+5) = 54
	Middle Lyell Canyon	52 (+5) = 57
	Lyell Fork Reach 1	82 (+5) = 87
	Lyell Fork Reach 2	71 (+5) = 76
	Segment Average	***63* (+5) = 68**
	Tuolumne Meadows Segment (average stability rating of all plots at each monitoring site, with the upper bound of the confidence interval shown)	
	Tuolumne Meadows Reach 1	47 (+5) = 52
	Tuolumne Meadows Reach 2	47 (+5) = 52
	Segment Average	**47 (+5) = 52**
Adverse impact: Average streambank stability rating below 50% averaged across all monitoring sites within a river segment for any single monitoring year.	None present.	
Degradation: Average streambank stability rating below 50% across all river segments for at least two consecutive monitoring years		

a A given level of uncertainty exists within observed estimates for streambank stability. Therefore, the observed values for streambank stability are adjusted upwards by 5% as shown, which is the reported range for 95% confidence intervals (adjusted from 5.2% for significant digits) by the protocol authors (Burton et al. 2011). Based on applying this adjustment to the observed values (as shown in this table), no river segments are currently below the proposed management standard, though most locations in Lyell Canyon and both those in the Tuolumne Meadows are below the proposed trigger point value. As NPS accumulates more data, it will develop confidence intervals that are specific to Yosemite sites.

In terms of streambank stability, management concerns are present in both the Lyell Canyon and the Tuolumne Meadows segments, while no such concerns are present with the meadows in the Dana Fork. Although the adjusted averages for stable locations of 68% for the Lyell Canyon segment and 52% for the Tuolumne Meadows segment are both above the management standard of 50%, a management concern is identified if the average falls below 75%, which is the case in both these segments.

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.

Management Concerns and Protective Actions

The management concerns related to the indicators of meadow fragmentation and streambank stability, identified above, cannot be addressed in isolation. The monitoring findings speak to the loss of ecological resistance of subalpine meadow and riparian ecosystems (the amount of disturbance that a system can take

before key ecosystem elements change). This section presents actions the NPS will take to protect and enhance the Tuolumne River's subalpine meadow and riparian complex as a whole, and to restore the hydrologic and biological functions necessary to sustain these ecosystems. 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 Priority Locations map (figure 5-10). Unless noted otherwise, all actions discussed herein are actions common to all alternatives.

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.
- 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.

These goals and objectives will be accomplished through the actions presented in the following subsections.

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:

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

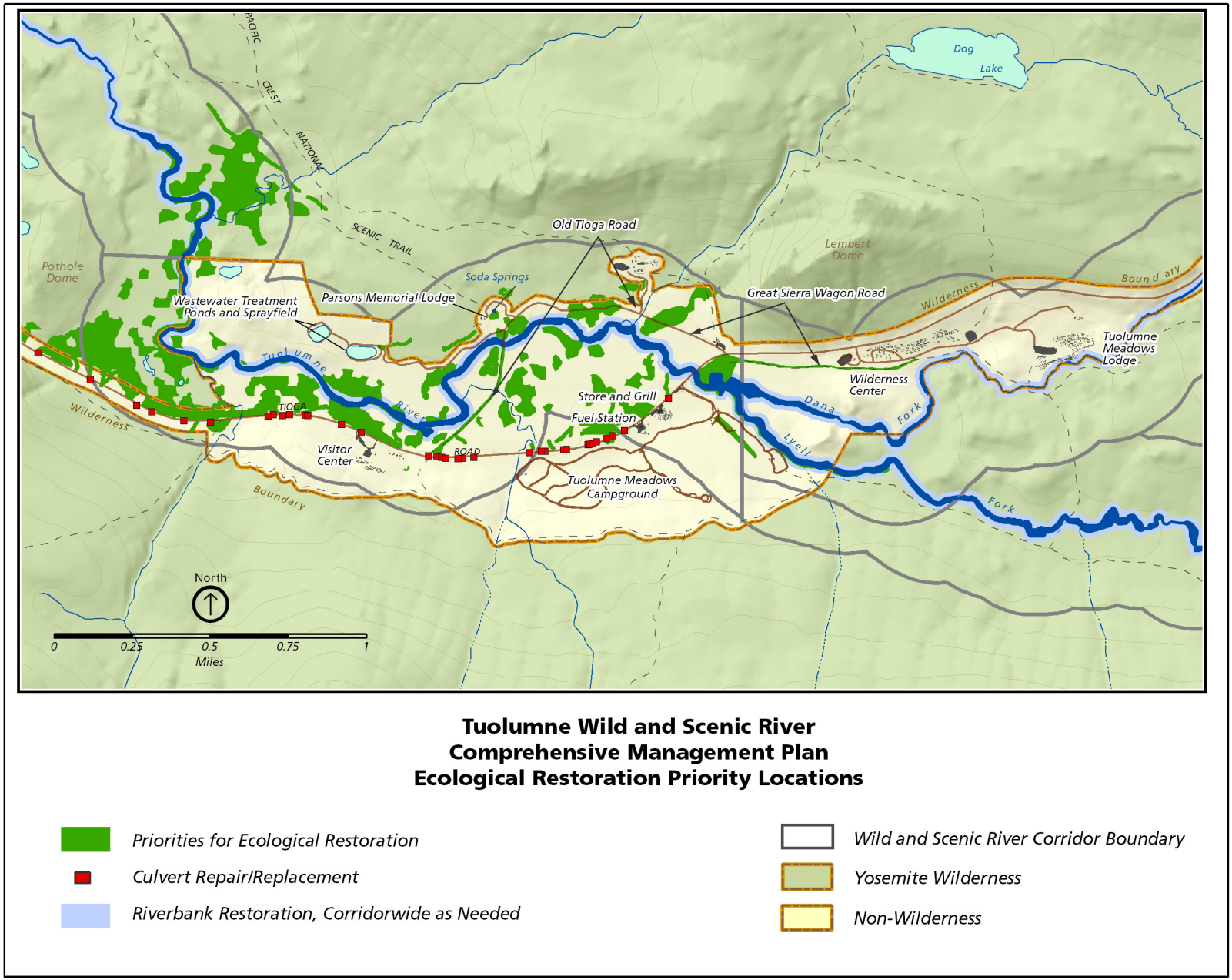


Figure 5-10. Tuolumne Meadows Ecological Restoration Priority Locations.

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. Pipes in meadows may be left in place and filled with slurry, while in other areas it may be more appropriate to remove the pipe.

The following nonhistoric 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 at the Tuolumne Meadows Lodge
- three visitor tent cabins near the river at the Tuolumne Meadows Lodge

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 8. Depending on the alternative, a riparian buffer may also be implemented.[25] The concept of a riparian buffer to protect river resources is well established in the scientific literature and has been applied by numerous federal, state, and local land management agencies (e.g., Welch 1991, Wenger 1999, Lee et al. 2004; Mayer et al. 2006). The riparian buffer would remove all development from within 100 feet of the river and prohibit new development from within 150 feet.

The following actions will be taken to restore previously disturbed sites (from which structures will be removed):

- Decompact, 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 affects 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.

[25] A riparian buffer is a strip of riparian vegetation along the banks of a river that filters runoff and provides a transition zone between the river and human land use (e.g., Osbourne and Kovacic, 1993).

- 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.
- Decompact, 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 F) 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 (NRHP), and the historic culverts contributing to the eligibility of that property to the NRHP 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 a 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 Lembert 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 Lembert Dome (north of the road) to reduce channeling, downcutting, and velocity, thereby 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 Lembert 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 culverts or elevate the trail on a raised walkway to accommodate high flows on the southern approach to the bridge at Parsons Memorial Lodge (no changes would be made to the bridge itself).
- Install sections of boardwalk or other surface types through wet and saturated areas to avoid disrupting 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 or any new culverts are consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties and are in conformity with the Yosemite Design Guidelines (NPS 2011a).

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):

- Specify campsites and access routes. Factors such as avoidance of rare plants and other resources of special concern will be considered in designating these areas.
- Set pack stock opening dates (or “range readiness” dates) for mountain meadows. 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.
- Annually monitor meadows receiving high use to ensure that the grazing capacity is protective of river values (NPS, Ballenger et al. 2010j). 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 167 – 249 stock nights per season, depending on the year’s precipitation patterns. This is an estimate of

the grazing level that could be sustained without undesirable effects on meadow habitat (NPS, Ballenger 2010h), and it could be adjusted if necessary to protect river values.

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. The NPS is overseeing research to understand meadow processes and the most effective ways to restore vegetation composition, belowground biomass, soil-forming processes, and stability of the meadow vegetation (Cooper et al. 2006). Ecological restoration techniques, if determined feasible and appropriate, would likely involve planting, seeding, and mulching, with temporary closure to foot traffic as vegetation reestablished. Future research is also important to provide information on the relationship between past land uses and the rate and extent of conifer seedling establishment. The cause(s) of conifer encroachment in Tuolumne Meadows is not thoroughly understood, but its impact is apparent on the landscape. Periodic manual removal of sapling lodgepole pines has taken place for over 60 years; for example, NPS staff and volunteers removed over 70,000 sapling conifers in the period between 2006 and 2007 (NPS 2008h). The NPS discontinued mechanical removal of conifer saplings in 2010 pending completion of studies that could provide site-specific insight into the issue. The NPS is utilizing an ecosystem-wide approach to understand conifer encroachment in the area, assess whether or not it is human-caused and within NPS control, and then adaptively manage the meadows accordingly.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.

Localized Concerns and Enhancement Actions

Existing studies show that localized concerns regarding bare soil cover values 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, also described above.

Conclusion: Protection and Enhancement of 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. Additionally, human actions are likely causing streambanks in the Lyell Canyon and Tuolumne Meadows to become unstable. Stock use is a contributing factor to streambank instability in Lyell Canyon.

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, removal of facilities from riverbanks and wet areas, and further regulation or elimination of commercial stock use (both alternatives are under consideration in chapter 8, "Alternatives for River Management"). These actions will be expected to protect and 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 8.

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 management triggers used to identify any decline in meadow or riparian condition under any of the three indicators before the condition drops to the management standard and 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

Poopenaut Valley is located in the river corridor downstream of the Hetch Hetchy Reservoir. The ecological health of the Poopenaut Valley's unique low-elevation meadow, wetland, and riparian habitats, which provide important wildlife habitat, depends upon the hydrology of Tuolumne River, which has been regulated by O'Shaughnessy Dam 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; thus it is likely that conditions then were similar to current conditions. Research conducted since designation (NPS, Stock et al. 2007k, described below) indicates that despite flow regulation, a diverse community of low-elevation riparian, wetland, meadow, and upland forest vegetation continues to persist, in turn supporting a diverse set of avian, bat, and other wildlife species (NPS, Stock et al. 2012b).

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 downstream of 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). Research conducted by Stock and others also suggests that some areas of wetland below O'Shaughnessy Dam might be transitioning to drier upland habitat, the result of lowering groundwater levels. Some conifer encroachment has occurred in these meadows, similar to conditions seen in Tuolumne Meadows. The degree to which these changes have been influenced by dam operations is being studied (NPS, Stock et al. 2007k).

In 2013 the Rim Fire burned over most of the Poopenaut Valley. In general, the fire burned coolly in the valley, largely burning grasses and other vegetation near the ground and leaving most of the streamside vegetation unburned, as well as most overstory trees. However, some willows near the center of the valley burned, with unknown effects on the birds that reside there. After the fire passed, park managers began efforts to monitor the ecological changes due to the fire. Managers are hopeful that the downstream bedrock constriction and low river gradient will continue to sustain a robust riparian and wetland community.

Management Indicator and Monitoring Program

Definitions of Management Standard, Adverse Impact, and Degradation

These terms are not defined in the *Tuolumne River Plan* because O'Shaughnessy Dam instream flow releases that sustain the outstandingly remarkable biological value in the Poopenaut Valley are subject to stipulations associated with the Raker Act. The existing stipulations do not include ecosystem monitoring elements. The NPS will continue collaboration with the San Francisco Public Utilities Commission (SFPUC) and other stakeholders to support the development and implementation of a new instream flow management plan for O'Shaughnessy Dam, which the SFPUC is preparing as part of the collaborative Upper Tuolumne River Ecosystem Program. The new flow plan will include monitoring and adaptive management elements linked to anticipated ecological outcomes.

Monitoring Program to Prevent Future Adverse Impacts or Degradation

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.

Management to Protect and Enhance Low-Elevation Riparian and Meadow Habitat

Because Poopenaut Valley is directly downstream of the Hetch Hetchy Reservoir and subject to the stipulations of the Raker Act, it is not possible to strictly manage the area using the standards and key terms as defined for other values in this plan.Nonetheless, the NPS will continue to work toward protection and enhancement of this river value, within the Raker Act provisions. The Raker Act authorizes the 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.

Conclusion: Protection and Enhancement of Low-Elevation Riparian and Meadow Habitat

Since 1923 O'Shaughnessy Dam has regulated the magnitude, timing, duration, and frequency of instream flow below the dam. Despite continued flow regulation, a diverse community of low-elevation riparian, wetland, meadow, and upland forest vegetation continues to persist, in turn supporting a diverse set of avian, bat, and other wildlife species. However, NPS studies conducted as part of the Upper Tuolumne River Ecosystem Program suggest that some portions of the wetlands and meadows in the Poopenaut Valley appear to be transitioning to drier upland vegetation types, while some encroachment of riparian vegetation into the river channel has taken place. These changes may be symptomatic of flow regulation by O'Shaughnessy Dam. The NPS will continue collaboration with the SFPUC and other stakeholders to support the development and implementation of a new instream flow management plan for O'Shaughnessy Dam, which the SFPUC is preparing as part of the collaborative Upper Tuolumne River Ecosystem Program. The new instream flow plan will modify O'Shaughnessy Dam instream flow releases to better support broad river ecosystem values in the upper Tuolumne River (including Poopenaut Valley wetlands and meadows), mimic natural hydrology, and provide for long-term ecological monitoring.

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 Indicator and Monitoring Program

Definitions of 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 to Prevent Future Adverse Impacts or Degradation

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 as well as other management actions protect and enhance this outstandingly remarkable geologic value.

Management to Protect and Enhance Stairstep River Morphology

Because the condition of stairstep river morphology in the river corridor is essentially impervious to human activities, no present or foreseeable management concern or localized concern exists regarding this geologic value. Because there are no concerns regarding the condition of this value, no action other than continued protection under the WSRA is necessary. Natural processes will continue to shape the landscape and the geologic value of the Tuolumne River corridor.

Conclusion: Protection and Enhancement of 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: Prehistoric Archeological Landscape

All Wild and All Scenic Segments

Condition Assessment

Condition at the Time of Designation

Information about the extent and significance of the prehistoric archeological landscape[26] 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 had been 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 NRHP. 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

[26] Archeological landscape' is a term specific to this WSRA analysis and is not linked to any NRHP archeological resource property type. The term is used here because this outstandingly remarkable value reflects the American Indian view that the Tuolumne River corridor was one whole landscape linked by the Tuolumne River (the "silver thread" linking the high country with the foothills).

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 of the Tuolumne River, none had been evaluated for eligibility for 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 Administrative Area 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 prehistoric 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 prehistoric 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 prehistoric 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 River 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 NRHP 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 prehistoric 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 Indicator and Monitoring Program

Indicator Description: Aggregate Condition of Prehistoric Archeological Sites

Within the Tuolumne River corridor, individual prehistoric sites combine to form the collective character and significance of the prehistoric archeological landscape. The indicator is the aggregate condition of the collection of prehistoric 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).

Prehistoric 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 Archeological Sites Management Information System (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 a descending 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 fire or vandalism (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 2011c). 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 place. Previous data recovery at the site may mean some impacts are less damaging for data potential at the excavated locations.

The Archeology Visitor Use Program augments ASMIS data collection on each site disturbance with an assignment of disturbance causation: 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 and the state historic preservation officer, 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 prehistoric archeological landscape, the management standard is that at least 85% of sites with high data potential and at least 80% of sites with low data potential must be free from serious unmitigated human impacts. *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. Estimates of data potential are based upon the best data currently available: ASMIS data potential assignments, definitions provided in Yosemite archeological reports, and Archeology Visitor Use Program site assessments. These estimates are preliminary, based largely on available surface archeological data, and subject to change based on future research (NPS, Bane 2012a).

In balancing visitor use and site preservation, some disturbances to resources can be acceptable if the site retains context and integrity (NRHP 1990). For prehistoric 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 historic can scatters), 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

An adverse impact occurs when the number of sites with high data potential and free from serious unmitigated human impacts falls to 70% or fewer, and 60% or fewer for sites with low data potential, both within 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 (≥ 50%) comprising the prehistoric 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 substantial loss of site significance (data potential) and integrity.

The prehistoric archeological landscape value for the Tuolumne River corridor is comparable to an archeological district as defined by the NRHP 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 prehistoric archeological landscape as a whole degrades (NPS 1991).

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 prehistoric 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 (defined below) for protecting prehistoric 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 prehistoric 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's Facilities Management Software System
- assessment every 10 years: sites with a currently good or fair condition that are not likely to be affected and that 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 prehistoric 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 2011c]; a 30-year interval for aggregate summary reporting for the entire landscape is necessitated by the large number of prehistoric 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 prehistoric 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 declines further, as described in table 5-8.

Table 5-8.
Management Actions and Trigger Points to Maintain Desired Conditions for the Prehistoric Archeological Landscape

Trigger	Required Management Response (at least one action will be taken)	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.	Increased monitoring frequency for affected sites. Increased management protection designed to counteract or minimize impacts, crafted to individual site specifications. Examples include: ▪ consultation with tribal partners ▪ site documentation, research, testing, or NRHP evaluation ▪ site stabilization, revegetation, trail reroutes, or trail removal ▪ increased public interpretation and education ▪ increased education for local user communities, such as backpackers and climbers ▪ Increased training for law enforcement in site damage recognition and protection ▪ NRHP reevaluations and/or data recovery at affected sites ▪ development of comprehensive site management plans for large, complex sites in developed areas ▪ 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.)	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

Management to Protect and Enhance the Prehistoric Archeological Landscape

Current Findings Regarding Management Standard, Adverse Impact, and Degradation

Table 5-9 compares the current condition of the prehistoric archeological landscape to the definitions of management standard, adverse impact, degradation, and management concern. Results drawn from site monitoring conducted in 2007–2011 of a sample set of 128 sites (54%) from a total of 235 sites in the prehistoric archeological landscape of the Tuolumne River corridor as of May 2011 show that 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 (see table 5-9). Based on recent site condition assessments, the prehistoric archeological landscape is well within the management standard.

Table 5-9.
Current Condition of Prehistoric Archeological Sites Based on Monitoring of Aggregate Condition of Sites

Metric	Location	Percentage of Sites Free from Serious Human Impacts, 2007–11[a] High Data Potential Sites	Low Data Potential Sites
Meets management standard: Sites with low data potential: 80% of sites free from serious unmitigated human impacts[a] 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 prehistoric archeological value)	98%	96%
Management concern present: Sites with low data potential: The number of individual sites free from serious unmitigated human impacts falls to 90% or less in a monitoring interval. Sites with high data potential: The number of individual sites free from serious unmitigated human impacts falls to 95% or less in a monitoring interval.	None present.		
Adverse impact: 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			
Degradation: 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.

Management Concerns and Protective Actions

No management concerns are currently associated with the prehistoric archeological landscape value.

Localized Concerns and Enhancement Actions

Localized 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 prehistoric 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).

Prehistoric archeological sites will continue to be documented and monitored through the ASMIS 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.

In Tuolumne Meadows, many of the actions related to ecological restoration, such as eliminating roadside parking and removing informal trails, will also help protect prehistoric archeological sites by diverting foot traffic away from sites and into less sensitive areas.

Localized concerns about potential impacts on prehistoric 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 8 and evaluated against the NHPA criteria of effect in chapter 9.

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

Conclusion: Protection and Enhancement of the Prehistoric Archeological Landscape

At the time of designation, the known prehistoric archeological resources in the river corridor were characterized generally as being in 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 prehistoric archeological sites occurring in every river segment either have or appear to have important research potential. Almost all the prehistoric 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 prehistoric archeological landscape remains well within the management standard of being fully protected. However, localized concerns about disturbances to sites caused by foot traffic and/or potential future facility development and maintenance remain.

Under the *Tuolumne River 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 the 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

Condition 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 an elevation of 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 had been 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 the 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 Indicator and Monitoring Program

Indicator Description: Condition of Parsons Memorial Lodge

The NPS Facility Management Software System (FMSS) is the primary computerized database for registration and long-term management of all park assets, including historic and prehistoric structures. The FMSS condition assessment program has largely replaced the servicewide List of Classified Structures as the primary database for tracking the condition of park historic buildings and structures. It is NPS agency policy to preserve and protect the Parsons Memorial Lodge in good condition as defined in the FMSS program. This standard will also ensure that the building is managed for its protection and enhancement as an outstandingly remarkable value according to the WSRA.

FMSS conditions are defined as follows:

- *Good:* The cost of deferred maintenance does not exceed 10% of the structure's current replacement value, and there are no significant problems with critical building systems.
- *Fair:* The cost of deferred maintenance is more than 10%, but does not exceed 14%, of the structure's current replacement value, and there are no significant problems with critical building systems.
- *Poor:* The cost of deferred maintenance is more than 14%, but does not exceed 49%, of the structure's current replacement value, or there are significant problems with critical building systems.
- *Serious:* The cost of deferred maintenance is 50% or more of the structure's current replacement value.

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 FMSS 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 FMSS 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 FMSS guidance, or if significant problems with critical building systems are allowed to continue without repair for a period of longer than six months.

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 (identified below) intended to ensure that any downward trend in conditions at Parsons Memorial Lodge can be identified and arrested while the condition remains within the management standard and well before adverse impact occurs.

Monitoring Protocols

The Yosemite National Park facilities management specialists, in concert with the park historical architect and 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 Director's Order (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

While this assessment is only required every five years, in actuality the Yosemite National Park historic preservation crew 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. Also, the rangers who staff Parsons Memorial Lodge inspect the lodge each year at the beginning of the season and submit work orders to have any problems fixed as they arise so that the condition of the structure never falls below good. Finally, in the performance of routine patrols of the Parsons Memorial Lodge area, the district ranger reports any observed threats or changes in condition.

Triggers and Management Responses

Because deferred maintenance representing more than 10% of the building's current replacement value would place the lodge into fair condition, the need for repairs will be triggered if this deferred maintenance cost reaches 7.5% of the current replacement value (see 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 and within the management standard.

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

Trigger	Required Management Response (at least one action below will be taken)	Rationale
Detection of deferred maintenance representing 7.5% of the current replacement value	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.

Management to Protect and Enhance Parsons Memorial Lodge

Current Findings Regarding Management Standards, Adverse Impact, and Degradation

Table 5-11compares the current condition of Parsons Memorial Lodge to the definitions of management standard, management concern, adverse impact, and degradation. Parsons Memorial Lodge is in good condition.

Table 5-11.
Current Condition of Parsons Memorial Lodge

Metric	FMSS Assessment, 2012
Meets management standard: Parsons Memorial Lodge is protected in good condition as defined in the FMSS guidance.	Parsons Memorial Lodge is in good condition.
Management concerns present: Detection of deferred maintenance representing 7.5% of the current replacement value	None present.
Adverse impact: The condition of the lodge is downgraded to fair as defined in the FMSS guidance.	
Degradation: The condition of the lodge is downgraded to poor as defined in the FMSS guidance.	

Management Concerns and Protective Actions

A management concern would occur if the condition of the lodge indicated that deferred maintenance represented 7.5% of the current replacement value (the trigger point identified in table 5-10). No management concern is currently present. The lodge will continue to be preserved in accordance with the Secretary's Standards 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).

Localized Concerns and Enhancement Actions

There is currently no localized concern at Parsons Memorial Lodge.

Conclusion: Protection and Enhancement of 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 FMSS 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 Tuolumne River corridor are addressed collectively because the same management indicators and monitoring program will be used for each value.

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 the national park 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 development 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 have been developed to protect nighttime views (NPS 2011f). The important visual relationships between the natural features of Tuolumne Meadows and its adjacent developed areas remain largely intact (NPS 2007t).

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 Visual Resource Management (VRM) system within the Tuolumne River corridor. Developed in 1995 by the U.S. Forest Service (USFS) (USFS 1995) and further refined by the Bureau of Land Management (BLM) (BLM 2007a), the VRM system is a widely accepted system for assessing the scenic character of a landscape and for 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 three steps in the VRM system: an inventory of the existing landscape, assignment of management classes, and a contrast analysis. The inventory is done to ensure that existing conditions are acceptable based on scenic quality, the sensitivity of viewers to potential changes in the landscape, and the distance from which the landscape is viewed. This also develops a baseline for future comparison. Management classes are then assigned in consideration of all resource values; these determine the acceptable level of visual change for each class. Finally, in the contrast analysis, the degree of contrast of a management action, as compared to the native landscape and the management class objectives, is quantitatively assessed. The contrast analysis is part of the monitoring program for this indicator and is described more fully in the "Monitoring Program to Prevent Future Adverse Impacts or Degradation" section below.

Definitions of Management Standard, Adverse Impact, and Degradation

Management Standard

After designation as a Wild and Scenic River, segments of the Tuolumne River were assigned a classification of either wild or scenic based on the level of existing development (see chapter 3). Segments classified as wild will meet the definitions of VRM class I areas, and scenic segments will meet the definitions of VRM class II areas. As presented in table 5-12, there is a natural parallel between wild and scenic river classifications and VRM classes.

Table 5-12.
WSRA Classification Definitions and VRM Class Definitions

WSRA Classification Definitions	VRM Class Definitions[a]
Wild 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.	**Class I** 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 1984).
Scenic 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.	**Class II** 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 1984).
Recreational 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.	**Class III** 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 1984).

a 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.

Adverse Impact

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

Monitoring Program to Prevent Future Adverse Impacts or Degradation

Using the VRM system described above, the monitoring program for the outstandingly remarkable values through Lyell Canyon, Dana and Tuolumne Meadows, and the Grand Canyon of the Tuolumne will consist of (1) a contrast analysis for any new proposed structures and/or modifications of existing structures, (2) revisions to the proposed structure or modification to bring its contrast to within acceptable levels, 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.[27]

[27] 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).

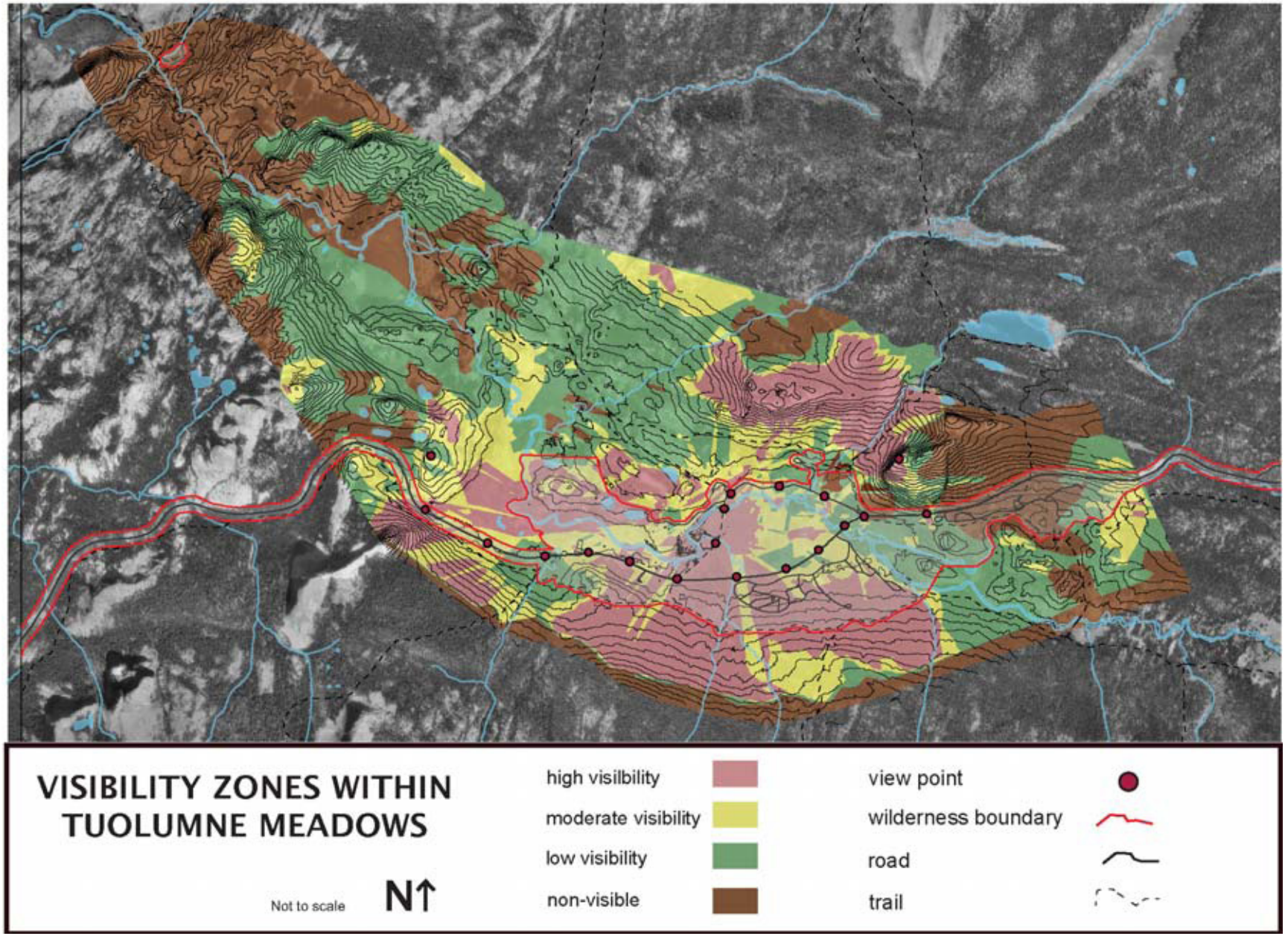
The NPS will perform a contrast analysis for all new structures and/or modifications of existing structures proposed for the Tuolumne River corridor (see figure 5-11, below). The contrast analysis will analyze whether the proposed structure or modification will harmonize with the class I or class II landscapes in which they will be located. For each of the 12 key components, contrast will be rated from strong (3 points) to none (0 points). The 12 scores will be added together, providing a comprehensive and quantitative analysis of the proposed structure's contrast with the existing landscape.This could result in a contrast rating as high as 36 if the structure is rated as having a strong contrast in all categories. Acceptable contrast ratings were determined based on interpretation of the river segment classification and review of the contrast rating of existing selected developed areas within the park. 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), thereby 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 the appropriate 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 contrast rating for proposed structures or structure modifications would be assessed from scenic vista points commonly used by park visitors and from which the proposed structure or modification would be visible. Eight primary vista points were identified as part of the scenic analysis conducted for this *Tuolumne River Plan*. They are listed and addressed under "Localized Concerns and Enhancement Actions," below. Other popular vista points might also be included in the assessments.

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 8. The analysis findings are summarized in figure 5-12.



Source: NPS, Torgerson and Schaible 2007m

Figure 5-12. Visibility Zones within Tuolumne Meadows.

Monitoring Protocols

Monitoring of both scenic and wild segments will only take place when planned construction of any new structure or exterior modifications to any existing structures occurs.

Triggers and Management Responses

Table 5-13 describes the triggers and required management actions to protect the scenic values within the river corridor. Any planned new construction or exterior modification of an existing structure would trigger a contrast analysis and design modification if needed. The rationale for this management trigger is to avoid the potential for adverse impacts or degradation and to ensure that scenic values remain within the management standard.

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

Trigger	Required Management Response	Rationale
Planned construction of any new structure or exterior modifications to any existing structure	Contrast analysis AND Design structure to produce no strong contrast rating and an overall contrast rating of 4 or less for structures in wild segments and 12 or less for structures in scenic segments.	The contrast analysis is intended to reveal effects on the outstandingly remarkable scenic value before a new structure is built. New or remodeled structures should minimize contrasts with the surrounding landscape to the maximum extent possible.

Management to Protect and Enhance Scenic Values

Current Findings Regarding Management Standard, Adverse Impact, and Degradation

Table 5-14 compares the current condition of the river's outstandingly remarkable scenic values to the definitions of management standard, management concern, adverse impact, and degradation.

Table 5-14.
Current Condition of Scenic Values Based on Visual Resource Management System

	Compliance with VRM Class Objectives, 2010	
Metric	**Wild Segments**	**Scenic Segments**
Meets management standard: Wild segments fit within VRM class I. Scenic segments fit within VRM class II.	The Lyell Fork and Grand Canyon of the Tuolumne segments meet the VRM objectives for class I areas.	The Tuolumne Meadows and Lower Dana Fork segments meet the VRM objectives for class II areas.
Management concerns present: Planned construction of any new structure or exterior modifications to any existing structure	None present	None present, but concerns will be triggered by certain actions during plan implementation. Contrast analyses will be performed and the structure designed or redesigned to keep contrasts at acceptable levels.
Adverse impact: A wild segments falls into VRM class II. A scenic segments falls into VRM class III.	None present	
Degradation: A wild segments falls into VRM class III. A scenic segment falls into VRM class IV.		

The scenic values in all the segments meet the management standards.

Management Concerns and Protective Actions

Management concerns occur when the condition of a resource reaches one of the trigger points identified in table 5-13. No management concerns are currently associated with any of the scenic values. However, management concerns will be raised by the planned construction of new facilities or exterior modification of

existing structures. These concerns will be addressed by subjecting all new or modified structures to a contrast analysis, complemented by design or redesign to keep contrasts at acceptable levels. With these protections in place, scenic values in all river segments (both wild and scenic) will be protected, with human development managed to minimize its contrast with the natural setting and to remain consistent with the VRM class specifications.

Localized Concerns and Enhancement Actions

Wild Segments: Lyell Canyon and Grand Canyon of the Tuolumne

Some Glen Aulin structures are visible from short segments of the trails through this area. Any new structures will be subject to the VRM contrast analysis explained above. Further, 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 8.

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).

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, the 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 the *Final Tuolumne River Plan/ 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 8.

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 I 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 (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
- Lembert 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 Lembert Dome (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 Lighting Guidelines* (NPS 2011f) 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*.

Conclusion: Protection and Enhancement of the Scenic Values of the River Corridor

The outstandingly remarkable scenic values across all segments are found to be within the management standard. Management concerns triggered by new construction in scenic segments will be addressed by subjecting all new proposed structures to a contrast analysis, complemented by design or redesign to keep contrasts to acceptable levels. Localized 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.

Recreational Value: Rare and Easy 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, 4 stock sites, and 21 backpacker sites, 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 Meadows 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).

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).

The NPS estimates that 4,222 people visit Tuolumne Meadows during peak hours on peak days (see table 8-19 in chapter 8). No comparative data for maximum people at one time are available from the time of designation; however, visitation parkwide has increased by 41% since the Tuolumne was designated a wild and scenic river (2.74 million in 1984 compared with 3.85 million in 2012 [NPS Public Use Statistics Office]). Parkwide visitation decreased somewhat between 2011, when it reached 3.95 million, and 2012.

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 (White 2011).

Management Indicator and Monitoring Program

Definitions of Management Standard, Adverse Impact, and Degradation

These terms are not defined for this river value. The action that is fundamental to protecting this value—keeping the Tioga Road (Highway 120) open for visitor travel, with no restrictions on through-traffic until the road is closed each winter due to weather—will continue under all alternatives. Therefore, under all alternatives, visitors will continue to have rare and easy access via the Tioga Road to river-related recreational opportunities in Tuolumne and Dana Meadows. Recognizing the outstandingly remarkable value of this access, all alternatives include management actions aimed at enhancing visitor satisfaction with this access. However, the fundamental decisions about how much access and the character of the recreational opportunities available to arriving visitors will vary among the alternatives as part of the discussion of visitors' differing preferences and resulting decisions about user capacity. WSRA requires all comprehensive river management plans to address user capacity, and in so doing to give "primary emphasis to protecting the river area's esthetic, scenic, historic, archeological and scientific features." The Secretarial Guidelines define carrying capacity in this context to

mean "the quantity and mixture of recreation and other public use which can be permitted without adverse impact on the resource values of the river area." [28](See chapter 6 for a full discussion of legal mandates regarding user capacity.) Because this recreational value could be protected and enhanced in a variety of alternative ways, and because it is, by mandate, secondary to other river values, it was not considered appropriate to establish measurable standards for this value. Rather, monitoring and management will be focused on ensuring that the user capacity, when it is selected in the record of decision for the *Tuolumne River Plan*, is maintained, and on managing the selected amount and type of use (through advance information, traffic management, and other management tools) to be as consistent as possible with visitor expectations and high satisfaction.

As explained in more detail in chapters 6 and 8, the primary management mechanism of enforcing the day visitor capacity will be the restriction of day parking to a limited number of designated spaces (overnight user capacity will be enforced through limits put on the capacities of the lodges and campground plus the overnight Wilderness trailhead quotas). All action alternatives would restrict parking to formal parking lots in Tuolumne Meadows, where the number of designated spaces would vary by alternative. By restricting parking to amounts consistent with the user capacities of the different alternatives, the NPS will comply with and enforce the WSRA mandate to specify the kinds and amounts of use the river corridor can accommodate while being protective of other river values.

Monitoring Program

In the busy summer months, NPS personnel will document any parking shortages and determine the most appropriate traffic management actions for minimizing impacts on the experience of visitors accessing the river corridor via Tioga Road. For example, when a given parking lot is full, NPS staff may recommend alternative locations or times of day when visitors may be able to find parking. Alternately, NPS staff may provide for increased public transportation, as long as the capacity of the given alternative is not exceeded. Because the availability of day parking will be used to enforce the day use capacity, some visitors will unavoidably be displaced to other locations; however, managers will monitor and manage traffic to minimize visitor inconvenience to the extent practicable.

Management to Protect and Enhance Rare and Easy Access to the River through Tuolumne and Dana Meadows

Rare and easy access to the river would be protected by maintaining the historic Tioga Road along its current alignment, with no restrictions on through-travel during the seasons when the road is currently open. (The road will continue to be closed during the winter, with opening and closing dates dependent on weather conditions.) 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. 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. Roadside parking along Tioga Road will be prohibited, and this action will reduce traffic congestion, safety hazards, and the intrusion of parked cars into the views of Tuolumne Meadows and surrounding domes and peaks, further enhancing access for arriving visitors and improving the scenic driving experience for visitors passing through on Tioga Road. Ultimately, enforcing the user capacity established through the *Tuolumne River Plan* will

[28] Secretaries' Guidelines for River Areas, at 39459. WSRA and the Secretaries' Guidelines for River Areas use the terms "carrying capacity" and "user capacity" interchangeably.

guarantee the availability of high-quality recreational opportunities at use levels that protect the visitor experience from increasing congestion, as well as protecting and enhancing other river values.

Conclusions: Protecting and Enhancing Rare and Easy Access to the River through Tuolumne and Dana Meadows

Under the *Tuolumne River Plan*, the Tioga Road will remain open for visitor travel, and under most alternatives, including the preferred alternative, the amount of designated parking would be increased to make it possible for more visitors to find a space in a designated parking area and to enjoy river-related recreational opportunities in a manner protective of all river values. The elimination of roadside parking along Tioga Road will reduce traffic congestion, safety hazards, and the intrusion of parked cars into the viewing experience. The enforcement of a user capacity in compliance with WSRA will protect the quality of the visitor experience from increasing congestion, as well as protecting 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 overnight wilderness permits.

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

At the time of wild and scenic river 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 as wild and scenic (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 alone 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 or primitive and unconfined 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

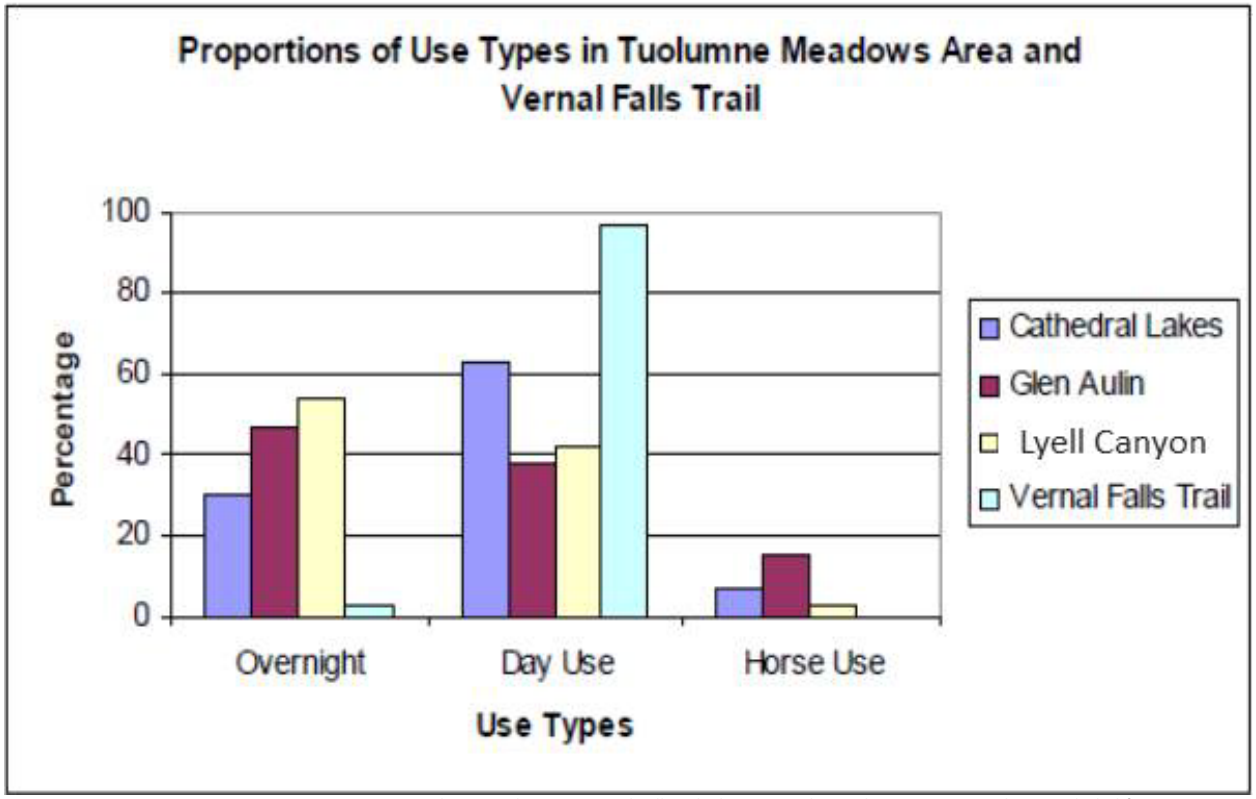
specific location, when Pate Valley was surveyed in 1984 (the year the Tuolumne Wild and Scenic River was designated), 18 campsites were recorded, while a 2006 survey recorded only 9 campsites. In 1984 five of the sites were within 25 feet of water; in 2006 only one site was that close (NPS, Fincher 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 can 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 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, although this quota system can temporarily deny some individuals access to a particular location on a particular date if the quota is already filled. Overnight Yosemite 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 that Newman asked respondents about 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 parties. Generally, respondents felt that it was more important to be able to obtain a permit than encountering many others while hiking, suggesting they are willing to give up some experience quality for access (Newman 2002).

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, from 1/3 to over 1/2 of use on the three major trails originating in Tuolumne Meadows (Glen Aulin, Cathedral Lakes, and the Lyell Fork) was day use, as shown in 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. Most of the use at Poopenaut Valley is day use, though a limited amount of overnight use does occur.



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.

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 is the opportunity for solitude, which is an enduring characteristic of a wilderness experience (Lucas 1964).[29] Expectations for solitude and actual numbers and types of parties 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 that there is a weak relationship between encounters and evaluations of global experience quality (Graefe et al. 1984, Lee 1977, Stewart and Cole 2001), stronger relationships have been found between encounters and perceived crowding, and a substantial body of literature supports 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, Pettebone 2013, Roggenbuck et al. 1982, Stewart and Cole 2001, Vaske and Donnelly 2002, Watson et al. 2000). For that reason, the number of encounters has been chosen by many wilderness managers as an indicator for the social setting, not only because encounters among parties have an effect on solitude but also because field measurements are easy to accomplish (Watson et al. 1998). 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 Wild and Scenic River.

[29] Another significant component of wilderness character, which is closely related to this river value, is the opportunity to partake in a primitive and unconfined type of recreation. All alternatives would continue the current trailhead quotas, and all forms of primitive and unconfined forms of recreation would continue, with nonmotorized boating permitted under two alternatives (at levels that will not increase overall use levels). In most ways, these forms of recreation are also unconfined, the primary exception being the restrictions against camping in the first several miles of trail up the Lyell Fork and down the Tuolumne River to Glen Aulin, and the requirement to carry a permit for presentation to NPS wilderness patrol rangers upon demand. These camping and permit restrictions will remain under all the action alternatives. Because this management will remain largely unchanged no matter which alternative (even no-action) is chosen, it will not be necessary to monitor opportunities for primitive and unconfined type of recreation.

However, research has also shown there to be a measurable difference in expectations about the level of solitude on wilderness trails, depending on the proximity of the trailhead to urban influences (Manning 1986, Cole and Hall 2008). Consequently, as described below and summarized in table 5-15, the management standards selected for different trail sections in the Tuolumne River corridor reflect this observation. Trail sections farther from Tuolumne Meadows and the Glen Aulin High Sierra Camp will be managed to provide a greater opportunity for solitude; trails nearer to Tuolumne Meadows will be managed more to provide abundant opportunities for primitive and unconfined type of recreation, though opportunities for solitude will continue to exist. To emphasize these differences, the trail to Glen Aulin and beyond and the trail up Lyell Canyon have both been divided into separate trail sections, which reflects their differing characteristics (Broom and Hall 2010).

The NPS has chosen to measure encounter rates in terms of parties encountered by others. Monitoring will be accomplished by measuring the average number of encounters per hour an individual has with other parties (groups) within each of the four trail sections.

Definitions of Management Standard, Adverse Impact, and Degradation

Management Standard

The management standard for the number of encounters with other parties is that the individual trail-section standards established for at least three of the four monitored trail sections[30] (as described below and summarized in table 5-15) must be met within in any four-year period, with no single section exceeding its trail-section standard for four consecutive years.

This approach recognizes that wilderness users have varying expectations about the level of solitude on wilderness trails, depending on the proximity of the trailhead to "urban influences" (in this case, Tioga Road). Research demonstrates that visitors are willing to accept more encounters when they are closer to the designated Wilderness boundary (where both day hikers and backpackers are present) than they are when deeper into Wilderness (Manning 1986, Cole and Hall 2008). In general, as distance from development increases, hikers become less tolerant of encounters with other parties and begin to associate high encounter rates with a negative experience.

The effect of encounters on experience is also a function of the difference between hiker expectations and actual encounter rates (Newman and Manning 2002, Patterson and Hammitt 1990, Vaske et al. 1986). Visitors who are making lodging reservations at the High Sierra Camp, for example, will likely be more tolerant of a higher encounter rate (knowing that 32 people will be traveling to the camp every day) than backpackers in more remote areas of the Wilderness. The standard for the Glen Aulin trail is higher than that for Pate Valley and the upper part of Lyell Canyonto account for this varying expectation.

The approach of setting different management standards recognizes that opportunities for primitive and unconfined recreation are equally valued with solitude under the Wilderness Act. (Wilderness must provide opportunities for "solitude *or* a primitive and unconfined type of recreation.")[31] Opportunities for primitive and unconfined recreation can be particularly abundant near easily accessible trailheads (like the trailheads leading into designated Wilderness from Tuolumne Meadows), while opportunities for solitude are more abundant in areas more distant from trailheads or other human developments. The trail section standards

[30] Use on the trail into Poopenaut Valley will not be monitored because the extremely small parking lot there (at most, four cars can be accommodated) effectively keeps encounter rates to less than three other parties per hour (the trail into the valley is about 1 mile long and extremely steep, meaning that a round-trip hike into and out of the valley takes most hikers two hours or more; assuming that the hikers from each car hike together, this means that any two-hour period will see no more than four parties on the trail).

[31] 16 USC 1131-1136, section 2 (c); emphasis added.

reflect an emphasis on either or both of these experiences, and they are informed by research done in Yosemite indicating that many visitors are willing to sacrifice some solitude if doing so improves their chances at having a primitive and unconfined type of recreation in the first place (by getting a wilderness permit).[32]

In summary, the specific value set for each trail section is a function of three things: (1) proximity to trailheads and associated hiker expectations about encounter tolerances; (2) typical expectations for encounter rates, given other salient attributes of the trail section (such as whether the trail section is part of a longer regional or national trail); and (3) the requirement to provide opportunities for solitude or primitive and unconfined recreation, or both, pursuant to the Wilderness Act and its applicability to providing a wilderness experience along the river. A discussion of each trail section and the rationale for the associated trail-section standard follows.

Table 5-15.
Trail-Section Encounter Standards

Trail Section[b]	Current Condition Average Hourly Group Encounter Rates [a]				Trail-section Standard
	2010	2011	2012	2013	
Lyell Canyon trail from Rafferty Creek to the Ireland Lake junction	7.1	7.5	7.0	8.6	12
Lyell Canyon trail from Ireland Lake junction to Kuna Creek.	- [b]	- [b]	- [b]	5.7	8
Glen Aulin trail from the Young Lakes junction to Glen Aulin	8.6	9.8	8.6	9.2	12
Grand Canyon of the Tuolumne trail from Rogers Creek crossing to Pate Valley	- [b]	- [b]	0.7	0.5	2

a Average number of hourly encounters per day measures the average predicted hourly encounter rate based on a 10-hour day. Predicted encounter rates are created from daily automated counter measurements that are related to actual encounter observations by trained observers through linear regression and then averaged across the season.
b Data is not available for these years.

Trail Section: Lyell Canyon from Rafferty Creek to the Ireland Lake junction

This section of trail experiences high levels of use due to its proximity to Tuolumne Meadows (where the campground and lodge offer overnight accommodations for more than 2,000 people) and the gentle terrain, making it possible for many hikers to traverse this segment in a day hike. Additionally, this section is part of the John Muir and Pacific Crest Trails, bringing many through-hikers to this trail. For these reasons, most hikers on this trail segment likely expect to see many other groups in the area and are more tolerant of encounters. The standard is also set to maintain abundant opportunities for primitive and unconfined recreation in this canyon for hikers and backpackers; opportunities for solitude would still be available, though hikers may have to step off the trail or hike at off-peak hours to find such opportunities. The management standard (up to 12 parties per hour[33]) for this section is comparable to other popular wilderness hikes in the western U.S. that have mixed day and overnight use, such as high use trails in Mt. Rainier National Park (at 8 encounters per hour) (Vande Kamp 2009) and in Yosemite (the Half Dome trail, at 16 encounters per hour) (NPS 2012d).

Trail Section: Lyell Canyon from Ireland Lake junction to Kuna Creek.

This trail has many of the same qualities as the other Lyell Canyon reach, such as being a part of the John Muir and Pacific Crest Trails, so it still receives significant overnight use. However, it is not as close to the Tuolumne Meadows trailheads (the Ireland Lake junction is 5.5 miles from the trailhead), so it receives less day use. Like

[32] Specifically, Newman and Manning (2001) found that 42% of Yosemite Wilderness users said that the number of encounters was very or extremely important to them, but even more (72%) said having a chance to obtain a wilderness permit was of equal importance.

[33] In contrast to the 10 parties per hour, 80% of the time management standard proposed in the Draft Tuolumne River Plan/EIS, this management standard (and that for the Glen Aulin trail) are fixed averages, with no provision for occasional exceedance (i.e., no 80% provision).

the lower Lyell stretch, though, these use levels are still akin to mixed day and overnight use trails in other national parks, but the management standard is set at the lower end of the range—up to 8 parties per hour. This is the level recommended to Mount Rainier by a researcher studying trail use there (Vande Kamp 2009) and almost the same as seen at Rachel and Rampart lakes, two lakes (also in Washington) with similar trail characteristics as that found in upper Lyell Canyon (Cole et al. 1997). This standard will maintain good opportunities for primitive and unconfined recreation as well as for solitude for hikers and backpackers.

Trail Section: Glen Aulin Trail from the Young Lakes Junction to Glen Aulin

This section of trail experiences high levels of use due to its proximity to Tuolumne Meadows (where the campground and lodge offer overnight accommodations for over 2,000 people). Additionally, the Glen Aulin High Sierra Camp and associated backpacker campground are located along this section, and the trail section is part of the Pacific Crest Trail. Consequently, many of the trail's users likely expect to encounter a larger number of visitors on the trail and are more tolerant of encounters. The standard is therefore set to maintain abundant opportunities for primitive and unconfined recreation for hikers and backpackers; opportunities for solitude would still be available, though hikers may have to step off the trail or hike at off-peak hours to find such opportunities. As with the Lyell Canyon sections, this management standard (up to 12 parties per hour) is comparable to other popular wilderness day hikes in the western U.S. that have mixed day and overnight use - such as high use trails in Mt. Rainier National Park (at 8 encounters per hour) (Vande Kamp 2009) and the Half Dome trail in Yosemite (at 16 encounters per hour) (NPS 2012d).

Trail Section: Grand Canyon of the Tuolumne Trail from Rodgers Creek Crossing to Pate Valley

This section of trail sees the lowest amount of use of all monitored sections because it is the most remote. Current use is estimated at one encounter or less per hour. Nonetheless, it is just downstream of Glen Aulin and is popular in the spring, when the runoff swells or creates many waterfalls. It therefore still receives moderate levels of use compared to other remote Wilderness areas (Cole and Hall 2008). The management standard for this section, up to 2 parties per hour, offers excellent opportunities for both solitude and primitive and unconfined recreation (Newman and Manning 2001). This standard is the same as a formal recommendation to the Mount Rainier for similar trails (remote, but still regularly visited areas) (Vande Kamp 2009). It is also the level at which surveyed Yosemite wilderness visitors felt NPS should take action to reduce use in such areas (Newman and Manning 2001; see below for triggers at which NPS would take action if use in this area exceeded 2 parties per hour).

Adverse Impact

An adverse impact to the wilderness experience along the Tuolumne River would occur if encounter rates for all trail sections exceeded their associated trail-section mnagement standards for five consecutive years.[34] This situation would constitute a substantial reduction in the condition of the recreational experience on a sustained and corridorwide basis. Under these conditions, all wilderness trails within the Tuolumne River corridor would be characterized by unacceptable levels of crowding, and opportunities for solitude would be few.

Degradation

This ORV would be degraded if encounter rates met or exceeded, for five consecutive years, displacement standards (the level of use at which a person would be displaced elsewhere) of 18 encounters per hour for all trails except for Pate Valley and 9 encounters per hour for Pate Valley. Studies on displacement of wilderness

[34] Data from the summer season is usually analyzed at the end of the field season, and thus recommendations for modifications to protect this recreational value would not be made until winter. However, as wilderness permits are usually available up to 24 weeks in advance, this timing does not provide adequate time for park staff to adjust trailhead quotas or zone capacities before the next summer season. Thus, the adverse impact and degradation standards are set at four years so as to give adjustments to the distribution of use time to correct conditions before reaching the next level.

users indicate that the level at which encounter-tolerant users in high use areas would be displaced is very high. In the cases where this displacement comes with consequences (such as reduced access), users would often prefer not to have a limit at all (Cole and Hall 2005, 2008), a situation observed in Yosemite with Half Dome visitors. However, a survey of trail users at Snow Lake, a popular destination near Seattle (and therefore with easy access very similar to Yosemite's) found that half of the trail users said that the level of use they experienced there (18 encounters per hour) had a negative effect on their experience (Cole et al 1997). Because Snow Lake more accurately reflects the situation in the Tuolumne River corridor (designated Wilderness, with a mix of day and overnight hikers, without a world-renowned icon), the displacement level at Snow Lake was used for the three Tuolumne trail segments with a mix of day and overnight users. Pate Valley, however, does not have day use, so its displacement standard is 9 encounters per hour, a level equal to the median displacement level[35] found in other high use areas (Cole and Hall 2005).

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 (defined below) intended to ensure that any downward trend in conditions can be identified and arrested well before adverse impact occurs.

Monitoring Protocols

All trail sections will be monitored annually during the high-use season using automated counters. Automated counts are made using infrared trail counters and collect data on trail use from 8 a.m. to 6 p.m. Broom and Hall (2010) demonstrate the appropriate methods for determining encounter rates from automated trail counters and actual observer counts. Using such methods, automated trail counters are calibrated each season by trained observers to ensure accurate predictions of trail encounters. All selected trails have been monitored with actual observations by trained technicians and volunteers. These actual encounter observations will be repeated every five years to confirm that the relationship between encounters and the automated counter remains the same.

Triggers and Management Responses

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

[35] Visitors were asked what number of encounters would detract them from going to that place.

Table 5-16.
Management Actions and Trigger Points to Maintain Desired Conditions for a Wilderness Experience along the Tuolumne River

Trigger	Required Management Response (at least one action specified for each trigger will be taken)	Rationale
Individual trail sections have an encounter rate exceeding the trail-section standard shown in table 5-15 for two years.	Decrease the sampling interval for direct observations. Disseminate information to visitors regarding alternative trails within the corridor. Encourage visitors to hike during days and times of day at which lower encounter rates occur.	To ensure that this recreational value remains protected, the NPS will immediately address early indications of crowding as they are discovered. More frequent monitoring will allow managers to identify permanent changes in use patterns and take appropriate actions. Management actions, such as education and outreach to visitors, would help to maintain the level of use within the target condition by providing visitors with information to help plan their trip to avoid high-use times.
Individual trail sections have an encounter rate exceeding the trail-section standard shown in table 5-15 for three consecutive years.	Make necessary changes in the wilderness quota system to better manage for opportunities for solitude. Establish day parking permits and institute changes to the shuttle system to manage the number of people arriving at trailheads feeding trail sections that have exceeded the trigger point. Institute hard closures of trailheads or parking as necessary to regulate use of designated Wilderness within the river corridor.	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. Restricting day use would address a currently uncontrolled portion of wilderness trail use.

Management to Protect and Enhance the Wilderness Experience along the River

Current Findings Regarding Management Standard, Adverse Impact, and Degradation

Table 5-17 compares the current condition of the wilderness experience to the definitions of management standard, management concern, adverse impact, and degradation.

Table 5-17.
Current Condition of Wilderness Experience, Based on Mean Encounter Rate

Metric	Rate of Encounters with Other Parties, 2010 –13
Meets management standard: At least three trail sections are within their trail-section standard in any three-year period, with no single section exceeding its trail-section standard for three consecutive years.	All trails have an average encounter rate less than their trail-section standard.
Management concerns present: Individual trail sections have an encounter rate exceeding the trail-section standard shown in table 5-15 for one year (trigger 1) or two years (trigger 2).	None present.
Adverse impact: Encounter rates for all trail sections exceed their associated trail-section standard listed in table 5-15 for four consecutive years	
Degradation: Encounter rates meet or exceed the section-level displacement standards for five consecutive years. The displacement standard for all trails except for Pate Valley would be 18 encounters per hour. The displacement standard for Pate Valley would be 9 encounters per hour.	

Management Concerns and Protective Actions

Management concerns occur when the condition of the wilderness experience has reached one of the trigger points identified in table 5-16. No management concerns are currently associated with the wilderness experience value. However, the number of people encountered per day when hiking in relatively high areas in the Yosemite Wilderness was identified as at least somewhat of a concern for about half 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 currently addressed by the wilderness overnight zone capacities and associated trailhead quota system. The establishment of management standards for encounters with other parties on designated Wilderness trails that are within a day's hike of Tuolumne Meadows will 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 make necessary changes in the backcountry quota system and/or establish a day use permitting system to better manage for opportunities for solitude or a primitive and unconfined type of recreation.

Localized Concerns and Enhancement Actions

A localized concern of overnight Yosemite Wilderness users cited in the Newman and Manning (2002) study was encounters with 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.

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 9. In addition to the guidance provided by the current *Wilderness Management Plan* (NPS 1989b) and the upcoming *Wilderness Stewardship Plan*, the *Tuolumne River Plan* will reduce stock use under any of 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, of 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.

Conclusion: Protection and Enhancement of the Wilderness Experience along the River

At the time of designation, the wild segments of the Tuolumne River offered outstanding opportunities for primitive and unconfined river-related recreation and/or solitude, and those opportunities continue today. Since the 1970s, an overnight zone capacity and trailhead quota system has helped protect this river value. The *Tuolumne River Plan* will manage day use levels in the river corridor and monitor the number of encounters with other parties on trails. Use on wilderness trails will be managed to remain within the management standards established for this indicator so that opportunities for solitude or a primitive and unconfined type of recreation (or both) remain abundant throughout the river corridor. Should use levels threaten to violate the management standard, a number of management actions are specified, including changes to the overnight trailhead quota system and, as a last resort, the implementation of a day use trailhead quota system.

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 2012, NPS 2011e). 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 2012 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 USEPA standards.

Because water quality is critical to the water supply for San Francisco and its water customers, the 1913 Raker Act requires certain sanitary regulations be established for the Tuolumne watershed above Hetch Hetchy Reservoir. 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 2006–2012 show that the water quality of the Hetch Hetchy water supply remains exceptional.

Numerous actions have been taken over the past three 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 under "Localized Concerns and Enhancement Actions," below.

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), total petroleum hydrocarbons, and *Escherichia coli* (*E. coli*)are appropriate variables to monitor because their levels can be tied to human activities and human contact with water. People swimming in the river or manure from horses can lead to elevated levels of *E. coli* and nitrogen-related nutrients; people bathing or washing dishes in the river can increase phosphorus /phosphate-related nutrients; and vehicular use, roads and other development contributes to hydrocarbon pollution. Total coliform (which is not the same as *E. coli*), temperature, dissolved oxygen, and conductivity also vary with human use, but are less effective variables to

monitor (as indicators) because they are lagging indicators of human impact and can be affected by other factors.

The following specific indicators derived from these metrics will be used to assess current water quality conditions on the Tuolumne River:

- Nutrient indicators: 75th percentile of annual nutrient concentrations (total dissolved nitrogen, total phosphorus, nitrate plus nitrite, and total dissolved phosphorous) sampled at each site
- Petroleum hydrocarbon indicator: number of samples with total petroleum hydrocarbon concentration equaling or exceeding 13 μg/L (micrograms per liter) at each site
- *E. coli* indicator: 50th percentile of annual *E. coli* concentrations sampled at each site

Definitions of Management Standard, Adverse Impact, and Degradation

Management Standard

The management standard for water quality is antidegradation of the indicator condition from a baseline established in 2004–2008. For nutrients, the baseline is defined as the 95% upper confidence limit of the 75th percentile of annual concentrations. For *E. coli* it is the 95% upper confidence limit of the 50th percentile of annual concentrations. Site-specific management standards are exceeded if any single nutrient or *E. coli* indicator exceeds the baseline condition in greater than one in five years. The baseline standard for the petroleum hydrocarbon indicator is one or more detections (at greater than 13μg/L) at a site in greater 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 for the Sacramento River and San Joaquin River Basins (Basin Plan*). 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.*

The above management standards adhere to this policy.

Adverse Impact

An adverse effect would occur with any of the following:

- exceedance of the USEPA's bacteriological criteria for water-contact recreation, which include an *E. coli* statistical threshold value standard of 410 CFU/100mL (colony-forming units per 100 milliliters) and a geometric mean standard of 126 CFU/100mL in a 30-day interval following two consecutive monthly samples exceeding the 235 CFU/100mL beach action value[36] (USEPA 2012)
- exceedance of the EPA maximum contamination level for nitrate+nitrite of 10 mg/L (milligrams of nitrate and nitrite per liter, expressed as the weight of elemental nitrogen)

[36] In addition to recommending criteria values, USEPA is now also providing states with *beach action values* for use in notification programs. This value is provided for states to use as a precautionary tool to provide an early alert to beachgoers, including families with children.

- a persistent presence of hydrocarbons (as opposed to a single event, such as an automobile accident) that causes nuisance, results in a visible film or coating on the surface of the water or on objects in the water, or otherwise adversely affects beneficial uses

Exceedance of the bacteriological standard indicates a persistent contamination problem beyond normal flushing rainstorms that would likely result in a violation of state water-quality standards (protecting the designated use of Tuolumne River waters for recreation). Exceedance of the nitrate+nitrite criteria would be a violation of state water-quality standards as applied to municipal water sources. Waters designated for municipal use must also adhere to the California drinking water regulations (title 22 of the California Drinking Water Regulations), which include the USEPA's maximum contaminant limit for nitrate+nitrite. Current levels of nitrate+nitrite within Yosemite National Park are only 1% to 10% of this maximum contaminant limit. Finally, a persistent presence of hydrocarbons would violate the San Joaquin Basin Plan, to which Yosemite must adhere.

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).

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 implementation of the *Tuolumne River 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 2011e). 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, colocation 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 3 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.

Triggers and Management Responses

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 table 5-18.

Table 5-18.
Management Actions and Trigger Points to Maintain Desired Conditions for Water Quality

Trigger	Required Management Action[a]	Rationale for Using this Action at this Threshold
Trigger Point 1: 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.
Trigger Point 2: Exceedance of recommended USEPA beach action value of 235 CFU/100ml at any one monitoring site	Repeat sampling within one month at affected site. If the beach action value is exceeded a second time, initiate weekly sampling of *E. coli* at sites exceeding the limit. Assure at least five samples are taken over the course of the 30 days following the second monthly sample in order to determine the 30-day geometric mean and adherence to the recommended *E. coli* standard. If the geometric mean is greater than the 30-day standard of 126 CFU/100ml, a subsequent investigation shall take place.	This trigger point indicates potential for 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.
Trigger Points 1 or 2	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.	Actions would be initiated during or after the investigations listed under either trigger point to protect water quality and human health.

a CFU/100mL = colony-forming units per 100 milliliters; *E. coli* = *Escherichia coli*; NPS = National Park Service; USEPA = U.S. Environmental Protection Agency

Management to Protect and Enhance Water Quality

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% upper confidence limit) 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.

Table 5-19 compares the current condition of the water quality value to the definitions of management standard, management concern, adverse impact, and degradation.

Table 5-19.
Current Condition of Water Quality

Metric	Based on Comparison to Baseline Conditions[a]
Meets management standard: Antidegradation from the baseline established in 2005–2008, for nutrients, *E. coli,* and petroleum hydrocarbons[a]	Samples taken between 2005 and 2010 were of very high quality and within the management standard.
Management concern present: 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	None present.
Adverse impact: Exceedance of USEPA bacteriological criteria for water contact recreation: *E. coli* and nitrates, or a persistent presence of hydrocarbons[b]	None present.
Degradation: 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[c]	

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* exceedance of the USEPA's bacteriological criteria for water-contact recreation, which includes an E. coli statistical threshold value standard of 410 CFU/100mL and a geometric mean standard of 126 CFU/100mL in a 30-day interval following two consecutive monthly samples exceeding the 235 CFU/100mL beach action value, or (2) exceedance of USEPA maximum contamination level for nitrate + nitrate of 10 milligrams per liter, or (3) a persistent presence of hydrocarbons (as opposed to a single event such as an automobile accident) that causes nuisance, results in a visible film or coating on the surface of the water or on objects in the water, or otherwise adversely affects beneficial uses.

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: CFU/100mL = colony-forming units per 100 milliliters; E. coli = Escherichia coli; mL = milliliter; 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 CFU/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.

Management Concerns and Protective Actions

Management concerns occur when the condition of a resource has reached one of the trigger points identified in table 5-19. There are no management concerns associated with the water quality river value and therefore no protective actions.

Localized Concerns and Enhancement Actions

The primary localized 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 National Park 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.

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.

NPS PHOTO BY KRISTINA RYLANDS

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

Other localized 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 that line and the line conveying wastewater from the lodge area to the wastewater treatment plant (on the Tioga Road bridge) remain in place.

All alternatives call for the Tuolumne Meadows wastewater treatment plant to be upgraded at its current location. 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. Because California wastewater treatment codes require tertiary treatment for new plants, treated water coming out of the upgraded plant may be of such high quality that it could be directly distributed to the sprayfield without holding in the containment ponds. In that event, the ponds would be eliminated and the site restored to natural conditions. 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.

Impacts from the fuel facilities at Tuolumne Meadows were corrected between 1997 and 2005 and are mitigated by secondary containment and periodic testing, as required by California regulations (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 localized concern that water quality could be affected remains, even though water quality is excellent. 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 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. The risk to water quality at the Glen Aulin High Sierra Camp would be addressed differently among the various alternatives (see chapter 8). After the NPS has selected an alternative in a formal record of decision, it will be incorporated as part of the final *Tuolumne River Plan*.

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 1/4 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. 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 1/4 mile of trails leading from stable operations and the diversion of overland flow away from corrals. 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.

Conclusion: Protection and Enhancement of 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 varied, ranging up to 80,000 – 100,000 gallons per day. 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.

Although not an impact on free-flowing condition, one vehicle bridge crossed the river at Tuolumne Meadows. The vehicle bridge abutments may have caused the river to back up during periods of high flows.

Current Condition

Flow levels remain 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 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 importance of snowmelt to streamflow increases by mid-summer, when the Lyell Fork, which receives meltwater from Lyell and McClure glaciers, contributes an even greater percentage (66–75%) of the total flow into Tuolumne Meadows than the Dana Fork, which is not fed by glaciers (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 water year to the next (in California a 'water year' extends from October 1 to September 30 of the following year). During the 1982–2002 period, the greatest annual discharge into Hetch Hetchy was about 539 billion gallons in 1983 (the water year ending on September 30, 1983), while the least annual discharge was about 108 billion gallons in 1987. The periods from 1983–1986 and 1995–1998 were relatively wet (averaging 354 billion and 379 billion gallons), while the periods of 1987–1994 and 2000–2002 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 consumption and associated withdrawals from the Dana Fork are currently measured in terms of daily withdrawals from the storage tank at Tuolumne Meadows. Table 5-20 summarizes these daily withdrawals from 2008–2012, showing the maximum daily withdrawal and the average daily withdrawal per month (June–October) in each of those years. The data account for total water consumption associated with both visitor use and administrative use, including employee housing, although no measures exist for determining the amount or percentage of water consumption for each type of use.

The maximum daily withdrawal was calculated using the 98th percentile from the recorded data (that is, 98% of the recorded data fell below that amount, and 1% of the data fell above that amount). The 98th percentile was selected to account for unexplainable anomalies in the data. Without exception, the maximum daily water withdrawal from the storage tank in each month was a uniquely high number for that month and was preceded and followed by periods of much lower daily water withdrawals. For instance, in August 2011 the maximum water withdrawal occurred on August 21, when 72,600 gallons were withdrawn; however, the water withdrawal on August 20 amounted to only 32,900 gallons and on August 22 amounted to only 36,400 gallons; the next highest water withdrawal recorded for that month was 61,000 gallons on August 6. In 2012, the highest maximum withdrawal was less than 55,000 gallons per day. The reasons for the rare spikes in some years are currently unknown, but the data indicate that these maximum withdrawals are unusual and unsustained events. Calculating the maximum daily water use at the 98th percentile indicates that it was about 65,640 gallons per day in August 2011, which is a more realistic estimate that still exceeds the second highest water withdrawal recorded for that month.

In comparing the withdrawal rates from the storage tank to river flows, it is also important to note that the available data are for withdrawals from the storage tank only and not from the river itself. However, these figures are an excellent proxy for withdrawals from the river itself because it is just a short distance from the river to the treatment facility, with very few release valves in this reach of river.

Table 5-20.
Maximum and Average Daily Water Consumption at Tuolumne Meadows, 2008–2012

Annualized Daily Maximum[a] and Average											5-Year Daily Maximum and Average	
	2008		2009		2010		2011		2012		2008–2012	
	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
June	54,660	30,460	45,208	27,667	37,852	NA	NA	NA	45,450	34,087	54,660	NA
July	64,980	44,200	57,760	47,852	61,440	47,552	66,818	46,561	54,540	43,910	66,818	46,015
Aug	60,940	46,506	57,740	45,268	51,780	44,106	65,640	48,529	46,000	39,165	65,640	44,715
Sept.	52,466	37,180	50,250	32,974	61,336	37,433	62,060	37,593	42,318	27,750	62,060	34,586
Oct.	24,952	NA	54,860	NA	45,480	NA	37,380	NA	25,280	NA	54,860	NA

a Daily maximum was calculated at the 98th percentile of the data collected for each month.
NA = not applicable because data not available for a full month.

As is typical for surface water diversions in the Sierra Nevada, maximum withdrawal coincides with annual minimum flows. Waddle and Holmquist (2013) 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 1 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 2013). Withdrawals of 65,000 gallons per day would approximate 10% of flow at 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 2013). 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) after it has been measured as part of the data shown in table 5-20 but before it can be used. The water supply system also lacks adequate storage capacity and does not take full advantage of available water conservation technologies. These deficiencies 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 Tioga Road bridge at Tuolumne Meadows remains.[37] The abutments for the Tioga Road bridge in Tuolumne Meadows might cause the river to back up during periods of high flows and might contribute to accelerated flows downstream (NPS, Noon and Martin 2010d). As defined in WSRA, these are not direct

37 Several other bridges span the Tuolumne River: a single-vehicle bridge below O'Shaughnessy Dam and eight 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. These bridges have no impacts on free flow because they are not impoundments, diversions, straightening, riprapping, or other modification of the waterway itself (WSRA 1968, Section 16).

impacts to free-flow, for they are not impoundments, diversions, straightening, riprapping, or other modification of the waterway itself (WSRA 1968, Section 16); however, the *Tuolumne River Plan* includes an action to correct this condition.

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

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

Management Standard

The NPS will monitor streamflows and withdrawals to ensure that withdrawals never exceed 65,000 gallons per day or 10% of low flows, whichever is less.

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.

Adverse Impact and Degradation

Because all the action alternatives were developed to stay within the abstraction limits and because the water monitoring and conservation program would be mandatory under all the action alternatives, definitions of adverse impact and degradation were not developed.

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 (defined below) intended to ensure that any downward trend in conditions can be identified and arrested while the value is still in a protected condition.

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 5-21, 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 Meadows would begin with mandatory closure of shower facilities and use of paper

plates in the lodge, proceed to use of portable toilets in the campground (or other water conservation measures), and could include 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 5-21.
Management Actions and Trigger Points to Maintain Desired Conditions for Free-Flowing Condition

Trigger	Required Management Response (at least one action will be taken)	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, with water withdrawals at 8% or more of the river's flow at any time.	Close restrooms in the campground and supply portable toilets until flows increase to above 3 cubic feet per second. Close parts or all of Tuolumne Meadows Lodge and/or the campground (completely) 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.

Management to Protect and Enhance the River's Free-Flowing Condition

Current Findings Regarding the Management Standard

Although degradation and adverse impact are not defined for free-flowing conditions, a management standard and triggers for management action are defined. Consequently, the current condition of this river value will be compared to the management standard and triggers. Current average withdrawals of up to 46,000 gallons per day, with rare spikes over the past five years occasionally reaching up to 67,000 gallons per day, appear to slightly exceed the management standard of withdrawing no more than 65,000 gallons per day from the river. However, as noted above, the occasional rare spikes in water withdrawals appear anomalous and do not directly measure daily withdrawals from the river itself, only withdrawals from the water storage tank. The maximum daily water withdrawal in 2012 was less than 55,000 gallons per day (10,000 gallons lower than the proposed management standard of the 65,000 gallon per day). The Waddle and Holmquist study (2011) found that a maximum abstraction rate of 65,000 gallons per day (the approximate five-year maximum) would 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.

Management Concerns and Protective Actions

Management concerns occur when conditions reach one of the trigger points identified in table 5-21. Although the trigger points have been reached on rare occasions in the past five years, they were not approached in 2012 after the NPS had begun to educate visitors and employees about the importance of water conservation. With the additional water conservation measures included in the *Tuolumne River Plan*, including water metering, the installation of low-flow fixtures throughout Tuolumne Meadows, and the repair or replacement of leaking water supply lines, these management concerns should not recur unless climate change results in significantly reduced low flows in the river. Also, because the current data are based on withdrawals from the water storage tank rather than from the river itself, actions to make withdrawals from the river into the tank more consistent might change the data and reduce or eliminate the anomalous spikes.

Based on the findings of the Waddle and Holmquist study (2011), the NPS developed all alternatives in this plan to limit water use to no more than 10% of the Dana Fork's flows at the critical low-flow level or 65,000 gallons per day, whichever is less. 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, additional management actions will be triggered, including

reductions in types and levels of visitor services, if necessary, to ensure that water withdrawals do not exceed 10% of low flows.

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 the final *Tuolumne River Plan*. A program of long-term monitoring and protective action could trigger additional reductions in water use, as described under "Monitoring Program to Prevent Future Adverse Impacts or Degradation," above.

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 WSRA, 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 be 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.

Localized Concerns and Enhancement Actions

To improve the ability of the Tioga Road bridge to accommodate peak flows, the bridge and/or the causeway to the east of it will be modified, under whichever of the action alternatives is selected. Improvements to the bridge will be compatible with its historic character, will require additional site-specific planning and compliance, and will be subject to section 7 determinations as part of future planning and assessment.

The short section of boulder riprap along the Lyell Fork near the campground A-loop road interferes with the free flow of the river. Under all the action alternatives, the riprap will be removed and the riverbank restored to natural conditions.

The natural flow regime of the Tuolumne River downstream of O'Shaughnessy Dam is regulated by water and power supply operations at O'Shaughnessy Dam. Required minimum instream flow releases from O'Shaughnessy Dam are currently governed by the 1985 and 1987 stipulations associated with the Raker Act. A new instream flow management plan for O'Shaughnessy Dam is being developed by the SFPUC as part of the Upper Tuolumne River Ecosystem Program, in collaboration with the NPS, USFS, U.S. Fish and Wildlife Service (USFWS), and the Upper Tuolumne River Stakeholder Group. The new instream flow plan will modify O'Shaughnessy Dam instream flow releases to better support broad river ecosystem values in the upper Tuolumne River (including Poopenaut Valley wetlands and meadows), mimic natural hydrology, and provide for long-term ecological monitoring.

Conclusion: Protection and Enhancement of the River's Free-Flowing Condition

The amount of water withdrawn from the Dana Fork for domestic use in the Tuolumne Meadows area has exceeded the standard of 65,000 gallons per day on rare occasions in the past five years; however, maximum water use was well below this level in 2012. With the additional water conservation measures included in the *Tuolumne River Plan*, this management concern should not recur unless climate change results in significantly reduced low flows in the future.

According to recent research, the current practice of withdrawing 10% or less of low flow from the river has a minimal effect on downstream aquatic habitat. The plan calls for long-term monitoring of river flows, and if future reductions in low flows associated with climate change threaten to decrease habitat at the current withdrawal rates, 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 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 downstream of the dam.

Localized concerns include the abutments of the vehicle bridge 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 the highway bridge.

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Chapter 6: Visitor Use and User Capacity

This chapter addresses the user capacity requirement of the Wild and Scenic Rivers Act (WSRA). Consistent with the direction in the 1982 Final Revised Guidelines for Eligibility, Classification and Management of River Areas (Secretarial Guidelines), this chapter outlines how the *Tuolumne River Plan* "determined the quantity and mixture of recreation and other public use which can be permitted without adverse impact on the resource values of the river area."[1]

This chapter is divided into three parts to describe how the user capacity requirement of the Wild and Scenic Rivers Act (WSRA, Section 3(d) (1)) is addressed in the *Final Tuolumne River Plan/EIS:*

"Part I: Introduction and Background to User Capacity" includes definitions and background for understanding how user capacity has been addressed in the *Final Tuolumne River Plan/EIS*. This section includes a list of factors that limit user capacity in the river corridor, as well as "Frequently Asked Questions" to address common misunderstandings or assumptions about user capacities and to establish a basis for the technical components of parts II and III.

"Part II: Process to Address User Capacity" provides an overview and explanation of the process used to address user capacity in the *Final Tuolumne River Plan/EIS*. Each part of the process is explained in general terms here, while the specific outcomes of each step are discussed in part III.

"Part III: User Capacities" provides more detail about the specific user capacity decisions in the *Final Tuolumne River Plan/EIS*, organized by plan alternative. The alternatives presented in chapter 8, "Alternatives for River Management," differ with regard to the kinds and amounts of use the Tuolumne River corridor would receive in the future and the infrastructure needed to support that use. The alternatives address management of visitor use and user capacity for each river segment by specifying the kinds and maximum amounts of use that would occur in each segment under each alternative. The kinds and amounts of use allowed under each alternative would protect and enhance river values.

Chapter 8, "Alternatives for River Management," summarizes the actions that would be taken under each alternative to ensure that river values are protected and enhanced in relation to the kinds and amounts of use proposed. The chapter provides a full list of these actions as well as actions common to all alternatives. Supplemental information on visitor use and the methods used to quantify use can be found in appendix J.

Under each alternative, all river values would be fully protected from any adverse impact or degradation, and many would be enhanced. Some alternatives may provide greater enhancement of certain river values and other resources, as described below. In addition, some alternatives would provide for public visitation and use at levels lower than the maximum capacity in order to provide the public with options regarding visitation levels and related user experience.

Part I: Introduction and Background

The intent of this chapter is to clarify how several components of the *Final Tuolumne River Plan/EIS* work together to meet the WSRA requirement to address user capacities when preparing a comprehensive river management plan. The user capacities presented in this chapter were derived from a series of interrelated

[1] National Wild and Scenic Rivers System; Final Revised Guidelines for Eligibility, Classification, and Management of River Areas, 47 *Federal Register* 39454 (1982). WSRA and the Secretarial Guidelines use the terms "carrying capacity" and "user capacity" interchangeably.

analyses, which are discussed in greater detail below, in chapter 5, "River Values and Their Management," and chapter 7, "Development of Lands and Facilities," and in appendix J. The following section provides a brief overview of the overall framework used to develop user capacities.

Background and Overview

The 1982 Secretarial Guidelines define carrying capacity as "the quantity of recreation use which an area can sustain without adverse impact on the outstandingly remarkable values and free-flowing character of the river area, the quality of recreation experience, and public health and safety." Under the Secretarial Guidelines, public use should be regulated and distributed where necessary to protect and enhance river values. Public use may be controlled by limiting public access to the river, by issuing permits, or by other means available to the managing agency through its general statutory authorities.

The U.S. Court of Appeals for the Ninth Circuit (Ninth Circuit) has interpreted the WSRA requirement for the NPS to "address…user capacities" to mean that the *Tuolumne River Plan* "must deal with or discuss the maximum number of people that can be received in the river area." To do so, the NPS must "adopt specific limits on user capacity consistent with both the WSRA and the instruction of the Secretarial Guidelines that such limits describe an actual level of visitor use that will not adversely impact the ORVs [Tuolumne's outstandingly remarkable river values]."

Decisions about user capacity are embedded within a comprehensive set of management actions that are packaged together to form different alternatives (Haas 2003, Whittaker et al. 2010). For example, the alternatives include different choices about the type of land use that would occur in Tuolumne Meadows, which is a relatively small area bounded by designated Wilderness, floodplains, and riparian and meadow ecosystems. Within this limited space, choices about the mix of overnight versus day use accommodation and development versus open space have a direct link to the associated capacities for visitor use. Alternatives with higher levels of use require more intensive measures to direct and control that use, such as fencing or boardwalks to protect meadows and riparian habitat. Given the interplay among resource protection measures, infrastructure placement and design, and the type of visitor experience to be provided, management alternatives can bracket a wide range of user capacities while remaining consistent with the protection of river values. All of these relationships have been examined and integrated into the development of the *Final Tuolumne River Plan/EIS*.

Because the protection and enhancement of river values is a primary goal of this plan, the planning process began by identifying the outstandingly remarkable values and their associated, measureable indicators that represented the quality of each river value. Each indicator was assigned a desired condition (management standard) to represent a healthy, fully functioning condition. Metrics were also assigned to signal when conditions reach levels of adverse impact and degradation. This set of data points was used to identify the conditions the NPS needed to prevent so that the NPS would meet the intent of WSRA for each river value, and to identify areas that need improvement. To determine whether the kinds and amounts of use currently allowed in the river corridor were adversely impacting river values, each river value was assessed and compared to its desired condition. None were found to be adversely impacted or degraded, although some management and localized concerns were found, especially in Tuolumne Meadows. The most significant action to correct these concerns, an ecological restoration plan for the meadows, was included in all of the action alternatives and is described in detail in appendix H. The complete analysis is presented in chapter 5, and corrective measures are included within each action alternative as described in chapter 8.

During the early stages of the planning process, NPS planners considered some scenarios that increased use over contemporary levels. In determining the maximum user capacity for each alternative, planners considered existing constraints that could affect such use. For example, visitor services and employee housing require

water withdrawals from the river, and the amount of water that can be withdrawn from the river is limited by the need to ensure free-flowing conditions and the health of downstream ecosystems. Therefore, potential limitations on the water supply were taken into account. This exercise determined the maximum capacity for Tuolumne Meadows and helped to define the range of reasonable alternatives developed for the *Tuolumne River Plan*. A more detailed list of the factors limiting user capacity in the Tuolumne River corridor follows this discussion.

The next question to be answered was whether the existing facilities and services provided for public use and enjoyment of river values were having an adverse effect on those values. After reviewing all of the infrastructure and its placement throughout the river corridor, no adverse impacts to river values were identified. Again, some localized effects were observed and would be remedied through mitigation measures included in the action alternatives. Plans for new facilities or realignments of existing operations were also screened for potential impacts to river values and modified as necessary to address concerns. The complete analysis is presented in chapter 7.

Finally, the need to provide for public health and safety is addressed in all alternatives. For example, protecting the safety of visitors and employees necessitates restricting some types of development and/or use of existing structures in areas at high risk of flooding. Also, all alternatives must retain important support infrastructure such as wastewater treatment systems that are sized appropriately for the expected use levels. All of these considerations have been factored into the design of the alternatives developed for this plan. Alternatives that would jeopardize public health and safety were not considered to be viable options.

The alternatives in the *Final Tuolumne River Plan/EIS* provide comprehensive direction for the river corridor and are informed by recent assessments of the condition and quality of river values and the recreation experience. All actions incorporated in each alternative, including choices about user capacities, are designed to address the concerns identified in these assessments and to prevent past problems from recurring. The monitoring program described in chapter 5 (which ensures that river values remain protected), the user capacity management program described in this chapter (which ensures that use limits are not exceeded), and the river value enhancement actions described in chapter 8 and appendix H are all key to managing the Tuolumne as a wild and scenic river.

Appendix J, "Characterizing Visitor Use of the Tuolumne River Corridor," provides more detail on existing kinds and amounts of use in the Tuolumne River corridor. Establishing user capacities is only one of many actions that help river managers protect river values, and it is assumed that the reader will consult other chapters in this document to gain a full appreciation of the suite of actions included in the plan to meet the overall objectives of WSRA.

Factors Limiting User Capacity

This section discusses the factors used to establish the overall maximum amounts of use that may be provided in the Tuolumne River corridor without adverse impact on river values. Under WSRA and its implementing Secretarial Guidelines, the NPS must specify the number of people who can be received in the river corridor consistent with the protection and enhancement of outstandingly remarkable values. This is the "maximum user capacity" for the river corridor.

Some alternatives would allow more people to visit the area, and some would allow fewer visitors. These differing use levels reflect differing visions of a visitor experience in the Tuolumne River corridor; these visions are based in large part on public comments received in the scoping phase of this process. Some of these visions introduce other restrictions on user capacity that reduce the use levels under an alternative. For example, alternative 1 envisions a visitor experience characterized by self-reliance and close experience with the river and the wilderness. As a result, the total number of people allowed in the meadows at any one time would be

low to allow visitors to have the opportunity for solitude and quiet reflection envisioned under alternative 1. The level of visitor use under alternative 1 would be substantially less than that allowed under the no-action alternative or the other action alternatives (see see tables 6-1 through 6-5 for summaries of visitor use under each alternative).

Depending on the alternative, the maximum user capacity of the Tuolumne River corridor will be limited by the following several factors:

Water Consumption

A key limiting factor to user capacity in the scenic segment of the river in Tuolumne Meadows is the availability of water. Water for Tuolumne Meadows is drawn directly from the Dana Fork of the Tuolumne upstream from Tuolumne Meadows Lodge. A minimum flows study (Waddle and Holmquist 2011) found that, at current flow levels, 65,000 gallons of water per day can be withdrawn before negative impacts on aquatic species occur. Water demand is primarily associated with overnight accommodations, camping, and employee housing. Alternative 2 provides for the highest use levels of the action alternatives, which would correspond to average water withdrawals of approximately 50,000 gallons of water per day (as projected from current consumption). The capacity associated with this alternative is a maximum of 4,884 day and overnight people at one time (visitors and employees) in Tuolumne Meadows,[2] which would correspond to a water consumption about 9% greater than at present (about 50,000 gallons per day, as compared to about 46,000 now). Because the actual amounts of water withdrawn from the river can exceed the daily average (depending on visitation and water purification needs), planners felt that an average of 50,000 gallons per day was the upper limit that would ensure daily withdrawals would not exceed the 65,000 gallons per day limit.

Constraints on the Level of Development

The level of development and related facilities that can be provided in the Tuolumne River corridor is constrained by designated Wilderness and by river segment classifications under WSRA. More than 90% of the Tuolumne River flows through federally designated Wilderness, which is described by the Wilderness Act as "an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation" (16 United States Code 1131-1136, section 2c). Similarly, the river classifications contained in WSRA pose restrictions on the level of development appropriate in river segments. The majority of the Tuolumne River corridor is classified as wild (generally coinciding with the areas also protected by Wilderness designation). Only the Dana and Tuolumne Meadows area and a small area below O'Shaughnessy Dam are classified as scenic (see river classifications in chapter 3, "Wild and Scenic River Corridor Boundaries and Segment Classifications"). According to WSRA, a scenic river segment contains shorelines largely undeveloped but accessible in places by roads. Collectively, these designations pose constraints on the level of development and infrastructure that may be provided in the river corridor and thus have a direct effect on the kinds and amounts of use that may be accommodated.

Resource Constraints and Site Suitability

Resource and site constraints include topography, meadow and riparian areas, rare and sensitive plant and animal populations, scenic vista points, and cultural resource sites (see figure 8-3 in chapter 8 for a map of these constraints). Generally, planning for visitor use and access to the river corridor seeks to avoid these sensitive resource areas to prevent unacceptable impacts. For instance, the parking associated with the Cathedral Lakes

[2] This number represents 4,607 day and overnight visitors at one time in Tuolumne Meadows, plus 277 NPS and concessioner employees housed in Tuolumne Meadows, for a total of 4,884 people at one time in the Tuolumne Meadows area under alternative 2. Table 8-19 in chapter 8 provides a summary and comparison of user capacities by alternative, including total visitor use and administrative use both corridorwide and in the Tuolumne Meadows area.

trailhead along Tioga Road is constrained by several factors, including its effect on the edge of the meadow, runoff from Budd Creek, high scenic visibility, cultural resources, and safety concerns associated with passing traffic and pedestrians. Considering these factors, the *Tuolumne River Plan* proposes various alternatives to provide this parking in a less sensitive location. Alternative locations for this parking are further constrained by topography and the various site constraints found within the Tuolumne Meadows area.

Wilderness Experience

As described in chapter 5, one of the two outstandingly remarkable recreational values in the Tuolumne River corridor is the opportunity for a wilderness experience along the river, characterized by solitude or primitive and unconfined recreation (or both) in a natural and undeveloped setting. A high level of enounters with other visitors could reduce a visitor's ability to obtain such a wilderness experience within the river corridor; therefore, this is the key constraint for user capacity in the wilderness segments of the Tuolumne River corridor. In these segments, use will be maintained at levels that provide for opportunities for primitive and unconfined recreation or solitude. For example, the preferred alternative would maintain use at levels that limit encounters with other parties to an average of 8 or fewer per hour in the Lyell Canyon area upstream of the Ireland Lake trail junction, 12 or fewer per hour in the Lyell Canyon area downstream of the Ireland Lake trail junction and on the Glen Aulin trail, and 2 or fewer in the Grand Canyon of the Tuolumne.

Summary

The capacities proposed in the plan are within the constraints discussed above because all site constraints were factored into the development of each alternative. No alternative would remove more water from the Dana Fork than the minimum flows allow; all development would be outside of designated Wilderness and located such that river values and other sensitive resources are protected; and the anticipated wilderness encounter rates in every alternative would allow many opportunities for either primitive and unconfined recreation or solitude, or both.

Frequently Asked Questions about User Capacity

The following questions and answers address important user-capacity issues commonly raised by stakeholders and the public. The purpose of this section is to present key ideas that drive user capacity decisions in the *Final Tuolumne River Plan/EIS*.

Is user capacity intrinsic to an area, determined as a single number by resource characteristics?

No. User capacities are an outcome of a decision-making process and part of a larger management program. They are the result of a series of judgments in the plan about river values, the desired future environmental and experiential conditions, and the acceptability of facilities and transportation infrastructure designed to handle use.

Do user capacities involve value judgments?

Yes. Several parts of the user capacity process involve decisions that include value judgments. While scientific inquiry can inform the public and decision makers about the consequences of different choices, research cannot tell us what the right choices are. Research-informed judgments start at a general level when river values are defined. Other decisions feed into the development of alternatives for different types of visitor experiences and the development of acceptable standards for river value conditions. Judgments are implicit in the combination of management actions included in each alternative.

How do biological values relate to user capacities?

Biological resources can be sensitive to an *amount* of use, in which case they may be a limiting factor in determining capacity. Most often, though, use-related effects on the condition of biological resources are related to the *type of use occurring* and *how it is managed*. For example, a trail crossing a sensitive meadow could be vulnerable to widening by hikers avoiding puddles by walking to the side of the trail. In this situation, the behavior or type of use is the problem, not the number of users. Such a problem could be remedied through trail construction, such as building a trail that drains better or has boardwalks over frequently wet areas. Once such a trail exists, impacts to biological resources are not the limiting factor for capacity, so the focus shifts to values that are more strongly related to numbers of users, such as social conditions (e.g., crowding).

How do cultural values relate to user capacities?

As with biological values, cultural values can be sensitive to an amount of use and be a limiting factor for capacity. However, cultural values are also more often affected by the type rather than the quantity of use. Cultural resources are particularly sensitive to depreciative behavior by a small minority of users (e.g., graffiti, vandalism, theft of artifacts by souvenir seekers); this problem is more effectively addressed through regulations and enforcement. This is not a capacity issue. Even if trail erosion in an artifact area uncovers or moves cultural resources, the most effective fix is a redesigned trail that prevents erosion or avoids the sensitive area. Like biological resources, cultural resources may constrain new development. Most new developments called for in this plan were sited at areas not known to contain archeological remains, but if previously unknown cultural artifacts are discovered during the site design for any of these, the design may have to be modified or the site excavated before construction proceeds.

Why does the *Final Tuolumne River Plan/EIS* present different user capacities by alternative? Do all the user capacities protect river values?

The National Environmental Policy Act (NEPA) requires environmental impact statements to consider a reasonable range of alternatives. The *Final Tuolumne River Plan/EIS* includes a range of alternatives, all of which protect river values, but in different ways. Each alternative is a stand-alone program that combines different user capacities, infrastructure, and related management actions to protect and enhance river values as required by WSRA. Alternatives that propose higher levels of use have higher levels of infrastructure and more intensive management to handle the use without unacceptable impacts. Alternatives that propose lower levels of use require less infrastructure and management, and offer more opportunities for restoration, but provide opportunities for fewer visitors.

What are the choices inherent in alternatives with higher versus lower user capacities?

Resource conditions, user capacities, and the infrastructure to support visitation are foundational elements to a plan's alternatives. Changing one component often has implications for the others. The range of proposed user capacities among the different alternatives illustrates how higher and lower amounts of use interact with the needs for infrastructure and management actions to protect river values. The alternatives represent choices about possible kinds of visitor experiences in the Tuolumne River corridor, any of which must protect river values as required by WSRA.

What are the limiting factors to user capacity?

The amount of use an area can sustain depends on its resource characteristics, the types and quantity of use anticipated, and the effectiveness of management actions. Ultimately, the factors that determine how much use is "too much" depend on the conditions being managed for and the type of use being considered. These factors vary by alternative and also by the Tuolumne River segments.

Why is the determination of an existing situation or the baseline condition at designation important in user capacity analyses?

The existing situation is an important reference point because it is what planners, stakeholders, and the public know best and is easiest to understand. Baseline condition at time of WSRA designation is another important reference point. But neither the existing nor the baseline conditions is necessarily the desired condition, and planning was designed to explore different ways to protect and enhance values in the Tuolumne River corridor with different capacities.

The attention to baseline and existing conditions also recognizes that no resource area is a "blank slate" during planning. Historical conditions, existing infrastructure, and traditions of management have a kind of inertia, and it is important to be realistic about which elements of the existing situation will likely remain (see the discussion about presenting different user capacities by alternative, above). A deliberate process was used to evaluate restoration and facility changes before capacity analyses were fully applied.

Does a given level of encounters equate to crowding?

No. This confuses an impact (encounters) with the evaluation of the impact (crowding, better described as "perceived crowding"). Crowding involves an individual's judgment about the number of other people encountered as compared to the individual's personal norms or expectations for that particular experience. Despite seeming subjectivity, social norms for encounters are usually lower for more remote, solitary backcountry experiences and higher for more social frontcountry experiences involving more interaction with other people. Park managers turned to studies done in Yosemite and in similar natural resource areas when setting indicators and standards for the various river segments and devising the use levels under the various alternatives. Planners then set the standards based on the desired experiences sought in each segment and in each alternative.

How are capacities different from estimated visitation?

User capacities identify the maximum number of people in specific locations and time periods in different alternatives. These capacities are based on how much use can occur ***at one time*** without causing conditions to reach unacceptable levels, and they consider the combined effects of overnight use and day use during peak periods. Managers, stakeholders, and the public are also interested how these capacities will produce different use levels over an entire day, season, or year. For example, the capacities for campgrounds assume full occupancy (e.g., six people per site), while the realistic estimate of actual visitation is calculated by multiplying the number of sites by the long-term average occupancy (about four people per site). Similarly, capacities are set for day use at one time based on assumptions about people per vehicle (about 2.9), parking occupancy levels (90% full), and the number of vehicles circulating on roads; but these capacities can be translated into daily day use visitation estimates by applying parking turnover rates developed from transportation modeling.

How are the concepts of *adverse impact* and *degradation* related to capacities?

As discussed in chapter 5, these terms have been defined for the *Tuolumne River Plan* in response to WSRA and *Merced River Plan* litigation. The *Tuolumne River Plan* has specified adverse impact and degradation levels that the NPS will proactively avoid, and these are common to all alternatives. They define a floor below which no impact will fall. However, NPS has also identified management standards for each indicator that are better than adverse impact or degradation levels. Because capacities are based on these better standards that the NPS also intends to achieve proactively, adverse impact and degradation levels are not central to determining capacities in the *Tuolumne River Plan*.

Can user capacities be changed after the plan is completed?

Yes. Depending on the situation, changes might be subject to renewed planning and environmental compliance for NEPA and WSRA. The NPS has applied the best available scientific information in the *Final Tuolumne River Plan/EIS* to make decisions related to management standards and user capacities. Monitoring and adaptive management allow the NPS to evaluate decisions and any needed changes in the future.

What are indicators and standards?

Indicators are variables selected to represent important ecological, cultural, or experiential conditions in a given setting. Standards define thresholds for those indicators, establishing the benchmark for acceptable conditions.

Establishing indicators and standards is an important step in addressing user capacity. For WSRA, indicators are typically chosen to evaluate conditions of specific river values. The *Final Tuolumne River Plan/EIS* identifies at least one indicator for most river values to assess and monitor conditions (see chapter 5). Some indicators are related more to visitor use impacts than are others. For example, to assess the quality of recreational values in wild segments, park staff members monitor encounter rates, or the number of other people encountered along a trail per hour. This indicator is directly related to the amount of use occurring in a segment. In contrast, water quality is more closely tied to point sources of contaminants, which may be linked to a number of variables other than visitor use. For more on indicators and standards, see chapter 5.

Part II: Process to Address User Capacity

User capacities were developed through a process that was integrated into overall planning. The *Final Tuolumne River Plan/EIS* alternatives are comprehensive management prescriptions that include a combination of restoration, facility protection, and capacity decisions as recommended in the capacity literature (Haas 2003, Whittaker et al. 2010). Capacities were not an independent "overlay," but an integral part of developing alternatives. ***While this process is listed serially, the nature of planning is iterative. Throughout the process, planners reconsidered analyses and made adjustments to ensure the plan evaluated a reasonable range of alternatives and capacities.*** A more detailed explanation of each step in the process follows.

Define River Values and Management Goals

River values (including free-flowing condition, water quality, and outstandingly remarkable values) and management goals create a starting point for developing alternatives with associated capacities. River values focus attention on the most important resource conditions and recreation experiences, while management goals are a commitment to actions to protect or enhance values while providing for public use. River values and management goals, which stem from agency mandates and enabling legislation, provide a foundation for the development of specific management standards that guide decisions about user capacity.

Management goals of the *Tuolumne River Plan* that relate to user capacity include protecting and enhancing river values, identifying the appropriate kinds and amounts of use that protect river values, and providing quality visitor experiences. These three broad goals were translated into proposed management actions for key river values, such as restoring ecological conditions within meadow and riparian habitats and rehabilitating the campground to improve naturalness of the setting and site delineation.

This task includes developing detailed maps to illustrate the location and extent of the river values to be protected. This information is provided in chapter 5 (see figure 5-1).

Document Conditions and Identify Management Issues

For this task, the NPS documented the baseline condition of the river values to be protected. This included a comprehensive review of existing research and monitoring information, as well as a targeted investment in additional research needed to provide a comprehensive assessment. An important component of this assessment, presented in chapter 5, was identifying the extent to which visitor use is affecting river values. Existing data were also used to develop maps of physical site constraints (see figure 8-3 in chapter 8) to guide the next steps of the planning process. The baseline assessment, understanding of visitor use impacts, and overlays of important resource considerations were used by the planning team to generate a comprehensive list of management issues that needed to be addressed by the *Tuolumne River Plan* to improve conditions in the Tuolumne River corridor and ensure the protection of river values. These issues are summarized in chapter 5.

Analyze Kinds of Use

Under WSRA, the NPS is to provide for public use and enjoyment of river areas in a manner that is consistent with the protection and enhancement of river values. The NPS may also provide for other types of uses if such uses are protective of river values and do not substantially interfere with public use and enjoyment of river values.[3]

Recreational use is the most significant subset of public use that occurs in the Tuolumne River corridor (administrative use to support recreational use and resource protection is another use, also addressed below). During plan initiation and scoping, NPS planners asked the public to describe what they liked to do in the Tuolumne River corridor and which facilities and services these activities would require. The resulting public scoping report (NPS 2006m) provided important feedback to the NPS regarding the level of public interest in different activities. This information gave planners a better sense of the uses that members of the public would like to preserve as well as uses that the public preferred to see be reduced or restricted. Planners also conducted visitor surveys and studies to understand use patterns and reviewed the findings of social research completed for similar settings for its relevance to the Tuolumne River (Littlejohn et al. 2005, Le et al. 2008). This effort provided additional insight into the types of activities and experiences visitors preferred. Finally, NPS planners compiled information on the historic, current, and projected levels of visitor use at Tuolumne Meadows and along the Tuolumne River (DEA 2007, NPS 2008d, NPS 2008e, NPS 2009c, NPS 2009e). Appendix J, and to some extent, chapters 5 and 8, provide more detail on the existing kinds and amounts of visitor use occurring in Tuolumne Meadows.

Develop Concepts and Themes for Alternatives

Based upon legal requirements, management issues, resource constraints, and public comments identified during the previous steps, NPS planners developed a set of preliminary alternative concepts. These concepts were designed to protect and enhance river values by specifying the kinds and amounts of use that could occur while meeting the established management standards for each river value (which are discussed in more detail in chapter 5). Several principles guided the development of preliminary alternative concepts:

- User capacities should vary across alternative concepts.
- Alternative concepts should represent a reasonable range of different futures (as required by NEPA), but all must protect river values by ensuring that their condition is maintained at a management standard well above adverse impact.

[3] Secretarial Guidelines, at 39456.

- Some restoration actions, new developments, or infrastructure changes would be common to all alternative concepts but others would vary across them.
- Similar management actions would be combined within alternative concepts to create conceptually meaningful and distinct themes.

At this preliminary stage, alternative concepts were not full management prescriptions but were sufficient for more detailed analyses to assess the different choices related to the level of infrastructure, river value conditions, and user capacities inherent in each alternative.

Identify Indicators and Standards

For most river values, Yosemite National Park scientists identified at least one, and as many as three, indicators and management standards. As explained in chapter 5, an indicator is a quantifiable measure of resource conditions that the NPS will periodically measure and monitor as representative of the condition of the river value. A management standard is the desired condition of the river value. A quantifiable management standard is established for most river values in chapter 5, along with specific quantifiable definitions of adverse impact and degradation, and triggers for management action. If a river value condition falls below one of these management triggers, then the park staff will take specific management actions (including, where appropriate, adjustments to user capacity) to address the situation and preserve the value's condition at a level above (better than) the management standard. These actions are also specified in chapter 5. (For definitions of adverse impact and degradation in the context of the *Tuolumne River Plan*, please see chapter 5.)

Analyze Use and Impacts to River Values

Another important task was to compare the existing condition of the river values to the definitions of management standard, adverse impact, and degradation, as well as the causes of any management concerns or localized concerns. This comparison (as well as the definition of management and localized concerns) is provided in chapter 5 for each river value. Additionally, that chapter also specifies a series of management actions to ensure that the river values are protected and enhanced. An analysis of kinds and amounts of use in the Tuolumne River corridor (including visitor demographics, use patterns, and activities) can be found in appendix J of this document.

As the Ninth Circuit has noted, WSRA "does not mandate one particular approach to user capacity."[4] In a river environment as diverse and dynamic as the Tuolumne, no single approach can be used to successfully address all issues. Rather, a suite of management strategies and tools is the most effective approach. These include actions such as providing visitors with information and education; establishing and enforcing regulations on visitor activities such as group size limits; manipulating sites and designing infrastructure to accommodate use, such as trails or boardwalks; implementing restrictions on use levels and access, such as trailhead quotas for backcountry use; and many other management activities. The management strategies and tools employed to protect and enhance river values differ among the alternatives presented in chapter 8.

Define Draft Alternatives and Initial User Capacities

Alternative concepts developed earlier in the process became more fully articulated as draft alternatives as park planners fully integrated the suite of management actions for each alternative, connecting indicators and standards to river values and determining the user capacities that would meet those standards and protect river values. Choices on facility locations and infrastructure design were guided by the location of outstandingly

[4] Friends of Yosemite Valley, Mariposans for Environmentally Responsible Growth v. Dirk Kempthorne et al., Opinion, March 27, 2008, 520 F.3d 1024 (Ninth Circuit 2008).

remarkable values, wetlands, floodplains, archeological sites, rare plants, and other important resource and financial considerations, such as water quantity and quality, costs, and operational logistics. Initial user capacities were based on river value conditions, related mapping of resource site constraints, and an analysis of the current visitor use and transportation patterns. NPS planners developed five draft alternatives (later revised down to four) to provide different visitor experiences and use levels within these constraints. These calculations varied depending on the type of use considered: overnight visitor, day visitor, and administrative use.

- **Overnight use**. This category includes people who stay in a campsite in the Tuolumne Meadows campground, in a guest tent cabin at the Tuolumne Meadows Lodge or the Glen Aulin High Sierra Camp, or who backpack in the Yosemite Wilderness.

  Overnight use levels are expressed in terms of the maximum occupancy of all camping, lodging, and wilderness zones for a given night. This represents the total maximum number of people per night. Based on past use rates, the overnight lodging, campsites, and wilderness trailhead quotas will not generally be used to full capacity. Only the maximum capacities are presented in chapter 8 and analyzed in chapter 9, "Affected Environment and Environmental Consequences."

- **Day use.** This category includes people who come for the day to sightsee, hike, or pursue other activities, then spend the night outside the river corridor. This includes individuals arriving by private vehicle, tour bus, or public transit. Much of this use is concentrated in the Tuolumne Meadows and Lower Dana Fork segments, although day visitors also hike into wilderness segments that can be reached on a day hike from Tuolumne Meadows or below O'Shaughnessy Dam. This category also includes people passing through on Tioga Road who make a brief stop at Tuolumne Meadows or at the roadside pullouts between Tuolumne Meadows and Tioga Pass.

  Day use capacities are expressed in terms of "people at one time, " which refers to the total number of people at a single point in time within a specified area. The calculation of day use capacity is based on the number of people who can be received in the corridor at one time without adverse impact on river values and without substantial interference with public use and enjoyment of those values.[5] Day use capacity is measured and managed by controlling day parking spaces and service levels of public transportation.

- **Administrative use.** This category includes NPS, park concessioner, park partner, and volunteer personnel. Specific examples of NPS, park partner, and volunteer administrative uses include trail and facility maintenance, resource protection, university research activities, visitor services, law enforcement, and emergency medical services, along with the housing, office space, parking, and other support for the personnel who conduct these activities. Specific examples of concessioner uses include the activities and support of employees who staff the lodge, campground, visitor center, store, grill, and stables at Tuolumne Meadows.

In the alternatives presented in chapter 8, administrative use levels are expressed in terms of the number of employees housed in the river corridor because this use has the highest per capita water demand and the most extensive footprint on the land. (Most of the other administrative uses are minimal and would not have a measureable effect on other public use).

[5] The calculations do not take account of the turnover of parking spaces because some day visitors leave and are replaced by other day visitors. Thus, it does not provide an estimate of the total number of unique daily visitors who can be received in the river corridor. No data are currently available from which a reliable estimate could be calculated.

Relate Capacities to River Value Conditions

After deriving the maximum user capacities for each alternative, NPS planners evaluated these capacities against the management standards for all river values to be sure the levels of use proposed would be consistent with protecting river values. Where capacities posed concerns, adjustments were made to the alternatives to ensure that the use permitted under each alternative would allow the NPS to meet the management standards established for river values. Planners then drafted the alternatives, specifying in each the final maximum capacities along with related management actions. The user capacity elements of each alternative are summarized in part III of this chapter.

This process resulted in various adjustments in management to protect river values, including changes to infrastructure to reduce capacity or additional mitigation measures that would ensure river values were protected and enhanced under any given capacity. For more information on the monitoring and study of river conditions refer to chapter 5, which contains a comprehensive discussion of the monitoring program for the Tuolumne Wild and Scenic River.

Monitor and Adapt Management

Measuring and monitoring the condition of river values is a crucial step in the process to address user capacity. While NPS planners designed each alternative to protect and enhance river values (for example, moving parking away from the meadow, restoring informal trails, and relocating some infrastructure outside of the river's 100-year floodplain), it is impossible to predict every possible impact from visitor use. Regardless of the kinds and amounts of use and related management actions specified in a plan, some degree of impact might still occur over time (Cole 1990, Cole and Stankey 1997, Marion 1998, Hammit and Cole 1998, Cole et al. 2005, Manning 2007, McCool et al. 2007). It is therefore important to monitor conditions to ensure that any impacts associated with visitor and other public use do not cause any adverse impacts or degradation of river values and that river values are protected and enhanced. The monitoring program for each river value is discussed at length in chapter 5.

Part III: Alternative User Capacities

This section provides a summary of the proposed user capacities for each alternative analyzed in this environmental impact statement, including a description of the kinds and amounts of use each alternative would provide as well as the actions necessary to protect river values from these uses over time. The implications of the proposed capacities and related management actions are also discussed. Readers can refer to chapter 8 for a more detailed description of the user capacities and associated management actions contained in each plan alternative, including actions common to all alternatives to protect river values.

To address user capacity, all aspects of use and the effects of use on river values must be considered, including seasonal variation in conditions and the construction of infrastructure, such as boardwalks, to prevent resource damage. For example, alternative 2 provides for an increase over current use and therefore requires additional infrastructure and river protection measures (like boardwalks in parts of the meadows), whereas alternative 1 provides for a decrease from current use and includes much less infrastructure. Accordingly, each alternative emphasizes different factors, depending on the mix of use and related management actions proposed, and each would be protective of river values. A summary of each alternative's proposed user capacity is described in this section.

No-Action Alternative

As described in chapter 8, the no-action alternative provides a baseline from which to compare the environmental and other impacts of the action alternatives proposed in this environmental impact statement. For user capacity, this includes the current kinds and amounts of use available in the Tuolumne River corridor.

These are summarized briefly below, while a more complete discussion of the kinds and amounts of use can be found in the discussion of affected environment in chapter 8.

Summary of the Kinds and Amounts of Use

Current use of the Tuolumne River is oriented toward the wilderness values that are prevalent in significant portions of the river corridor. Recreational activities include day hiking, backpacking, camping, swimming, fishing, stock trips and day rides, interpretive and educational programs, rock climbing, and other similar activities. Current capacities are presented in table 6-1.

Table 6-1.
Maximum User Capacity, No-Action Alternative

Visitor Overnight Capacity		
River Segment	**Existing Use Calculation**	**Current Maximum Overnight Visitors**
Tuolumne Meadows Lodge	# of lodging units (69) × max of 4 people per unit	276
Tuolumne Meadows Campground	# of campsites (329 sites × max of 6 people per site, plus 7 group sites × max 30 people per site)	2,184
Glen Aulin HSC	# of lodging units (8) × max of 4 people per unit	32
Wilderness	Maximum capacity of wilderness zones (400)	400
Subtotal, Visitor Overnight Capacity		***2,892***
Visitor Day Use Capacity		
River Segment	**Existing Use Calculation**	**Maximum Observed People At One Time, 2011**[a]
Access from Tuolumne Meadows	# of cars parking in designated parking spaces (340) × 2.9[b]	986
	# cars parking in undesignated spaces (190) × 2.9[b]	551
	Maximum people arriving by in-park hiker bus, tour buses, and regional public transit	225
Access from Below O'Shaughnessy Dam	# of cars parking in designated spaces (4) × 2.9[b]	12
Subtotal, Visitor Day Use Capacity		***1,774***
Total Visitor People At One Time		**4,666**
Administrative Capacity		
River Segment	**Existing Use Calculation**	**Maximum Employees (existing)**
Concessioner	Approximately 9 employees at Glen Aulin HSC	9
NPS	Approximately 150 employees based at Tuolumne Meadows	150
Concessioner	Approximately 103 employees based at Tuolumne Meadows	103
Total Administrative People At One Time		**262**
Total People at One Time		**4,928 (existing)**

a The peak number of vehicles observed during vehicle counts in 2011 (observed on August 13, 2011).
b The vehicle occupancy rate is 2.9 people per vehicle, based on visitor studies conducted over the past 20 years that found an average vehicle occupancy ranging from 2.6 to 3.4 (Van Wagtendonk and Coho 1980, FHWA 1982, ORCA 1999, Littlejohn et al. 2005, Le et al. 2008). Based on this range, an average of 2.9 persons per vehicle is used for estimating visitor numbers for planning purposes in this document.
Abbreviations: HSC = High Sierra Camp; max = maximum; # = number

Alternative 1: Emphasizing a Self-Reliant Experience

As explained in detail in chapter 8, alternative 1 would significantly reduce the kinds and amounts of use that would be allowed in the Tuolumne River corridor in an attempt to increase opportunities for self-reliant recreational experiences. The emphasis on self-reliance means that visitors would need to come prepared for their wilderness excursion because they would not have additional facilities and services readily available in Tuolumne Meadows to support their activities. For example, the store and grill, gas station, and Tuolumne Meadows Lodge would all be removed under this alternative.

Summary of the Kinds and Amounts of Use

The kinds of use under alternative 1 would include hiking, camping, backpacking, fishing, swimming, and rock climbing, and other similar activities. Under this alternative, all commercial visitor services, including lodging at Glen Aulin High Sierra Camp and the Tuolumne Meadows Lodge, would be removed along with concessioner stock day rides for visitors and commercial outfitter hiking and stock trips.

Based on the existing constraints in the Tuolumne River corridor and the kinds and amounts of use prescribed for this alternative, the maximum user capacity for alternative 1 is calculated at 3,317 people (table 6-2).

Table 6-2.
Corridorwide Visitor and Administrative Use Capacity, Alternative 1

Visitor Overnight Capacity			
Location	**Proposed Action**	**Units**	**Maximum Overnight Visitors, Alternative 1**
Tuolumne Meadows Lodge	Remove lodge (minus 69 guest tent cabins).	0 guest cabins	0
Tuolumne Meadows Campground	Remove A-loop campsites (minus 67 campsites).	262 sites plus 7 group sites	1,782
Glen Aulin HSC	Remove Glen Aulin HSC (minus 8 guest tent cabins).	0 guest cabins	0
Wilderness	Retain current wilderness zone capacities.	–	400
Subtotal, Visitor Overnight Capacity			***2,182***
Visitor Day Use Capacity			
Location	**Proposed Action**	**Proposed Units**	**Maximum People At One Time, Alternative 1**
Access from Tuolumne Meadows	Reduce designated day parking (minus 35 spaces).	305 spaces at 90%[a] occupancy[a] × 2.9[b]	796
	Eliminate undesignated roadside parking.	–	0
	Maintain current level of arrivals via tour bus and regional public transit.	–	225
Access from Below O'Shaughnessy Dam	Retain existing parking.	4 spaces × 2.9	12
Subtotal, Visitor Day Use Capacity			***1,033***
Total Visitor People At One Time			**3,215**
Administrative Capacity			
Employer	**Proposed Action**	**Units**	**Maximum Employees, Alternative 1**
Concessioner	Remove Glen Aulin HSC.	0	0
NPS	Meet staffing need with 100 employees at Tuolumne Meadows.	100 employees	100
Concessioner	Meet staffing need with 2 employees at Tuolumne Meadows.	2 employees	2
Total Administrative People At One Time			**102**
Total People at One Time			**3,317 (proposed)**

a The 90% factor is applied to account for the vacancy of a percentage of parking spaces after visitors leave and before new visitors find the empty spaces. This is applied as the maximum capacity because no single parking area is feasibly used to 100% efficiency. Because the parking lot at Poopenaut Valley is so small, using the 90% figure is inappropriate because all empty stalls can be seen by a typical driver.

b The vehicle occupancy rate is 2.9 people per vehicle, based on visitor studies conducted over the past 20 years that found an average vehicle occupancy ranging from 2.6 to 3.4 (Van Wagtendonk and Coho 1980, FHWA 1982, ORCA 1999, Littlejohn et al. 2005, Le et al. 2008). Based on this range, an average of 2.9 persons per vehicle is used for estimating visitor numbers for planning purposes in this document.

Abbreviations: HSC = High Sierra Camp; max = maximum; # = number

Management of User Capacity

Visitor Overnight Use. Levels of overnight use in wild segments would continue to be managed through a system of zone capacities and related overnight trailhead quotas under alternative 1. Overnight use levels in the scenic segment at Tuolumne Meadows would be managed by the facility capacity of the campground (the lodge would be eliminated). Some campsites would continue to be available through a reservation system and some on a first-come, first-served basis.

Visitor Day Use. Day use levels would be managed by controlling day parking, which would be restricted to paved or otherwise authorized spaces. No undesignated roadside parking would be allowed through the Tuolumne Meadows area. Undesignated roadside parking would continue to be allowed along Tioga Road west and east of Tuolumne Meadows. Service levels of public transportation systems serving the Tuolumne Meadows area (the regional transit bus service, Yosemite Area Regional Transit Service [YARTS]) would remain under NPS control, with the number of visitors delivered into the river corridor by such services managed according to the user capacity limits established for alternative 1. NPS may use any combination of limits on the numbers of buses, the stops they make, the number of passengers they accept, and/or the numbers of routes they run per day.

Administrative Use. Commensurate with the discontinuation of commercial services, the number of NPS and concessioner employees would be reduced. The levels of administrative use would be managed through the allocation of housing in the Tuolumne Meadows area. Housing would be maintained at the levels specified in alternative 1.

Actions to Protect River Values Given the Kinds and Amounts of Use in Alternative 1

Under alternative 1, river values would be protected from the effects of generally unconfined visitor use by decreasing use levels. See chapter 5 for a comprehensive listing of river protection measures; see chapter 8 for specific management actions associated with visitor use under alternative 1.

Free-Flowing Condition of the River

As noted in chapter 5, the existing average water withdrawals of up to 46,000 gallons per day meet the standard of being at or below 10% of low flow (1 cubic foot per second). Alternative 1 would reduce the estimated average water demand by approximately 34% due to reduced amounts and types of use, particularly overnight visitor use and employee housing. The average estimated water demand for alternative 1 is calculated as about 30,000 gallons per day, as calculated from existing use figures. As with all other alternatives, withdrawals from the Dana Fork would vary by day but would not be allowed to exceed 65,000 gallons on any one day, which is the maximum allowable withdrawal (10% of low flow). Based on these calculations, alternative 1 would be protective of river flow and downstream habitat. Even in years where low-flow durations occurred earlier in the summer, withdrawal levels would be well within the standard of no more than 10% of low flows presented in chapter 5.

Management to Protect Water Quality

Reducing water withdrawals would reduce the amount of wastewater to be treated and disposed and would allow for the elimination of the wastewater ponds and sprayfields on the north side of Tioga Road and the crushing or removing of the wastewater line that runs beneath the river and the meadow. Further reductions in risks to water quality under alternative 1 would be achieved by eliminating the fuel storage associated with the public fuel station and greatly reducing the size of the concessioner stable operation. Monitoring (detailed in chapter 5) would be ongoing to ensure that water quality remained excellent.

Management to Protect the Subalpine Meadow and Riparian Complex

Most of the actions to protect and enhance the subalpine meadow and riparian complex would be common to all the action alternatives. Alternative 1 would additionally reduce the maximum people at one time in the river corridor by an estimated 34% (from a current maximum capacity of 4,928 users to a maximum capacity of 3,317 users), primarily through the elimination of all commercial services. This would substantially reduce pack stock and foot traffic in the river corridor. Although visitors would be allowed relatively unconfined access to the subalpine meadow and riparian areas, the reduction in visitor and administrative use numbers would be expected to keep impacts associated with visitor use within the protective standard.

These actions would be expected to reduce the stresses on the subalpine meadow and riparian system and increase their ecological resistance to the kinds and levels of use that would continue. Conditions would be monitored to ensure that the protective management standards for meadow and riparian habitat would be achieved and maintained over time. If conditions were not being maintained within the protective standards, additional actions would be taken to further manage or reduce visitor use, as identified in chapter 5.

Management to Protect Archeological Sites

Management of visitor use for alternative 1 would also reduce impacts on archeological sites in the Tuolumne Meadows and Lower Dana Fork segments. The NPS would conduct monitoring to ensure that site disturbance did not exceed the protective standard established for these sites. If conditions were not being maintained within the protective standards, additional actions would be taken to further manage or reduce visitor use, as described in chapter 5.

Management to Protect and Enhance Scenic Values

Scenic views and viewpoints in the Tuolumne Meadows area and along the Tioga Road corridor would be protected and enhanced by managing unnatural features related to visitor and administrative use, such as facilities and parked cars, to minimize their intrusion into remarkable views.

Management to Protect and Enhance the Wilderness Experience along the River

Day use levels along most trails in wild segments of the river corridor within reach of a day hike from Tuolumne Meadows would be restricted to levels that resulted in encounters with no more than four other parties per hour; for the trail section through the Grand Canyon of the Tuolumne, the encounter rate would be no more than two other parties per hour. If required to achieve this standard, a day use trailhead quota system would be implemented for some trails under alternative 1. This management would protect visitors' opportunity to experience solitude throughout the wild segments of the river corridor, even on a day hike from Tuolumne Meadows. The wilderness experience would be enhanced by eliminating commercial stock use in the river corridor.

Management to Protect and Enhance Rare and Easy Access through Tuolumne and Dana Meadows

Under all alternatives, the Tioga Road would remain open for travel to Tuolumne and Dana Meadows. Opportunities for scenic driving along Tioga Road would be enhanced under alternative 1 by eliminating roadside parking and the congestion currently caused by vehicles slowing to park and pedestrians crossing the road. Designated parking would be provided that would allow for the amounts of use envisioned in this alternative. Parking availability would be monitored, with enforcement mechanisms designed to minimize adverse effects on the visitor experience. If parking availability was regularly exceeded, NPS would implement a day use reservation system, subject to further environmental compliance and public comment.

Management to Protect and Enhance Parsons Memorial Lodge, Poopenaut Valley, and Stairstep River Morphology

Parsons Memorial Lodge would be little affected by use levels proposed in any alternatives because visitation to the lodge is light and preservation actions are ongoing. Similarly, Poopenaut Valley would be little affected by the varying use levels because its parking lot accommodates only four cars and that lot would not be changed under any alternative. The stairstep river morphology is impervious to the human activity proposed in this plan, being the product of massive earth-building forces well beyond human control. (For these reasons, the discussion of use level effects on these three outstandingly remarkable values will not be repeated under the other alternative discussions below).

Alternative 2: Expanding Recreational Opportunities

As explained in greater detail in chapter 8, alternative 2 would expand the kinds and amounts of use while still protecting river values by managing use as described below. This alternative presents the highest use levels that may be accommodated across the range of action alternatives. The primary constraint to capacity with alternative 2 would be the consumption and treatment of water (as described above). See chapter 5 for a comprehensive listing of river protection measures; see chapter 8 for specific management actions associated with visitor use under alternative 2.

Summary of the Kinds and Amounts of Use

The various kinds of use proposed under alternative 2 would remain the same as are currently provided, with the addition of allowing limited private boating down the Grand Canyon of the Tuolumne. Additional opportunities for picnicking and walk-in camping at the Tuolumne Meadows campground would be provided for day visitors with this alternative. Designated day parking would be increased and consolidated in resource appropriate areas that are protective of river values.

Based on the kinds and amounts of used prescribed for this alternative and consideration of the constraints described earlier in this chapter, the maximum user capacity for alternative 2 is calculated at 5,337 people (table 6-3), about 9% more than existing maximum use levels.

Table 6-3.
Corridorwide Visitor and Administrative Use Capacity, Alternative 2

Visitor Overnight Capacity			
Location	**Proposed Action**	**Units**	**Maximum Overnight Visitors, Alternative 2**
Tuolumne Meadows Lodge	Retain lodge capacity.	69 guest tent cabins	276
Tuolumne Meadows Campground	Add walk-in loop (plus 41 campsites).	370 sites, plus 7 group sites	2,430
Glen Aulin HSC	Convert HSC to seasonal camp; no capacity change.	8 guest tents	32
Wilderness	Retain current wilderness zone capacities.	–	400
Subtotal, Visitor Overnight Capacity			***3,138***
Visitor Day Use Capacity			
Location	**Proposed Action**	**Proposed Units**	**Maximum People At One Time, Alternative 2**
Access from Tuolumne Meadows	Increase designated day parking (plus 302 spaces).	642 spaces at 90%[a] occupancy × 2.9[b]	1,676
	Eliminate undesignated roadside parking.	–	0
	Maintain current level of arrivals via by in-park shuttles, tour buses, and regional public transit.	–	225
Access from Below O'Shaughnessy Dam	Retain existing parking.	4 spaces × 2.9[b]	12
Subtotal, Visitor Day Use Capacity			***1,913***
Total Visitor People At One Time			**5,051**
Administrative Capacity			
Employer	**Proposed Action**	**Units**	**Maximum Employees, Alternative 2**
Concessioner	Retain all employees at Glen Aulin HSC.	9	9
NPS	Meet staffing need with 174 employees at Tuolumne Meadows.	174 employees	174
Concessioner	Meet staffing need with 103 employees at Tuolumne Meadows.	103 employees	103
Total Administrative People At One Time			**286**
Total People at One Time			**5,337 (proposed)**

a The 90% factor is applied to account for the vacancy of a percentage of parking spaces after visitors leave and before new visitors find the empty spaces. This is applied as the maximum capacity because no single parking area is feasibly used to 100% efficiency. Because the parking lot at Poopenaut Valley is so small, using the 90% figure is inappropriate because all empty stalls can be seen by a typical driver.

b The vehicle occupancy rate is 2.9 people per vehicle, based on visitor studies conducted over the past 20 years that found an average vehicle occupancy ranging from 2.6 to 3.4 (Van Wagtendonk and Coho 1980, FHWA 1982, ORCA 1999, Littlejohn et al. 2005, Le et al. 2008). Based on this range, an average of 2.9 persons per vehicle is used for estimating visitor numbers for planning purposes in this document.

Abbreviations: HSC = High Sierra Camp; max = maximum; # = number

Management of User Capacity

Visitor Overnight Use. Levels of overnight use in wild segments of the Tuolumne River corridor would continue to be managed through a system of zone capacities and related overnight trailhead quotas. In the wild segment below Tuolumne Meadows, recreational whitewater boating would be allowed and regulated through the wilderness overnight trailhead quota system. The Glen Aulin High Sierra Camp (as converted to a temporary outfitter camp under this alternative) would continue to be managed by a concession contract, with spaces allocated on an advanced reservation system. Overnight use levels in the scenic segment of the river corridor under alternative 2 would be managed by the facility capacities of the Tuolumne Meadows campground and Tuolumne Meadows Lodge. These facilities would continue to be available through a reservation system, with some campsites also available on a first-come, first-served basis. The NPS would retain oversight of all concessioner overnight services and capacities.

Visitor Day Use. Day use levels would be managed by controlling day parking, which would be restricted to paved or otherwise authorized spaces. No undesignated roadside parking would be allowed through the Tuolumne Meadows area. Undesignated roadside parking would continue to be allowed along Tioga Road

west and east of Tuolumne Meadows. Service levels of public transportation systems serving the Tuolumne Meadows area (YARTS, the hiker bus operated by the concessioner, and other transit services) would remain under NPS control, with the number of visitors delivered into the corridor by such services managed according to the user capacity limits established for alternative 2. The NPS may use any combination of limits on the numbers of buses, the stops they make, the number of passengers they accept, and/or the numbers of routes they run per day.

Administrative Use. NPS staffing would be increased to provide for increased visitor and resource protection needs (including management of the user capacity program, below), additional interpretive and educational services, resource management and monitoring, and maintenance. NPS employee housing or campsites would be increased to accommodate this staffing level; campsites would meet the need for incidental housing for employees on temporary duty in the Tuolumne Meadows area. Concessioner employee staffing and housing necessary to support commercial services would remain the same as under the no-action alternative. All housing would be maintained at the levels specified in alternative 2.

Actions to Protect River Values Given the Kinds and Amounts of Use in Alternative 2

Alternative 2 would expand the kinds and amounts of use in the Tuolumne River corridor but would maintain uses within the constraints and management actions to protect river values, as described below. See chapter 5 for a comprehensive list of river protection measures, and see chapter 8 for a complete list of all management actions associated with alternative 2.

Free-Flowing Condition of the River

As noted in chapter 5, the existing average water withdrawals of up to 46,000 gallons per day meet the standard of being at or below 10% of low flow (1 cubic foot per second). The estimated average water demand for alternative 2 is calculated as about 50,000 gallons per day. As with all other alternatives, withdrawals from the Dana Fork would vary by day, but would not be allowed to exceed 65,000 gallons on any one day, which is the maximum allowable withdrawal (10% of low flow). Additional management effort, including water metering, replacing inefficient fixtures, and implementing educational programs, would be required to ensure that water use remained within the standard. If low-flow durations occurred earlier in the summer, alternative 2 would have the greatest potential for requiring reductions in water consumption, including reducing the capacities at the Tuolumne Meadows Lodge and/or campground, to ensure that the level of water consumption remained protective of river flows.

Management to Protect Water Quality

Risks to water quality in the Tuolumne Meadows area under alternative 2 would be mitigated by upgrading the wastewater treatment plant, wastewater ponds, and sprayfields. The improved utilities would be designed for loads commensurate with the estimate of domestic water use noted above. Risks to water quality at Glen Aulin would be reduced by removing the current wastewater treatment system and leach mound and replacing it with a new composting toilet. Water used for meal preparation and sanitation would be screened before disposal in a wastewater sump. Monitoring would be ongoing (as described in chapter 5) to ensure that water quality remained excellent at both Tuolumne Meadows and Glen Aulin.

Management to Protect the Subalpine Meadow and Riparian Complex

Most of the actions to protect and enhance the subalpine meadow and riparian complex would be common to all the action alternatives (note in particular the ecological restoration program, outlined in chapter 5 and included in full in appendix H). Although use levels would be highest under alternative 2, this alternative would direct visitors to designated trails and delineate or fence certain trail segments to facilitate ecological recovery of adjacent vegetation. By requiring visitors to remain on designated trails, meadow fragmentation, bare soil,

and streambank instability would be greatly reduced. In tandem with the ecological restoration program, natural processes will flourish in Tuolumne Meadows to a much greater degree than at present, allowing it to be dominated by ecological processes to the maximum extent possible.

Management to Protect Archeological Sites

The same management of visitor use described above would also reduce impacts on archeological sites in the Tuolumne Meadows and Lower Dana Fork segments. Monitoring would be ongoing to ensure that site disturbance did not exceed the protective standard established for these sites.

Management to Protect and Enhance Scenic Values

Scenic views and viewpoints in the Tuolumne Meadows area and along the Tioga Road corridor would be protected and enhanced under alternative 2 by managing unnatural features related to visitor and administrative use, such as facilities and parked cars, to minimize their intrusion into remarkable views.

Management to Protect and Enhance the Wilderness Experience along the River

Day use levels along trails in wild segments of the river corridor within reach of a day hike from Tuolumne Meadows would be managed as follows to protect solitude and/or opportunties for primitive and unconfined recreation: ensure that average encounters do not exceed 12 other parties per hour on the Glen Aulin trail and the Lyell Canyon trail downstream of the Ireland Lake trail junction, 8 parties per hour on the Lyell Canyon trail above the Ireland Lake trail junction, and 2 parties per hour on the trail through the Grand Canyon of the Tuolumne. If required to achieve these standards, a day use trailhead quota system would be implemented for some trails.

Management to Protect and Enhance Rare and Easy to the River through Tuolumne and Dana Meadows

Under all alternatives, the Tioga Road would remain open for travel to Tuolumne and Dana Meadows. Opportunities for scenic driving along Tioga Road would be enhanced under alternative 2 by eliminating roadside parking and the congestion currently caused by vehicles slowing to park and pedestrians crossing the road. Opportunities for people wishing to park and get out of their cars would be enhanced by increasing the number of designated parking spaces. Parking availability would be monitored, with enforcement mechanisms designed to minimize adverse effects on the visitor experience. If parking availability is regularly exceeded, NPS would implement a day use reservation system, subject to further environmental compliance and public comment.

Alternative 3: Celebrating the Tuolumne Cultural Heritage

Alternative 3 would celebrate the cultural heritage of the Tuolumne experience by maintaining historic opportunities for recreation while providing for needed improvements to protect river values. Some restrictions on the levels of visitor services and reductions in overnight and day use capacities would occur, although the overall traditional experience of the Tuolumne as expressed in public comments would be preserved. See chapter 5 for a comprehensive listing of river protection measures; see chapter 8 for specific management actions associated with visitor use under alternative 3.

Summary of the Kinds and Amounts of Use

The majority of the current kinds of use in the Tuolumne River corridor would be retained with alternative 3. However, some proposed changes could affect the kinds of use in specific areas. For example, meals-only service, wood stoves, and flush toilets would be discontinued or removed at the Glen Aulin High Sierra Camp. Similarly, concessioner day rides would be reduced.

The overnight and day use capacities would be lowered slightly with alternative 3. In particular, the overnight capacity of the Glen Aulin High Sierra Camp and Tuolumne Meadows Lodge would be reduced. Designated

day parking would be increased and consolidated in resource appropriate areas that are protective of river values. Additional shuttle bus service would provide visitors with more opportunity to access their desired recreational activities in the Tuolumne Meadows area without the use of their private vehicle.

Based on the kinds and amounts of used prescribed for this alternative and consideration of the constraints described earlier in this chapter, the maximum user capacity for alternative 3 is calculated at 4,552 people (table 6-4), about 8% less than existing use levels.

Table 6-4.
Corridorwide Visitor and Administrative Use Capacity, Alternative 3

Visitor Overnight Capacity			
Location	**Proposed Action**	**Units**	**Maximum Overnight Visitors, Alternative 3**
Tuolumne Meadows Lodge	Reduce lodge capacity (minus 35 guest tent cabins).	34 guest tent cabins	136
Tuolumne Meadows Campground	Retain campground capacity.	329 sites, 7 groups sites	2,184
Glen Aulin HSC	Reduce Glen Aulin HSC capacity (minus 1 guest tent cabin).	7 guest tent cabins	28
Wilderness	Retain current wilderness zone capacities.	–	400
Subtotal, Visitor Overnight Capacity			***2,748***
Visitor Day Use Capacity			
Location	**Proposed Action**	**Proposed Units**	**Maximum People At One Time, Alternative 3**
Access from Tuolumne Meadows	Increase designated day parking (plus 170 spaces).	510 spaces at 90%[a] occupancy × 2.9[b]	1,331
	Eliminate undesignated roadside parking.	–	0
	Maintain current level of arrivals by in-park shuttles, tour buses, and regional public transit.	–	225
Access from Below O'Shaughnessy Dam	Retain existing parking.	4 spaces × 2.9[b]	12
Subtotal, Visitor Day Use Capacity			***1,568***
Total Visitor People At One Time			**4,316**
Administrative Capacity			
Employer	**Proposed Action**	**Units**	**Maximum Employees, Alternative 3**
Concessioner	Retain all employees at Glen Aulin HSC.	9	9
NPS	Meet staffing need with 124 employees at Tuolumne Meadows.	124 employees	124
Concessioner	Meet staffing need with 103 employees at Tuolumne Meadows.	103 employees	103
Total Administrative People At One Time			**236**
Total People at One Time			**4,552 (proposed)**

a The 90% factor is applied to account for the vacancy of a percentage of parking spaces after visitors leave and before new visitors find the empty spaces. This is applied as the maximum capacity because no single parking area is feasibly used to 100% efficiency. Because the parking lot at Poopenaut Valley is so small, using the 90% figure is inappropriate because all empty stalls can be seen by a typical driver.

b The vehicle occupancy rate is 2.9 people per vehicle, based on visitor studies conducted over the past 20 years that found an average vehicle occupancy ranging from 2.6 to 3.4 (Van Wagtendonk and Coho 1980, FHWA 1982, ORCA 1999, Littlejohn et al. 2005, Le et al. 2008). Based on this range, an average of 2.9 persons per vehicle is used for estimating visitor numbers for planning purposes in this document.

Abbreviations: HSC = High Sierra Camp; max = maximum; # = number

Management of User Capacity

Visitor Overnight Use. Levels of overnight use in wild segments of the Tuolumne River corridor would continue to be managed through a system of zone capacities and related overnight trailhead quotas. The Glen Aulin High Sierra Camp would continue to be managed by concession contract, with spaces allocated on an advanced reservation system. Overnight use levels in the scenic segments of the river corridor would be managed by the facility capacities of the Tuolumne Meadows campground and Tuolumne Meadows Lodge.

These facilities would continue to be available through a reservation system, with some campsites also available on a first-come, first-served basis. The NPS would retain oversight of all concessioner overnight services and capacities.

Visitor Day Use. Day use levels under alternative 3 would be managed by controlling day parking, which would be restricted to paved or otherwise authorized spaces. No undesignated roadside parking would be allowed through the Tuolumne Meadows area. Undesignated roadside parking would continue to be allowed along Tioga Road west and east of Tuolumne Meadows. Service levels of public transportation systems serving the Tuolumne Meadows area (YARTS, the hiker bus operated by the concessioner, and other transit services) would remain under NPS control, with the number of visitors delivered into the river corridor by such services managed according to the user capacity limits established for alternative 3. The NPS may use any combination of limits on the numbers of buses, the stops they make, the number of passengers they accept, and/or the numbers of routes they run per day.

Administrative Use. NPS staffing would be reduced under alternative 3. In addition to current housing, employee campsites would be provided to meet the need for incidental housing for employees on temporary duty in the Tuolumne Meadows area (even with the reduction in number of employees, there is not enough housing in the meadows area for the number of employees called for in this alternative). Concessioner employee staffing and housing necessary to support commercial services would remain the same as under the no-action alternative.

Actions to Protect River Values Given the Kinds and Amounts of Use in Alternative 3

Under alternative 3, the NPS would reduce capacities while providing for traditional kinds of use in the Tuolumne River corridor. See chapter 5 for a more comprehensive list of river protection measures, and see chapter 8 for a complete list of all management actions associated with alternative 3.

Free-Flowing Condition of the River

As noted in chapter 5, the existing average water withdrawals of up to 46,000 gallons per day meet the standard of being at or below 10% of low flow (1 cubic foot per second). The average estimated water demand for alternative 3 is calculated as about 42,000 gallons per day. As with all other alternatives, withdrawals from the Dana Fork would vary by day, but would not be allowed to exceed 65,000 gallons on any one day, which is the maximum allowable withdrawal (10% of low flow). This level of water withdrawal would be expected to remain within the standard of no more than 10% of low flow.

Management to Protect Water Quality

Risks to water quality in the Tuolumne Meadows area would be mitigated by upgrading the wastewater treatment plant, wastewater ponds, and sprayfield. The improved utilities would be designed for loads commensurate with the estimate of domestic water use above. The risk to water quality at Tuolumne Meadows would be reduced by eliminating the fuel storage associated with the public fuel station. Risks to water quality at Glen Aulin would be reduced by replacing flush toilets for guests with a new composting toilet. Monitoring (as described in chapter 5) would be ongoing to ensure that water quality remained excellent at both Tuolumne Meadows and Glen Aulin.

Management to Protect the Subalpine Meadow and Riparian Complex

Most of the actions to protect and enhance the subalpine meadow and riparian complex would be common to all the action alternatives. Alternative 3 would additionally reduce the maximum people at one time in the Tuolumne Meadows area by a modest amount. Although visitor access to the meadows and the river would not be as restricted as under alternative 2, the reduction in numbers of visitors would be expected to work in tandem with the ecological restoration program to allow natural processes to flourish in Tuolumne Meadows

to a much greater degree than at present, thereby allowing it to be dominated by ecological processes to the maximum extent possible.

Management to Protect Archeological Sites

The same management of visitor use described in the preceding paragraph would also reduce impacts on archeological sites in the Tuolumne Meadows and Lower Dana Fork segments under alternative 3. Monitoring would be ongoing to ensure that site disturbance did not exceed the protective standard established for these sites. If conditions were not being maintained within the protective standards, additional actions would be taken to further manage or reduce visitor use, as described in chapter 5.

Management to Protect and Enhance Scenic Values

Scenic views and viewpoints in the Tuolumne Meadows area and along the Tioga Road corridor would be protected and enhanced by managing unnatural features associated with visitor and administrative use, such as facilities and parked cars, to minimize their intrusion into remarkable views.

Management to Protect and Enhance the Wilderness Experience along the River

Day use levels along trails in wild segments of the river corridor within reach of a day hike from Tuolumne Meadows would be managed as follows to protect solitude and/or opportunties for primitive and unconfined recreation: ensure that average encounters do not exceed 12 other parties per hour on the Glen Aulin trail and the Lyell Canyon trail downstream of the Ireland Lake trail junction, 8 parties per hour on the Lyell Canyon trail above the Ireland Lake trail junction, and 2 parties per hour on the trail through the Grand Canyon of the Tuolumne. If required to achieve these standards, a day use trailhead quota system would be implemented for some trails.

Management to Protect and Enhance Rare and Easy to the River through Tuolumne and Dana Meadows

Under all alternatives, the Tioga Road would remain open for travel to Tuolumne and Dana Meadows. Opportunities for scenic driving along Tioga Road would be enhanced under alternative 3 by eliminating roadside parking and the associated congestion currently caused by vehicles slowing to park and pedestrians crossing the road. Opportunities for people wishing to park and get out of their cars would be enhanced by increasing the number of formally designated parking spaces. Parking availability would be monitored, with enforcement mechanisms designed to minimize adverse effects on the visitor experience. If parking availability was regularly exceeded, the NPS would implement a day use reservation system, subject to further environmental compliance and public comment.

Alternative 4 (Preferred): Improving the Traditional Tuolumne Experience

As explained in greater detail in chapter 8, alternative 4 would maintain the traditional Tuolumne experience while making marked improvements to infrastructure to further connect visitors to the river and protecting its resources. The range of visitor and administrative activities would be similar to the no-action alternative. See chapter 5 for a comprehensive listing of river protection measures; see chapter 8 for specific management actions associated with visitor use under alternative 4.

Summary of the Kinds and Amounts of Use

Except for some services at the Glen Aulin High Sierra Camp and the elimination of concessioner stock day rides, the kinds of use that currently exist in the Tuolumne River corridor would continue, with the addition of allowing limited private boating down the Grand Canyon of the Tuolumne. The overnight and day capacity with alternative 4 would also be similar to existing conditions but reduced somewhat, especially at Glen Aulin, as shown in table 6-5.

Based on the kinds and amounts of used prescribed for this alternative and consideration of the constraints described earlier in this chapter, the maximum user capacity for alternative 4 is calculated at 4,988 people (see table 6-5), about 1.5% more than existing maximum use levels.

Table 6-5.
Corridorwide Visitor and Administrative Use Capacity, Alternative 4

Visitor Overnight Capacity			
Location	**Proposed Action**	**Units**	**Maximum Overnight Visitors, Alternative 4**
Tuolumne Meadows Lodge	Retain lodge capacity.	69 guest tent cabins	276
Tuolumne Meadows Campground	Retain campground capacity.	329 sites, 7 group sites	2,184
Glen Aulin HSC	Reduce Glen Aulin HSC capacity (minus 3 guest tent cabins).	7 guest tent cabins	28 or less
Wilderness	Retain current wilderness zone capacities.	–	400
Subtotal, Visitor Overnight Capacity			***2,888***
Visitor Day Use Capacity			
Location	**Proposed Action**	**Proposed Units**	**Maximum People At One Time, Alternative 4**
Access from Tuolumne Meadows	Increase designated day parking (plus 222 spaces).	562 spaces at 90%[a] occupancy × 2.9[b]	1,467
	Eliminate undesignated roadside parking.	–	0
	Maintain current level of arrivals by in-park shuttles and tour buses; increase capacity for regional public transit.	–	360
Access from Below O'Shaughnessy Dam	Retain existing parking.	4 spaces × 2.9[b]	12
Subtotal, Visitor Day Use Capacity			***1,839***
Total Visitor People At One Time			**4,727**
Administrative Capacity			
Employer	**Proposed Action**	**Units**	**Maximum Employees, Alternative 4**
Concessioner	Reduce staffing at Glen Aulin HSC to 8 employees.	8 employees	8
NPS	Meet staffing need with 163 employees at Tuolumne Meadows.	163 employees	163
Concessioner	Meet staffing need with 90 employees at Tuolumne Meadows.	90 employees	90
Total Administrative People At One Time			**261**
Total People at One Time			**4,988 (proposed)**

a The 90% factor is applied to account for the vacancy of a percentage of parking spaces after visitors leave and before new visitors find the empty spaces. This is applied as the maximum capacity because no single parking area is feasibly used to 100% efficiency. Because the parking lot at Poopenaut Valley is so small, using the 90% figure is inappropriate because all empty stalls can be seen by a typical driver.

b The vehicle occupancy rate is 2.9 people per vehicle, based on visitor studies conducted over the past 20 years that found an average vehicle occupancy ranging from 2.6 to 3.4 (Van Wagtendonk and Coho 1980, FHWA 1982, ORCA 1999, Littlejohn et al. 2005, Le et al. 2008). Based on this range, an average of 2.9 persons per vehicle is used for estimating visitor numbers for planning purposes in this document.

Abbreviations: HSC = High Sierra Camp; max = maximum; # = number

Management of User Capacity

Visitor Overnight Use. Levels of overnight use in wild segments of the Tuolumne River corridor would continue to be managed through a system of zone capacities and related overnight trailhead quotas. In the wild segment below Tuolumne Meadows, recreational whitewater boating would be allowed and regulated through the wilderness overnight trailhead quota system. The Glen Aulin High Sierra Camp would continue to be managed by concession contract, with spaces allocated on an advanced reservation system. Additionally, stock trips to Glen Aulin would be limited to two strings per week (with a string consisting of five mules, one horse, and one rider) to protect the wilderness experience in this area. Initially the capacity of the camp will be

reduced to 28 guests. If, after two years of operation, the stock restriction was not being met, the camp's capacity would be progressively lowered until it was achieved.

Overnight use levels in the scenic segments of the river corridor would be managed by the facility capacities of the Tuolumne Meadows campground and Tuolumne Meadows Lodge. These facilities would continue to be available through a reservation system, with some campsites also available on a first-come, first-served basis. The NPS would retain oversight of all concessioner overnight services and capacities.

Visitor Day Use. Day use levels would be managed by controlling day parking, which would be restricted to paved or otherwise authorized spaces. No undesignated roadside parking would be allowed through the Tuolumne Meadows area under alternative 4. Undesignated roadside parking would continue to be allowed along Tioga Road west and east of Tuolumne Meadows. In addition, regional transit capacity would be increased by 135 people, the equivalent of three 45-passenger shuttle buses, to encourage use of regional transit and relieve traffic congestion at Tuolumne Meadows on peak days. These regional transit service levels (YARTS, the hiker bus operated by the concessioner, and other transit services) would remain under NPS control, with the number of visitors delivered into the river corridor by such services managed according to the user capacity limits established for alternative 4. The NPS may use any combination of limits on the numbers of buses, the stops they make, the number of passengers they accept, and/or the numbers of routes they run per day.

Administrative Use. NPS staffing would be increased for more resource protection needs (including management of the user capacity program), resource management, and monitoring. NPS employee housing or campsites would be increased. Campsites at Gaylor Pit would meet the need for incidental housing for employees on temporary duty in the Tuolumne Meadows area, with a bunkhouse to be constructed as funds become available for these employees. Concessioner employee staffing and housing necessary to support commercial services would be reduced by 13 employees due to the elimination of concessioner stock day rides. All housing would be maintained at the levels specified under alternative 4.

Actions to Protect River Values Given the Kinds and Amounts of Use in Alternative 4

The kinds and amounts of use proposed with alternative 4 would be protective of river values because of the variety of management actions listed below. For a more comprehensive list of river protection measures, see chapter 5. For the full list of management actions associated with alternative 4, see chapter 8.

Free-Flowing Condition of the River

As noted in chapter 5, the existing average water withdrawals of up to 46,000 gallons per day meet the standard of being at or below 10% of low flow (1 cubic foot per second). The estimated average water demand for alternative 4 is calculated as about 47,000 gallons per day; this amount would be due primarily to an increase in employee housing (although the numbers of employees assigned to Tuolumne Meadows is the same as existing levels, many employees do not currently have housing). As with all other alternatives, withdrawals from the Dana Fork would vary by day but would not be allowed to exceed 65,000 gallons on any one day, which is the maximum allowable withdrawal (10% of low flow). This slightly increased level of water withdrawal would be expected to remain well within the standard of no more than 10% of low flow unless climate change led to longer low-flow durations occurring earlier in the summer, in which case further reductions in water use would be required.

Management to Protect Water Quality

Risks to water quality in the Tuolumne Meadows area would be mitigated by upgrading the wastewater treatment plant, treatment ponds, and sprayfields. The improved utilities would be designed for loads commensurate with estimates of domestic water use presented above. Further reductions in risks to water

quality would be achieved by eliminating the fuel storage associated with the public fuel station and by greatly reducing the size of the concessioner stable operation. Risks to water quality at Glen Aulin would be mitigated by replacing all flush toilets with composting toilets. Monitoring would ensure that water quality remained excellent at Tuolumne Meadows and Glen Aulin.

Management to Protect the Subalpine Meadow and Riparian Complex

Most of the actions to protect and enhance the subalpine meadow and riparian complex would be common to all the action alternatives (note in particular the ecological restoration program, outlined in chapter 5 and included in full in appendix H). Alternative 4 would additionally restrict visitor access to meadow and riparian areas and allow use only on designated trails and paths. By requiring visitors to remain on designated trails, meadow fragmentation, bare soil, and streambank instability would be greatly reduced. In tandem with the ecological restoration program, natural processes will flourish in Tuolumne Meadows to a much greater degree than at present, thereby allowing it to be dominated by ecological processes to the maximum extent possible.

Management to Protect Archeological Sites

The same management of visitor use described above would also reduce impacts on archeological sites in the Tuolumne Meadows and Lower Dana Fork segments under alternative 4. Monitoring would ensure that site disturbance did not exceed the protective standard established for these sites. If conditions were not being maintained within the protective standards, additional actions would be taken to further manage or reduce visitor use, as described in chapter 5.

Management to Protect and Enhance Scenic Values

Scenic views and viewpoints in the Tuolumne Meadows area and along the Tioga Road corridor would be protected and enhanced under all the action alternatives by managing unnatural features associated with visitor and administrative use, such as facilities and parked cars, to minimize their intrusion into remarkable views.

Management to Protect and Enhance the Wilderness Experience along the River

Day use levels along trails in wild segments of the river corridor within reach of a day hike from Tuolumne Meadows would be managed as follows to protect solitude and/or opportunties for primitive and unconfined recreation: ensure that average encounters do not exceed 12 other parties per hour on the Glen Aulin trail and the Lyell Canyon trail downstream of the Ireland Lake trail junction, 8 parties per hour on the Lyell Canyon trail above the Ireland Lake trail junction, and 2 parties per hour on the trail through the Grand Canyon of the Tuolumne. If required to achieve these standards, a day use trailhead quota system would be implemented for some trails.

Management to Protect and Enhance Rare and Easy Access to the River through Tuolumne and Dana Meadows

Under all alternatives, the Tioga Road would remain open for travel to Tuolumne and Dana Meadows. Opportunities for scenic driving along Tioga Road would be enhanced under alternative 4 by eliminating roadside parking and the associated congestion caused by vehicles slowing to park and pedestrians crossing the road. Opportunities for people wishing to park and get out of their cars would be enhanced by increasing the number of designated parking spaces. Parking availability would be monitored, with enforcement mechanisms designed to minimize adverse effects on the visitor experience. If parking availability was regularly exceeded, the NPS would implement a day use reservation system, subject to further environmental compliance and public comment.

Chapter 7: Development of Lands and Facilities

The Wild and Scenic Rivers Act (WSRA) requires management plans prepared for rivers designated under the act to address "development of lands and facilities" in the river area.[1] WSRA and the 1982 Final Revised Guidelines for Eligibility, Classification, and Management of River Areas (Secretarial Guidelines, or the guidelines) provide direction on the types of facilities that may be located within river areas. In addition, the 2008 opinion of the U.S. Court of Appeals for the Ninth Circuit (Ninth Circuit) in *Friends of Yosemite Valley v. Kempthorne* questioned whether the level of development in some parts of the Merced River corridor was sufficiently protective of river values.[2] This opinion informed not only the comprehensive plan for the Merced Wild and Scenic River, but also this *Tuolumne River Plan*.

This chapter addresses the development of lands and facilities in the Tuolumne River corridor, including the rationale for locating major public-use facilities within each segment. The chapter first discusses the legal requirements governing such development and the process the NPS used to evaluate what developments were necessary. It then provides a synopsis of the history of land development in the Tuolumne River corridor and concludes with the results of the NPS's analysis of all major public use facilities in the river corridor. The content of this chapter informed the level of development proposed in the alternatives described in chapter 8.

Legal Requirements Governing Development and Facilities

WSRA, the 1982 Secretarial Guidelines, and judicial opinions interpreting the law all provide guidance for determining the permissibility of the level and type of development in the Tuolumne Wild and Scenic River corridor. Guidance from WSRA and the guidelines pertains primarily to segment classifications and related amounts of development, with the guidelines providing additional direction for major public use facilities. Judicial opinions—mainly pertaining to previous versions of the *Merced River Plan* in Yosemite—have emphasized the importance of this task and clarified the direction from WSRA and the guidelines.

Segment Classifications and Facilities

WSRA provides important guidance on the type and intensity of development that is allowable in river segments, depending upon the segment's classification.[3] The act and the guidelines describe development that may exist in river areas in terms of a continuum, with the least amount of development tolerated in wild segments. Wild segments are to be managed as "vestiges of primitive America," containing little or no evidence of human activity, although a few inconspicuous structures may be present. These areas generally do not contain roads and are free of impoundments. Scenic river segments may contain more discernible development. A scenic segment retains its overall natural character but may have structures or concentrations of structures in short reaches of the total area. Scenic segments may be accessible in places by roads. Finally, recreational segments are defined as being readily accessible by road and may have roads paralleling the river on one or both banks, as well as bridge crossings. Recreational segments may also have some residential, commercial, or other development, and may have evidence of impoundment or diversion.[4]

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1 16 *United States Code* (USC) 1274(d).
2 *Friends of Yosemite Valley v. Kempthorne*, 520 F.3d 1024, 1035-36 n.5 (9th Cir. 2008) [hereinafter FYVIII].
3 16 USC 1273(b).
4 *47 Federal Register* at 39457-58.

The guidelines provide that the classification for each segment is one that best fits the existing level of development at the time of designation. Although each classification permits certain nonconforming existing development, "the criteria do not imply that additional inconsistent development is permitted in the future."[5] Accordingly, segment classifications affected the level of new development proposed in particular segments in this plan. The Tuolumne River corridor contains only segments classified as wild or scenic.

Limits on Major Public Use Facilities

In addition to limiting development based on segment classification, the 1982 Secretarial Guidelines contain additional criteria for facilities located in the corridor. Facilities are divided into two categories: major public use facilities and basic facilities. The guidelines state that "major public-use facilities such as developed campgrounds, major visitor centers and administrative headquarters will, where feasible, be located outside the river area. If such facilities are necessary to provide for public use and/or to protect the river resource, and location outside the river area is infeasible, such facilities may be located within the river area provided they do not have an adverse effect on the values for which the river area was designated."[6]

Other facilities, such as picnic areas, public restrooms, roadside pullouts, shuttle bus stops, and campground kiosks, are denominated "basic facilities" by the guidelines. Basic facilities may be located in river areas because they help to absorb the impacts from use and protect the river. Finally, the guidelines also make allowance for structures related to resource management, such as trail bridges, fences, and other minor structures, as long as they are compatible with the segment's classification and the structures harmonize with the surrounding environment.[7]

Judicial Opinions

The 2008 Ninth Circuit ruling emphasized the importance of this task when it addressed development in Yosemite Valley.[8] In this decision regarding the *Merced River Plan*, the court found that the NPS could not presume that facility levels in existence in 1987 were protective of river values. Pointing to "dozens of facilities and services operating in the river corridor," the court stated that the many recreational and commercial facilities located in the corridor were evidence of "past degradation" of the Merced River, and held that the NPS must "explain how maintaining [the] status quo in the interim would protect or enhance the river's unique values as required under the WRSA," giving primary emphasis to the river's esthetic, scenic, historical, archeologic, and scientific features.[9] Using this rationale, the NPS similarly cannot assume that facilities in the Tuolumne River corridor in existence prior to 1984 were protective of river values. This means that every facility must be evaluated to ensure it is consistent with the protection of river values regardless of whether it was present in the corridor at the time the river was designated as wild and scenic; no facilities allowed to remain or be built in the corridor may result in adverse impacts or degradation of any river values. The analysis of the impacts of major public use facilities on river values is founded on the baseline conditions for river values and the management concerns and localized concerns described in chapter 5, "River Values and Their Management." As shown in chapter 5, there are no adverse impacts or degradation from any source occurring to any river values. However, some management or localized concerns affecting a river value are present, some of which are related to a major public use facility.

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5 47 *Federal Register* at 39456-57. See also "Wild and Scenic River Management Responsibilities" (IWSRCC 2002, pp. 4–6); "A Compendium of Questions and Answers Relating to Wild and Scenic Rivers" (IWSRCC 2011, p. 31).

6 47 *Federal Register* at 39459.

7 47 *Federal Register* at 39459.

8 FYVIII, 530 F.3d 1024 (9th Cir. 2008); *Friends of Yosemite Valley v. Norton*, 366 F.3d 731 (9th Cir. 2004) [hereinafter FYVII]; see also *Friends of Yosemite Valley v. Norton*, 348 F.3d 789 (9th Cir. 2003) [hereinafter FYVI], and *Friends of Yosemite Valley v. Scarlett*, 439 F.Supp.2d 1074 (E.D. Cal. 2006).

9 *FYVIII*, at 1035–36.

Process Used to Evaluate Public-Use Facilities in this Plan

The Tuolumne River corridor within Yosemite National Park contains major public use facilities for purposes such as resource protection; camping and lodging; food, retail, and other commercial services; administration; and utility infrastructure. In order to comply with the legal requirements described above, the NPS evaluated all existing and proposed major public use facilities pursuant to the direction in WSRA, the Secretarial Guidelines, and judicial opinions. NPS used a rigorous three-step process that determined (1) whether it would be feasible to relocate the facility outside the river corridor; (2) if the facility would be infeasible to relocate, whether it is necessary for public use and/or resource protection; and (3) if the facility is both infeasible to relocate and necessary for public use or resource protection, whether it could be maintained without adverse impacts to river values. Before presenting the results of this analysis, it is necessary to discuss definitions and guidance for determining "feasibility" and "necessity."

Feasibility

"Feasible" is defined in this plan as "capable of being done, accomplished, or carried out; possible, practicable."[10] In making a determination as to whether or not a facility could feasibly be relocated out of the river corridor, the NPS considered a variety of constraints, including economic and technical issues as well as resource and safety hazards. As indicated in figure 8-3 in chapter 8, "Alternatives for River Management," many constraints on site development exist within the Tuolumne Meadows area, both in and outside of the river corridor, because of the Yosemite Wilderness boundary and the locations of sensitive natural and cultural resources. The Wilderness Act precludes siting or relocating structures within designated Wilderness unless they are the minimum requirement necessary for administration of the Wilderness. Many other nonwilderness locales were eliminated from consideration for facility development or relocation by the presence of rare plants, sensitive archeological sites, or other resources that the NPS is obligated to protect. Collectively, these constraints left just a small area suitable for development outside of the river corridor. This area is on the south side of the Tioga Road and is already occupied by part of the campground. Consequently, there is no available space in the Tuolumne Meadows area that is both outside the river corridor and also currently free from existing necessary facilities.

The NPS also considered relocating facilities to locations away from Tuolumne Meadows, such as White Wolf to the west on Tioga Road or Lee Vining to the east. The only facilities that could be relocated to these places would be those that do not require proximity to the Tuolumne River and Tuolumne Meadows and the other infrastructure and services there. At White Wolf, site constraints and water availability are limiting factors for new development. At other locations to the west, the potential for new development is limited by Wilderness boundaries. To the east, locating NPS facilities in Lee Vining (such as housing for NPS employees) presents unacceptable management risks (the road is subject to unpredictable, but frequent, closures due to rockslides or snow) or other unacceptable impacts (such as financial impacts on Tuolumne Meadows employees, the majority of whom do not own vehicles or would find housing in Lee Vining to be beyond reasonable commuting distance).

[10] This is the definition from the *Oxford English Dictionary*, 2013online edition (<*http://oxforddictionaries.com/us/definition/american_english/feasible*>), which defines feasible as "possible to do easily or conveniently." Other dictionary definitions are similar, e.g., Merriam-Webster.com. (<http://www.merriam-webster.com/dictionary/feasible>).

Necessary for Public Use or Resource Protection

No universal criteria for what is "necessary" exist for all the diverse areas that comprise the national wild and scenic river system. Rather, what is necessary must be determined for each wild and scenic river area with reference to the particular resource and other concerns specific to that area. Because the Tuolumne Wild and Scenic River is located in Yosemite National Park, determinations of the kinds of facilities that are necessary for public use were informed by the NPS *Management Policies 2006* and by the 1980 *Yosemite General Management Plan* (*General Management Plan*), in addition to the WSRA. It is also important to understand the reasoning behind decisions made regarding developments in the Tuolumne Meadows area before the *General Management Plan* was issued and before wild and scenic designation occurred. Relevant guidance from these sources follows.

NPS Management Policies 2006

The NPS *Management Policies 2006* interprets the National Park Service Organic Act, which contains the agency's well-known mandate: "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."[11] Visitor enjoyment of park resources occurs through activities in the park, activities that are determined during park-specific planning. The range of activities that are appropriate in parks is broad and often includes common recreational activities such as boating, camping, biking, fishing, hiking, horseback riding and packing, cross-country skiing, and rock climbing.[12]

The determination of appropriate activities in turn determines what supporting facilities are made available to park visitors. The NPS *Management Policies 2006* provides guidance on the development of facilities to support appropriate visitor use activities and administrative needs. For example, it directs that major facilities should be located outside park units where feasible. However, it also recognizes that many facilities, including overnight visitor use facilities and food services, may need to be provided inside parks when travel distance to similar facilities outside the park is too great to permit reasonable use or when having to leave the park would substantially detract from the quality of the visitor experience.[13]

The application of the direction found in *Management Policies 2006* to a specific park occurs within a general management plan. *Management Policies 2006* requires each unit of the national park system to prepare a general management plan, which serves as "the basic foundation for decision-making" within the park. A park's general management plan should address the question of facilities and development.[14]

Yosemite's 1980 General Management Plan

Yosemite's 1980 *General Management Plan* establishes direction for facility development within the park. It includes five broad goals for the park: reclaim priceless beauty, allow natural process to prevail, promote visitor understanding and enjoyment, markedly reduce traffic congestion, and reduce crowding.[15] As discussed in appendix E, these five goals remain valid and helped to inform decisions in the *Tuolumne River Plan*. The *General Management Plan* establishes the desired level of development as one in which visitors would "step into Yosemite and find nature uncluttered by the piecemeal stumbling blocks of commercialism, machines, and fragments of suburbia."[16] The plan describes the park's ultimate goal for visitor experience as one that would

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[11] 16 USC 1-1a-1; see also NPS *Management Policies 2006*, section 1.4.3, page 21.
[12] NPS *Management Policies 2006*, section 8.2.2, page 112.
[13] NPS *Management Policies 2006*, section 9.3.2, page 136.
[14] 16 USC 1(a)-7(b) (2013); NPS *Management Policies 2006*, section 9.1.1, page 124; NPS *Management Policies 2006*, section 2.2, page 22-23; NPS GMP Dynamic Sourcebook, version 2.2, accessed online July 2013 (<http://planning.nps.gov/GMPSourcebook/Purpose_new.htm#>).
[15] *General Management Plan* (NPS 1980b), p.1-4.
[16] *General Management Plan* (NPS 1980b), p. 1.

reduce "congested" conditions and refocus on assisting park visitors to grasp, appreciate, and participate in the park's conservation mission.

Yosemite's 1980 *General Management Plan* was completed before either the Tuolumne Wilderness or the Tuolumne River were designated in 1984; it therefore does not consider protection and enhancement of river values in accordance with WSRA. Consistent with the NPS *Management Policies 2006,* the *Tuolumne River Plan* will revise the *General Management Plan* to include those considerations. The specific revisions to the *General Management Plan* resulting from the *Tuolumne River Plan* are outlined in appendix E. The *Tuolumne River Plan* is consistent with the 1980 *General Management Plan* in regards to all goals and most facilities. For example, the *General Management Plan* calls for a reduction in the size of the campground (from what existed in 1980), a focus on resource protection, upgrading facilities for visitors and administrative use, and relocating parking; all the alternatives in the *Tuolumne River Plan* would carry out these actions. The *Tuolumne River Plan* will revise the *General Management Plan* regarding some public use facilities based on new information regarding resource conditions and natural hazards (such as floodplains), changes in visitor use patterns, and designation of the Yosemite Wilderness, which rendered some *General Management Plan* actions as impractical and infeasible.[17]

In summary, the NPS *Management Policies 2006* recognize that a comprehensive river management plan is similar to a general management plan and can be treated as a general management plan for lands inside a designated river corridor. The overarching direction of Yosemite's *General Management Plan*—to reduce the development footprint, limit commercial facilities, reduce traffic congestion, and refocus on protecting and enhancing natural and cultural resources—is wholly consistent with and reflected in *Tuolumne River Plan* determinations of which major public use facilities are "necessary" in the Tuolumne River corridor. Specific revisions to the *General Management Plan* proposed by the *Tuolumne River Plan* are found in appendix E.

Historical Resource Conditions Associated with Development

Before either the *General Management Plan* or the *Tuolumne River Plan* was issued, Yosemite managers had already issued guidance for developments in Tuolumne Meadows. It is important to understand why previous decisions were made and how the developments at Tuolumne Meadows came to appear as they do today.

Tuolumne Meadows has long served as a focal point of visitation to the Yosemite high country and a primary visitor destination within Yosemite National Park. Beginning in the 1920s, the National Park Service gradually constructed the facilities that it determined were necessary for visitor use and resource protection in the Tuolumne Meadows area based roughly on a development plan that was drafted in 1929. As noted in the historic properties discussion in chapter 9, "Affected Environment and Environmental Consequences," central to this planning effort was the creation of a public campground, with treated running water and a sewer system. Complementing the campground was the Tuolumne Meadows Lodge, constructed as part of the High Sierra Camp loop system, which began operation in 1916 and also includes the Glen Aulin High Sierra Camp. In addition to these services, the NPS constructed a visitor contact station, a wilderness center, and the housing necessary for the NPS and concessioner employees who support the visitor services in the area. The 1929 plan also called for the removal of some of the temporary buildings that were in place at the time and consolidation of facilities to reduce impacts on scenic and cultural resources. The plan was never fully realized, however, and many of these facilities remain today, with some considered historic.

Responding to these developments, the improvements to the Tioga Road in the 1930s and 1960s, California's growing population, and other societal trends, visitation to the Tuolumne Meadows area gradually and

[17] See appendix E for a complete description of all revisions to the *General Management Plan* made by the *Tuolumne River Plan*.

continuously grew. By the 1990s, visitation to the area far exceeded available support facilities. Instead of constructing additional facilities to meet increasing visitor demand, however, the NPS responded by reducing some development in order to control visitation and its impacts and to improve aspects of the visitor experience. The most notable change was a significant reduction in the number of sites at the Tuolumne Meadows campground, from about 600 sites to its current size of 329 sites, plus seven group sites. During the same period that it reduced some development, the NPS constructed a new wilderness center to provide a place where wilderness travelers could be educated about "leave no trace" wilderness practices while enforcing the wilderness trailhead quota system. These actions succeeded in protecting park resources and improving those visitor experiences, but day use has continued to increase, with associated environmental impacts (as discussed in chapter 5). Visitor demand continues to far exceed available facilities.

Results: Necessary Facilities for the Tuolumne River Corridor

Based on the identified recreational values of the Tuolumne River, the Tuolumne Meadows area will continue to serve as a primary visitor destination within Yosemite National Park, one with accessible overnight facilities for visitors. This decision is consistent with the Wild and Scenic Rivers Act, which stipulates 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."[18] In light of this decision, many facilities in the Tuolumne Meadows area would be expected to be necessary to support the kind of visitor use and resource protection traditionally envisioned for the area. However, because the *Final Tuolumne River Plan/EIS* considers a range of alternatives for managing the river corridor within this broader context, not all facilities would automatically continue to be necessary under all alternatives. Also, as explained in chapter 5, facilities that are not protective of river values have to be eliminated or replaced with more suitable facilities.

Table 7-1 presents the analysis of all public use facilities within the corridor to meet the intent of the Secretarial Guidelines. The analysis includes all facilities in the river corridor that do not meet the definition of "basic" under WSRA.

The table indicates that a limited range of overnight accommodations at Tuolumne Meadows are needed under every alternative due to the remote location of this major visitor use area and the lack of suitable locations for overnight accommodations outside the corridor and within a reasonable driving distance. The other facilities necessary to support visitor use under most alternatives and determined infeasible to relocate outside the river corridor include the wastewater and water treatment plants, maintenance facilities, visitor contact station, wilderness center, store and grill, picnic areas, and the stables. Housing is also necessary for both NPS and concessioner employees, although the amount of such varies by alternative, pursuant to the needs of each alternative. Some alternatives would dispense with the fuel station, store and grill, and/or the Glen Aulin High Sierra Camp because those major public use facilities would not be necessary to achieve the desired visitor experiences under those alternatives. Table 8-21 in chapter 8 presents a comparison of the actions taken with regard to facilities at specific locations across the range of alternatives. The retail function of the mountaineering shop was determined unnecessary in all of the action alternatives, as many of the items sold there can be purchased in Lee Vining.

[18] 16 USC 1281 (a).

Table 7-1.
Evaluation of Existing Major Facilities

Location[a]	Facility	1980 GMP Action	Feasible to relocate outside the river corridor?	Necessary for public use or resource protection?	Management or Localized Concerns and Enhancement Actions					
					Biological Value: Subalpine Meadow/ Riparian Complex	Cultural Value: Historic Properties	Cultural Value: Prehistoric Archeological Landscape	Scenic Value	Water Quality	Free-flowing Condition
Scenic Segments: Tuolumne Meadows Area										
1	Pothole Dome parking	N/A	No: Topographic constraints require this trailhead to be in its existing location.	Yes: Trailhead parking is needed for visitors while hiking trails.	Concern: Informal trails from parking areas near Pothole Dome cause trampling of meadow soils and vegetation. Some areas are protected with signs and fencing. Action: Ecologically restore informal trails around parking area.	NONE	NONE	NONE	NONE	NONE
2	Tioga Road	N/A	No: Due to wilderness boundaries, massive resource impacts if moved, and economic considerations.	Yes: Road provides rare and easy access to the river, which is an outstandingly remarkable recreational value of the Tuolumne River.	Concern: Inadequate culverts along Tioga Road cause localized disruptions to sheet flow into and across Tuolumne Meadows. Action: Improve culverts to facilitate water flow to the river and adjacent meadows.	NONE	NONE	NONE	NONE	NONE
	Shoulder parking	N/A	No: While off-shoulder parking is possible throughout the corridor (as shown in various alternatives), topographic constraints prevent relocation outside the corridor.	Yes: Parking is needed, but not along the roadsides.	Concern: Shoulder parking along Tioga Road results in informal trails across Tuolumne Meadows and along the banks of the Tuolumne River, causing trampling of soils and vegetation. Action: Install curbing or naturalistic barriers along Tioga Road and the road to Tuolumne Meadows Lodge, and provide formal parking in appropriate areas.	NONE	NONE	Concern: Lines of vehicles parked along road intrude into views. Action: Eliminate roadside parking and require visitors to park in formal parking areas located away from highly visible areas.	NONE	NONE
	Tioga Road bridge	Retain.	No: Impact on resources from relocating the bridge and the road would be too substantial.	Yes: Road must cross the river at some point, and moving the bridge and road would cause unnecessary resource disturbance and impacts to river values.	NONE	NONE	NONE	NONE	NONE	NONE
3	Cathedral Lakes trailhead	Relocate parking.	No: Topographic constraints require this trailhead to be inside the river corridor, at its existing location or nearby.	Yes: Trailhead parking is needed for visitors while hiking trails, but is relocated under all alternatives.	Concern: Insufficient parking for the Cathedral Lakes trailhead results in roadside parking and informal trails across the adjacent wet meadow, causing trampling of soils and vegetation. Action: Eliminate roadside parking and restore roadside at Cathedral Lakes trailhead to natural conditions. Reroute trail to new trailhead near parking at the location of the existing visitor center.	NONE	Concern: Known prehistoric archeological resources occur in this area. Action: Use natural features to conceal and divert foot traffic around sites.	NONE	NONE	NONE

Location[a]	Facility	1980 GMP Action	Feasible to relocate outside the river corridor?	Necessary for public use or resource protection?	Management or Localized Concerns and Enhancement Actions					
					Biological Value: Subalpine Meadow/ Riparian Complex	Cultural Value: Historic Properties	Cultural Value: Prehistoric Archeological Landscape	Scenic Value	Water Quality	Free-flowing Condition
4	Sprayfield	Upgrade sewage disposal.	No: No suitable locations occur outside the corridor due to wilderness boundaries and other resource constraints. (Lower use levels in alternative 1 allow the sprayfield to be located at the site of the existing wastewater plant).	For alternative 1, No: The reduced level of use would no longer require the current sprayfield. For alternatives 2–4, Yes: Sufficient visitor use would continue to necessitate wastewater disposal through a sprayfield.	NONE	NONE	NONE	NONE	Concern: Occasionally saturated conditions at the upland sprayfield pose potential risks to water quality. Water quality is monitored and conditions observed by SFPUC and NPS staff. Action: Upgrade the wastewater treatment plant to meet current standards. Design capacity varies by alternative.	NONE
	Wastewater containment ponds	Upgrade sewage disposal.	No: No suitable locations occur outside the corridor, due to wilderness boundaries and other resource constraints.	For alternative 1, No: The reduced level of use would no longer require the current wastewater containment ponds. For alternatives 2–4, Yes: Sufficient visitor use would probably necessitate the continued use of the containment ponds. If technology for an upgraded treatment system someday allowed, the NPS would remove the containment ponds; however, until a new solution is found, the ponds would remain an essential part of the wastewater treatment system.	Concern: Wastewater containment ponds in the upland habitat above the meadow pose a potential risk to water quality and meadow and riparian habitat. Action: Upgrade the wastewater treatment plant to meet current standards. Design capacity varies by alternative.	NONE	Concern: Known prehistoric archeological resources exist at site of upper pond. Action: Confine new development, repair, and maintenance of facilities and underground utilities to nonsensitive areas wherever feasible and mitigate unavoidable effects in compliance with section 106 of National Historic Preservation Act.	NONE	Concern: Wastewater containment ponds in the upland habitat above the meadow pose a potential risk to water quality and meadow and riparian habitat. Action: Upgrade the wastewater treatment plant to meet current standards. Design capacity varies by alternative.	NONE
	Wastewater line beneath the river and meadow	Upgrade sewage disposal.	No: The wastewater line must remain inside the corridor to get from the wastewater treatment plant to the wastewater containment ponds.	For alternative 1, No: The removal of the containment ponds and sprayfield from the north side of Tioga Road would eliminate the need for the wastewater line beneath the river and meadow. For alternatives 2–4, Yes: Wastewater must be pumped from the wastewater treatment plant to the ponds, which requires the wastewater line to pass beneath the river and the meadow.	Concern: The wastewater line between the wastewater treatment plant and the wastewater containment ponds runs beneath the meadow and the river. The potential for leakage is a risk to water quality and meadow and riparian habitat. Action: Upgrade the wastewater treatment plant to meet current standards. Design capacity varies by alternative.	NONE	NONE	NONE	Concern: The wastewater line between the wastewater treatment plant and the wastewater containment ponds runs beneath the meadow and the river. The potential for leakage is a risk to water quality and meadow and riparian habitat. Action: Upgrade the wastewater treatment plant to meet current standards. Design capacity varies by alternative.	NONE
	Wastewater line underneath the Tioga Road bridge	Upgrade sewage disposal.	No: The wastewater line must remain inside the corridor to get from the lodge and housing areas to the wastewater treatment plant.	Yes: The line conveys the wastewater from the lodge and nearby housing areas on the north side of the river to the wastewater treatment plant on the south side. Provided these facilities remain in their current locations, wastewater must be collected and conveyed to the plant, which requires the line to cross the river.	NONE	NONE	NONE	NONE	Concern: The wastewater line connecting the lodge area and campground to the wastewater treatment plant crosses the river underneath the Tioga Road bridge. The potential for leakage is a risk to water quality. Action: Upgrade the wastewater treatment plant to meet current standards. Design capacity varies by alternative.	NONE

Location[a]	Facility	1980 GMP Action	Feasible to relocate outside the river corridor?	Necessary for public use or resource protection?	Management or Localized Concerns and Enhancement Actions					
					Biological Value: Subalpine Meadow/ Riparian Complex	Cultural Value: Historic Properties	Cultural Value: Prehistoric Archeological Landscape	Scenic Value	Water Quality	Free-flowing Condition
6	Visitor Center, Road Camp, and administrative areas	Convert Civilian Conservation Corps (CCC) mess hall to housing. Consolidate NPS and concessioner stables at this location.	No: No suitable locations occur outside the corridor, due to wilderness boundaries and other resource constraints.	Yes: Visitor contact facilities are needed to help visitors, especially visitors with only a short time to spend in the area, plan their visit and gain an appreciation of the Tuolumne River. An on-site visitor contact station is also the primary place/ means for the NPS to educate visitors about resource protection. Rationale for revision to GMP: In the preferred alternative, the current visitor center (formerly the CCC mess hall) is needed for office space. Housing needs are addressed in other locations. The NPS and concessioner stables are consolidated to minimize the disturbance footprint.	NONE	NONE	Concern: Known prehistoric archeological resources near entrance road intersection with Tioga Road. Action: No effect. No action necessary.	NONE	NONE	NONE
7	Wastewater treatment plant	Retain and upgrade.	No: No suitable locations occur outside the corridor, due to wilderness boundaries and other resource constraints.	Yes: Under all alternatives, sufficient visitor use continues to necessitate wastewater treatment.	NONE	NONE	NONE	NONE	Concern: No immediate threat to river values. Aging wastewater treatment facility is in need of updating to be within state standards. Action: Upgrade the wastewater treatment plant to meet current standards. Design capacity varies by alternative.	NONE
8	Parsons Memorial Lodge and Soda Springs structures and trails	Retain.	No: Location is integral to the historic integrity of the lodge, which is an outstandingly remarkable cultural value. Soda Springs structures must be located by Soda Springs.	Yes: The lodge is an outstandingly remarkable cultural value of the river corridor, the Soda Springs structures are historic and context sensitive, and the trails protect the springs and rare plant habitat in the area.	Concern: Informal trails around the Soda Springs area cause trampling of soils and vegetation associated with the mineral spring habitat and adjacent subalpine meadow habitat. Action: Ecologically restore informal trails, decompact soils, recontour unnatural landforms, and revegetate denuded areas.	NONE	NONE	NONE	NONE	NONE
10	Campground A-loop and portion of B-loop (the only portions of the campground inside the 1/4-mile river corridor boundary)	Reduce size of campground to 400 sites. Remove campground A loop and access road adjacent to Lyell Fork.	No: Complete relocation is not possible because wilderness boundaries and other resource constraints preclude development of the amount necessary to completely relocate this much of the campground. However, the alternatives consider various ways of addressing the impacts identified.	Yes: Tuolumne Meadows is a major visitor destination, far enough from most visitors' homes or other visitor service centers to necessitate opportunities to spend the night. Camping is a traditional use at Tuolumne Meadows that allows visitors to enjoy the outdoors and to experience the park at night. Rationale for revision to GMP: The preferred alternative does not eliminate this loop because the resource impacts associated with replacing the loop would be too significant. However, the alternative has been revised to include a 100-foot riparian buffer to protect river values, thereby mitigating concerns with the proximity of 21 campsites to the river. The GMP will be revised by this plan; see appendix E. The A loop would also be retained in alternatives 2 and 3. Under alternative 1, the A loop would be removed and not replaced as part of the overall reduction in facilities envisioned for that alternative.	Concern: The A-loop campsites and overall access to the river near the shoreline of the Lyell Fork result in informal trails, causing localized trampling of soils and vegetation in riparian habitat. Action: Alternative 1 would remove the A loop and associated campsites. Alternatives 2–4 would retain the A loop. Campsites closest to the river would be relocated in alternative 2, and all campsites within 100 feet of the river would be relocated in alternative 4.	NONE	NONE	NONE	NONE	Concern: Boulder riprap installed to protect the campground A-loop road from flooding interferes with the free flow of the river. Action: Remove riprap and restore riverbank to natural conditions.

Location[a]	Facility	1980 GMP Action	Feasible to relocate outside the river corridor?	Necessary for public use or resource protection?	Management or Localized Concerns and Enhancement Actions					
					Biological Value: Subalpine Meadow/ Riparian Complex	Cultural Value: Historic Properties	Cultural Value: Prehistoric Archeological Landscape	Scenic Value	Water Quality	Free-flowing Condition
11	Store and grill	Remove and relocate to fuel station building.	No: Locating outside the corridor is not feasible due to other facility requirements and topographic constraints.	For alternative 1, No: The store and grill would not be compatible with the self-reliant experience and smaller number of campsites envisioned in that alternative. For alternatives 2–4, Yes: A campground of 300+ sites necessitates at least a basic store to avoid excessive traffic to and from Lee Vining, Crane Flat, and/or Yosemite Valley. A store is also necessary for the significant number of employees who live at Tuolumne Meadows and would otherwise need to travel to Lee Vining to purchase basic necessities. Rationale for revision to GMP: In the preferred alternative, the store and grill are retained in their current location to have the least impact overall on historic and natural resources; the fuel station site is needed for parking that is removed along Tioga Road.	NONE	NONE	NONE	NONE	NONE	NONE
	Concessioner employee housing by store and grill	Remove.	No: No locations exist outside the corridor. All alternatives relocate this housing to other locations also within the corridor.	Yes: Housing for concessioner employees is necessary; viable options for service worker housing outside the corridor do not exist, and such employees are necessary on location or within reasonable commuting distance. However, all alternatives would move this housing out of the wetland in which it is currently situated.	Concern: The concessioner employee tent cabins behind the store and grill interrupt sheet flow through a wet meadow area. Action: Remove concessioner employee housing behind the store and grill.	NONE	NONE	NONE	NONE	NONE
	Public fuel station and mountaineering shop	Retain and consolidate store in this location.	For the fuel station: No suitable locations occur outside the corridor due to wilderness boundaries and other resource constraints. For the mountaineering shop and school, Yes: Lee Vining already contains at least one such store.	For alternatives 1, 3, and 4, No: These alternatives seek to enhance opportunities for visitors wishing to get out of their cars and spend some time in the corridor with fewer commercial services but enhanced opportunities for outdoor recreation. Because vehicles carry 300–700 miles worth of gasoline, they can reasonably be expected to reach Lee Vining (20 miles east) or Crane Flat (40 miles west) instead of requiring gasoline at Tuolumne Meadows. For alternative 2, Yes: The kinds of use encouraged under alternative 2, which would include short-term use by visitors passing through on Tioga Road who might stop primarily to use the gas station but who then might spend a short time learning about the area, would necessitate the gas station along with other existing commercial facilities. The retail function of the mountaineering shop is not necessary under any alternative; however, its function as a guiding school would be retained and operated out of the Tuolumne Meadows Lodge. Rationale for revision to GMP: In the preferred alternative, the fuel station and building is removed to accommodate parking that is removed along Tioga Road. Retention of the store and grill in their current location and redevelopment of the fuel station site was determined to have the least impact overall on historic and natural resources.	NONE	NONE	NONE	NONE	Concern: Past impacts from fuel leakage have been mitigated, but potential risk to water quality remains. Action: Ongoing monitoring will continue.	NONE
	Campground reservation office	Retain.	No: It is not feasible to relocate the campground reservation office away from the campground, which is in the corridor; additionally, there is insufficient space at the former D-loop entrance to locate a campground entrance or reservation office.	Yes: The facility is where visitors check in for their stay at the campground.	NONE	NONE	NONE	NONE	NONE	NONE

Location[a]	Facility	1980 GMP Action	Feasible to relocate outside the river corridor?	Necessary for public use or resource protection?	Management or Localized Concerns and Enhancement Actions					
					Biological Value: Subalpine Meadow/ Riparian Complex	Cultural Value: Historic Properties	Cultural Value: Prehistoric Archeological Landscape	Scenic Value	Water Quality	Free-flowing Condition
12	Concessioner stable	Relocate to area west of current Visitor Center.	No: Site constraints preclude relocation outside the corridor, and stock must be kept near their site of use.	Yes: The facility houses the stock necessary for High Sierra Camp support (even if Glen Aulin is removed, as in alternative 1, other high camps would remain and need stocking, with the Tuolumne Meadows stable being the only location from which all can be supplied). Rationale for revision to GMP: In the preferred alternative, the NPS and concessioner stables would be consolidated at the site of the existing concessioner stables. A new stable in an undisturbed location would not be necessary due to the reduction in stock use associated with the elimination of day rides and would result in additional resource impacts.	NONE	NONE	NONE	NONE	Concern: Potential risk to water quality from stock use and manure. Action: Current practices of regular manure removal help prevent impacts to water quality. Ongoing monitoring will continue.	NONE
13	Lembert Dome parking	Relocate to old telephone building site to accommodate Glen Aulin trailhead and day users; provide comfort station.	No: Topographic constraints require this trailhead to be in its existing location.	Yes: Trailhead parking is needed for visitors while hiking trails. The Lembert Dome parking area accesses multiple trails: the Glen Aulin trail, John Muir Trail, Dog Lake trail, and Young Lakes trail. Removal of this parking area would require expansion of other parking areas, which would be infeasible given site constraints at those locations. Rationale for revision to GMP: The preferred alternative would retain this parking area in its current location as resource concerns preclude its relocation.	NONE	NONE	Concern: Foot traffic impacts known prehistoric archeological resources in this area. Action: All alternatives would direct foot traffic away from the archeological site when the picnic area and restrooms are improved.	NONE	NONE	NONE
14	Great Sierra Wagon Road trail	Retain.	No: Topographic constraints require this trail to be in its existing location.	Yes: The trail provides critical public access to the meadows and Parsons Memorial Lodge.	Concern: The historic roadbed locally interrupts sheet flow, and associated foot traffic causes trampling of meadow soils and vegetation. Action: Mitigate the effects of the road through culvert improvements and construction, ecological restoration, trail improvements, and roadbed improvements.	NONE	Concern: Foot traffic affects known prehistoric archeological resources in this area. Action: Improvements to road and elimination of informal trails will decrease visitor use and impacts on archeological resources.	NONE	NONE	NONE
15	Wilderness center, ranger station	Remove ranger station; construct operations building.	No: Site constraints preclude relocation outside the corridor. However, all the alternatives do move the facility to various other locations, all within the river corridor.	Yes: NPS needs office space and wilderness center for resource protection. Rationale for revision to GMP: The preferred alternative would retain the existing ranger station to minimize impacts to historic resources. The wilderness center is located where the operations building would have been constructed.	Concern: Social trails radiate from the wilderness center and John Muir Trail to Puppy Dome (climbing areas) and river access. A nearly continuous social trail extends along Dana Fork from Tuolumne Meadows Lodge to the confluence with the Lyell Fork and Tioga Road. Action: Ecologically restore informal trails, decompact soils, recontour unnatural landforms, and revegetate denuded areas.	NONE	NONE	NONE	NONE	NONE
	NPS stable	Relocate stable and housing to area west of current visitor center.	No: Site constraints preclude relocation outside the corridor, and stock must be kept near the site of use. However, the alternatives do move the facility to various locations, all within the river corridor.	Yes: NPS needs stock to maintain trails and provide visitor protection. Rationale for revision to GMP: In the preferred alternative, the NPS and concessioner stables would be consolidated at the site of the existing concessioner stables. A new stable in an undisturbed location would not be necessary due to the reduction in stock use associated with the elimination of day rides and would result in additional resource impacts.	NONE	NONE	NONE	NONE	Concern: Stock use and manure pose a potential risk to water quality. Action: Current practices of regular manure removal help prevent impacts to water quality. Ongoing monitoring will continue.	NONE

Location[a]	Facility	1980 GMP Action	Feasible to relocate outside the river corridor?	Necessary for public use or resource protection?	Management or Localized Concerns and Enhancement Actions					
					Biological Value: Subalpine Meadow/ Riparian Complex	Cultural Value: Historic Properties	Cultural Value: Prehistoric Archeological Landscape	Scenic Value	Water Quality	Free-flowing Condition
16 and 17	NPS housing at Ranger Camp and Bug Camp	Upgrade housing for 60 employees. Remove housing at Bug Camp.	No: Housing supply in Lee Vining is very limited, and no feasible locations exist elsewhere within reasonable commuting distance.	Yes: NPS staff is needed to protect resources, to provide public safety, and to manage and monitor visitor use of the corridor. Rationale for revision to GMP: In the preferred alternative, the housing would be retained and upgraded in place to minimize impacts to historic resources and to avoid building new housing in undisturbed areas. Complete removal of housing is infeasible given the number of employees necessary.	NONE	NONE	NONE	NONE	NONE	NONE
17	Dog Lake/John Muir Trail trailhead parking	Expand trailhead parking for 110 vehicles.	No: Topographic constraints require this trailhead to be in its existing location.	Yes: Trailhead parking is needed for visitors while hiking trails. This parking area accesses the John Muir and Pacific Crest Trails. Removal of this parking area would require expansion of other parking areas, which would be infeasible given site constraints at those locations.	NONE	NONE	NONE	NONE	NONE	NONE
18	Tuolumne Meadows Lodge	Retain 66 units, restaurant, 100-car parking. Relocate dining hall and kitchen away from river.	No: Locating the lodge outside the corridor is not feasible due to other facility requirements and topographic constraints.	For alternative 1, No: This alternative calls for a wilderness-oriented and self-reliant visitor experience in which the lodge would be incompatible. For alternatives 2–4, Yes: Tuolumne Meadows is a major visitor destination, far enough from most visitors' homes or other visitor service centers to necessitate opportunities to spend the night. Some level of affordable accommodations is necessary to provide this opportunity for visitors who choose not to camp or who do not have the ability or the equipment to camp. While lodging is available in Lee Vining, that lodging does not provide visitors with an easy opportunity to experience the meadows in the evening, at night, and in the early morning hours; moreover, most of it is considerably more expensive than the rustic accommodations provided at Tuolumne Meadows Lodge.	Concern: The three guest tent cabins near the river are located in a wet riparian area with social trails along the Dana Fork. Action: Alternative 1 would remove the lodge. Alternatives 2– 4 would move the three visitor tent cabins nearest to the river. Additionally, alt four would relocate the dining hall and kitchen away from the river.	NONE	NONE	NONE	NONE	NONE
	Concessioner employee housing at Tuolumne Meadows Lodge	Upgrade	No: Housing supply in Lee Vining is very limited, and no feasible locations exist elsewhere within reasonable commuting distance.	Yes: Concessioner staff is needed to operate the lodge and other concession services.	Concern: The concessioner employee tent cabins near the river at Tuolumne Meadows Lodge are located in a wet riparian area with social trails along the Dana Fork. Action: Relocate concessioner employee housing at Tuolumne Meadows Lodge.	NONE	NONE	NONE	NONE	NONE
19	Water treatment facility	Bring drinking water quality up to standard.	No: The sole water source in Tuolumne Meadows is the river, and resource or wilderness constraints preclude relocation elsewhere in the meadows.	Yes: NPS is required to provide potable water for visitors and park staff.	NONE	NONE	NONE	NONE	NONE	Concern: The Dana Fork water intake and diversion has the potential to affect the free-flowing condition of the river during periods of low flows. Action: Limit water withdrawals to 10% of the river's low flow or 65,000 gallons per day, whichever is less.
20	Gaylor Pit Helipad	Remove horse camp and restore Gaylor disposal site.	Helipad, No: No other helipad locations are possible in the area.	Helipad, Yes: A helipad is required for public health and safety (e.g., fire suppression, rescues). Rationale for revision to GMP: In the preferred alternative, the site would be used as a dry campground for employees with short-term assignments. It has since been restored and is no longer used as a horse camp or a disposal site. Any new development would avoid sensitive resources and would be located in previously disturbed areas.	NONE	NONE	NONE	NONE	NONE	NONE

Location[a]	Facility	1980 GMP Action	Feasible to relocate outside the river corridor?	Necessary for public use or resource protection?	Management or Localized Concerns and Enhancement Actions					
					Biological Value: Subalpine Meadow/ Riparian Complex	Cultural Value: Historic Properties	Cultural Value: Prehistoric Archeological Landscape	Scenic Value	Water Quality	Free-flowing Condition
	Mono Pass trailhead (parking lot, vault toilet)	N/A	No: Resource constraints preclude relocation elsewhere.	Yes: Trailhead parking is needed for visitors while hiking trails.	NONE	NONE	NONE	NONE	NONE	NONE
Wild Segment: Grand Canyon All facilities noted below are consistent through their trail-only access with the wild classification.										
	Glen Aulin High Sierra Camp tent structures	N/A	No: The Glen Aulin High Sierra Camp was not included in Yosemite's designated Wilderness. The camp is surrounded by designated Wilderness. The Wilderness Act precludes construction of new facilities such as this.	For alternative 1, No: The camp does not provide the self-reliant experience envisioned under that alternative. For alternatives 2–4, Yes: The High Sierra Camp is essential for providing a high-country experience for a diversity of visitors, including those who lack the ability to backpack into the wilderness. Also, it is a critical link in the larger system of High Sierra Camps that supports a multiday hut-to-hut guided loop trip.	NONE	NONE	NONE	Concern: Camp structures can be seen from some locations in the class I view corridor. Action: New structures will be assessed through Visual Resource Management contrast analysis. When tents are replaced, fabric colors will be chosen that blend with the landscape.	NONE	NONE
	Glen Aulin water treatment system	N/A	No: All suitable locations for this are within the river corridor. The Wilderness Act precludes construction of new facilities such as this. However, the water intake line and all water supply lines in designated Wilderness/ outside of the Glen Aulin potential wilderness addition will be removed.	Yes: Consistent with NPS DO-83, NPS must provide treated and filtered water.	NONE	NONE	NONE	Concern: Photovoltaic panels on small treatment shed can be seen from some locations in the view corridor. The intake hose and water line are also visible from the Glen Aulin trail. Action: No action. These are necessary to run the water treatment system.	NONE	NONE
	Glen Aulin wastewater treatment	N/A	No: All suitable locations for this are within the river corridor. The Wilderness Act precludes construction of new facilities such as this.	Yes: To protect water quality, NPS must treat wastewater.	NONE	NONE	NONE	NONE	Concern: Septic tank and mounded leachfield are within 150 feet of Conness Creek. Leach mound is at capacity with the flow currently limited to 600 gallons per day to protect water quality. Alternative 1 would remove the Glen Aulin High Sierra Camp and restore the site to natural conditions, which would eliminate the septic tank and leachfield. Alternative 2 would eliminate the septic tank and abandon the leach field. Alternatives 3 and 4 would reduce use to mitigate the risk to water quality.	NONE

Location[a]	Facility	1980 GMP Action	Feasible to relocate outside the river corridor?	Necessary for public use or resource protection?	Management or Localized Concerns and Enhancement Actions					
					Biological Value: Subalpine Meadow/ Riparian Complex	Cultural Value: Historic Properties	Cultural Value: Prehistoric Archeological Landscape	Scenic Value	Water Quality	Free-flowing Condition
	Glen Aulin corrals	N/A	No: All suitable locations for this are within the river corridor. The Wilderness Act precludes construction of new facilities such as this.	Yes: The camp is supplied by pack stock, so a means of containing their impacts is necessary.	NONE	NONE	NONE	NONE	Concern: Potential risk to water quality from stock use and manure. Action: Current practices of regular manure removal help prevent impacts to water quality; ongoing monitoring will continue.	NONE
	Glen Aulin backpacker campground	N/A	No: Few suitable camping locations with access to water exist outside of this location.	Yes: Camping is necessary to allow backpackers to experience this part of the river corridor.	NONE	NONE	NONE	NONE	Concern: Composting toilet is undersized for current demand and poses a potential risk to water quality. Action: Replace the current composting toilet with a new composting toilet slightly uphill and out of the area with potential to flood.	NONE
Scenic Segment: Below O'Shaughnessy Dam										
	Dam operation facilities and administrative road	N/A	No: Such facilities must be near the dam.	Yes: The Raker Act allows such facilities to be located in Yosemite.	NONE	Concern: One prehistoric archeological site has been impacted by development. Action: Monitoring will continue as well as increased management protection to counteract or minimize impacts.	NONE	NONE	NONE	NONE
Wild Segment: Poopenaut Valley No known facilities										
Wild Segment: Lyell Fork No major facilities										

a Location numbers correspond to locations on figure 8-2 in chapter 8. Abbreviations: CCC = Civilian Conservation Corps; DO-83 = Director's Order 83; GMP = *Yosemite General Management Plan*; N/A = not applicable; NPS = National Park Service; SFPUC = San Francisco Public Utilities Commission