The Big Five: Dam Removal Planning in the California Coast Ranges

by

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List of Acronyms

CAW = California American Water Company
CDFG = California Department of Fish and Game
CDRI = Clearinghouse for Dam Removal Information
CEQA = California Environmental Quality Act
CPUC = California Public Utilities Commission
CWA = Clean Water Act
DSOD = California Department of Water Resources Division of Safety of Dams
DWR = Department of Water Resources
EIR = Environmental Impact Report
EIS = Environmental Impact Statement
ESA = Endangered Species Act
ESU = Evolutionary Significant Unit
FEMA = Federal Emergency Management Agency
FERC = Federal Energy Regulatory Commission
JPA = Joint Powers Authority
JRBP = Jasper Ridge Biological Preserve
JRAC = Jasper Ridge Advisory Committee
NEPA = National Environmental Protection Act
NID = National Inventory of Dams
NMFS = National Marine Fisheries Service
SFCJPA = San Francisquito Creek Joint Powers Authority
SHPO = State Historic Preservation Office
PCLF = Planning and Conservation League Foundation
USACE = United States Army Corps of Engineers
USBoR = United States Bureau of Reclamation
USFWS = United States Fish and Wildlife Service
VCWPD = Ventura County Watershed Protection District
WRDA = Water Resources Development Act

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Abstract

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Dam removal is an increasingly common phenomenon throughout the United States, especially in California where reservoirs are rendered obsolete by infilling with sediment from high yield catchments. This condition is found in the California Coast Ranges, where the Mediterranean climate and active faults contribute to reservoir infilling. This thesis examines five case studies of dams in the California Coast Ranges, which are being considered for removal because they impound infilled reservoirs and prevent threatened steelhead from accessing potential upstream spawning habitat. The objective is to discern lessons about the dam removal planning process for application to future dam removals. Case study analysis focuses on actors involved, the process followed, and an evaluation of risks associated with the proposed removal strategy. A set of recommendations is provided for consideration in development of dam removal planning policies.

CHAPTER 1: Introduction

Dam removal is an increasingly common phenomena throughout the United States. Dams previously constructed for water storage or hydropower are aging, and the ecological and economic consequences of their construction are progressively documented. Dealing with these consequences, through removal or other mitigation measures, is a complex task that requires social, political, and scientific considerations. This thesis examines these factors in the context of five planned dam removals, all located in the California Coast Ranges. Comparative analysis of actors involved, process steps, and risk-benefit tradeoffs inform recommendations for consideration in future dam removal projects.

Dam Impacts and Reasons for Removal

Dams and reservoirs are constructed on rivers to store water for future use, or for hydroelectric power generation (Palmieri et al, 2001). Rivers convey water and sediment from surrounding uplands. When a river is impounded by a dam, water flowing from upstream slows down, leading to sediment deposition in a reservoir (Figure 1-1) (Morris & Fan, 1998). Common engineering practice was to design reservoirs to allow them to fill with sediment slowly, resulting in a finite lifetime for reservoirs and their impounding structures as storage capacity decreased with increasing siltation (Palmieri et al, 2001). Reservoir sedimentation is an increasing problem globally, especially in Mediterranean climates which rely on reservoir storage to provide water when it is not available in dry summers, and experience extreme climatic events that can contribute significant amounts of sediment into reservoirs (Gasith & Resh, 1999). When reservoirs and dams are rendered obsolete by sedimentation, various management techniques are employed in a effort to restore storage capacity, such as dredging or flushing (Morris & Fan, 1998). However, these short term solutions require frequent maintenance. Thus, when these options are exhausted, dam removal is introduced as an option.

ENVIRONMENTAL IMPACTS

Dams have significant impacts on their surrounding environment. Dams disrupt a river's hydrologic regime, and prevent transport of sediment, nutrients, and aquatic organisms (Figure 1-2) (Petts, 1984). The presence of a migration barrier to anadromous fish can prevent access to upstream spawning habitat, and often fish ladders are put in place in an effort to allow migration over barriers, although these structures are found to be only partially effective (Morris & Fan, 1998; American Rivers et al, 1999). Sediment deposition in the upstream portion of a reservoir causes deltas to form, leading to decreased water depths and limited flow. Resulting water quality impacts include increased temperatures, decreased dissolved oxygen levels and eutrophication, especially if

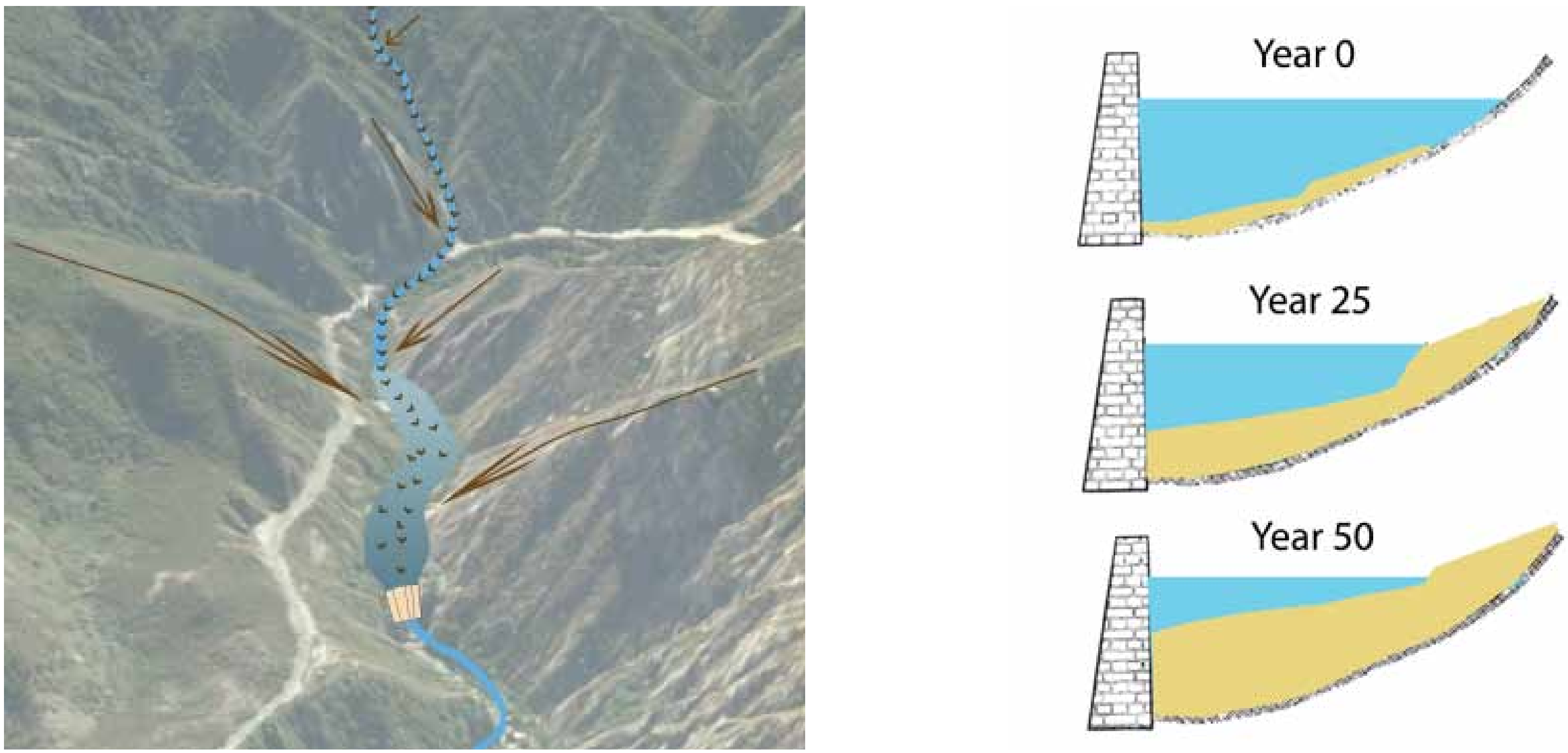


Figure 1-1. Sediment deposition from upstream watershed (left) and resulting deposition in reservoir.

excessive amounts of nutrients are used in watersheds with high agricultural activity (Morris & Fan, 1998).

Downstream channel morphology is affected by the loss of sediment transport from upstream reaches (Morris & Fan, 1998). Water that is not transporting sediment will tend to erode the streambed and banks (aka "hungry water"), resulting in increased bed armoring which can compromise instream habitat quality and decrease spawning gravel availability (Kondolf & Batalla, 2005). Channel incision can also lower groundwater levels in riparian areas, and in coastal areas this can lead to saltwater intrusion in the groundwater, lending these aquifers useless (Morris & Fan, 1998). Dams prevent transport of organic material, which is a food source for the downstream ecosystem (Gasith & Resh, 1999). Furthermore, reduced sediment discharge contributes to changes in coastal morphology, notably shoreline recession and delta subsidence (Morris & Fan, 1998).

SAFETY IMPACTS

Aging dams pose a hazard to surrounding communities. Of the 82,642 dams listed in the United States Army Corps of Engineers' (USACE/the Corps') National Inventory of Dams (NID) (Figure 1-3), 12,656 are listed as a "high hazard" and 13,859 are

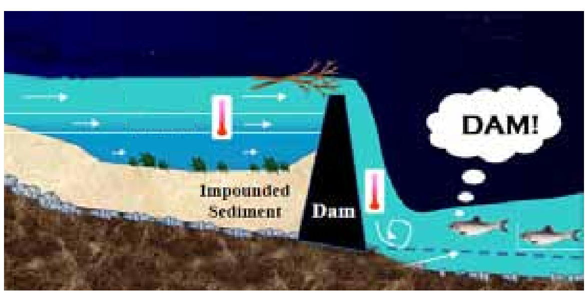


Figure 1-2. Transport impact of dams. (Wildman, 2006)

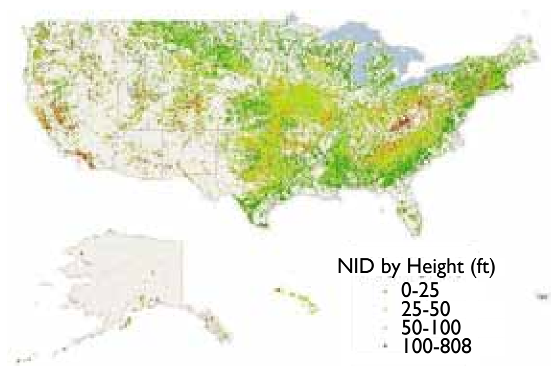


Figure 1-3. Dams in the US by height. (USACE, 2009)

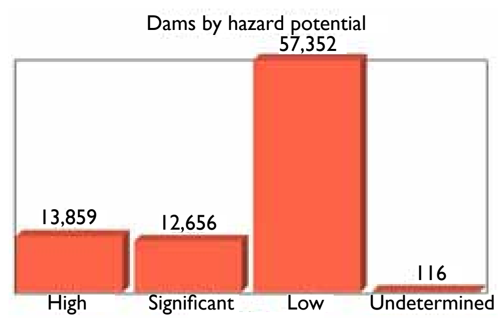


Figure 1-4. Dams in the US by hazard potential. (USACE, 2009)

listed as a “significant hazard” (Figure 1-4) (USACE, 2009)[1]. It is estimated that by 2020, 80% of these dams will be near the end of their planned operational lives of approximately 60 to 120 years (ASDSO 2000).

The gradual accumulation of sediment behind a dam can lead to structural safety and flooding issues (Morris & Fan, 1998). While water is easily moved from a reservoir through spillway structures, sediment transport through outlets is more complicated and requires sophisticated engineering (Morris & Fan, 1998). Sediment deposition can compromise the safety of the impoundment structure, from spillway overtopping or cracking under increased pressure from the weight of the sediment. Reservoir deltas can cause channel aggradation extending upstream from the reservoir, and vegetation growth in these deposits increases upstream flood risk due to augmented hydraulic roughness and sediment entrapment (Figure 1-5 & 1-6). Landslides and debris flows can fill reservoirs to near capacity (Figure 1-7) or in extreme cases cause catastrophic floods that can break a dam (Figure 1-8). Changes in sediment loading in a reservoir can affect species composition, and if not managed, sedimentation can cause open-water habitat to turn into upland area above the water surface (Morris & Fan, 1998).

RESERVOIR SEDIMENT MANAGEMENT TECHNIQUES

Preventative measures to limit sediment accumulation in reservoirs can be grouped into three categories (Figure 1-9). The first set is designed to prevent sediment from entering the reservoir by placing the reservoir in a catchment with a low sediment yield or controlling land use practices in the catchment to reduce sediment yield (Annandale, 1987; Palmieri et al, 2001). Water diversions can be constructed to pass floods transporting large amounts of sediment around the reservoir controlled by flood control gates and diversion canals (Annandale, 1987). Reservoirs can also be constructed off-stream of the reservoir (Annandale, 1987).

1 Dams that are in NID are greater than 25 feet high with a 15 acre-feet capacity reservoir or greater than 6 feet high with a 50 acre-feet capacity reservoir.

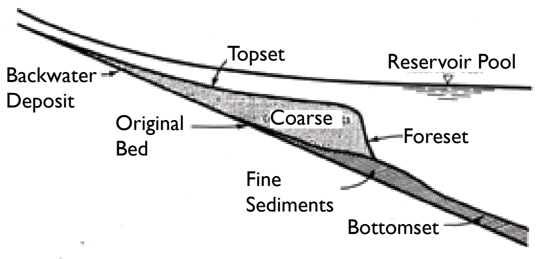


Figure 1-5. Delta deposition in reservoir. (Mahmood, 1987)

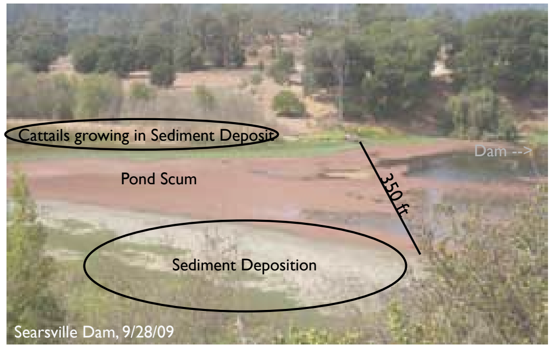


Figure 1-6. Example of reservoir sediment deposit.

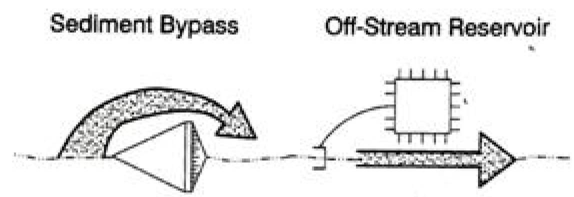
Figure 1-7. Infilled reservoir. (Morris & Fan, 1998)

Figure 1-8. Bar-lin Dam on the Dahan River in Taiwan, full of sediment in 2006 four years after completion (left), and post-failure in 2007 (right). (Kondolf, 2006 & 2007)

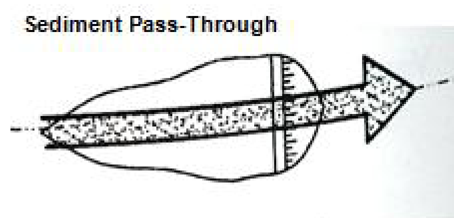
The second set of techniques attempts to create conditions within a reservoir to prevent sediment deposition. Sediment discharged into a reservoir can be controlled if sediment carrying capacity of the stream flowing through the reservoir is close to the carrying capacity of the unmodified river (Annandale, 1987; Palmieri et al, 2001). This is difficult to achieve, but can be accomplished during floods using gates in dams or maintaining low reservoir levels during flood periods (Annandale, 1987; Palmieri et al, 2001).

Once sediment has been deposited in a reservoir, it can be removed by dredging or flushing sediment from the reservoir. Dredging is often very expensive and locations for dredge spoil storage are limited. Flushing, or transporting deposited sediment through bottom outlets by increasing flow velocity, can increase reservoir capacity but has limited reliability in semi-arid environments where reservoir capacity can significantly exceed mean annual runoff (Palmieri et al, 2001; Annandale, 1987).

1) Reduce volume of sediment entering reservoir



2) Create conditions within reservoir to prevent sediment deposition



3) Remove sediment that has already been deposited

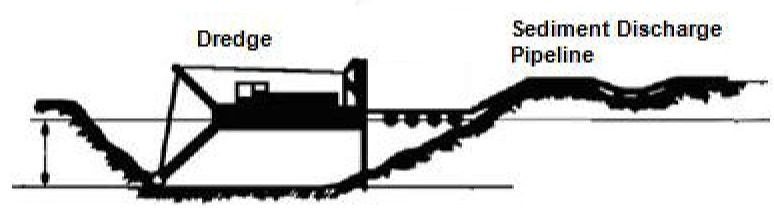


Figure 1-9. Reservoir sediment management techniques. (top & middle: Morris & Fan, 1998; bottom: Ellicot Dredges)

DAM AND RESERVOIR RETIREMENT OPTIONS

If sediment management options to extend a reservoirs' functional lifetime are exhausted because they are too costly or not feasible for other reasons, dam decommissioning and reservoir retirement may be proposed. Dam decommissioning involves either modifying the dam to allow for fish passage, altering the structure to ensure its safety but not completely removing it, or dismantling a dam to restore full river flow through the dam's former location (Wildman, 2006). Of these options, dam removal is proposed to permanently address the aforementioned environmental impacts and reduce safety concerns (Pejchar & Warner, 2001; Collier et al, 1996).

However, dam removal can have detrimental impacts on rivers as well. Dam removal can leave terraced sediment deposits in the former reservoir pool susceptible to flood erosion and lateral incision due to the altered longitudinal bed profile created by the reservoir (Collier et al, 1996). Release of reservoir sediment as part of dam removal can create easily eroded floodplains, and impair downstream habitat due to increased pollution or smothering of downstream spawning gravels (Pejchar & Warner, 2001; Palmieri et al, 2001). If sufficient mitigation procedures are not put in place, flood control provided by the reservoir may be lost following retirement, assuming there is remaining storage capacity in the reservoir to hold flood waters (Pejchar & Warner, 2001). These impacts and benefits of dam removal as discussed in depth in the context of risk analysis in Chapter 3.

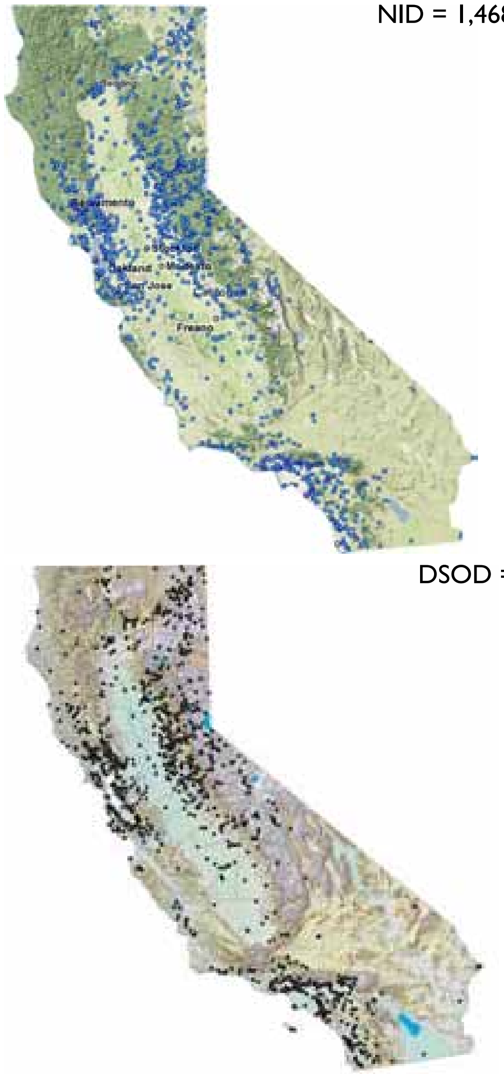


Figure 1-10. Dams in California. (USACE, 2009; DSOD, 2009)

Dams and Reservoirs in California

CALIFORNIA'S CONTEXT

California's Mediterranean climate results in demand for water to be out-of-phase with supply, thus necessitating reservoir storage most frequently from dams (Kondolf & Batalla, 2005). California has 1,468 dams listed in the NID and 1,391 in the California Division of Safety of Dams (DSOD) (Figure 1-10)[2], of which the majority are used for irrigation according to NID (Figure 1-11) (USACE, 2009; DSOD, 2009). Intense agricultural production requires freshwater for irrigation, making California's rivers particularly susceptible to flow regulation through water diversions and reservoir construction (Gasith & Resh, 1999). Additional common storage purposes include water supply, hydropower generation, and flood control (USACE, 2009).

Coastal California's location in a Mediterranean climate and geologically active region make the area's reservoirs susceptible to reservoir sedimentation (Minear & Kondolf, 2009). After extended drought periods, typically lasting from April to November, sediment is easily mobilized after the precipitation events into surface water (Kondolf & Batalla, 2005). The amount of sediment mobilized will depend on the amount of precipitation that falls and the land cover in a given

2 It is not clear where this discrepancy comes from, given that DSOD and NID use the same criteria for including dams in their databases.

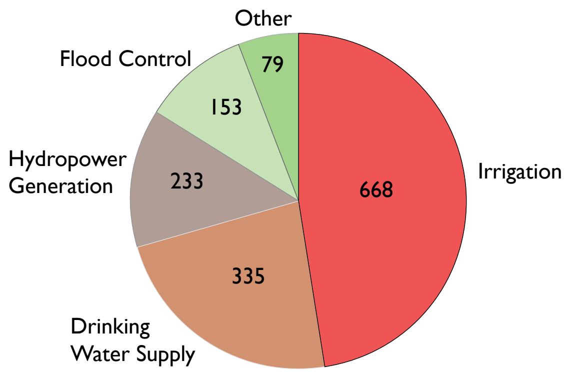


Figure 1-11. California dam purposes. (USACE, 2009)

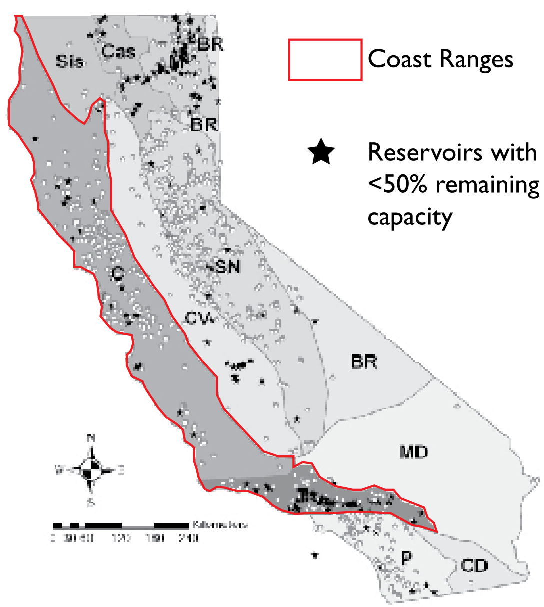


Figure 1-12. 3W reservoir sediment modeling results indicating high sedimentation rates in Coast Ranges. (Minear & Kondolf, 2009)

watershed (Kondolf & Batalla, 2005). Recent modeling work for sediment yield rates and reservoir capacity found that reservoirs in the California Coast Ranges are particularly susceptible to sediment infilling (Figure 1-12) (Minear & Kondolf, 2009).

DAM REMOVAL IN CALIFORNIA

The aforementioned impacts of infilled reservoirs and dams are mitigated using various techniques, and increasingly dam removal is chosen as the preferred option to eliminate these effects. In the United States, 748 dams have been removed nation-wide, with 306 of them removed since 1999 (American Rivers, 2008). Of these, over 70 dams have been removed in California, leading the nation in dam removals by state (Pohl, 2002). What is thought to be the first dam removal in the nation took place in California in 1922 on a tributary to the Klamath River, followed by 23 others initiated by the California Department of Fish and Game (CDFG) in an effort to increase anadromous fish access to spawning habitat (Pohl, 2002; Handly and Coots, 1953 in Gilbreath, 2006).

Ecosystem restoration remains a primary motivating factor for dam removal projects in California (Pohl, 2002). Dams continue to block access to ninety percent of historical spawning grounds in California, and declines in anadromous fish populations reflect this limitation (Friends of the River, 1999). Additional reasons for dam removal include safety – the NID lists 807 in California with a "high" hazard potential (USACE, 2009). Environmental benefits and reduction of safety concerns are the leading motivations for dam removal both nationally and in California (Pohl, 2002).

Dam Removal Planning and Policies

Like most environmental issues, decision making in dam repair or removal processes is a complex and contentious process. Relatively little guidance exists in current policies regarding dam removal (Doyle et al, 2003). Scientific understanding of the environmental effects of dam removal is in beginning stages, and there is little documentation of impacts from executed removals (Doyle et al, 2003). Therefore, management decisions regarding dam removal are difficult to achieve because policies which guide these decisions often require a higher degree of certainty than currently employed scientific methods are able to provide (Wilcock et al 2003). However, there are several relevant federal and state policies which can instigate the removal process. Although some dam removals were voluntarily initiated by the owner, typically dam removal is the result of legal proceedings related to the following policies (Bowman, 2002).

FEDERAL POLICIES

The federal government is the largest single owner and operator of large dams in the nation, with the United States Army Corps' of Engineers and the Bureau of Reclamation (USBoR/the Bureau) responsible for building and operating most federal dams (American Rivers et al, 1999).[3] Federally operated dams are not subject to dam safety inspections by other government agencies, such as the Federal Energy Regulatory Commission (FERC) or state dam safety inspection agencies. If a dam is owned by the Corps' is found to be unsafe or impacting critical habitat through their own assessment procedures, the Corps' can be held liable for removal or modification (Bowman, 2002).

3 Of the 82,642 dams listed in NID, the federal government is the attributed owner of 3,075 of these dams, yet it is unclear based on the various abbreviations of Army Division names how many are specifically operated by the Corps.

Federal Energy Regulatory Commission (FERC) Relicensing

Non-federally operated hydropower dams are regulated and licensed by FERC, and operators must obtain a license subject to renewal every 30 to 50 years (Bowman, 2002). During the relicensing process (Figure 1-13), FERC must determine if it is in the public's interest to maintain the dam, giving "equal consideration" to power development and non-power uses of the river (US Code, title 16, sec. 797[e] in Bowman, 2002). This consideration of environmental benefits in the relicensing process has brought dam removal to the table as an option for restoring river function (Pejchar and Warner 2001). The removal of the Edwards Dam on the

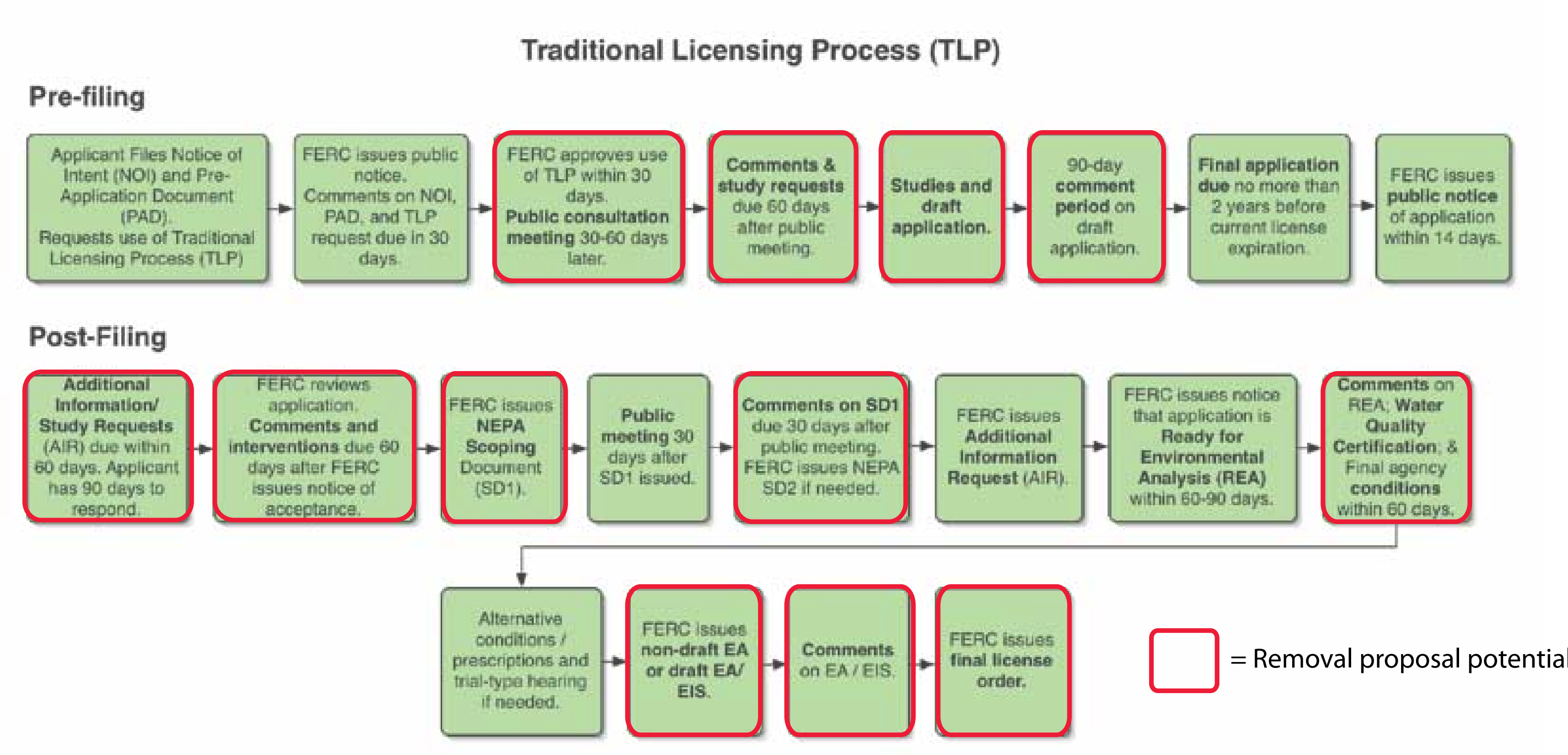


Figure 1-13. Opportunities to introduce dam removal in the FERC relicensing process. (Hydropower Reform Network, ____)

Kennebec River in Maine is frequently touted as an example of invoking the FERC relicensing process to put forth dam removal as an option for river restoration (American Rivers et al, 1999). FERC will considered 550 dam licenses for renewal nationwide between 2001 and 2010 (Pejchar and Warner, 2001).

FERC also conducts dam safety inspections, which can result in the owner choosing to remove the dam rather than perform the necessary safety measures. Owners may also choose to surrender their license to FERC under certain circumstances, such as ending power generation. However, the surrender of a license does not require the dam owner to remove the dam or plan for continued dam safety maintenance, which can result in the dam remaining in place (Bowman, 2002).

Endangered Species Act

While the federal Endangered Species Act (ESA) was never invoked to mandate dam removal, it has raised consideration and eventual implementation in several cases. Section 7 (Figure 1-14) of the law forbids federal actions that impair the survival of listed species by compromising their "critical" habitat quality, including habitat not presently occupied by necessary for their life cycle

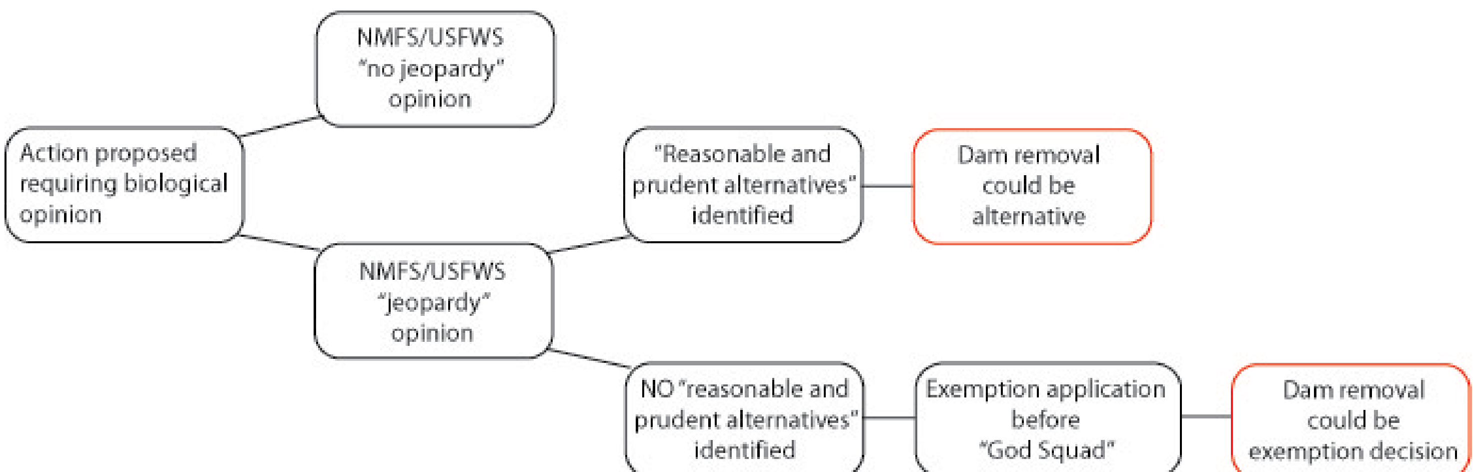


Figure 1-14. ESA Section 7 biological opinion process.

functions (US Code, title 16, sec. 1536[a][2] in Bowman, 2002). The National Marine Fisheries Service (NMFS) or United States Fish and Wildlife Service (USFWS)[4] issue biological opinions to determine if proposed actions will put species in "jeopardy," and then recommend "reasonable and prudent alternatives" if they can be identified (US Code, title 16, sec. 1536[b][3] in Bowman, 2002). If not, applications for exemptions are brought before the Endangered Species Committee, or "God Squad" (US Code, title 16, sec. 1536[g] in Bowman, 2002)). Jeopardy opinions can recommend dam removal as a reasonable and prudent alternative if the project is within the jurisdiction of a federal actor (Bowman, 2002).

The definition of critical habitat is ambiguous regarding dams blocking access to critical habitat, particularly with regards to migratory species such as anadromous fish (Pejchar and Warner, 2001). Criteria for critical habitat include "habitats that are…. representative of the historical geographical and ecological distributions of the species;" however, "unoccupied areas are not to be included in critical habitat unless the present range would be inadequate to ensure the conservation of the species." (NOAA 2000, in Pejchar and Warner 2001). This language results in dams considered as the upstream-most extent of critical habitat (Pejchar and Warner, 2001). NMFS will consider areas above dams as critical habitat areas if it can be proven by interested parties, typically environmental advocates and or commercial fishers, thus deferring NMFS' regulatory responsibility to the public (Pejchar and Warner, 2001).

Section 9 of the ESA, which prohibits "takings" of a species (including harm to their habitat), has also been invoked as impetus for dam removals (US Code, title 16, sec. 1532[19] in Bowman, 2002). USFWS and NMFS are required under ESA to develop and implement recovery plans for threatened and endangered species, yet implementation of this stipulation has been hindered by funding and political constraints (Bowman, 2002).

4 Whether USFWS or NMFS is responsible for regulating actions affecting an endangered species depends upon its status as a species that supports a commercial industry. For example, salmonids are regulated by NMFS, a division within the Department of Commerce, because there has historically been a commercially viable fishery.

Simply the presence of ESA listed species on dammed rivers has been enough to warrant consideration for dam removal, such as the Saeltzer Dam on Clear Creek in California, which was voluntarily removed in the interest of restoring habitat for endangered spring-run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*) (Bowman, 2002; Gilbreath, 2006). NMFS has designated runs of steelhead, Chinook, and Coho salmon (*Oncorhynchus kisutch*) in California as endangered, threatened, candidate, or listing not warranted (NOAA, 2000 in Pejchar and Warner, 2001).

Reservoir Sedimentation

A federal policy does not exist yet to systematically evaluate the effects of reservoir sedimentation on dam safety for non-hydropower dams. Dam safety is guided by the federal National Dam Safety Program Act, passed in 1996 tasking the Federal Emergency Management Agency (FEMA) to provide oversight to other federal agencies involved in dam safety and state dam safety programs (FEMA, 1997). While FEMA has no regulatory responsibility for dams, it is responsible for making sure that authorizing agencies are able to ensure dam safety by providing trainings and identifying research needs (FEMA, 1997). Most commonly, legal proceedings which lead to dam removal are initiated following safety inspections by state agencies, which may find the dam to be structurally unsound (Bowman, 2002). The owner then must make the choice to reinforce or remove the dam (Bowman, 2002).

CALIFORNIA POLICIES

Dam Safety Inspections

As specified in California Water Code (Section 6000 to 6004.5 and 6025.5), the Department of Water Resources Division of Safety of Dams (DSOD) is responsible for carrying out these inspections on privately owned or state controlled dams, excluding federally regulated dams (DSOD,____). These inspections are intended to be performed out annually, or "as needed on a case by case basis." Safety inspection results in a hazard classification based on factors including dam height, estimated evacuation time and potential damage. Dam condition is classified based on age, general condition, geologic, and seismic setting (ASDSO, 2000). If a dam is found to be structurally unsound, emergency action such as lowering water levels, or remedial actions such as dam buttressing, may be taken (Figure 1-15). A recommendation for remedial action may lead to removal. Reservoir capacity is rarely evaluated during annual inspections, which tend to focus on the safety of the dam structure itself.

Fish and Game Code

The California Department of Fish and Game (CDFG) implements several policies to address habitat impacts from dams. The California Endangered Species Act is similar in purpose to the federal ESA, and provides for mitigation planning resulting from incidental take of listed species, if certain conditions are met (CWIS, 2005). CDFG code sections 5900 – 6100 address fishways, screening, and flow releases at dams and other diversions. Section 5931 requires that a dam owner provide "durable and efficient passage" where fish cannot pass freely over a dam (CDFG, ____). However, CDFG does not have any rules, policies, or standard practices to implement these codes (Roos-Collins et al, 2009).

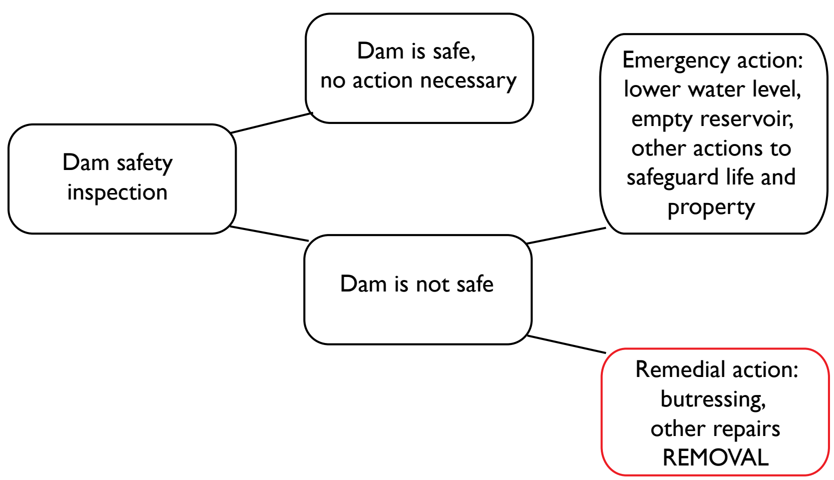


Figure 1-15. California dam safety inspection process.

While federal and state policies address specific types of dams and their habitat impacts, sediment in-filled reservoirs are not explicitly addressed. There is no legal mechanism that mandates consideration of removing obsolete dams impounding substantial amounts of reservoir sediment, except where dam safety inspections identified the dam to be structurally unsound. River advocates in California previously proposed a bill, the California River Restoration Act of 2000 (SB 1540), specifying that the State Secretary of Resources should conduct a statewide inventory of dams that are abandoned or obsolete, which would include dams impounding infilled reservoirs (Pejchar and Warner, 2001). Identified dams would be further studied to determine the cost and feasibility of removing them, funded by a proposed Dam Decommission Fund in the State Treasury based on legislature appropriations (Pejchar and Warner, 2001). The bill passed in the State Senate, but did not receive funding from the Assembly Appropriations Committee.

PERMITS REQUIRED FOR DAM REMOVAL

Federal Permitting

Dam removal requires permits from several levels of government to ensure that removal is carried out in a safe manner that minimizes short and long term impacts to the ecosystem and surrounding communities. The Corps' is almost always involved in dam removal from a regulatory perspective because of their permitting authority specified in Section 404 of the Clean Water Act (CWA) and Rivers and Harbors Act for non-federal projects (Bowman 2002). However, with regards to federal projects, CWA does not require wetland delineation or dredged material management plan for excavated sediment.

The National Environmental Protection Act (NEPA) requires preparation of an environmental impact statement (EIS) for projects that involve federal agencies. This would include carrying out a public interest review, and determining the impact of dam removal on wetlands, aquatic organisms, water quality, navigation, economics, and social factors (Conyngham et al, 2006). Additional federal consultations may be required by the Corps' or FERC as part of their permitting processes; for example, impacts on fisheries management plans prepared under the Magnunson-Stevens Act. If the dam is within a coastal zone, a consistency review for compliance with the Coastal Zone Management Act is required (Bowman, 2002). Review for compliance with the National Historic Preservation Act may also be required if the dam is located in an important archeological area, or it is listed in the National Registry of Historic Places (Gilbreath, 2006).

State and Local Permitting

States must demonstrate consistency with federal reviews through their permitting processes. This includes issuing a water quality certification pursuant to CWA section 404 as discussed previously. Under the California Environmental Quality Act, an environmental impact statement is required for dam removal projects, and may be prepared in conjunction with documentation required under NEPA. Dam removal would also require notifying CDFG of lake and streambed alternation pursuant to CDFG Code 1602 (CDFG, ____). Municipal entities may require demolition or building permits to permit activities that may be part of the removal process (Gilbreath, 2006).

As dams continue to age, obsolete dams that negatively impact aquatic ecosystems should be evaluated for removal in a systematic process. Consideration for how science is presented and understood in dam removal planning is necessary for developing meaningful policies to guide future dam removal projects that will become increasingly necessary as dams age throughout the country. The remainder of this thesis will examine five case studies in an effort to develop recommendations for future policies to guide removal of dams rendered obsolete by reservoir sediment.

CHAPTER 2: Methods

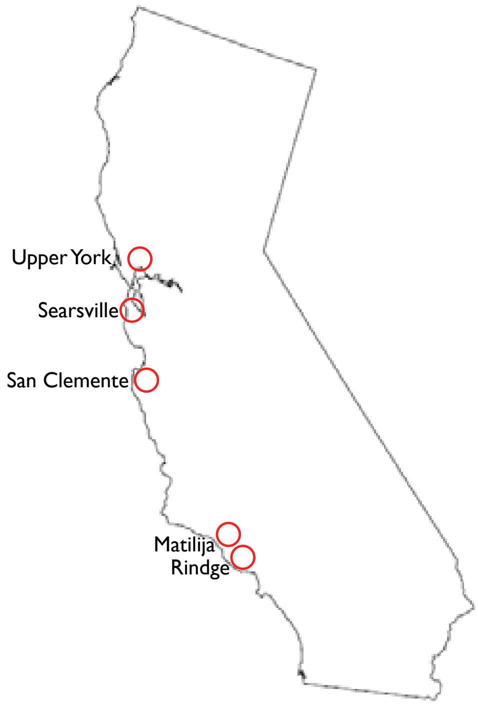


Figure 2-1. Case study locations.

This thesis examines the dam removal planning process in five dam removal projects in the California Coast Ranges: Upper York Creek Dam on York Creek, Searsville Dam on San Francisquito Creek, San Clemente Dam on Carmel River, Matilija Dam on Ventura River, and Rindge Dam on Malibu Creek (Figure 2-1). Methods used for site-selection and data collection are presented below. Conceptual frameworks for case study analysis and comparison were developed based on review of theoretical literature and precedent examples. These are discussed in depth in the following chapter.

Case Study Selection

Case studies were chosen based on similarities in their geographic and regulatory context. All case studies involve dams that are in the process of removal planning, or removal has been proposed to mitigate the ecological impacts and safety hazards posed. They are all located within the California Coast Ranges, a geologically active region of California underlain by several fault systems (Argus & Gordon, 2001). High sediment yield due to geologic activity and location in a Mediterranean climate have contributed to reservoirs behind these dams filling with sediment, rendering them obsolete. The Matilija, San Clemente, and Searsville dams are large enough to meet the criteria for annual dam safety inspections by DSOD and for inclusion in the

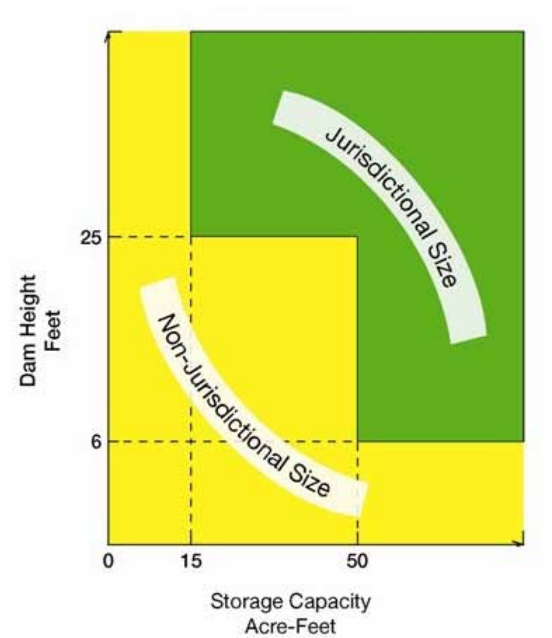


Figure 2-2. DSOD dam safety inspection size and capacity thresholds (DSOD, 2009).

NID (Figure 2-2) (DSOD, 2009; USACE, 2009). The original storage capacity of Upper York Creek reservoir is below the threshold for dam safety inspections. Rindge Dam was decommissioned in 1965, therefore dam safety inspections are no longer conducted on an annual basis (DSOD, 2009). All of the dams are located on streams that historically supported runs of steelhead trout.

Socioeconomically, the five selected dams are all upstream of urban areas where property values are greater than the state and national average, and four of the five dams are located upstream of cities where the median household income is well above the state and national average (Table 2-1) (US Census Bureau, 2000). Searsville and Rindge are located above Palo Alto and Malibu, respectively, which have property values that are about an order of magnitude greater than the national average (US Census Bureau, 2000).

	United States	*California*	*Upper York*	*Searsville*	*San Clemente*	*Matilija*	*Rindge*
Downstream City			St. Helena	Palo Alto	Carmel Valley	Ojai	Malibu
Median household income	$41,994	$47, 493	$58,902	$117,574	$70,799	$44,593	$102,031
Median Property Value	$119,600	$211,500	$453,600	$811,800	$457,100	$272,100	$1,000,001

Table 2-1. Socioeconomic characteristics of downstream cities (US Census Bureau, 2000).

Case Study Data Collection

Background information review included collecting and reading planning literature prepared for each active or proposed removal project. Topics of such reports include removal feasibility, sediment transport, hydrology, and ecological impacts. Other planning documents are draft and final Environmental Impact Reports (EIR) and Environmental Impact Statements (EIS), and the associated public comments. Document collection and initial literature review was first conducted by Sarah Richmond (UC Berkeley Energy & Resources Group graduate), who contacted government agencies and consulting groups for reports. These documents were then entered into the Clearinghouse for Dam Removal Information (CDRI), housed in the Water Resources Center Archives at UC Berkeley. Literature collection review and expansion for the purposes of this thesis began in December 2008, including visiting project specific websites and re-contacting individuals from whom previous documentation was obtained. Dam safety inspection reports and records available from DSOD were also reviewed for Searsville and San Clemente dams.

Visits to each of the five case study sites took place from September 2009 through January 2010. Visits were conducted to visually assess sedimentation impacts, to photo-document current conditions, and to compare current conditions with historical photographs. Visits were accompanied by a stakeholder engaged in the planning process, either a project manager, expert in reservoir sedimentation, or an individual familiar with the dam removal proposal.

Interviews were conducted with those familiar with the planning process, such as staff from government agencies responsible for planning, technical support, permitting, or project management; staff from non-governmental advocacy; and individual citizens familiar with the dam removal project or proposal. Appendix A lists all individuals interviewed for each case study. Interviews were held either in person or over the phone. Questions focused on obtaining clarification regarding the project process and actors involved, current status, additional considerations included in decision making processes not included in available documentation, and perspectives on the efficacy of the dam removal planning process.

A caveat: *I attempted to gather and supplement previous collections of information about these five case studies, but I may not have been able to obtain all existing documentation. Additional pertinent background information may exist currently, and information presented in case study analysis is intended to illustrate what can be learned from dam removal planning processes.*

Comparative Analysis Methods

Several methods were drawn from the supporting literature review to shape the presentation of case study information and to conduct comparative analysis. Criteria for dam removal consideration drawn from Pejchar and Warner (2001) are used to present important background information, such as ecological, political, and safety factors considered in the removal planning process, as listed in Appendix B. Diagrams were developed for each case study to illustrate actors' roles and interactions, and how these factors changed over time and influenced the planning process. Conceptual models for dam removal and environmental planning developed by the Heinz Center (2002), the American Society of Civil Engineers (ASCE, 1997), CONCUR, Inc. (CONCUR, 2009), the US Army Corps of Engineers, and river restoration experts were reviewed to craft a conceptual planning process model. This model was applied to case studies through a comparative time series analysis (Yin, 2009) to discern similarities and differences in the case study planning processes. Case study evaluation included an assessment of the likelihood of achieving desired project benefits and undesired consequences, forming a set of common risks and case study specific tradeoffs. Review of power and process diagrams, interview responses, planning literature, and background literature led to crafting a set of lessons learned from each case study, and recommendations for future consideration in dam removal planning.

CHAPTER 3: Conceptual Framework

Dam removal is a politically complex process that requires the involvement of many actors in varying capacities. Therefore, development of a conceptual framework to conduct a comparative analysis is necessary to distill similarities and differences among the case studies, leading to further refinement of this information into a set of lessons learned and recommendations for future dam removal projects. The conceptual framework is three-fold, examining actors, processes, and benefits and risks of dam removal. First, actors involved in dam removal and their roles and responsibilities are presented to illuminate the power structure among entities involved in dam removal planning. Second, a conceptual process model for dam removal planning is illustrated based upon review of precedent models for dam removal and environmental planning. Finally, an assessment of the likelihood of achieving common benefits of dam removal as compared with associated risks contributes to forming tradeoffs associated with each case study. This third component includes consideration of inherent uncertainty in scientific elements incorporated into dam removal planning. The following presentation will introduce the conceptual framework used to analyze the case studies presented in Chapter 4.

Institutional Actors in the Dam Removal Planning Process

Several actors are frequently part of dam removal planning. These include governmental and non-governmental entities, as well as local residents. Government actors are involved because of permitting and regulatory roles mentioned above, as well as their ability to provide substantial funding for large infrastructure projects pending Congressional approval. Non-governmental entities serve is a variety of capacities, and tend to have an advocacy focus in their activities. The dynamic nature of power relationships between these actors can significantly affect progress in dam removal planning.

OWNERS

Perhaps the most important actor to engaged in dam removal is the owner of the dam. Owners of dams in the Coast Ranges used for water storage are either government agencies or private entities. Without the owner's support for at least exploring dam removal, this option will not gain very much traction, unless there is a legal mandate binding the owner to removing the dam. At various times in the removal process, dam owners hold significant amounts of power regarding decisions about how and if the removal planning process moves forward, depending on how the power relations among other actors in the process change over time.

ELECTED OFFICIALS

Elected officials across all levels of government are often important players in dam removal because of their political influence and power. Dam removal is expensive, requiring continuous funding which elected officials are usually charged with authorizing through budget votes. Elected officials can also put pressure on dam owners to seriously consider the removal option by pointing out legal obligations and potential liabilities owners face if a dam is not dealt with. Politicians can also direct various agencies under their auspices to pursue removal studies. While elected officials may not be physically present at all dam removal planning meetings, their role can at times be described as an invisible hand maneuvering funding streams to keep planning progress moving forward.

FEDERAL AGENCIES

United States Army Corps of Engineers (the Corps)

The Corps is almost always involved in dam removal from a regulatory perspective because of their permitting authority specified in Section 404 of the Clean Water Act and Rivers and Harbors Act for non-federal projects (Bowman 2002). However, with regards to federal projects, the Clean Water Act states that:

'the discharge of dredged or fill material as part of the construction of a Federal project specifically authorized by Congress... is not prohibited by or otherwise subject to regulation under this section,... if information on the effects of such discharge... is included in an environmental impact statement for such project pursuant to the National Environmental Policy Act of 1969 and such environmental impact statement has been submitted to Congress before the actual discharge of dredged or fill material in connection with the construction of such project and prior to either authorization of such project or an appropriation of funds for each construction'

(Section 404.H.1.r.)

Therefore, the Corps is not required to complete wetland delineations or dredged material management plans for sediment excavated from reservoirs they manage because all Corps projects are federal projects specifically authorized by Congress. The Corps must complete an Environmental Impact Statement under NEPA, regardless of the federal or non-federal nature of the project (Bowman, 2002). This would include carrying out a public interest review, and determining the impact of dam removal on wetlands, aquatic organisms, water quality, navigation, economics, and social factors (Fischenich et al, 2006).

Pursuant to Section 206 of the Water Resources Development Act (WRDA) of 1997, the Corps may assist state or local government agencies in planning, designing, and building projects to restore aquatic ecosystems, including dam removal (USACE, ____a). Corps involvement in these types of projects begins with a reconnaissance study which the Corps will fund up to $100,000, followed by a feasibility study typically funded in partnership with a local partner. Certain types of projects may be eligible for specified amounts of funding ranging from $1,000,000 to $7,000,000 under the Corps Continuing Authorities Program (USACE, ____b). Following approval and Congressional authorization of the preferred alternative identified in the feasibility study, progress will continue between partners for construction, real estate acquisition and monitoring (USACE, ____a). Approval is contingent upon response to public comment, and compliance with "Principles and Guidelines" governing water resources planning (USACE, ____a). If a project, such as dam removal, is deemed feasible, the Corps will assume 65% of design and construction costs, with the remaining

35% assumed by the local partner (USACE, ____a). Federal funding is dependent upon Congressional authorization specified in a Water Resources Development Act (WRDA), which is voted on by Congress every two to three years.

United States Bureau of Reclamation (the Bureau)

Like the Corps, the Bureau owns and operates dams, primarily in the western United States. The Bureau is the largest wholesaler of water in the west and the second largest producer of hydropower (USBoR, 2010). Most of the Bureau's recent activities are related to managing aging water supply infrastructure, including dams and reservoirs, while maintaining supply obligations (USBoR, 2010). The Bureau provides substantial technical support to dam removal projects, specifically through appraisal studies which include investigating and modeling sediment transport, hydrology, and physical removal scenarios (USBoR, 2010). The Bureau does not have a formal planning and cost-share mechanism like the Corps, which limits its ability to act as a project manager for removing dams other than those that the Bureau owns and operates. The Bureau can function as a contracted entity to provide technical expertise as requested by other agencies leading a project.

National Marine Fisheries Service (NMFS)

NMFS has regulatory authority under the Endangered Species Act (ESA) to develop and implement plans for the conservation of federally listed endangered fishes that are commercially important for the nation's economy, such as most salmonid species. NMFS issues biological opinions under Section 7 of the ESA for projects subject to federal permitting, like dam removals (Bowman, 2002). NMFS may also conduct biological studies as part of a dam removal planning to evaluate baseline fisheries conditions, and assess how removal will affect a fishery (Bowman, 2002). Funding for NMFS involvement in dam removal projects is dependent on their annual budget (B. Cluer, personal communication, 3/10/10).

United States Fish and Wildlife Service (USFWS)

Like NMFS, USFWS regulates activities affecting endangered species listed under ESA. USFWS makes determinations about how proposed projects will affect listed species, and if mitigation activities are necessary to protect endangered species habitat. Mitigation can include recreating habitat in areas outside of where it was originally impacted (Bowman, 2002). Also like NMFS, USFWS involvement in dam removal is dependent on their annual budgetary allocations.

CALIFORNIA AGENCIES

Department of Water Resources, Division of Safety of Dams (DSOD)

DSOD is responsible for carrying out dam safety inspections on all dams that meet its threshold requirements as previously described. If a dam is found to be structurally unsound in an annual inspection, DSOD can legally mandate the owner to remove the dam (DSOD, _____).

Department of Fish and Game (CDFG)

CDFG is responsible for protecting California's fish and wildlife populations through implementation of codes. Most relevant to dam removal are codes stipulating activities that will alter streambeds (CDFG Code 5900 - 6100). If CDFG finds that a dam owner altered a downstream streambed through a sediment release or other activity, CDFG can request the local legal entity to issue a mandate requiring the owner to remove the dam to prevent that alteration from occurring again. CDFG also conducts studies on in-stream aquatic populations from time to time, and may consult on engineering and geomorphology aspects of dam removal projects (M. Whitman, personal communication, 2/10/10).

California Public Utilities Commission (CPUC)

The CPUC regulates privately owned utility providers, including water supply providers. They function as a consumer protection agency to ensure that reliable utility service is provided at a reasonable rate while not causing significant environmental harm or detriment to California's economy (CPUC, 2010). If a dam removal will result in reduction of a water suppliers' available storage or a significant change in water supply rates, the CPUC will work with the entity it regulates to ensure that ratepayers do not bear a significant burden as a result of removal (J. Klein, personal communication, 1/25/10).

California Regional Water Quality Control Boards (RWQCB)

RWQCBs are responsible for ensuring that water quality in a region's rivers and streams meet quality standards through various management programs. In relation to dams, the local RWQCB is responsible for making sure that a dam does not compromise downstream water quality, and that water quality is not significantly impacted during the removal process. Removal projects that involve dredging sediment from behind a dam require a Water Quality Certification permit.

California Coastal Conservancy (The Coastal Conservancy)

For dams located within coastal watersheds, the Coastal Conservancy may become involved in removal projects if requested by project planners and managers to provide partnerships services that relate to the Conservancy's goals of protecting and restoring coastal watersheds, waters and streams (California Coastal Conservancy, 2010). The Conservancy has a unique role, frequently serving as an intermediary among government, citizens, and the private sector in a non-regulatory, problem solving function. In dam removal planning, the Conservancy can act as a coordinating entity among the various jurisdictions and agencies that have a regulatory role in dam removal. The Conservancy can also assist in identifying and securing funding for dam removal, as well as providing grants to other entities to fund studies related to dam removal.

LOCAL AGENCIES

Local agencies relevant to dam removal vary depending upon who the dam owner is and how removal is initiated. In most cases, standard land use review procedures are followed to ensure compliance with the local government's (city or county) general plan and zoning ordinances, and a building permit is required from the local agency for any construction or grading activities. Other than the local government, various municipal districts may have control over a river or its catchment, such as flood control or watershed protection districts. Where multiple jurisdictions have control over river functions, a joint powers authority (JPA) may be created to "jointly exercise any power common to the contracting parties," as per an established legal agreement (California Government Code, Section 6502). Local agencies can engage in a cost share with the Corps to fund the dam removal project, as described above.

NON-GOVERNMENTAL ENTITIES

Dam removal is advocated for by several non-governmental entities in California who often have a focus on environmental protection. Input from these groups may be sought by government agencies and elected officials through invitation to advisory committees, and comment on publicly available plans. Non-governmental organizations also analyze policy relevant to dams, and join with local communities to craft campaigns advocating for dam removal. These groups are vital for lobbying elected officials for initial and continuing project funding.

Several national environmental organizations are actively involved in proposing dam removal as a way to resolve concerns about ecological impacts from dams and safety. In relation to dam removal in the Coast Ranges, these include American Rivers, and local chapters of the national Surfrider Foundation, Sierra Club, and Trout Unlimited organizations. Within California, several state-based organizations are actively involved in dam removal projects and policy development, primarily with the objective of restoring river functions, such as Friends of the River, California Trout (Cal Trout), and the Planning and Conservation League Foundation (PCLF).

Numerous local environmental groups are often involved in dam removal projects that will significantly impact their local environments. These include watershed organizations, fishing groups, historical societies, and property owners associations. Depending on their level of involvement in a specific dam removal project, these groups can play a vital role in the planning and decision making process. Watershed based groups may collect data about water quality or population dynamics of aquatic ecological communities. This information can be used in preparing baseline conditions reports that inform feasibility and planning studies. Local organizations are valuable conduits for sharing information about a proposed dam removal project with other watershed residents. These groups also communicate values held by a community regarding intangible factors, such as the cultural or historic significance of a dam.

The following section describes development of a conceptual process model followed by the aforementioned actors in dam removal planning. Power distribution among actors can shift depending upon steps followed in the planning process, as illustrated in case study discussions in the next chapter.

Conceptual Planning Process

Dam removal planning is a complex and lengthy process that requires careful consideration of risks and benefits to reach decisions. Little legal guidance exists for how dam removal should take place, but several conceptual process models exist in environmental planning literature and practice, some specifically for various phases of the dam removal process. Several of these models were reviewed and refined to develop a systematic process for application to case studies, from which recommendations were developed for future dam removal planning efforts. They are described in brief below with accompanying diagrams.

ENVIRONMENTAL PLANNING PROCESS MODELS

Two environmental planning models developed for practical applications to large scale projects were reviewed as a basis for conceptual planning development: CONCUR Inc.'s Stepwise Agreement Building Model and the Corps' "beehive" planning process model. While neither of these models specifically addresses dam removal, they provide an iterative decision review processes which are used as frameworks for environmental planning efforts.

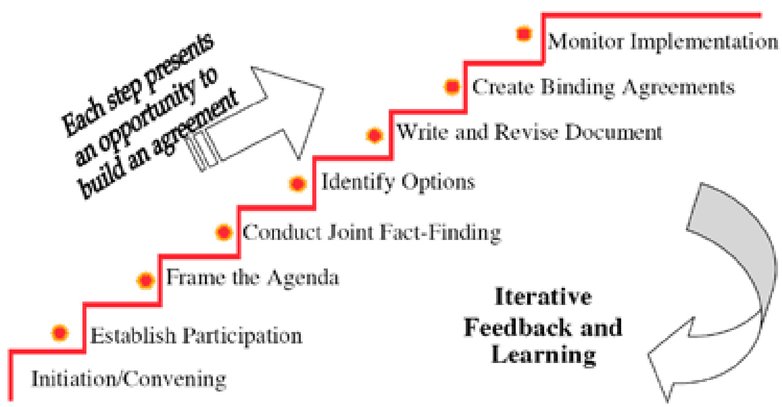


Figure 3-1. CONCUR Stepwise Agreement Building Model. (CONCUR Inc., 2009)

CONCUR Stepwise Agreement Building Model

Reaching a decision for a complex environmental undertaking, such as a dam removal, can be a contentious process requiring several rounds of negotiation between involved actors. The Stepwise-Agreement-Building Model developed by CONCUR (Figure 3-1) is one process employed in environmental decision making to navigate parties towards a consensus-based decisions (CONCUR, 2009). Each step represents an opportunity for parties involved to reach

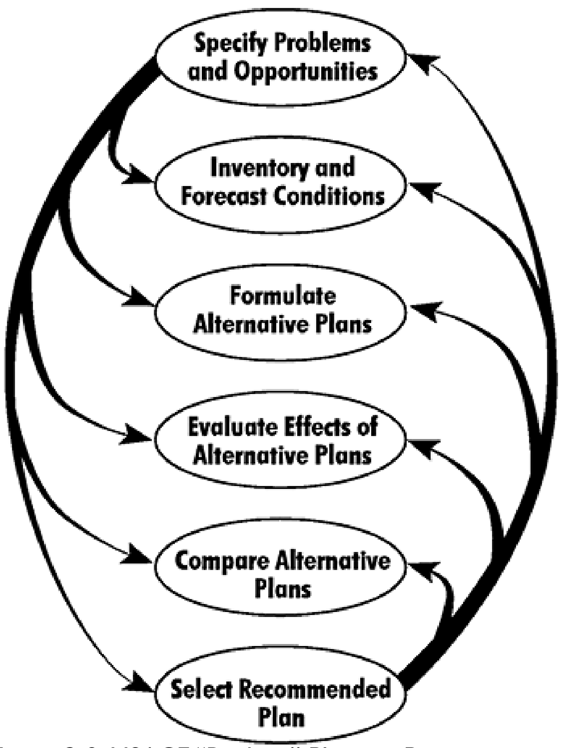


Figure 3-2. USACE "Beehive" Planning Process. (USACE, ____a)

an agreement required before moving forward with the planning process, with recognition that revisiting steps in the process is a necessary part of iterative negotiation (CONCUR, 2009). Producing a written document or agreement as the ultimate goal results in a binding agreement that can be referred to in the future when the process is revisited for monitoring or evaluation (CONCUR, 2009).

USACE Planning Process

As described above, the Corps is often involved in dam removal and aquatic ecosystem restoration projects due to their role in managing the nation's water resources, leading to application of their planning process as illustrated in Figure 3-2. Local entities identify a problem that is beyond their capacity to solve, and approach the Corps for assistance in resolving the issue. A request for federal approval is submitted to Congress to begin the reconnaissance and feasibility study phases, leading to alternative solution development and eventual selection. While the illustration suggests that the process is iterative, it is dependent on annual Congressional authorization for project budgets, which often leads to difficulty in advancing project planning in a timely manner. In addition, the Corps planning process does not substantially incorporate cooperation with other federal agencies that have significant roles in aquatic ecosystem restoration, such as NMFS or USFWS (USACE, ____a).

DAM REMOVAL PLANNING PROCESS MODELS

Three process models were reviewed that were developed specifically for river restoration and dam removal planning specifically in mind. They focus on more technical aspects of removal and restoration, although in a general conceptual manner that can be applied to removal projects across the United States, not specific to California's situation.

River Restoration Analysis Tool (River RAT)

River RAT (Figure 3-3) was developed by several scientists from NMFS and USFWS in consultation with other state and federal agencies to facilitate evaluation of potential impacts of proposed river restoration projects. Through answering a series

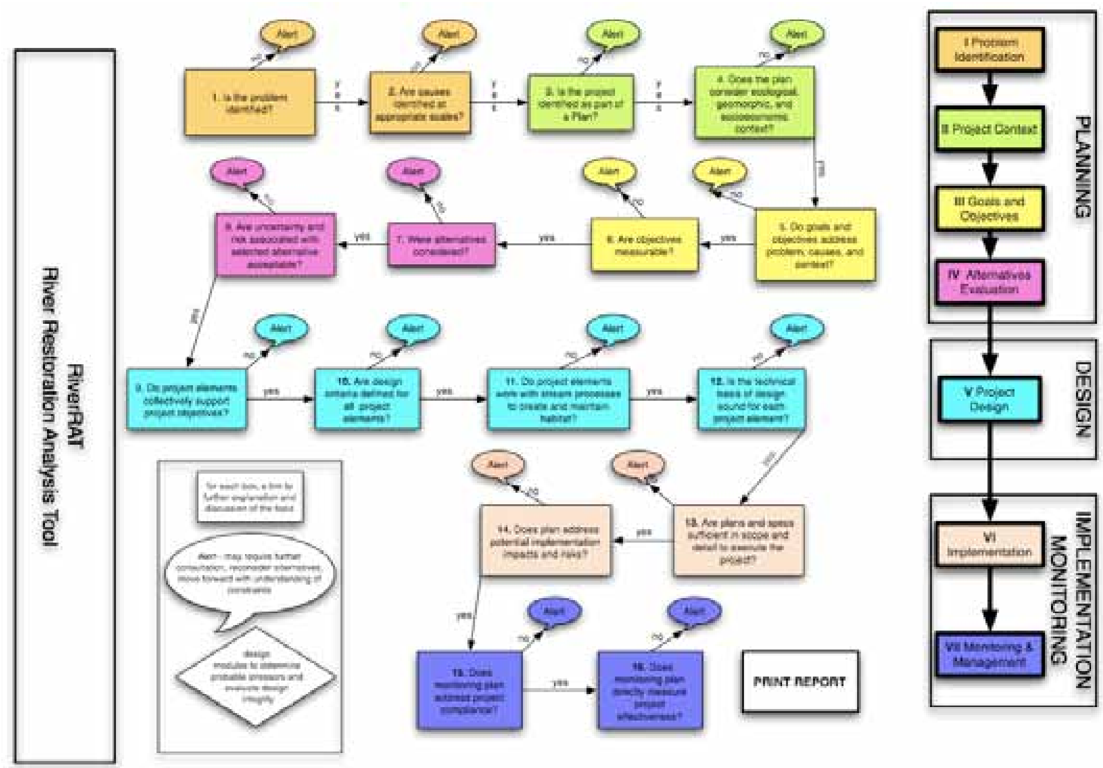


Figure 3-3. River Restoration Analysis Tool. (Skidmore et al, 2010)

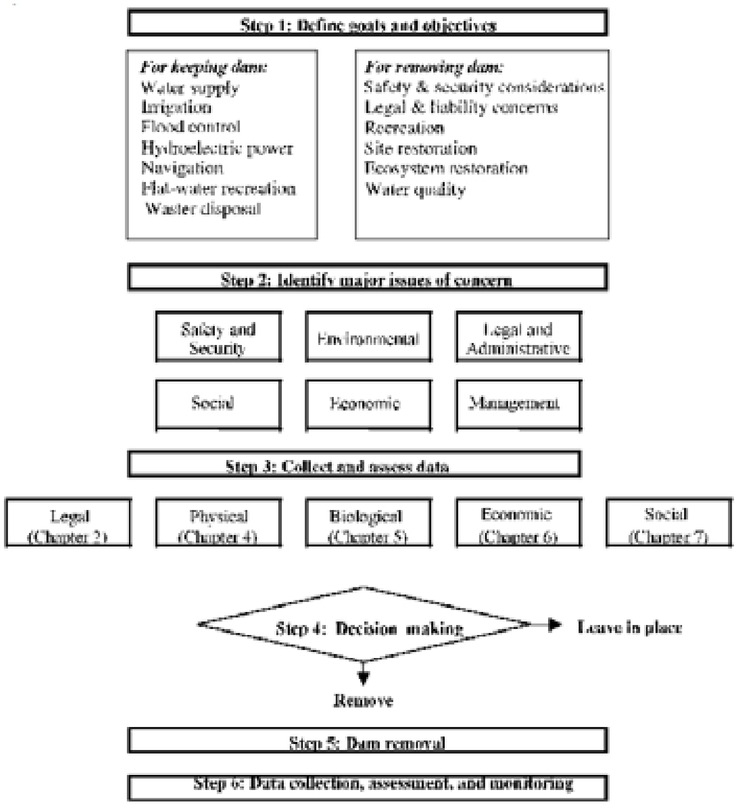


Figure 3-4. Heinz Center Dam Removal Decision Making Model. (Heinz Center, 2002)

of questions that parallel phases in restoration planning and implementation, the online tool enables professionals to assess restoration project potential for achieving measurable goals and objectives in consideration of technical aspects and risks posed by the project proposal. The questions provide guidance for ongoing project progress as well as review, and the emphasis on developing a monitoring plan specific to goals is necessary for successful completion (Skidmore et al, 2010).

Heinz Center Dam Removal Decision Making Model

The Heinz Center for Science, Economics and the Environment developed a model for dam removal decision making in 2002 to complement additional academic literature about dam removal (Heinz Center, 2002). The process focuses on how to reach a decision about dam removal by providing a framework to consider data and analyses (Figure 3-4). Steps in the process are:

1. Establishing goals, objectives, and sound basis for a removal decision, through collecting information about the environmental, social, economic, regulatory, and policy contexts

for a decision and its outcomes.

2. Identifying major issues of concern across a broad spectrum, from safety and security of a dam to culturally-related interests.

3. Assessing potential outcomes and gathering data about river operations; the dam; relevant policies and political mechanisms; and ecological, social, and economic systems associated with these elements. These assessments depend on evaluation of a series of indicators that provide insight into present and likely future conditions.

4. Making decisions within a framework that encompasses available knowledge about gains and losses, costs and benefits, public support and concerns, and private and public interests.

The focus of this process is reaching an agreement about whether or not to remove a dam. This model was developed with small dam removals (< 1,000 AF reservoir capacity) in mind, which are the most common type of dams removed (Heinz Center, 2002). Additional factors need to be carefully examined when deciding to remove large dams. The role of public participation is not clearly incorporated into this model, which may result in a more iterative process as additional information and perspectives are interjected by the public. Other process models are necessary for guiding planning and execution of the actual removal, such as through the following described process.

American Society of Civil Engineers (ASCE) Guidelines for Retirement of Dams and Hydroelectric Facilities

The ASCE "Guidelines for Retirement of Dams and Hydroelectric Facilities" were created in an effort to guide dam retirement efforts for aging dams nationwide (ASCE, 1997). The process (Figure 3-5) was developed with the awareness that no one set of guidelines applies to the various types of dams present in the United States, but certain information should be collected to inform assessment and implementation methods, and techniques for evaluating costs and benefits (ASCE, 1997). This recommended

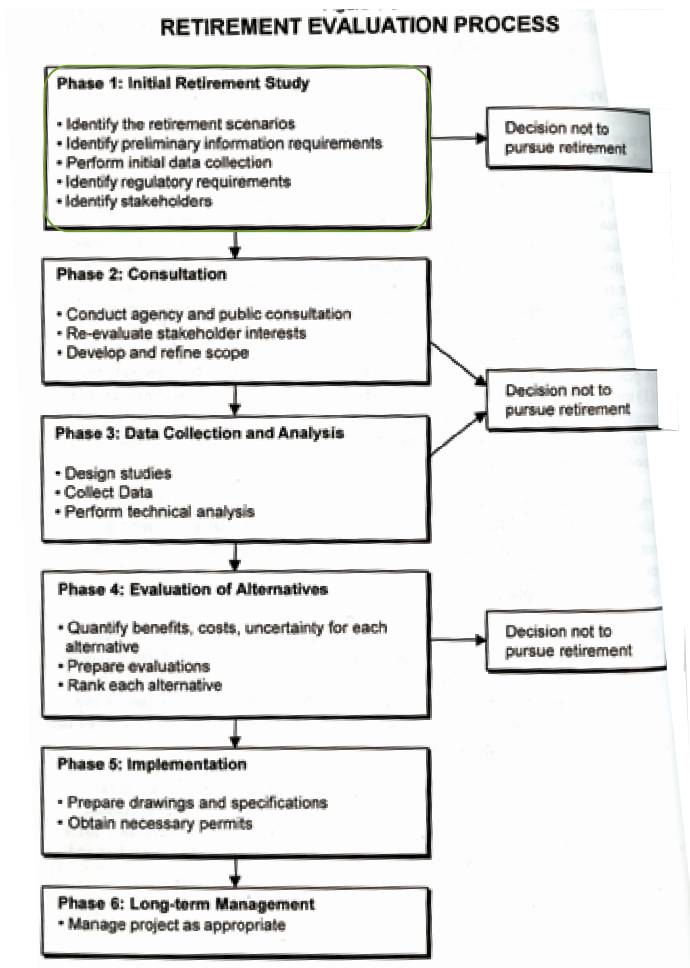


Figure 3-5. ASCE Retirement Evaluation Process (ASCE, 1997).

model has the strongest parallels with the Corps' process for civil works projects, beginning with the initial retirement study, followed by public consultation, additional data collection, and evaluation of alternatives and final selection of an alternative to be implemented. However, the linear presentation of this process does not consider the need for iterative refinement of data and alternatives, particularly as public input is incorporated into the process.

CONCEPTUAL PROCESS MODEL FOR DAM REMOVAL

Individual application of the models to case studies results in limited treatment of one specific portion of the dam removal process, and reveals a lack of consideration for public participation and input in several phases. Through synthesizing these models, a conceptual process model for phased dam removal planning was crafted to drawing upon their individual strengths and commonalities. This model was originally developed through individual application of CONCUR, Inc., Heinz Center, and ASCE precedent model examples to the Matilija Dam case study (Figure 3-6), which is the furthest along among the case studies. It was additionally refined following case study interviews, during which some people who were interviewed suggested additional models for consideration and provided specific information about the dam removal planning case they were familiar with. The final conceptual process model is presented in Figure 3-7.

As outlined in the Heinz Center model, several factors should be considered and assessed in relation to goals and objectives when deciding whether or not dam removal is an appropriate solution for contextual problems. The initial appraisal phase should be iterative as data is collected to establish baseline conditions, and goals and concerns are articulated in relation to existing project conditions. Once a removal decision has been reached by the relevant authority, typically the dam owner, a coalition of interested parties who will be involved at various phases in the process should be compiled, with a clearly identified coordinating entity maintaining consistent engagement throughout the project. This coalition assesses project feasibility and alternatives development through an iterative stepwise process which may require revisiting certain steps following public input. When an alternative is

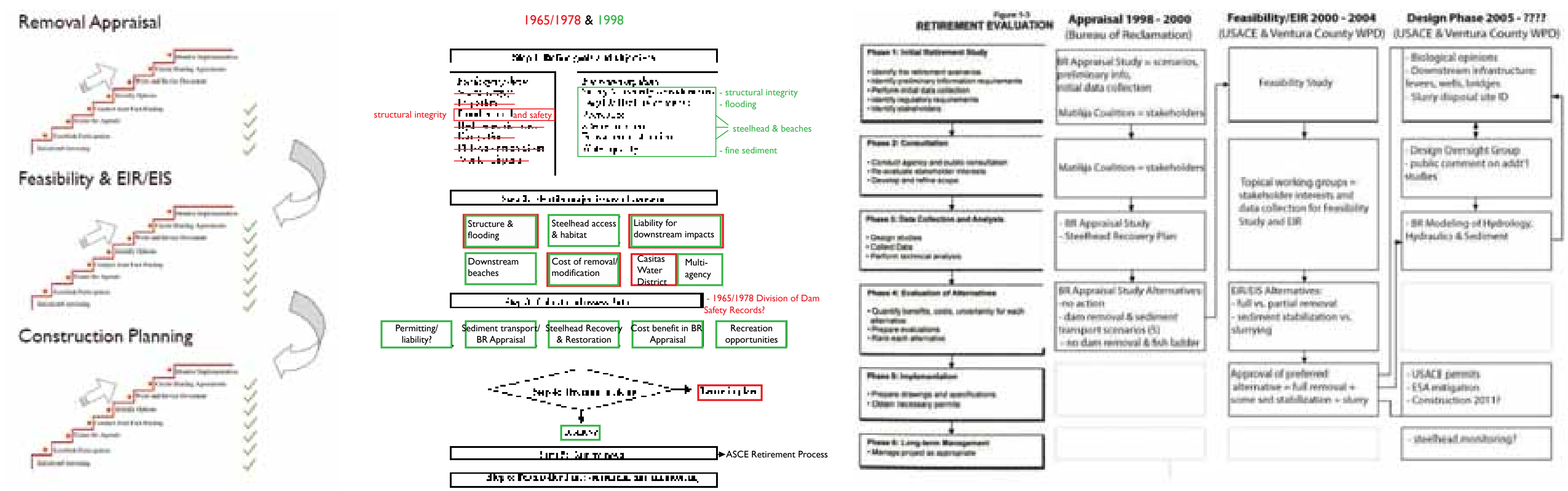


Figure 3-6. Precedent process model application to Matilija Dam: CONCUR (left), Heinz Center (center), and ASCE (right).

selected and approved, further studies in the implementation phase should inform development of a monitoring plan. This plan should incorporate adaptive management principles, recognizing that dam removal is inherently experimental and involve varying degrees of uncertainty for project components, which may require future corrective actions.

While dam removal is a very political process, science plays a significant role in influencing the political decisions that allow dam removal projects to move forward. These decisions can be framed in the context of evaluating the likelihood of achieving benefits against risks posed by dam removal. The following section presents several factors relevant to these judgements, and common tradeoffs that are the results.

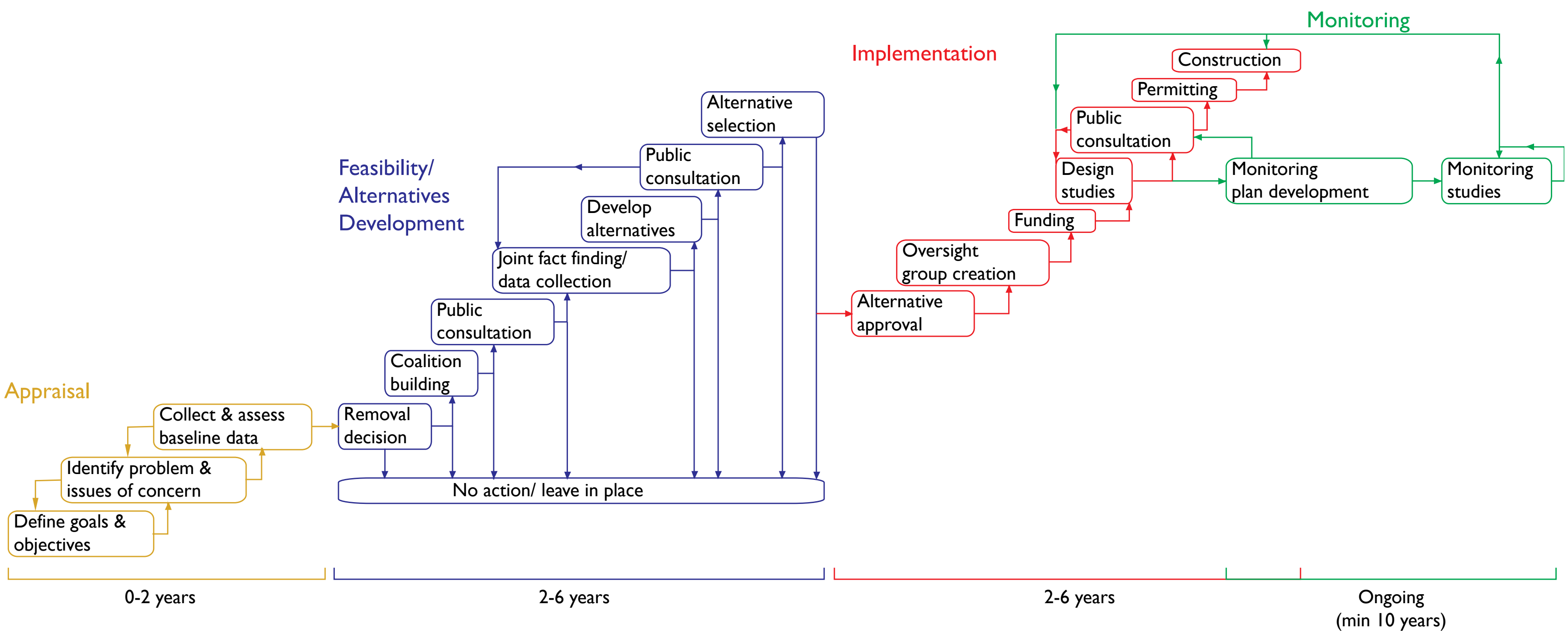


Figure 3-7. Conceptual process model for dam removal.

RISKS IN DAM REMOVAL PLANNING

Because dam removal is a relatively new field, there are limited precedents to reference when attempting predict dam removal outcomes. Therefore, dam removal efforts draw upon existing understanding of hydrology, geomorphology and ecology in an effort to predict how a river and its surrounding ecosystem will respond to a dam removal. These variables contain assumptions and introduce elements of uncertainty in discerning the likelihood of achieving desired benefits and undesired consequences from removing a dam, or the risk of project success or failure (Aven, 1992 in Bea, 2009). Common desired benefits of dam removal include increased fish passage, sediment transport, restored downstream habitat, decreased threat of structural failure, and increased recreational opportunities. Undesired consequences include impacts to sensitive species, compromised water quality, loss of upstream habitat, increased flood risk, and loss of water supply.

Uncertainties that contribute to risks come from either inherent variability, technical sources, or organizational factors (Moan, 1993a & 1993b in Bea, 2009). Dam removal planning relies heavily on predictive modeling and to determine the likelihood of achieving benefits and resulting consequences (Randle et al, 2010). Model results are derived from baseline data and assumptions about river and ecosystem functions (Randle et al, 2010; Hart et al, 2002). For example, it is often assumed that the ecological impacts caused by a dam can be reversed by removing it (Hart et al, 2002). However, the limited number of dam removals performed to date, combined with the limited number of completed post-project appraisals, provide inconclusive results about the success of dam removal for ecological restoration (Gilbreath, 2006). Additionally, scientific results regarding the probability of outcomes often do not match the high level of certainty required by policies and permitting entities (Wilcock et al, 2003). The substantial cost of dam removal is an investment risk for funding partners, who are likely hesitant to fund project components that do not reliably demonstrate maximum benefit potential or may pose significant liabilities that they may be held responsible for if a catastrophic event occurs during or post-dam removal (Skidmore et al, 2010). While consensus can be reached among project partners about how risk and uncertainty are handled internally, challenges can arise when this information is communicated to the public. Post-removal liability is a substantial political consideration that depends upon accurate science to protect the responsible entity from future legal actions by affected parties.

Presenting benefits and consequences as tradeoffs along a spectrum of values is one technique for guiding risk management (Figure 3-8) (Stoelsnes & Bea, 2005). Dam removal requires continual consideration of tradeoffs between the aforementioned benefits and consequences and resulting risk. Negotiating tradeoffs requires extensive scientific review in each phase of the removal planning process, specifically in appraisal, alternatives analysis & selection, and design development. Benefits and consequences listed in Figure 3-8 are common factors in dam removal in coastal California, but may not be applicable to all situations. The following is a review of these benefits and consequences, and scientific methods used to determine the likelihood of these outcomes.

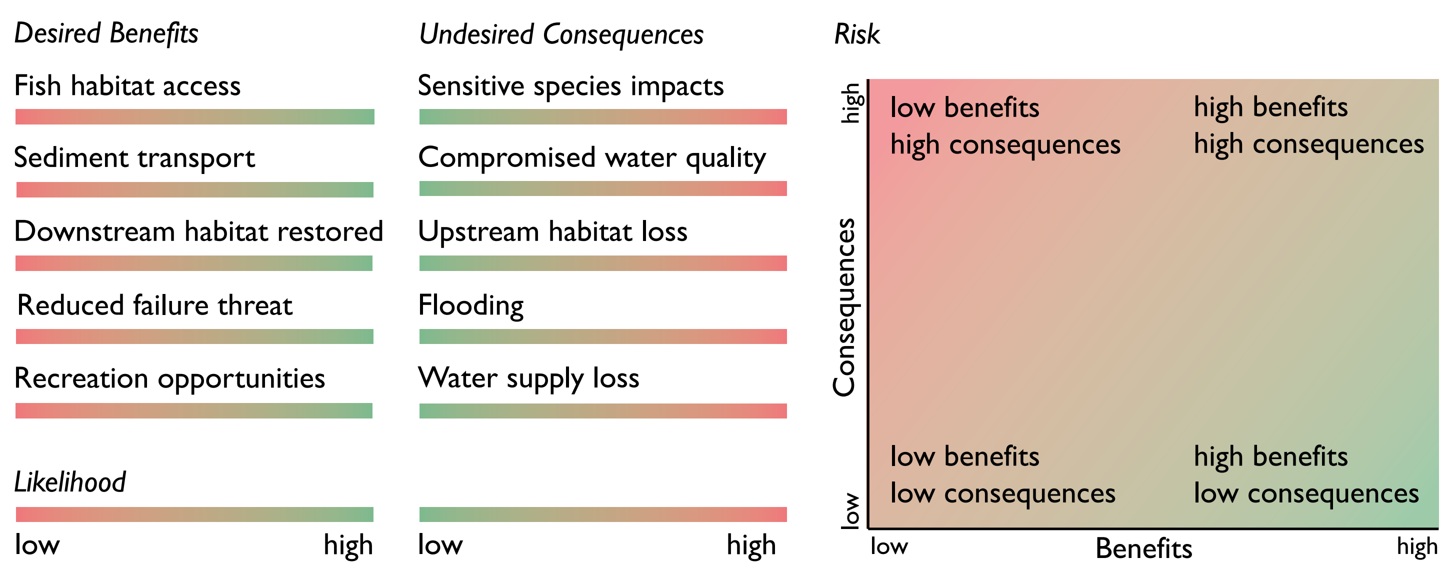


Figure 3-8. Benefits & consequences spectrum.

Desired Benefits

FISH PASSAGE

Where dam removal is proposed for anadromous fish recovery, it is often assumed that providing access to critical spawning areas will lead to population recovery (Hart et al, 2002). The quality and quantity of this habitat should be evaluated on a species specific basis through field assessments of spawning gravel availability, fine sediment dynamics, presence of pool habitats, and other elements of spawning habitat structure (Hart et al, 2002; Minear, 2003). While a degree of fish passage can be achieved by installing a fish ladder, removing a dam increases the likelihood that greater numbers of fish will be able to access upstream spawning grounds than those that are able to pass through a ladder (American Rivers, 1999). Developing a quantitative estimate of the number of fish likely to access upstream habitat post-removal is a useful input for cost benefit analyses (Whitelaw & MacMullan, 2002). Fish population studies should be conducted pre-, during, and post-removal for the anadromous species in question (Stanley & Doyle, 2003).

SEDIMENT TRANSPORT

Re-establishing a river's natural flow regime post-removal affects rates of sediment delivery to downstream reaches, which in turn alter channel evolution, and associated biogeochemical processes and habitat availability (Hart et al, 2002). Predicting how a river will behave post removal requires examination of pre-dam hydrographs and upstream catchment sediment yield rates (Randle et al, 2010). Sediment management is a particularly significant component of dam removal projects, especially in in-filled reservoirs. Because dams block sediment transport downstream, figuring out what to do with the stored sediment and how to re-establish transport functions while minimizing undesired downstream consequences is a complex problem in dam removal.

Assessments of sediment-related impacts from dam removal projects currently do not follow a standard methodology. However, the Subcommittee on Sedimentation (SOS) of the Advisory Committee on Water Information of the Water Information

Coordination Program is in the process of developing guidelines for assessing sediment-related effects of dam removal (Randle et al, 2010). Sediment transport is often examined in dam removal planning through modeling various scenarios of channel response, which depend upon sediment size, channel slope, flow magnitude, and dam removal methods (Hart et al, 2002). Models are used to select the most appropriate sediment management method given factors such as the amount and type of impounded sediment and downstream conditions (presence of infrastructure, communities, etc.). In general, sediment is believed to move either via dispersion, the decay of sediment supply in place and gradual transport, or translation, a wave of sediment that propagates downstream (Pizzuto, 2002 in Gilbreath, 2006). Several sediment transport models are commonly used in dam removal planning to predict channel change post-removal (Table 3-1).

Model Name	*Use*	*Description*	*Limitations*
HEC-2	Floodplain model	1 - D energy equation model to compute WSE at specific locations for given flows. Based on Standard Backwater Method, where energy losses due to friction are evaluated with Manning's equation. Assumes steady, gradually varied flow, and small slopes. Requires discharge at cross section, and channel and structure survey information (e.g. slope).	
HEC-RAS	Stepback model	1 - D, natural and constructed channels (1) steady flow WSE, (2) unsteady flow simulation, and (3) moveable boundary sediment transport calculations ("integrated approach" unlike HEC-2)	
HEC-6T	Sediment routing model	1 - D, numerical model to predict changes in river profiles resulting from erosion/deposition over moderate time periods. A continuous flow record is partitioned into series of steady flows of variable discharges and durations. For each flow a WSE is calculated thereby providing the energy slope, velocity, depth, etc. at each cross section. These rates, combined with the duration of the flow, permit volumetric accounting of the sediment within each reach. Amount of erosion/deposition within each reach is then computed and the cross section is adjusted accordingly. The computations proceed to the next flow beginning with the updated channel geometry.	Simulates vertical changes in bed elevations only, not bank erosion and lateral channel migration directly. Originally designed to for analyzing long-term river and reservoir behavior rather than the response of streams to short-term, single event floods (although it has successfully been applied to these situations). Doesn't predict watershed sediment yield - upstream sediment supply is a user-defined input variable.

Table 3-1. Commonly used sediment and hydraulics models for dam removal planning. Adapted from work done by Sarah Richmond.

The SOS guidance proposes that sediment impact risk is the product of the probability of the impact and the consequence of the impact (Randle et al, 2010). Characterizing the nature of the reservoir sediment and modeling transport scenarios allows determination of the impact probability (Randle et al, 2010). Associated consequences include bed aggradation from sediment releases, which can increase flood risk to downstream communities adjacent to the river (Hart et al, 2002). Attempts to mitigate these consequences include improvements to downstream infrastructure to reduce future liabilities.

DOWNSTREAM HABITAT RESTORATION

Empirical findings support theories of downstream habitat response following dam removal (Gilbreath, 2006). Increased nutrient transport to downstream reaches following removal can enhance in-stream, riparian, and estuarine ecological communities (Wildman, 2006; Pejchar & Warner, 2001). Sediment transport post-removal can mitigate in-stream impacts such as channel incision that occurred due to the former upstream dam holding back sediment (Hart et al, 2002). Fine sediment contributions from upstream can also help re-establish coastal wetlands, and add sand to beaches (Pejchar & Warner, 2001). However, downstream habitat response is difficult to predict, depending upon the type of sediment, channel slope, and flow magnitude (Hart et al, 2002).

REDUCED DAM FAILURE THREAT

As dams age and sediment builds up, stress on the structure can lead to cracking and pose safety risks (American Rivers, 1999). Dam failure could seriously damage downstream property and threaten lives (American Rivers, 1999). Many dams nationwide continue in operation beyond their expected lifetimes, and removing a dam reduces the risk that failure will occur (American Rivers, 2009). Quantifying the resulting damages due to potential dam failure can contribute to cost-benefit analysis of alternatives developed in dam removal feasibility studies (Whitelaw & MacMullan, 2002).

RECREATION OPPORTUNITIES

Recreational use of a former reservoir will be lost through dam removal, but may increase downstream recreation opportunities (Heinz Center, 2002). Reestablishing a free flowing river increases access for recreational boaters and others to enjoy a contiguous reach. Increased sand transport nourishes downstream beaches and mitigates the impacts of beach erosion, a common problem in coastal California (Pejchar & Warner, 2001). Economic studies quantifying recreation benefits of dam removal for surrounding communities can contribute to a supporting case for access to funding sources for removal.

Undesired Consequences

SENSITIVE SPECIES IMPACTS

Dam removal can eliminate habitat of sensitive species, particularly wetland species that inhabit backwater reservoir sediment deposits. The threatened California red-legged frog (*Rana draytonii*) is found in some wetlands near reservoirs that are nearly full of sediment (Pejchar & Warner, 2001). Data about threatened species populations should be collected as part of baseline conditions studies for appraising dam removal. Mitigation for wetland habitat loss can occur as part of channel reconstruction following dam removal.

COMPROMISED WATER QUALITY

Supersaturation, or sudden increase in velocity and air pressure above natural conditions, can occur post-dam removal and impact in-stream conditions that organisms depend upon (Bednarek, 2001). Substantial release of fine sediment can compromise downstream water quality, which is a particular problem in areas where downstream diversions provide drinking water supply (Bednarek, 2001). In coastal California, increasing freshwater releases from upstream may impact downstream salinity flux in estuarine environments (Pejchar & Warner, 2001). If sediment contained behind a dam contains contaminants, toxic sediment could flow downstream following a removal, as occurred with the removal of the Fort Edwards Dam on the Hudson River (Bednarek, 2001). Pre-removal studies and monitoring can reveal the extent of sediment contamination, and management options include dredging or capping the contaminated sediment in place.

UPSTREAM HABITAT LOSS

As previously mentioned, wetlands often form in reservoir sediment deposits. Lacustrine species in a reservoir could be eliminated following dam removal. Short term impacts during removal activities are likely to disturb habitat upstream of a dam (Bednarek, 2001). Upstream habitat conditions pre-removal should be characterized and monitored post-removal, and adaptive restoration techniques should be put in place to mitigate undesired impacts from removal.

FLOODING

Sediment transport to downstream reaches following removal can lead to bed aggradation, which can could exacerbate flood impacts in reaches already susceptible to flooding, especially in urban areas where floodplains are developed. Sediment transport and hydraulics studies contribute to understanding how flood conditions may change following removal, but these often rely on models with have inherent degrees of uncertainty. A common mitigation measure is to reinforce downstream levees before a dam is removed (Heinz Center, 2002).

WATER SUPPLY LOSS

Eliminating a reservoir by removing a dam results in loss of water supply storage, although that storage capacity may be already diminished through sedimentation as described earlier. Dam removal can change flow regimes, affecting water rights holders along the river and to the former reservoir. New water diversions downstream of a former reservoir may be installed to maintain water allocation, which in California would most likely result in some form of legal action to maintain the water right and not injure additional water rights holders along a river (Pejchar & Warner, 2001).

The benefits and consequences of a dam removal on surrounding communities will vary depending on watershed characteristics. The following chapter presents background information and analyses of five dam removal planning case studies with varying contexts within the California Coast Ranges. Case study discussions are organized using the conceptual framework presented in this chapter for analyzing actors, process, and risks.

CHAPTER 4: Case Studies

The five case studies selected for this thesis have several attributes in common as described in the: location in the California Coast Ranges, infilled reservoirs, and socioeconomic characteristics of downstream communities. Their dam removal planning efforts have some similar actors, and are subject to many of the same regulations. However, differences in the dynamics between these actors, planning process steps and timing, and treatment of risks provide enlightening lessons for dam removal. Case studies are presented beginning with background information, summarized in Table 4-1. The criteria identified by Pejchar and Warner (2001) were used as a framework through which background information is presented (Appendix B). Following this information is an analytical discussion of actors, process and risks through the frameworks described in the preceding chapter. Evaluation of risks for each case study are scaled in relation to the other case studies and the size of the project.

Dam name	*Year Built*	*Height (ft)*	*Original Purpose*	*Original Capacity (AF)*	*Remaining Capacity (AF)*	*Impounded Sediment (yd^3)*	*Sediment Management Proposal*	*Primary Removal Reason*	*Upstream reach (mi)*
Upper York Creek	1900	50	Drinking water supply	30	0	28,100	Mechanical removal	ESA - Steelhead	2
Searsville	1892	68	Drinking water supply	1,365	~100	~1,000,000	Mechanical removal	Upstream flooding	10
San Clemente	1921	106	Drinking water supply	1,425	125	2,500,000	Stabilization and natural transport	Dam safety	5
Matilija	1948	168*	Drinking water supply	7,018	<500	6,100,000	Mechanical removal and upstream stabilization	Dam safety	18
Rindge	1926	102	Irrigation	574	0	800,000	Mechanical removal	ESA - Steelhead	6

Table 4-1. Case study characteristics.
*Originally 198 ft, height reduced post 1968 & 1975 notchings.

Upper York Creek Dam

BACKGROUND INFORMATION

Upper York Creek Dam (Figure 4-1) is an 50 foot high and 140 foot long earthen dam, and impounds York Creek approximately a mile and a half west of downtown St. Helena in Napa County (Figure 4-2) (Prunuske Chatham Inc., 2007). York Creek is a tributary to the Napa River, and flows from the eastern side of the California Coast Ranges in western Napa County (USACE & City of St. Helena, 2007b). The upper watershed is sparsely populated in contrast to the downstream watershed, which includes downtown St. Helena and several vineyards (USACE & City of St. Helena, 2007b). The watershed is almost entirely privately owned (USACE & City of St. Helena, 2007b).

The dam impacts the aquatic ecosystem by preventing the continuous flow of water and sediment, and prevents anadromous fish, notably steelhead trout, from accessing two miles of upstream habitat. Presently, the dam does not significantly impact downstream water quality. The dam's sediment trap efficiency is significantly diminished because the reservoir's original capacity of 30 acre-feet (AF) is nearly full of sediment with an estimated 28,100 cubic yards (Prunuske Chatham Inc., 2007). The dam is below

Figure 4-1. Photo of Upper York Creek dam and infilled reservoir. (J. Pollak, 4/8/08)

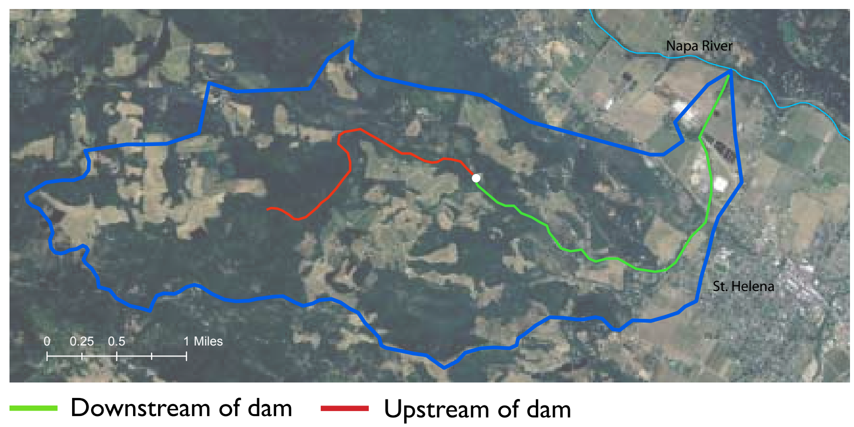


Figure 4-2. Upper York Creek dam location and watershed.

the height and reservoir capacity threshold for DSOD jurisdiction. The dam was initially built in 1900 to augment the water supply for the City of St. Helena (the City), which has owned and operated the dam and reservoir in since construction. The City has not significantly modified the dam since it was built. The City stopped using the reservoir for water supply storage during the 1980s, when sediment infilling was first identified and other water sources were identified (Prunuske Chatham Inc., 2007).

Four large fine-grained sediment releases have occurred since 1965 in an effort to increase reservoir storage capacity. The most recent and final sediment release accidentally occurred in 1992 during maintenance work on the reservoir outlet, which resulted in toxic sediment deposits travelling downstream to sensitive steelhead trout habitat. Bedrock in the area contains mineral compounds that can form asbestos when under pressure, such as in a reservoir (USACE & City of St. Helena, 2007b). Sediment deposits following this release were found as close as immediately downstream of the dam and as far away as .5 miles downstream (USACE & City of St. Helena, 2007a). CDFG reported that "dense anaerobic sediments, high in toxic hydrogen sulfide, were released from the dam and deposited in pool and riffle areas downstream, quickly suffocating and burying all fish and aquatic invertebrates within a mile or so of the dam" (USACE & City of St. Helena, 2007a). Following this finding, CDFG filed a complaint with the Napa County District Attorney's Office, which resulted in the City agreeing to remove the dam (FPIP, 2002a). Upon this court-ordered injunction, the City encountered several permitting delays related to approval of the "Dredge and Fill" permit required by the federal Clean Water Act Section 404 (USACE & City of St. Helena, 2007b).

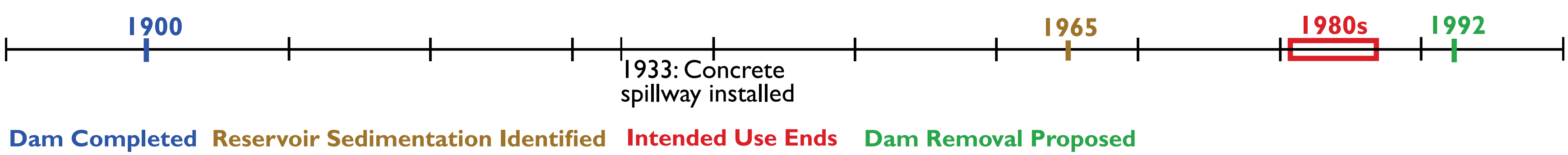


Figure 4-3. Upper York Creek Dam removal timeline.

In 2000, the NMFS designated York Creek as critical habitat for threatened steelhead trout as part of their designation of evolutionarily significant units (ESU) in California (NOAA, 2000 in Pejchar & Warner, 2001). This designation included the identification of Upper York Creek Dam as a "complete barrier to nearly two miles of high quality steelhead habitat" in the upper portion of the watershed (FPIP, 2002a). NMFS law enforcement sent a letter to the City clarifying the City's potential liability if they did not take action to restore steelhead access to critical habitat (USACE & City of St. Helena, 2007b). This prompted the City to meet with multiple federal, state, and local agencies in 2001 to discuss details of the dam removal project (USACE & City of St. Helena, 2007b). This resulted in the City entering into a cost-share agreement with the Corps as the local match partner for the Upper York Creek Ecosystem Restoration Project (USACE, 2006a). A small diversion dam about .25 miles downstream of the Upper York Creek dam was removed by the City in cooperation with DWR's Fish Passage Improvement Program, and DWR also provided technical assistance in preparing and funding studies necessary for obtaining permits (USACE, 2006a).

Several studies were conducted by consulting firms hired by the City to characterize the portion of York Creek that would be affected by dam removal, and to understand potential downstream flood risks that may be increased by dam removal (USACE & City of St. Helena, 2007b). Results from HEC-RAS modeling suggest that dam removal is unlikely to significantly increase flood discharge or timing (Prunuske Chatham Inc., 2007). However, sediment transport studies suggest that increases in sediment load following removal could cause the channel bed to augment downstream of the dam near bridges or along long reaches with a low gradient (Prunuske Chatham Inc., 2007). Local property owners, including several notable vineyards, expressed concerns about increased flood risks resulting from bed aggradation, and therefore would like the City to be held liable for any additional risk posed by removing Upper York Creek Dam.

ACTORS

The dynamics of the early years of the Upper York Creek dam removal planning process suggest that without bringing all the actors to the table at first, little can get done in dam removal planning. Despite legal action by CDFG and the Napa County Attorney General, and eventual listing of steelhead by NMFS, little progress could be made because of permit refusals by the Corps due to lack of information provided by the City in their permit applications. Lack of coordination across levels of government left the City with their hands tied, unable to move forward with removing the dam despite their legal commitment because they did not possess the necessary technical resources to meet permitting requirements. After nearly a decade of delays, additional threats of enforcement action from NMFS brought several government agencies to the table to coordinate their responsibilities and objectives,

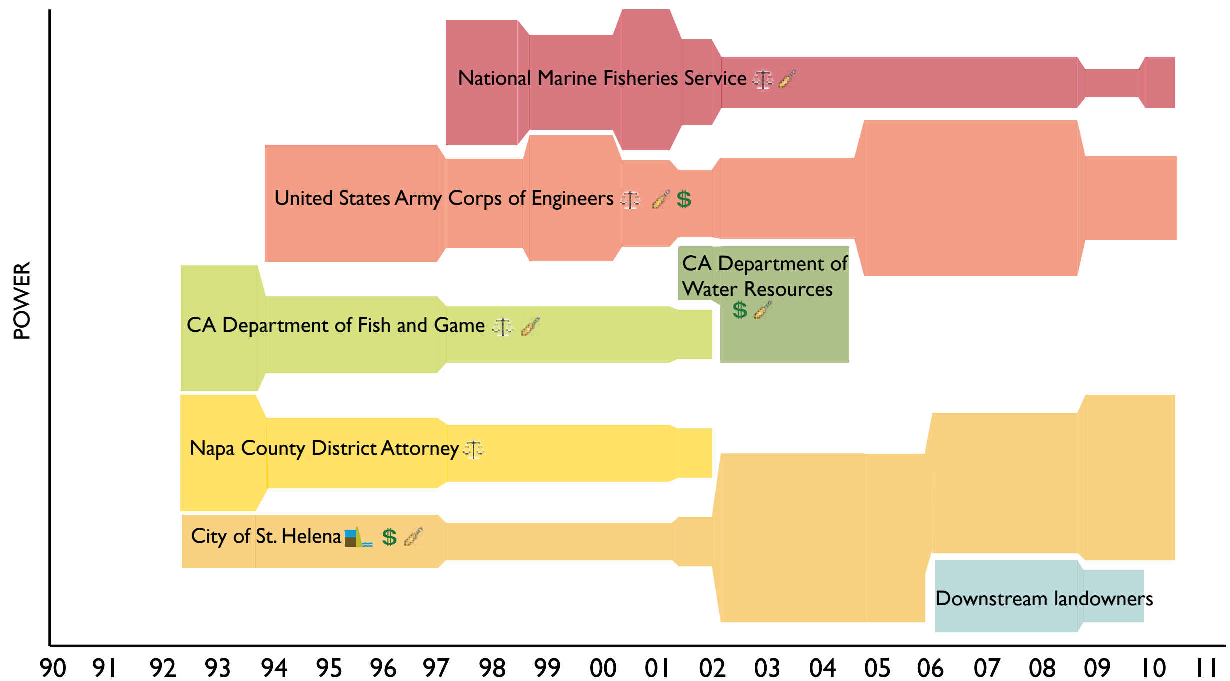


Figure 4-4. Upper York Creek power map. Dam Owner Regulator $ Funder Technical Supporter Advocate

and to provide assistance to the City to fulfill their obligations as dam owner. Progress was possible once all actors were present and coordinated across multiple levels of government, and monthly meetings facilitated by the Corps helped to establish trust relationships among project partners. (USACE & City of St. Helena, 2007b; J. Benegar, personal communication, 1/20/10).

This case study shows the difficulty that local governments have in pursuing dam removal without support from state and especially federal government agencies with technical expertise to provide important information and guide dam removals. In this instance, the Fish Passage Improvement Program was able to provide technical assistance in meeting federal permitting requirements, and joined with the city in removing a smaller downstream diversion barrier that would have prevented meeting objectives identified in planning for removing Upper York Creek Dam. Much of the information collected by DWR was used by the Corps and the City to prepare their feasibility study and draft EIR (USACE & City of St. Helena, 2007b). Additional information on fish populations and potential for increasing habitat access was provided by the Napa Resource Conservation District, which helped to Corps make a strong case of Congressional authorization of funding to support the preferred alternative of notching the dam (J. Benegar, personal communication, 1/20/10; J. Koehler, personal communication, 1/27/10; USACE & City of St. Helena, 2007b).

Based on interviews with individuals familiar with the project and those who work in the area, watershed residents and community groups appear to have limited involvement in or knowledge of project planning efforts. Public meetings regarding Corps planning reports and the Draft EIR were advertised by the Corps and the City, but were not well attended (J. Benegar, personal communication, 1/20/10). It is unclear if watershed residents were unaware of the meetings, or there was a lack of interest in the issue (J. Benegar, personal communication, 1/20/10; J. Koehler, personal communication, 1/27/10).

However, downstream landowners', notably vineyards', concerns about potentially increased flood risk led to Prunuske Chatham's report on hydrology and hydraulics in Lower York Creek (J. Benegar, personal communication, 1/20/10; Prunuske Chatham, Inc., 2007). Their study found that dam removal would "have essentially no impact on the volume or timing of peak flows" (Prunuske

Chatham, Inc., 2007). Despite these findings, lower watershed residents concerns about flood risk posed by both York Creek and Napa River have contributed to a shift in the City's priorities towards resolving this liability.

The lack of an active and engaged community group in support of removing the dam has temporarily removed pressure on the City to fulfill its project obligations in partnership with the Corps. In addition, personnel changes among City employees engaged in project planning may have contributed to dam removal figuratively falling lower on the Department of Public Works' project priority list. Because the Corps requires equal progress with its partners for meeting project milestones and spending, the Corps cannot make significant project progress. The primary task remaining for the City is coming up with a sediment removal plan, specifying how sediment will be removed and transported, and where it will be deposited (E. Nixdorf, personal communication, 1/13/10).

PROCESS

The City was faced with deciding whether or not to remove the dam when threatened with legal action by the Napa County District Attorney's injunction sought by CDFG following the accidental toxic sediment release. The City agreed to remove the dam through a legal settlement; therefore, an appraisal phase was not completed, and the lack of baseline data collection to inform a removal decision likely contributed to extensive permitting delays from the Army Corps. The Corps denied multiple permit requests from the City, deeming their application incomplete (USACE & City of St. Helena, 2007b). Information that would be collected during an appraisal phase, specifically determining the benefit of removal to steelhead populations, was collected in later phases of the planning process (J. Benegar, personal communication, 1/20/10; J. Koehler, personal communication, 1/27/10).

NMFS' listing of steelhead as a threatened species also posed a threat of legal action, which led the City to seek technical assistance from additional entities to obtain the permits necessary to move forward with removal. Building this coalition with

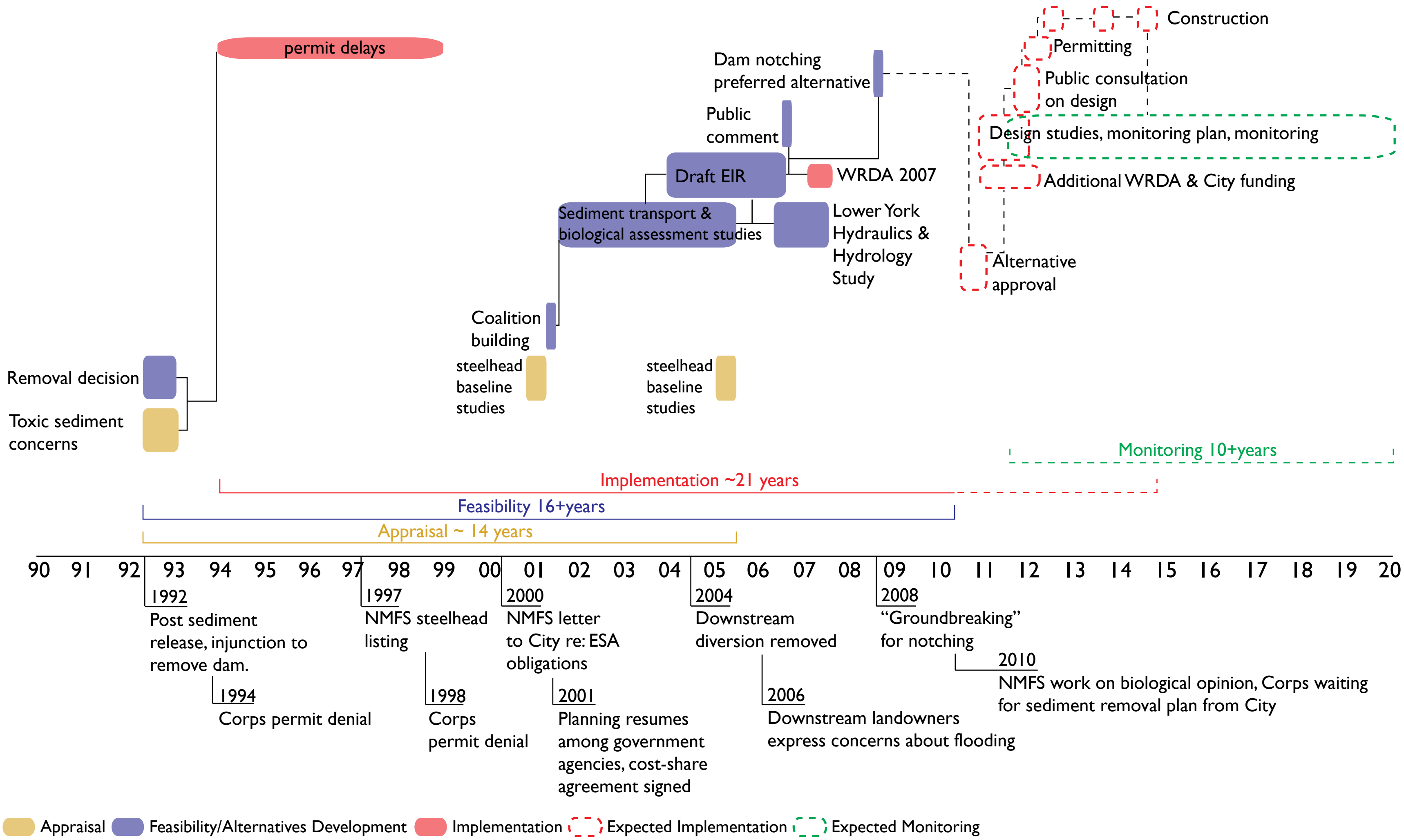


Figure 4-5. Upper York Creek process steps and events.

government partners helped the City move forward with project planning, primarily through DWR's Fish Passage Improvement Program as described above (FPIP, 2002a). Removing the downstream barrier (Figure 4-6) enhanced the likelihood of successfully increasing steelhead access to upstream rearing habitat, demonstrating consideration for watershed context in planning for dam removal. Studies regarding sediment transport capacity and potential benefits to steelhead for the diversion removal informed alternatives development in the Corps' Feasibility Study & EIR, specifically the preferred alternative to notch the dam rather than fully remove it in order to maintain structural stability of adjacent Spring Mountain Road (Figure 4-7) (USACE & City of St. Helena, 2007b). Achievement of Corps' milestones supported project authorization in the 2007 Water Resources Development Act (WRDA) (J. Benegar, personal communication, 1/20/10).

Figure 4-6. Former downstream diversion structure below Upper York Creek dam. (USACE & City of St. Helena, 2007b)

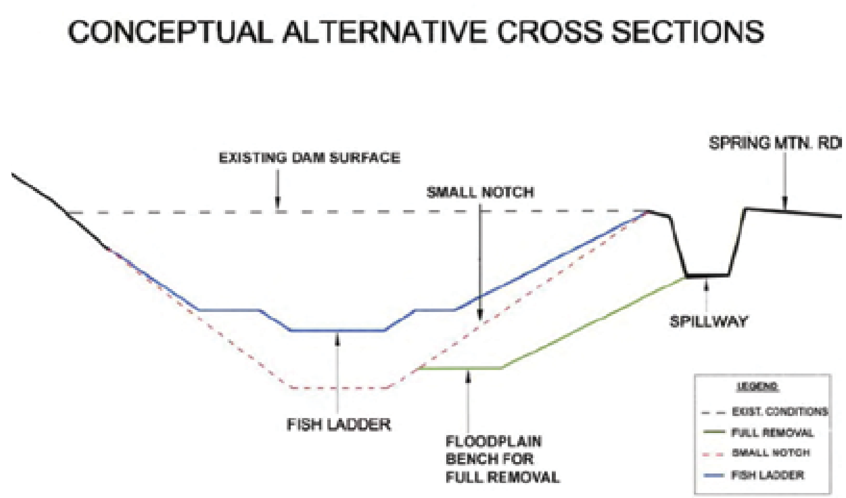


Figure 4-7. Conceptual sections of Upper York Creek Dam removal alternatives. (USACE & City of St. Helena, 2007b)

Limited public involvement during coalition building may have contributed to a lack of public comment on the EIR, and a general lack of awareness among watershed residents of the dam removal proposal (E. Nixdorf, personal communication, 1/13/10; J. Koehler, personal communication, 1/27/10). The lack of an engaged community organization in support of the project is a contributing factor to the limited progress that has occurred over the past two years. Although several important studies were completed between 2005 and 2008, and a "ground-breaking ceremony" was held on August 25, 2008, the project has come to a virtual standstill. Review of the draft EIR by the City Council and development of a sediment removal plan are among the City's unfulfilled responsibilities. The Corps is currently dependent upon additional progress by the City in order to move forward due to the stipulation in their local cost share agreement that partners must proceed at an equal pace in terms of spending (E. Nixdorf, personal communication, 1/13/10; J. Benegar, personal communication, 1/20/10). The City is attempting to seek credit for hydraulic and sediment studies done in 2007, although these were technically outside of project scope according to the cost share agreement (E. Nixdorf, personal communication, 1/13/10). Additionally, the Corps' is waiting for a final biological opinion from NMFS regarding impacts of the preferred alternative on steelhead habitat, and consultation from the State Historic Preservation Office (SHPO) regarding mitigation actions because the preferred alternative will remove most of the historic dam (E. Nixdorf, personal communication, 1/13/10).

When these issues are resolved, implementation phase steps can proceed. Additional funding for design development studies and construction are likely to be sought by the Corps' in the next WRDA bill, with construction taking place over three seasons (E. Nixdorf, personal communication, 1/13/10). The Corps will jointly pay for monitoring when the dam is notched, and the City is responsible for future maintenance of the project site and the stream (E. Nixdorf, personal communication, 1/13/10).

RISKS

Downstream landowners who experienced significant damage during the 2005/2006 winter storm raised concerns about potentially increased flood risk with the City, leading to additional studies on sediment and hydraulics that found notching the dam would have no impact on timing or peak flows of downstream floods (Prunuske Chatham, Inc., 2007). Despite these findings regarding the primary project risk, the City's efforts to ameliorate flooding concerns along Lower York Creek and the Napa River through their flood control plan may be a contributing factor to lack of recent project progress by the city (E. Nixdorf, personal communication, 1/13/10).

Earlier proposals to store dredged material near a downstream reservoir raised concerns among neighboring residents about water supply security and aesthetic impacts (Duarte, 2007). Additionally, increased truck traffic along Spring Mountain Road during construction may have short term impacts on neighboring residents and vineyards (USACE & City of St. Helena, 2007a). These issues

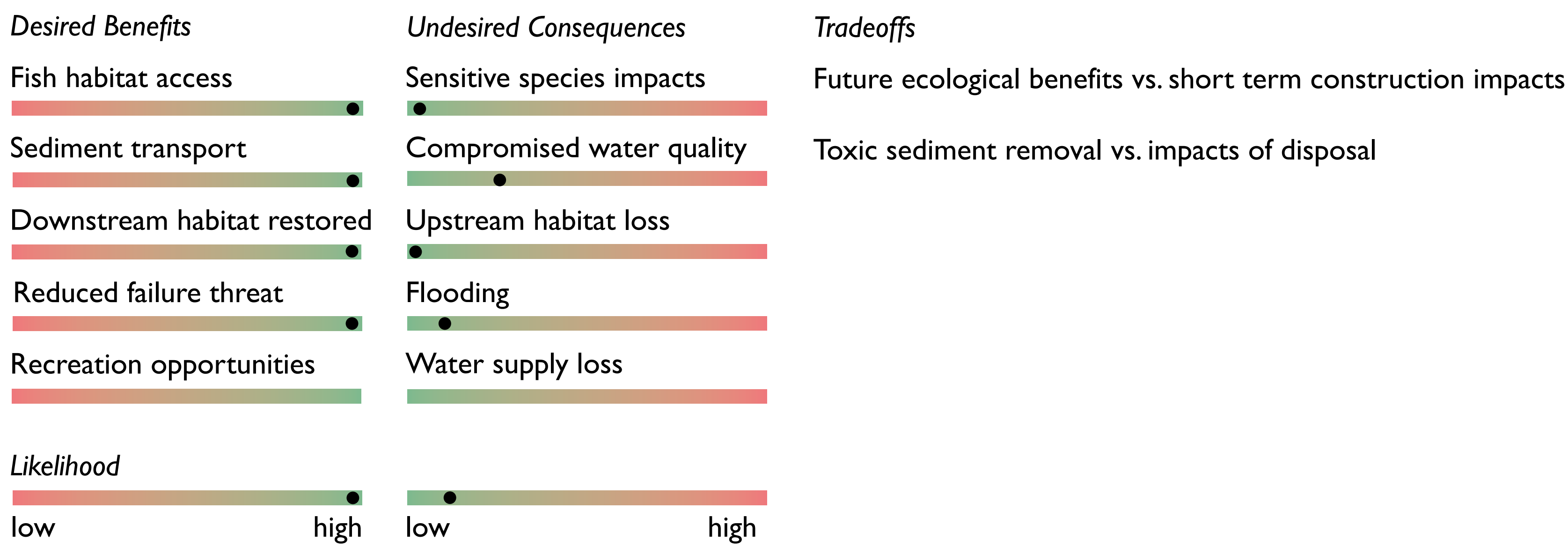


Figure 4-8. Upper York Creek risks & tradeoffs.

remain unaddressed until the City completes the sediment removal plan. Quantification of ecosystem benefits performed by USACE and the Napa Resource Conservation District (Table 4-2) demonstrate the high likelihood of benefits, and this information helped secure funding for implementation in the 2007 WRDA. The sediment removal plan for Upper York Creek dam should include an evaluation of this trade-off to address neighboring residents' concerns.

Alternative	*Steelhead carrying capacity*	*% Effectiveness for passage*	*Avg annual cost/ benefit*
No action	1810	0%	
Complete removal	1810	100%	$247
Small notch	**1810**	**100%**	**$222**
Fish ladder	1810	65-95%	$238-338

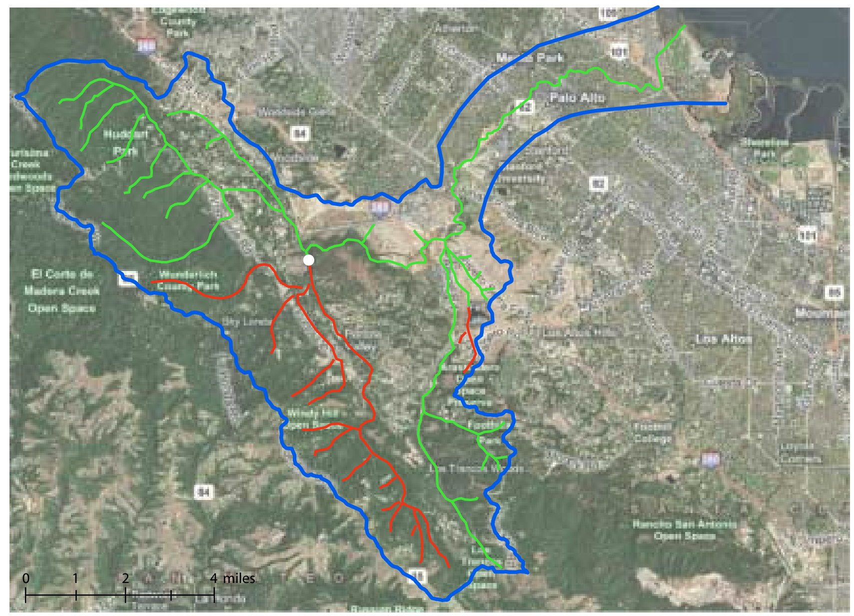
Table 4-2. Comparison of benefits among alternatives for removing Upper York Creek dam.

Searsville Dam

BACKGROUND INFORMATION

Searsville Lake and Dam (Figure 4-9) are located in a confluence valley, where five creeks (Corte Madera, Bear, Sausal, Westridge, and Alambique) flow together to form San Francisquito Creek (Northwest Hydraulic Consultants, Inc. and Jones & Stokes Associates, 2004). The dam is approximately four miles upstream of Stanford University in Portola Valley (Figure 4-10). The dam is 68 feet tall and 275 foot long, and is constructed of imbricated concrete blocks with two 16 in cast iron pipes as bottom outlets (Freyberg et al, 2001). These creeks drain the eastern side of the Santa Cruz Mountains (Freyberg et al 2001). The upland watershed is forested and steeply sloped, and partially developed with large-lot, and often high-valued, suburban and mountain

Figure 4-9. Searsville Dam from below. (Stanford University Land Use & Environmental Planning Office, 2009)



Downstream of dam Upstream of dam

Figure 4-10. Searsville Dam location and San Francisquito Creek watershed.

residences (Freyberg et al, 2001). The original storage capacity of the reservoir (~1360 AF) was reduced by 90% due to infilling from the upstream watershed, primarily from episodic debris flows (Freyberg et al, 2001). The dam blocks access to 10 miles of potential spawning habitat for steelhead (Becker et al, 2007). Steelhead were first documented in a 1905 report (Snyder, 1905 in Leidy et al, 2005), and currently spawn in the accessible downstream reach (Becker et al, 2007).

The dam and reservoir were originally constructed by the Spring Valley Water Company (SVWC) between 1888-1892 to provide water to the City of San Francisco. However, nearby Leland Stanford Junior University (Stanford) was expanding around this time, and Leland Stanford contracted with SVWC to deliver water to the university, so the reservoir was never connected to the San Francisco water supply. In 1919 Stanford University bought the dam and reservoir, and the surrounding watershed lands. Stanford has owned and operated the dam since then (Freyberg et al, 2001).

Sediment infilling concerns were first identified in 1913, and the reservoir was never used as a potable water source because of turbidity, taste, and color issues related to sedimentation. Stanford operated the lake as a recreational area from 1922 to 1976, which included maintenance of an artificial beach with sand that also ultimately contributed sediment to the reservoir. In 1976, Stanford designated Searsville Lake and the surrounding land as part of the Jasper Ridge Biological Preserve (JRBP), and maintained the lake for purposes related to preserve function, and as a non-potable water supply for campus irrigation and fire reserves (Freyberg et al, 2001). Dam safety inspections are conducted annually since 1929 by DSOD, which have reported some small leaks but concluded that the dam is structurally sound. Current research topics at JRBP include environmental and biotic change, terrestrial

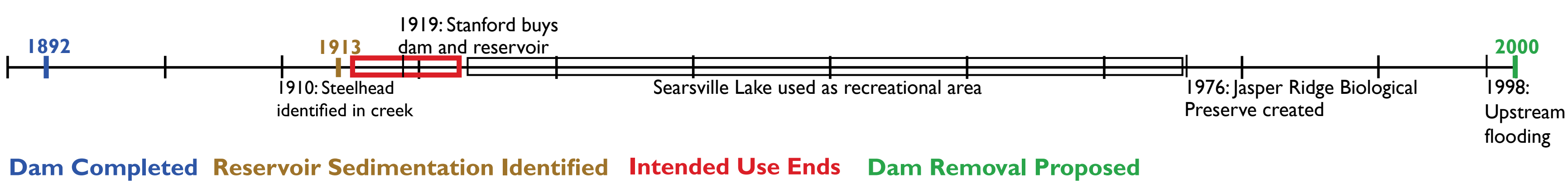


Figure 4-11. Searsville Dam timeline.

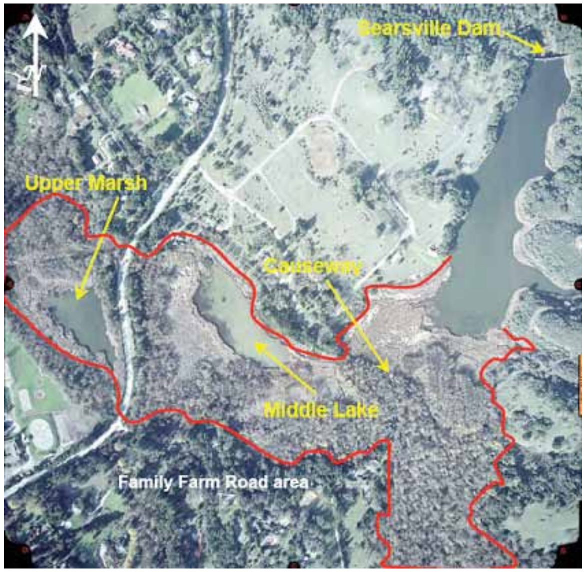


Figure 4-12. Original extent of Searsville Lake (red line) and remnant open water. (Freyberg et al, 2001)

ecological community structure, geology and geophysics, and human influence on the landscape (JRBP, 2009a).

The lake is still managed for preserve function, and provides irrigation water for the Stanford campus when water levels are high enough to reach the upper pumps, usually between April and November (Stanford University Land Use & Environmental Planning Office, 2009; T. Zigterman, personal communication, 2/1/10). Sediment deposits prevent water withdrawl via the bottom outlets, and increasing sediment contributions from the upstream watershed are an ongoing concern (Freyberg et al, 2001; D. Freyberg, personal communication, 9/28/09; T. Zigterman, personal communication, 2/1/10; P. Cohen, personal communication, 2/1/10). The original extent of Searsville Lake has been substantially diminished because of sediment infill (Figure 4-12) (Freyberg et al, 2001).

In an effort to develop a management strategy to maintain open water in Searsville Lake while allowing research to continue at JRBP relatively undisturbed, Stanford University commissioned several studies in the early 2000s to understand sediment dynamics of the upstream watershed and reservoir (Freyberg et al, 2001; Northwest Hydraulic Consultants et al, 2002; Northwest Hydraulic Consultants, and Jones & Stokes Associates, 2004). The results of these studies found that the reservoir currently contains about one million cubic yards of sediment, and that the trap efficiency of the lake to capture sediment from the upstream watershed is significantly reduced because the reservoir is nearly full of sediment (Northwest Hydraulic Consultants et al, 2002). Sediment previously trapped in the reservoir has formed a delta deposit in the upstream end of the reservoir, which is colonized primarily by willows and poplars (Freyberg et al, 2001). It is expected that as this delta front advances, sediment will pass over the dam to the downstream watershed, and contribute to channel narrowing as riparian vegetation traps the sediment downstream of the dam, which may potentially exacerbate flood impacts downstream (Northwest Hydraulic Consultants, Inc. et al, 2002). If the dam remains in place and a sediment management strategy is not implemented, it is anticipated that "Searsville Valley" will form, with a single thread channel eventually forming through the sediment deposits (Northwest Hydraulic Consultants, Inc. et al, 2002). It is estimated that if current sediment transport rates from the upstream level remain the same, the lake will completely infill in the next 15 to 30 years (Northwest Hydraulic Consultants, Inc. et al, 2002).

Reservoir infilling raises concerns about flood risks both upstream and downstream of the reservoir. During the 1998 El Nino storm season, properties along Corte Madera Creek flooded, including an access road (D. Freyberg, personal communication, 9/28/09). Property owners suggested that flooding was the result of backwater effects from the delta deposit in Searsville Lake (D. Freyberg, personal communication, 9/28/09). Following the flood, Stanford hired Balance Hydrologics to maintain a monitoring station for stream flow and sediment on Corte Madera Creek, and Stanford maintains upstream channel conveyance by removing woody debris from Corte Madera Creek (JRBP, 2009b).

Downstream of the dam, San Francisquito Creek continues for 12 miles to San Francisco Bay, and is unchannelized for the majority of its length (Becker et al, 2007). The San Francisquito Creek Joint Powers Authority (SFCJPA) is working with the Corps to develop a flood control management plan and project to prevent flooding in parts of Palo Alto, East Palo Alto, and Menlo Park adjacent to San Francisquito Creek. SFCJPA includes the cities of Palo Alto, East Palo Alto, and Menlo Park, the Santa Clara Valley Water District, and the San Mateo County Flood Control District, with Stanford University as an associate member (SFCJPA, 2009).

Several environmental groups have joined together as the Beyond Searsville Dam Coalition (the Coalition) to propose removing Searsville Dam as a way to permanently provide flood control for upstream areas in conjunction with downstream projects, and to restore steelhead access to historic upstream spawning areas (Beyond Searsville Dam, 2009). San Francisquito Creek was identified as an "anchor" watershed for steelhead habitat in tributaries to San Francisco Bay by the Center for Ecosystem Management and Restoration in 2007, indicating that watershed characteristics are favorable for steelhead restoration efforts. This finding and significant historical documentation suggest that removing the dam to increase access to well protected potential spawning habitat could provide conditions for a resilient steelhead population (Leidy et al, 2005; Becker et al, 2007).

Figure 4-13. Searsville Reservoir currently (left) and artist's rendition of reservoir area post-removal (images courtesy of Matt Stoecker, 2010).

ACTORS

Searsville differs from the other case studies in that most of the power is concentrated in the hands of the owner, Stanford University, who controls when and if dam removal is actively pursued or examined in a formal feasibility study, which has not occurred to date. Efforts to initiate this process have started and stopped at several points in time, primarily through the SFCJPA's Searsville Working Group. A movement is building among dam removal advocates to educate watershed residents about the potential benefits of removing Searsville Dam, and to re-engage Stanford in discussions regarding including appraisal of dam removal.

As the owner and operator of the dam and surrounding biological preserve, Stanford University has the most power and control over the removal discussion process. Searsville Dam and Reservoir are operated by the Civil Infrastructure Group of

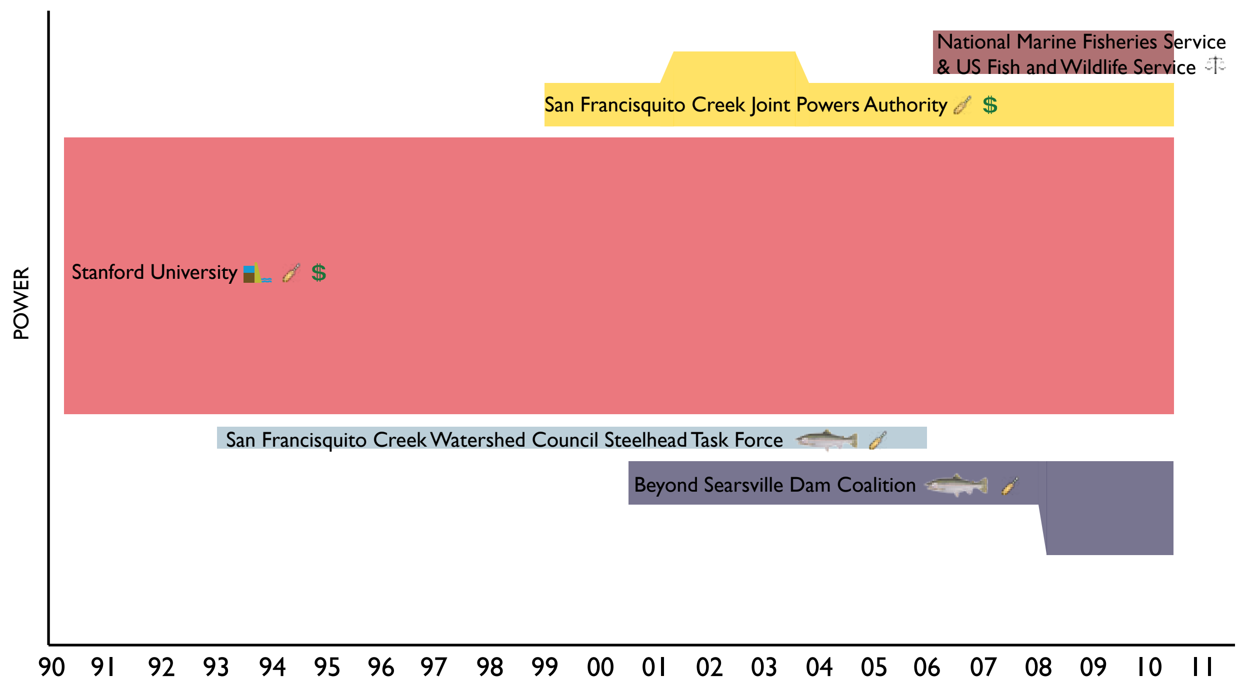


Figure 4-14. Searsville Dam power map. Dam Owner Regulator $ Funder Technical Supporter Advocate

the Stanford Sustainability and Energy Management Division, which is responsible for water infrastructure throughout Stanford's properties. Currently, the Civil Infrastructure Group is engaged in providing additional water supply infrastructure to new buildings on the campus, including upgrading diversions from Los Trancos Creek and San Francisquito Creek (T. Zigterman, personal communication, 2/1/10). By virtue of its location within JRBP, decisions about the future of Searsville Dam and Reservoir are also subject to review by the Jasper Ridge Advisory Committee (JRAC), who would determine what affects dam removal or reservoir modification would have on research conducted in JRBP. Based on the aforementioned studies, JRAC has expressed its judgment "that the continued existence of a reservoir provides important values for the Preserve," and that removing the dam "would result in significant disruption to the Jasper Ridge mission" (JRAC, 2007). JRAC has suggested that dam removal will not result in the "certain" restoration of steelhead, due to low summer stream flows in upstream tributaries (JRAC, 2007; Stephens et al, 2002). Additionally, dam removal would disturb the wetland habitat present in upstream sediment deposits, which currently supports several species of conservation interest (JRAC, 2007). Allowing Searsville Lake to continue filling with sediment would also impact wetland habitat that has formed in the reservoir deposit.

It is unlikely that any movement towards considering dam removal will happen without Stanford's support, or without a mandate from government agencies. These could include a finding from DSOD that the dam is structurally unsound, but given the dam's unique construction, satisfactory safety inspections over the past 80 years, and withstanding of the 1989 Loma Prieta earthquake, it is unlikely that this determination will be made in the near future (T. Zigterman, personal communication, 2/1/10). Under agreements with NMFS and USFWS regarding the scope of Stanford's Habitat Conservation Plan, determining "long term management" of the reservoir was specifically identified as beyond the scope of the plan (Stanford University Land Use & Environmental Planning Office, 2009; P. Cohen, personal communication 2/1/10). However, the Habitat Conservation Plan does specify that fish passage will be addressed if Stanford decides to perform major modifications or repairs on the dam, and "commits to study the technical feasibility of fish passage alternatives at Searsville Dam within 10 years of approval of the" Habitat Conservation Plan (Stanford University Land Use & Environmental Planning Office, 2009). Dam removal appraisal may be part of the fish passage study, and findings may lead to NMFS or USFWS requiring modification of the dam for fish passage.

The political situation surrounding Searsville Dam and watershed protection efforts is complicated by multiple jurisdictions within the watershed - the cities of East Palo Alto, Palo Alto, Menlo Park, Stanford, Portola Valley, and Woodside; and Santa Clara and San Mateo counties (Figure 4-15). This prompted the creation of SFCJPA to combine authorities to address flooding and ecosystem

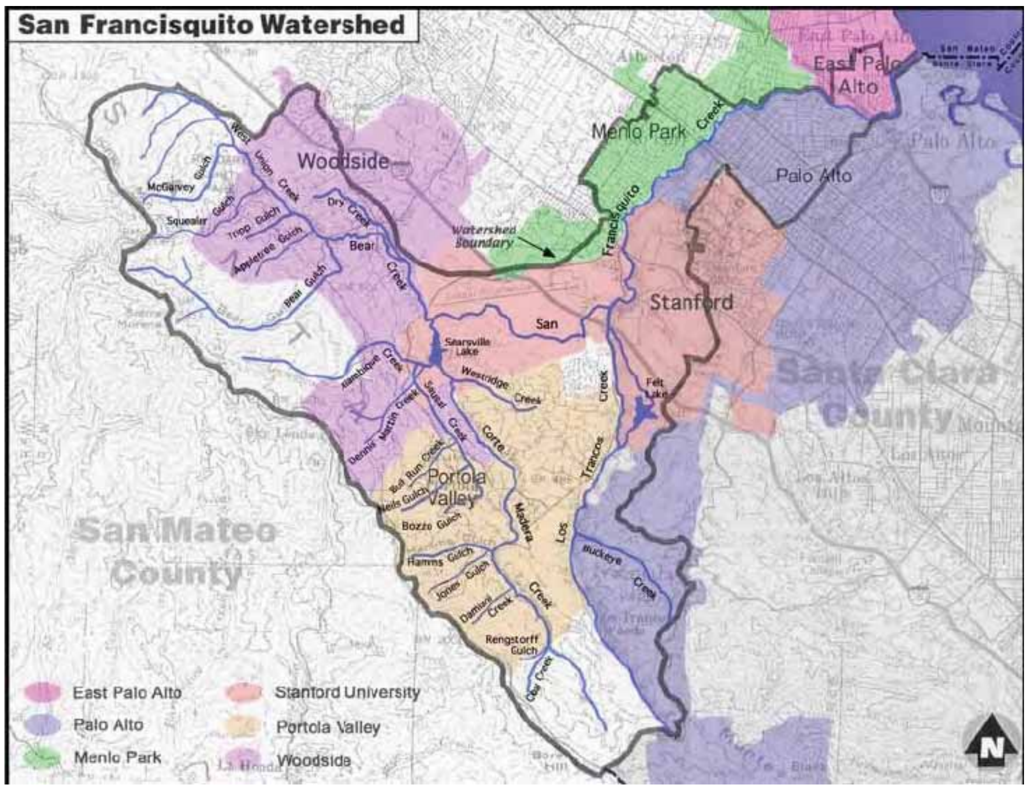


Figure 4-15. Jurisdictions in the San Francisquito Creek watershed. (Harris & Koecher, 2006)

concerns (SFCJPA, 2010). However, the upstream towns, Portola Valley and Woodside, do not participate in SFCJPA, which limits its ability to implement projects throughout the entire watershed (Harris & Koecher, 2006). Portola Valley has collaborated with SFCJPA previously regarding fish-friendly bank stabilization methods, and but they have not formally participated in SFCJPA's Searsville Lake/ Dam Workgroup (Murray et al, 2001). If upstream towns were included in SFCJPA, politically they may be capable of significantly influencing Stanford to make a decision about the future of Searsville Dam and Reservoir.

SFCJPA formed the Searsville Lake/Dam Workgroup in 2001 to compile and identify options for next actions and/or research steps with regards to Searsville Lake and Dam (Murray et al, 2001). Common motivations among workgroup participants was recognition that Searsville Lake and Dam are part of a dynamic system, and "a desire to achieve the most educated and fair solution(s) to managing this impending change" (Murray et al, 2001). Workgroup objectives included identifying solutions to minimize flood impacts of the reservoir both upstream and downstream of the dam, and to protect and restore ecological conditions in the watershed, including steelhead trout habitat (Murray et al, 2001). Review of the Northwest Hydraulic Consultants study of sediment dynamics in the upstream watershed was part of the workgroup's activities, and members found that "the draft study results do not present a roadblock to lowering, removal or other alternatives that would result in the full sediment load passing downstream of" Searsville Dam (Murray et al, 2001). The workgroup has not been active since 2003 when their review of the Northwest Hydraulic Consultants report was completed, including supplemental review by Moffat & Nichol Engineering (SFCJPA, 2003). Stanford sought approval from SFCJPA of the report's conclusion that increased sediment transport to downstream reaches would lead to further channel constriction (Northwest Hydraulic Consultants et al, 2002; K. Murray, personal communication, 2/3/10). However, SFCJPA was not able to state that this condition would be tolerable because of potential legal implications and assumption of responsibility for flood damage mitigations (K. Murray, personal communication, 2/3/10).

Local watershed groups previously considered potential opportunities for enhancing steelhead habitat in the watershed,

Figure 4-16. Beyond Searsville Dam Coalition display in Palo Alto Patagonia Store creatively illustrates potential removal benefits (image courtesy of Matt Stoecker, 2010).

including the San Francisquito Creek Watershed Council Steelhead Task Force (Stoecker Ecological, 2009). Efforts are currently underway by the Beyond Searsville Dam Coalition (the Coalition) to engage watershed stakeholders in a discussion about the advantages of dam removal for restoring steelhead access to the upstream watershed and resolving sediment management issues (M. Stoecker, personal communication, 9/20/09). The Coalition proposes that sediment trapped in the reservoir could be used for ongoing wetland restoration projects in San Francisco Bay, but how sediment would be removed and transported to these areas still needs to be determined, and is likely to be very costly (Beyond Searsville Dam, 2009). With the national organization American Rivers providing non-profit organization status to the Coalition, the credibility of a reputable dam removal advocacy organization is transferred to a localized effort. Additional well known, national and state advocates of dam removal have signed the Beyond Searsville Dam Coalition Statement, including Patagonia, Inc., Earth Island Institute and Friends of the River. Several local groups, such as Acterra, are identified as participating in the Coalition as well without fully endorsing the Coalition's pro-removal stance. Currently the majority of the signatories of the Coalition Statement are from outside of the watershed, and educational activities and events are underway to increase awareness among watershed residents of the dam's presence and the potential opportunities posed by its removal (Beyond Searsville Dam, 2010).

PROCESS

Removing Searsville Dam has been proposed by watershed activists for several years, but the concept has not been thoroughly investigated in an appraisal or feasibility study devoted to the future of Searsville Dam, analyzing alternative approaches to sediment management and alternative means to maintain Stanford's water rights (T. Mulvey, personal communication, 5/9/10). While Stanford recognizes that one day it will need to deal with the significant amount of sediment behind the dam, there is no legal mechanism or government agency mandating the university to come up with a solution any time in the near future (D. Freyberg, personal communication, 9/28/09; P. Cohen, personal communication, 2/1/10; T. Zigterman, personal communication 2/1/10). Stanford and SFCJPA commissioned studies conceptually consider sediment management proposals, and evaluate future sediment contributions from the upstream watershed (Freyberg et al, 2001; Northwest Hydraulic Consultants et al, 2002; Northwest Hydraulic Consultants and Jones & Stokes, 2004). Additional studies on watershed characteristics, such as downstream barriers to steelhead habitat and pollutant sources, were conducted or commissioned by various watershed affiliated groups like the San Francisquito Creek Watershed Council (San Francisquito Creek Watershed Council, ____).

While these various studies mention dam removal as one option for addressing future management of reservoir sediments, to date there has not been a detailed appraisal or feasibility study commissioned by Stanford or any other watershed related entity. Studies were commissioned to identify and investigate multiple concerns regarding problems posed by an infilled reservoir, but the studies do not identify measurable goals and objectives for proposed management options. Beyond Searsville Dam Coalition is attempting to revive Stanford's interest in formally evaluating dam removal as part of the aforementioned fish passage study, but would need permission from Stanford to use data compiled about the dam and reservoir, as well as access to the dam within JRBP (M. Stoecker, personal communication, 2/3/10). Quality and quantity of steelhead habitat in the upper watershed would need to be evaluated as part of an assessment of ecological benefits gained from removal. A feasibility study would address how natural

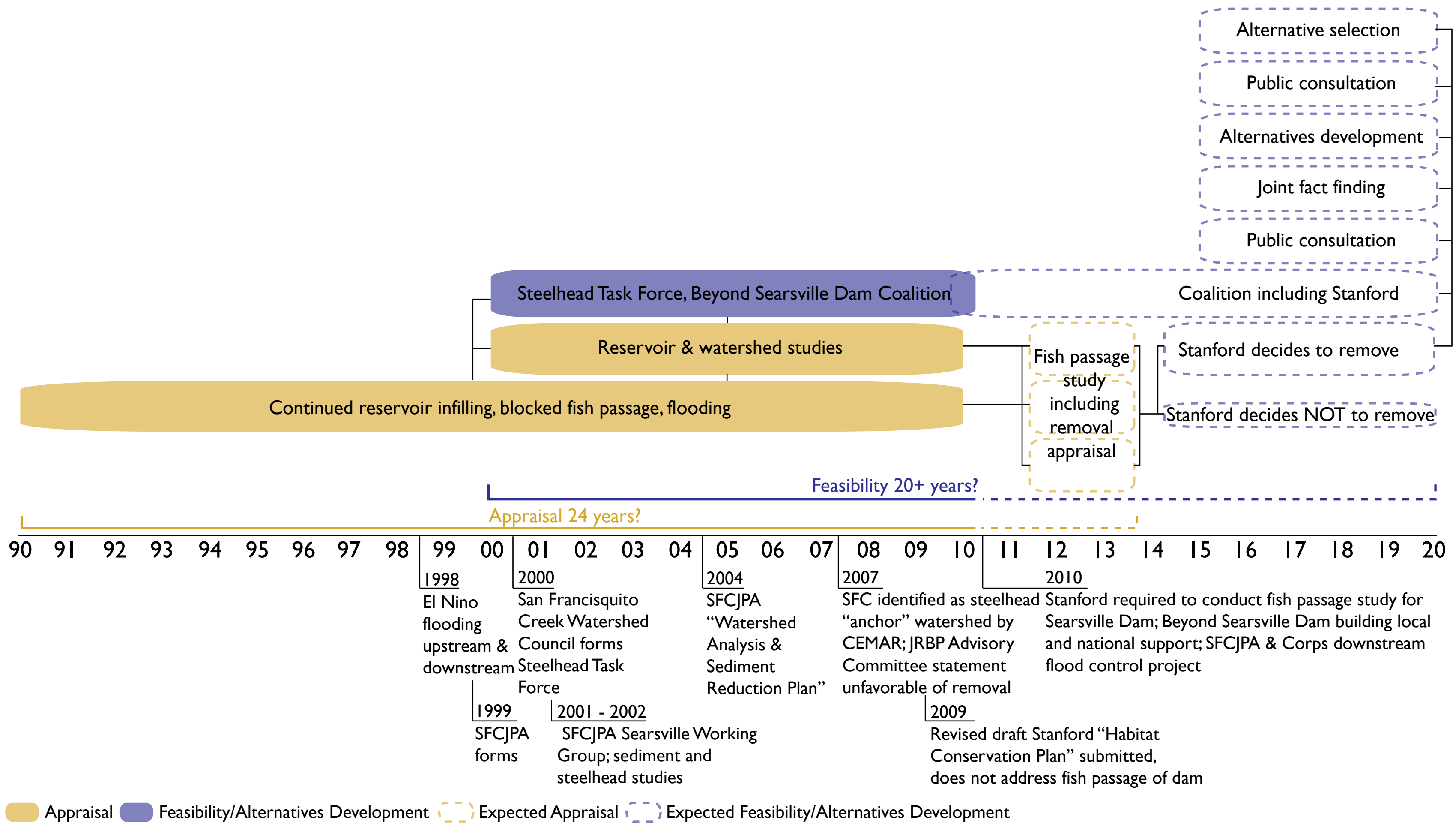


Figure 4-17. Searsville Dam process steps and events.

flow patterns, channel morphology, water temperature, nutrient and sediment loads would be restored following dam removal. Possible sediment impacts, including flooding and pollutant contamination, would also need to be addressed before removing the dam. Additional barriers in the Bear Creek watershed have been previously identified, and removal of Searsville Dam should be coordinated in conjunction with passage opportunities throughout the watershed (Smith & Harden, 2001).

RISKS

Considering removal of Searsville Dam brings to light several tradeoffs. Removing the dam would open up several miles of potentially viable steelhead spawning habitat as confirmed by watershed scale analyses, but a field study thoroughly evaluating the quality and quantity of spawning habitat in upstream reaches currently does not exist (Becker et al, 2007). Removal also has the potential to reestablish riparian vegetation within the reservoir site, but it would also results in the loss of wetlands in the backwater

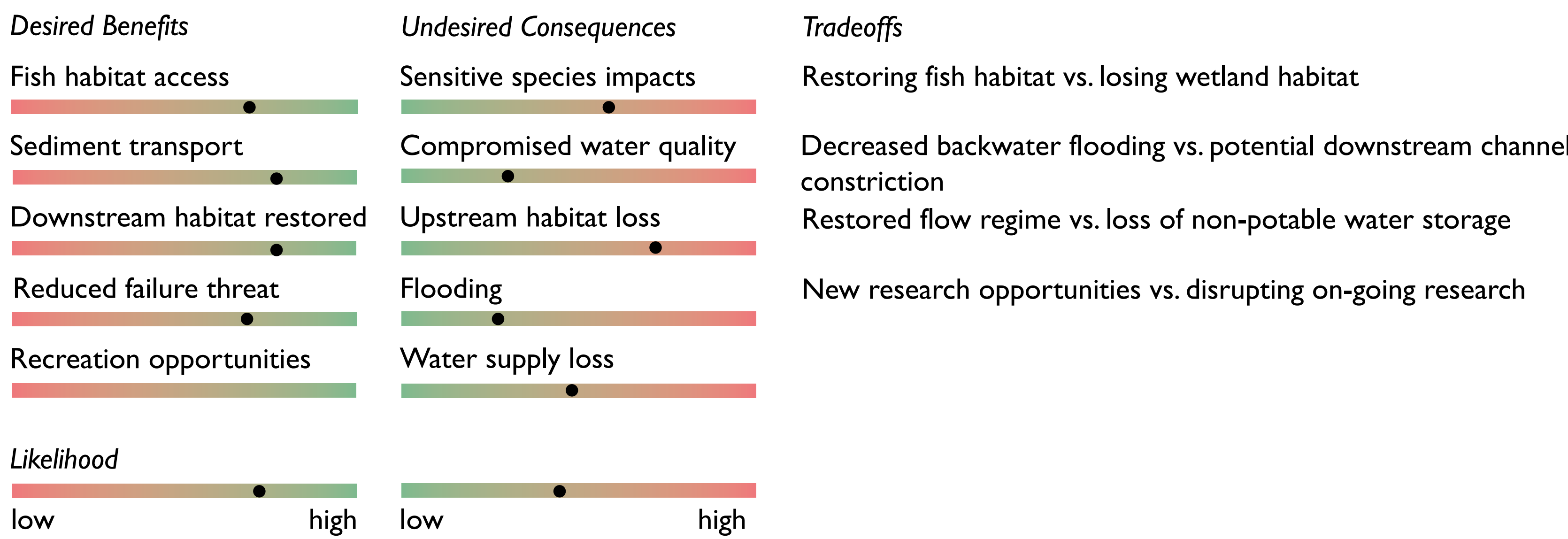


Figure 4-18. Searsville risks & tradeoffs.

deposits, which support populations of California red-legged frog (JRBP, 2009a). Non-potable water currently stored behind the dam is used to irrigate the Stanford campus downstream, and loss of this supply by removing the reservoir would require modification of Stanford's water right and identification of a downstream diversion point (D. Freyberg, personal communication, 9/28/09; T. Zigterman, personal communication, 2/1/10). Flooding is a problem both upstream and downstream of the reservoir, but the scale of the problem and number of people impacted is substantially greater downstream. Removing the dam would likely eliminate upstream flooding, but may increase downstream flooding as a result of channel constriction. Although removing the dam presents many opportunities for researching geomorphic and ecological responses, several ongoing research experiments within Jasper Ridge would likely be significantly disrupted by construction activities related to removal.

These tradeoffs and others identified by individuals intimately familiar with the reservoir's history and operation should be evaluated in detail in future studies to determine an appropriate long term solution for Searsville Lake and Dam. However, deciding what this solution should be is currently not near the top of Stanford's priorities list, although the upcoming fish passage study may move it closer to the top (D. Freyberg, personal communication, 9/28/09; T. Mulvey, personal communication, 4/7/10).

San Clemente Dam

BACKGROUND INFORMATION

San Clemente Dam (Figure 4-19) on the Carmel River is a 106 foot high and 300 foot wide arch concrete structure. Its thickness varies from 50 feet at the base to 8 feet at the crest. The dam is located approximately 18.5 miles inland from the mouth of the Carmel River in Carmel-by-the-Sea in Monterey County (Figure 4-20). The dam impounds water and sediment from the northern side of the Santa Lucia Mountains (Capelli, 2007).

Los Padres Dam, the most upstream dam on the Carmel River, is approximately seven miles upstream of San Clemente. Beyond Los Padres is another 18 miles of potentially viable steelhead habitat, totalling approximately 25 miles of potential steelhead

Figure 4-19. San Clemente Dam.

Figure 4-20. San Clemente Dam and Carmel River watershed.
Downstream of dam   Upstream of dam

Figure 4-21. San Clemente fish ladder.

habitat upstream of San Clemente. The Carmel River reportedly supported an annual steelhead run of 20,000 adults/year prior to construction of the dam in 1921. A fish ladder was built at the same time as the dam in an attempt to provide access to upstream spawning habitat, but the ladder does not meet NMFS criteria for step pool dimensions (Figure 4-21) (Capelli, 2007; J. Ambrosius, personal communication, 1/20/10). Current steelhead runs vary annually in size (Capelli, 2007; F. Emerson, personal communication, 1/25/10). Central coast steelhead were listed as "critically threatened" by NMFS in 1997, and the Carmel River was designated as "critical habitat" in 2005 (Capelli, 2007). Wetlands that have formed in the delta deposit in the reservoir provide habitat to California red-legged frog, (ENTRIX, Inc., 2008).

San Clemente Dam was constructed in 1921 by the investor-owned public water supplier California America Water Company (Cal-Am), who is regulated by the California Public Utilities Commission (CPUC) (Capelli, 2007). The impounded reservoir was originally designed to hold 1,425 AF for drinking water supply, now reduced to 125 AF (Coastal Conservancy, 2008). Reservoir sedimentation was first noted in the 1960s, and during the 1980s proposals to construct new

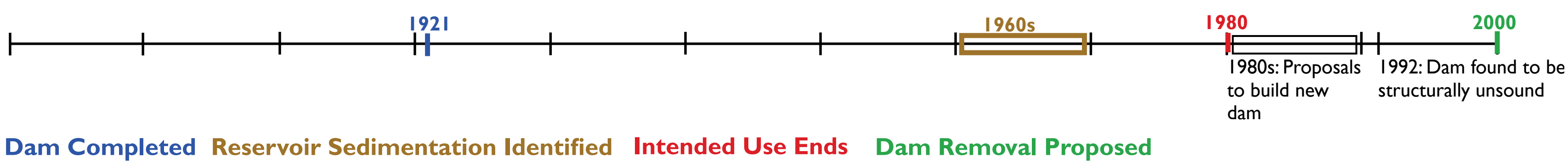


Figure 4-22. San Clemente Dam timeline.

reservoirs were considered to make up for lost water storage capacity at San Clemente (ENTRIX, Inc., 2008; L. Hampson, personal communication, 1/14/10). San Clemente reservoir now contains 2.5 million cubic yards of sediment (Coastal Conservancy, 2008). The dam currently functions as a diversion point for water withdrawls from the river (Coastal Conservancy, 2008).

Sediment contributions from the upland watershed are primarily derived from debris flows post-wildfires and heavy rains (ENTRIX, Inc., 2008). The region is also seismically active, and the dam is situated between the San Andreas, Palo-Colorado, Monterey Bay, and Tulacritos fault zones (Capelli, 2007). Between 1800 and 1985, 400 earthquakes of 4.0 or greater on the Richter scale were measured within 60 miles of the dam (ENTRIX, Inc., 2008). In the early 1990s, DSOD commissioned engineering studies to evaluate the seismic safety of the dam, and concluded in 1992 that the dam would not withstand the "Maximum Credible Earthquake" or "Probable Maximum Flood" due to previous seismic activity and increased pressure on the dam from reservoir sedimentation (ENTRIX, Inc., 2008; Capelli, 2007). This finding forced Cal-Am to consider how to reduce the safety hazard posed by the dam, initially advancing a proposal to buttress the dam to provide structural support, and stabilize reservoir sediment in place (ENTRIX, Inc., 2008). Many studies and several EIR/EISs were prepared to consider this option, leading to public comment suggesting that dam removal should be investigated as an option (ENTRIX, Inc., 2008).

Dam removal would increase steelhead to access former spawning grounds currently buried by reservoir sediments, and spawning and rearing habitat between San Clemente and Los Padres dams (Capelli, 2007). Management of the approximately 2.5 million cubic yards of sediment behind the dam is the most complex and expensive challenge (Capelli, 2007). A "re-route and removal" option was identified as the preferred alternative in the Final EIR/EIS to addresses these concerns (Figure 4-23) (ENTRIX, Inc., 2008). This alternative would breach the rock ridge separating the Carmel River from San Clemente Creek, therefore "rerouting" the Carmel River through reservoir sediment deposits into the former channel of San Clemente Creek (Philip Williams & Associates and HT Harvey, & Associates, 2007). Reservoir sediment would be excavated from the San Clemente Creek branch, and sediment from the Carmel River branch would be stabilized in place (Philip Williams & Associates and HT Harvey, & Associates, 2007). This concept was under consideration by a coordinated group of state, federal, and non-governmental interests in partnership with Cal-Am until February 2009, when Cal-Am stepped away from the table (Schuchat, 2009). Recently, this collaborative effort was re-established with the signing of an agreement to continue investigating re-route and removal (California American Water Company, 2010).

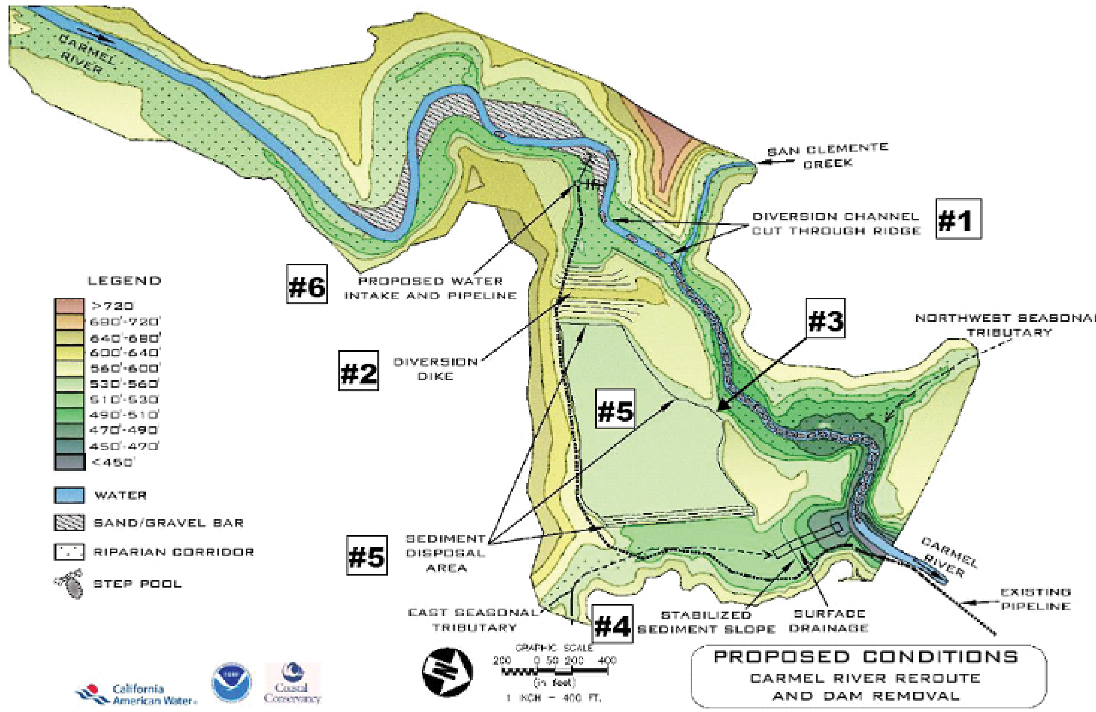


Figure 4-23. "Re-route and Removal" in aerial (left) and plan view (right). (left: Coastal Conservancy et al, 2008; Philip Williams & Associates and HT Harvey & Associates, 2007

ACTORS

As the owner of the dam, Cal-Am holds substantial power in allowing the removal planning process to move forward, and have previously exercised that power to delay serious consideration of removal. During earlier EIR development processes, reluctance to seriously consider dam removal as a feasible solution to alleviate safety hazards posed by San Clemente Dam caused substantial delays in project planning. Cal-Am is a for profit business that operates with a different set of objectives than the other entities involved, which are mostly government agencies required to implement certain policies, or non-profit organizations with public interest objectives. Cal-Am has expressed their concern that any proposed solution for fixing dam safety will impact their rate structure, and CPUC serves in a similar capacity to protect ratepayers from bearing an undue burden through water supply rate

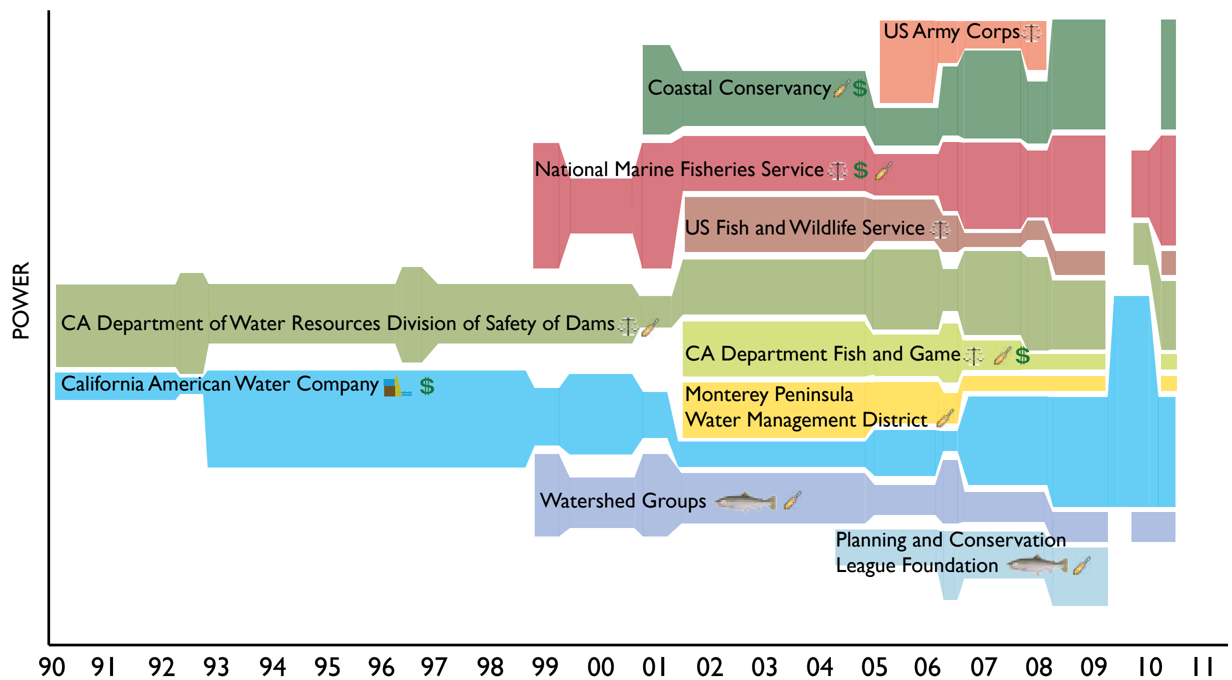


Figure 4-24. San Clemente power map. Dam Owner Regulator $ Funder Technical Supporter Advocate

increase (Klein et al, 2007).

DWR used their authority to deem proposed solutions as acceptable or unacceptable to push removal, and NMFS strongly encouraged consideration of dam removal in public comments on earlier EIRs (Rutten, 2001). NMFS comments focused on the proposal to re-establish fish habitat as part of the buttressing project, noting that the habitat quality would be "extremely simple" and additional protection measures for fish habitat populations would need to be put in place during construction (Rutten, 2001). NMFS also informed Cal-Am of the likelihood of their issuing a jeopardy opinion regarding impacts that the buttressing project would have on threatened steelhead (J. Ambrosius, personal communication, 1/20/10). These messages from NMFS to Cal-Am helped drive the process towards serious consideration of the removal option. In addition, community organizations, such as the Carmel River Steelhead Association and the Carmel Valley Watershed Conservancy, were able to gather significant public comment on previous EIRs to propose removal (M. Hunter, personal communication, 2/3/10). These groups, as well as the Coastal Conservancy and the Planning and Conservation League Foundation (PCLF), worked to keep watershed residents informed during the 2008 process of exploring re-route and removal (T. Chapman, personal communication, 1/20/10; M. Hunter, personal communication, 2/3/10). This may have led to residents contacting their elected officials to pressure Cal-Am into re-initiating the removal exploration process (F. Emerson, personal communication, 1/25/10).

The Coastal Conservancy has a particularly important role in the planning process as coordinator and funding seeker. While the Coastal Conservancy does not have any regulatory authority to force Cal-Am to remove the dam, their cooperation with NMFS was critical to initiate conceptual exploration of the re-route and removal option. The Coastal Conservancy's preparation of educational materials and presentations to residents has kept the community informed of project progress (Coastal Conservancy, 2008; M. Hunter, personal communication, 2/3/10). Coastal Conservancy staff members reached out to various agencies for funding, and are expected to provide $7 million of the additional $34 million necessary for re-route and removal, on top of $49 million provided by Cal-Am, equivalent to the estimated cost of buttressing the dam (Coastal Conservancy, 2008; Klein et al, 2007; T. Chapman, personal communication, 1/20/10). The Coastal Conservancy and NMFS have committed to working with permitting entities to "fast track" and secure permits necessary for project completion (California American Water Company, 2010).

PROCESS

Since DSOD determined that San Clemente Dam was not structurally sound in 1992, the planning process has for the most part focused on how to make the dam seismically safe (Figure 4-25). Buttressing the dam as proposed by Cal-Am would maintain diversion capacity at this point in the river to downstream off-stream storage areas. Cal-Am's proposal to buttress the dam through various means was considered in feasibility and engineering studies, which led to preparation of a draft EIR in 1998 that evaluated dam removal, notching and mitigated retrofit with sediment management alternatives (ENTRIX, Inc., 2008). Public comment on the 1998 EIR, specifically from NMFS, requested further analysis of several impacts and the dam removal and notching alternatives, resulting in a recirculated draft EIR in 2000 (ENTRIX, Inc.,1998; J. Ambrosius, personal communication, 1/20/10). Comments received on the 2000 EIR led to extensive studies funded by Cal-Am and conducted by NMFS, USFWS, and other government agencies, which looked at how to improve fish passage through various means. A new draft EIR in 2004 also received substantial public comment, leading to the final published draft EIR in 2006 and its eventual approval in 2008, which lists "re-route and removal" as the preferred alternative.

The many rounds of EIR preparation in response to public comment demonstrate the power of public input when a community is well organized and mobilized. Although strengthening the dam remains Cal-Am's proposed solution, public input has spurred additional studies that led to pursuing "re-route and removal" as the most feasible alternative for resolving safety issues and other dam-related impacts. Following EIR approval in 2008 from the Corps and DWR, Cal-Am signed a memorandum of

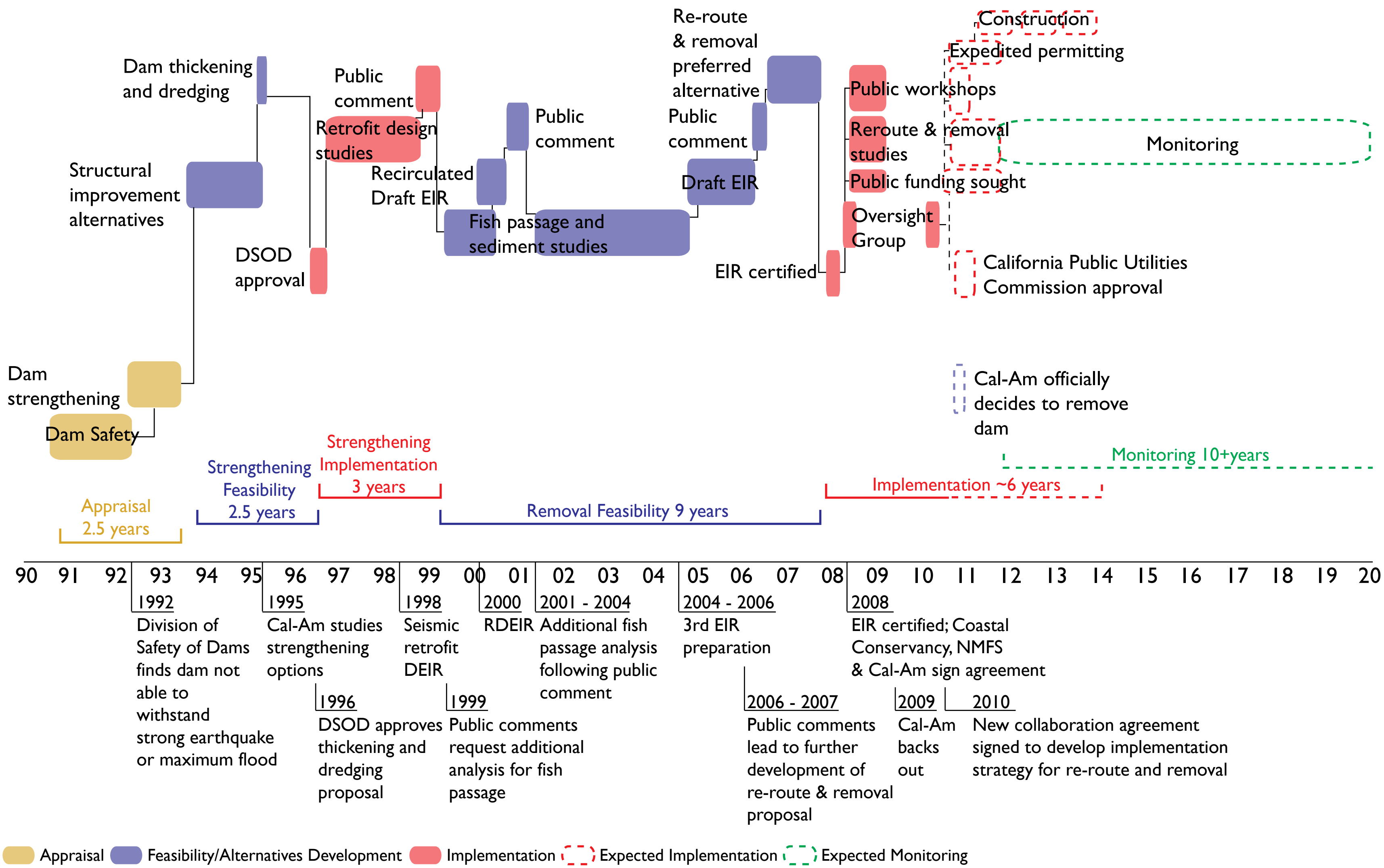


Figure 4-25. San Clemente process steps and events.

Figure 4-26. San Clemente project costs (Coastal Conservancy, 2008).

understanding with NMFS and the Coastal Conservancy as the oversight agency (Coastal Conservancy, 2008). Cal-Am initially agreed to provide partial funding for removal (total estimate $83 million), equivalent to what a buttressing method would cost ($49 million). The Coastal Conservancy agreed to explore funding options to cover remaining costs, including through the US Department of Defense's Innovative Readiness Training Program which employs members of the military reserves in civilian projects (Figure 4-26) (Coastal Conservancy, 2008). However, in February 2009, Cal-Am issued a statement that it was no longer willing to explore the re-route and removal option because of unresolved concerns regarding liability issues and project funding from the state (Schuchat, 2009). Lack of clarity about government agency processes may have contributed to Cal-Am's frustration with what they perceived to be a slow moving process (T. Chapman, personal communication, 1/20/10).

Environmental groups and government agencies involved in the project expressed their disappointment in Cal-Am's reversal, and pressured DSOD to reject dam buttressing as a viable option (Abraham, 2009). The recent change in leadership at Cal-Am and threat of an unfavorable biological opinion from NMFS were significant reasons why the removal appraisal process was re-established (J. Ambrosius, personal communication, 1/20/10; J. Klein, personal communication, 1/25/10; B. Cluer, personal communication, 3/9/10). Cal-Am's internal assessment of assets and liabilities brought to light that San Clemente is Cal-Am's greatest liability, prompting them to reconsider resolving long-standing structural safety issues through removal (B. Cluer, personal communication, 3/9/10). In November 2009, Cal-Am issued a statement in favor of proceeding with re-route and removal planning with previous project partners, and a new legal agreement was signed on January 11, 2010 (Abraham, 2009; California American Water Company, 2010). The recently signed legal agreement between Cal-Am, local elected officials and various government agencies specifies that Cal-Am is "amenable to removal of the dam instead of buttressing it," provided that the removal option will not increase water supply rates or negatively impact their shareholders. A project plan is to be developed by June 2010, including a comparison of re-route and removal costs and liabilities with buttressing, to be presented for approval to DSOD and CPUC. The remainder of 2010 will be spending securing the public share of funding, preparing the preliminary engineering designs and construction approach, and initiating the permitting process (California American Water Company, 2010; T. Chapman, personal communication, 3/3/10).

RISKS

While removing the dam and rerouting the river will allow fish to pass through the former San Clemente dam site, Los Padres dam, seven miles upstream, currently limits steelhead passage. There is a fish passage facility operated by Cal-Am on Los Padres that transports some steelhead above the dam, but is deemed inadequate (MPWMD & Carmel River Watershed Conservancy, 2004). Therefore, maximum benefits for fish passage and steelhead population recovery are not realized as part of the current project to remove San Clemente Dam. The conceptual design includes construction of step pools for fish habitat in the former reservoir area, but conditions beneath the reservoir sediment that may influence in-stream structure designs remain unknown until the sediment is excavated (Philip Williams & Associates and HT Harvey, & Associates, 2007; M. Burke, personal communication, 2/3/10). Some wetland habitat loss will occur from re-routing the Carmel River, which support California red-legged frog. However, USFWS has identified bullfrogs as the limiting factor for California red-legged frog populations in the Carmel River watershed, not wetland habitat availability (J. Ambrosius, personal communication, 1/20/10). Some wetland habitat mitigation is part of the re-route and removal proposal (Philip Williams & Associates and HT Harvey, & Associates, 2007).

Removing the dam reduces safety issues in the event of potential failure, but may create new risks to downstream communities adjacent to the floodplain if an uncontrolled release of sediment downstream occurs and exacerbates conditions that contribute to periodic flooding in the urbanized portion of the lower Carmel River floodplain (Mussetter Engineering, Inc., 2002). Resolution of potentially increased liability related to flooding and dam removal must be resolved prior to implementation. Identifying an entity to assume liability during construction and following removal remains a significant challenge in the planning process (T. Chapman, personal communication, 1/20/10; J. Klein, personal communication, 1/25/10).

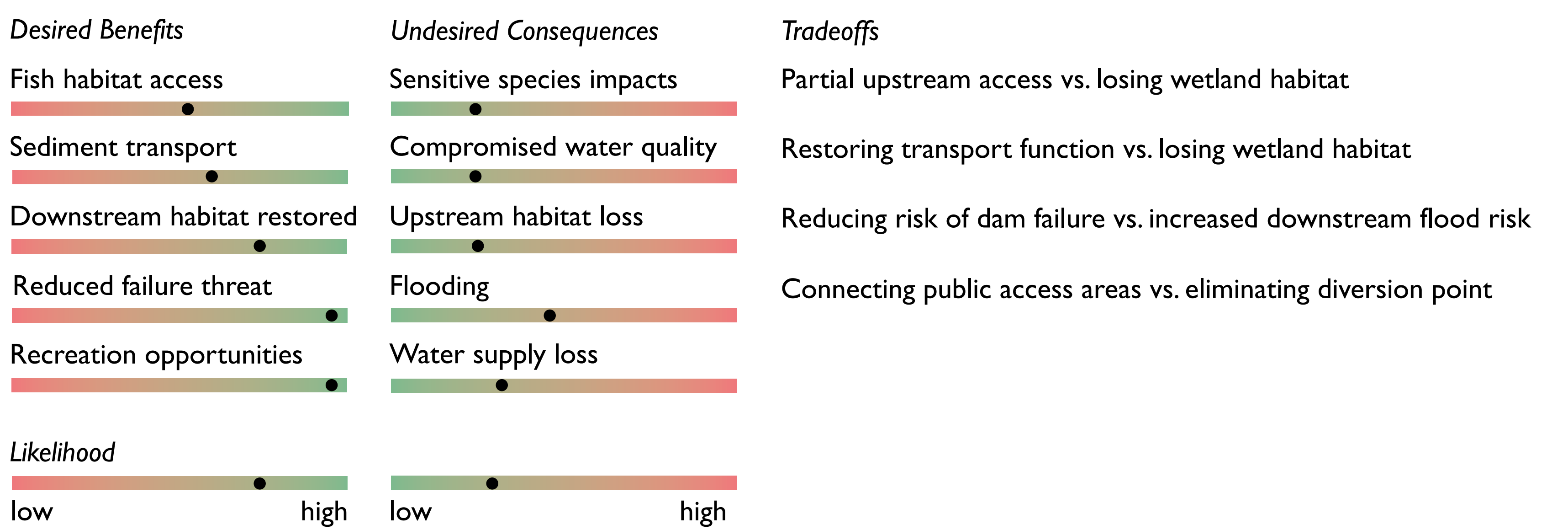


Figure 4-27. San Clemente risks & tradeoffs.

Significant traffic impacts are likely to occur during construction because Carmel Valley Road, the closest main thoroughfare, is very narrow, and access to the dam is currently only possible through the downstream Sleepy Hollow community. A new traffic access route will need to be established upstream of the dam. Future public access to the land surrounding the existing reservoir and dam site will be secured through incorporation into a public park as part of the Monterey Peninsula Regional Park District (L. Hampson, personal communication, 1/14/10).

Matilija Dam

BACKGROUND INFORMATION

Matilija Dam (Figure 4-28) is located on Matilija Creek, a tributary of the Ventura River. It is approximately 16 miles inland from the coast (Figure 4-29) (USBoR, 2000). The dam is a concrete arch structure, originally constructed to be approximately 190 feet high, and 620 feet wide (USBoR, 2000). The dam was completed in 1948 by the Ventura County Flood Control District (now the Ventura Country Watershed Protection District – VCWPD) for local water supply and flood control (USBoR, 2000). The reservoir created by the dam originally stored 3,800 acre feet of water, but its storage capacity has been reduced to approximately 400 AF due to sediment infilling and notching of the dam structure (USBoR, 2000). It is estimated that by 2010, the reservoir will be totally filled with sediment (USBoR, 2000). Downstream water supply infrastructure is operated and managed by Casitas Municipal Water District

Figure 4-28. Matilija Dam.

Figure 4-29. Matilija Dam and Ventura River watershed.
Downstream of dam Upstream of dam

Figure 4-30. Infrastructure downstream of Matilija Dam. (USACE & VCWPD, 2005)

under contract with the Bureau of Reclamation (the Bureau) (Capelli, 2007). These facilities include Robles Diversion Dam and Casitas Dam, forming the Lake Casitas reservoir on Coyote Creek (Figure 4-30) (Capelli, 2007). Downstream diversions were authorized in 1956 under the Bureau's Ventura River Project, one of the largest projects implemented by the Bureau in Southern California (USBoR, 2000).

Episodic storms, weak bedrock composed of marine sediments, active faults, and wildfires are significant factors that contribute to high sediment yields in the watershed (Scott & Williams, 1978 in Minear, 2003). Matilija Dam prevents sediment transport to downstream reaches, and the reservoir now contains approximately 6.1 million cubic yards of sediment (Figure 4-32) (USBoR, 2000).

The Ventura River and Matilija Creek watersheds upstream of the dam are mostly in Los Padres National Forest (Capelli, 2007). The City of Ojai lies just upstream of the dam, and is largely undeveloped (Capelli, 2007). The communities of Meiners Oaks, Oak View, and Ventura are downstream, and portions of the urbanized lower Ventura River floodplain are behind levees (Capelli, 2007).

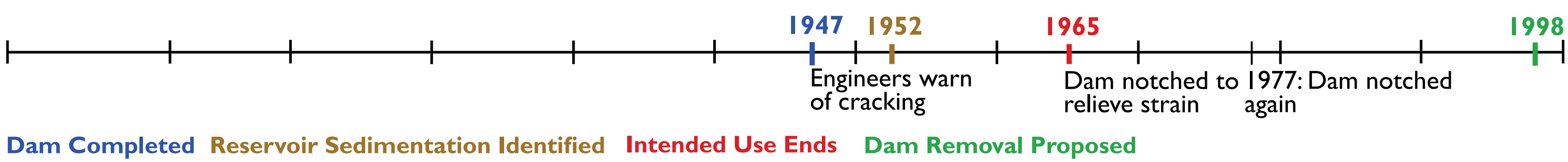


Figure 4-31. Matilija Dam timeline.

Ecological impacts of the dam include reduced sediment supply to downstream beaches, and blocked fish passage to the well protected upstream watershed. Prior to dam construction, the Ventura River delivered approximately 213,000 – 230,000 cubic yards of sand to the coastal beaches of Ventura County (USBoR, 2000). Matilija Dam and Casitas Dam on Coyote Creek prevent downstream transport of most sediment[1], contributing to significant beach erosion and retreat (USBoR, 2000). Decreased sediment transport also compromises quality of downstream southern steelhead spawning habitat, and prevents passage to approximately 18 miles of upstream habitat (Capelli, 2007). Prior to dam construction, the Ventura River reportedly supported a steelhead run of approximately 4,000 to 5,000 fish (USBoR, 2000). Southern steelhead were listed as an endangered species by NMFS under the federal ESA in 1997, and the Ventura River system was designated as critical habitat in 2005 (Capelli, 2007). There is a fish passage facility in place on the Robles Diversion Dam on Ventura River, and an ineffective fish ladder currently in place on Matilija Dam,

1 The Upper North Fork of Matilija Creek and tributaries on the east side of the Ventura River still contribute some sediment to downstream reaches.

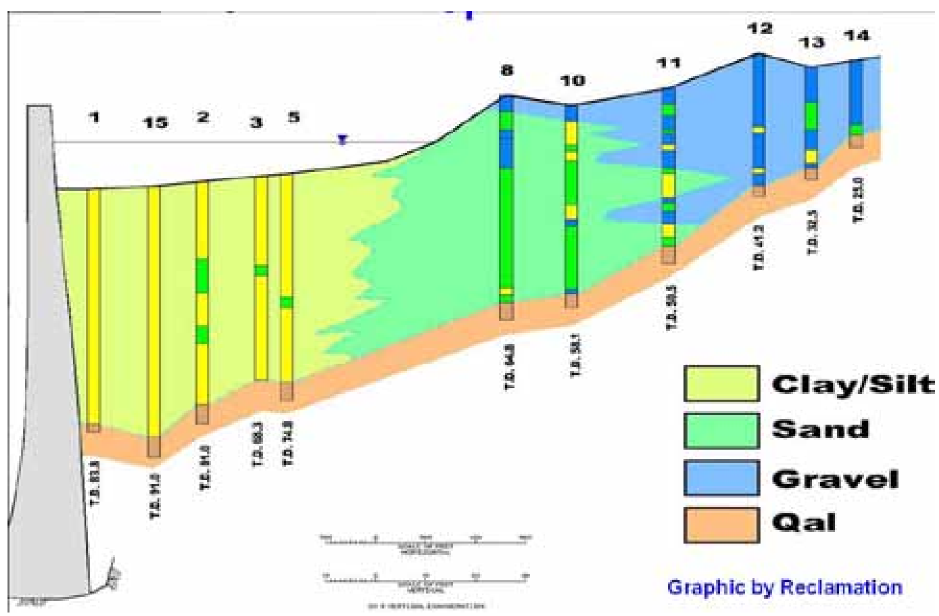


Figure 4-32. Sediment profile of Matilija Reservoir. (USACE & VCWPD, 2010).

making Matilija Dam the further upstream barrier to southern steelhead spawning habitat (Capelli, 2007).

Structural safety concerns about the dam were first identified shortly after construction was completed, with noticeable cracks resulting from aggregate-alkali reactions in the dam's concrete. The dam was notched in 1965, reducing the dam height by 30 feet, and notched again in 1978 to address structural concerns. The notches created a central spillway and reduced reservoir capacity by 3,200 AF (USBoR, 2000). Dam removal was first formally investigated by USBoR at the request of the Ventura County Board of Supervisors in 1998, in recognition that the dam has outlived its usefulness, is structurally unsound, and dam removal would provide access to upstream habitat to threatened southern steelhead populations and enhance recreational opportunities (USBoR, 2000). Following a feasibility study under leadership by the Corps and VCWPD and alternative approval, the project is currently in the design development phase.

ACTORS

The Matilija Coalition and the Bureau of Reclamation initially used their scientific knowledge and political connections to strongly encourage the Ventura County Board of Supervisors to make a decision regarding the fate of Matilija Dam. Following completion of the appraisal study, transferring project management from the Bureau to the Corps was a politically challenging process, given the Board of Supervisors' initial mistrust of the Corps based on previous project experiences (J. Hutchison, USACE, 12/15/09, personal communication). However, the Bureau does not have a formal planning process or cost sharing mechanism like the Corps, and therefore could not assume full agency responsibility for the dam removal project (J. Hutchison, USACE, 12/15/09, personal communication). The Bureau has remained involved as a comparatively non-political partner, providing valuable technical assistance, especially investigations of sediment transport scenarios which have been incorporated into the Corps' feasibility and design studies.

Working with a variety of federal, state, local government and non-governmental entities through a working group approach to synthesize existing data and conduct additional studies resulted in a well informed and supported feasibility study (Figure 4-34) (USACE & VCWPD, 2004; J. Hutchison, personal communication, 12/15/09). Non-governmental stakeholders served as information gatherers, outreach partners, and feedback providers. In addition to working groups tasked with examining factors such as hydraulics & hydrology, environmental factors, and recreation access, a legislative/lobbying & funding group composed of VCWPD, the Board of Supervisors, and the Coastal Conservancy worked throughout the process to insure than annual funding appropriations were secured for the project throughout feasibility study preparation. These appropriations, obtained through a highly political process, are key for continued progress into the construction phase. The role of non-governmental partners' ability to influence elected officials

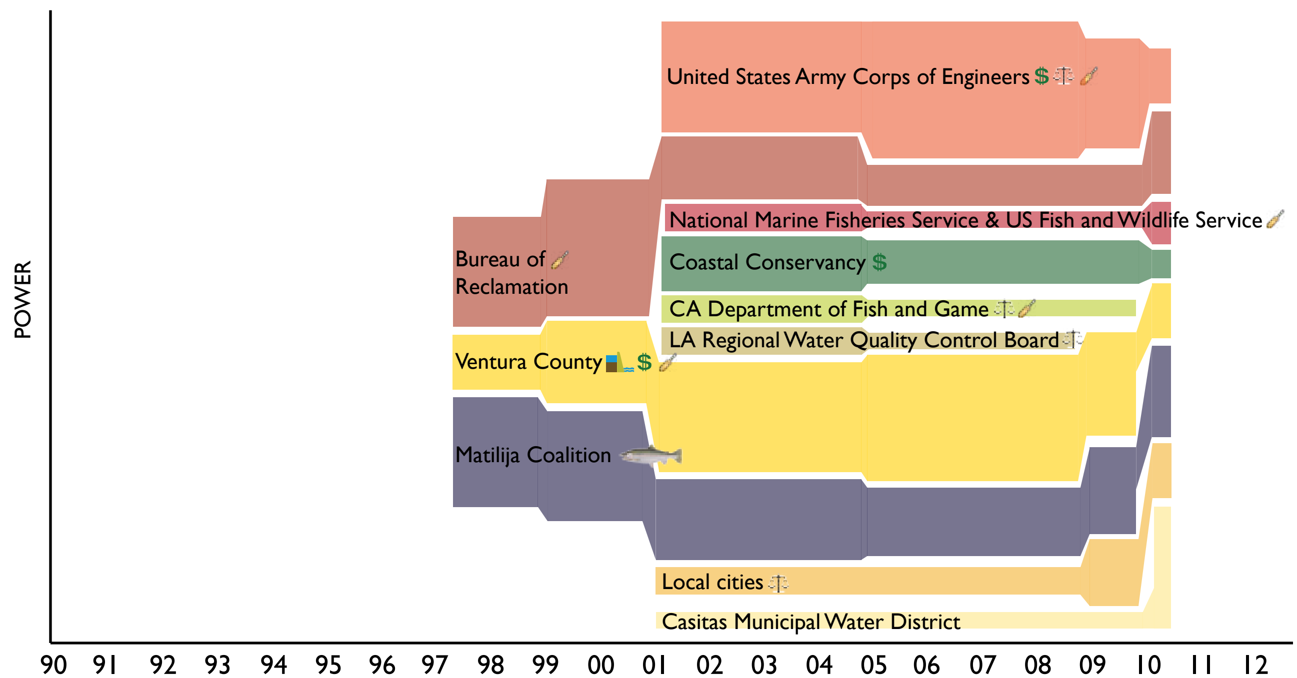


Figure 4-33. Matilija power map. Dam Owner Regulator $ Funder Technical Supporter Advocate

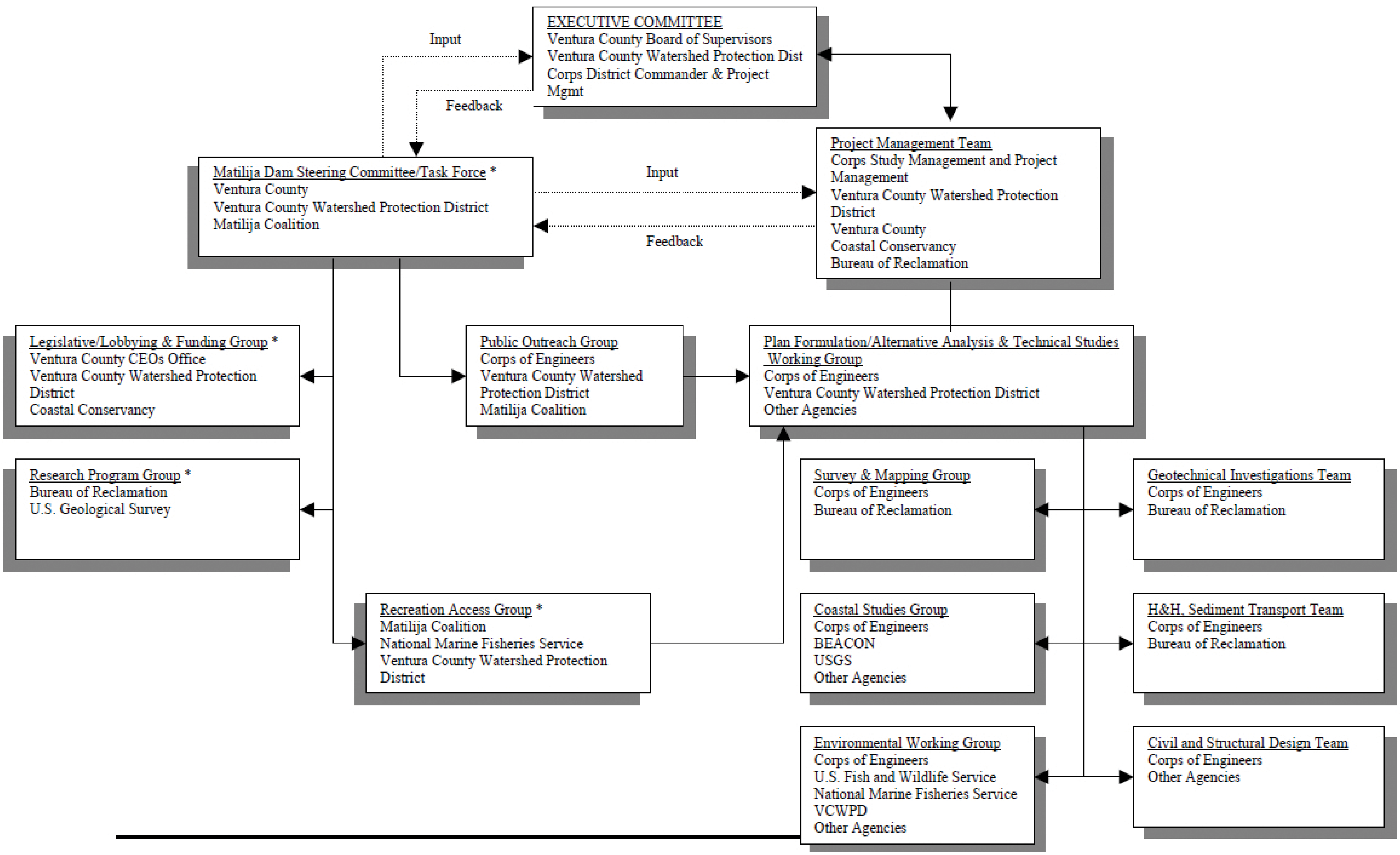


Figure 4-34. Matilija Dam feasibility study working group structure. (USACE & VCWPD, 2004).

who secure these appropriations should be considered essential to eventual project implementation.

Dam removals of this scale require significant federal assistance to local governments. Despite Ventura County's role as the local cost share partner, local cities, districts, and watershed residents were not actively involved in the feasibility phase (B. Cluer, personal communication, 3/10/10; J. Hutchison, personal communication, 12/15/09). Therefore, they were not fully informed of the potential impacts of slurrying downstream sediment until after the preferred alternative was agreed upon by working group members through a consensus process, approved by the study authorities, and funded by Congress through WRDA 2007. Lack of involvement and support by local communities has contributed to the project management team's inability to secure downstream sediment disposal sites. In addition, residents of the downstream Cities of Ojai and Meiners Oaks expressed significant concerns about techniques employed during the early construction phase project components, specifically herbicides used for arundo removal (K. Hockstedler, personal communication, 12/14/09).

One local entity that has demonstrated significant influence during the design study phase is the Casitas Municipal Water District. The Bureau technically owns Casitas Dam, and the Casitas Municipal Water District (Casitas) operates the diversion structures and owns the water in Casitas Reservoir (USBoR, 2009). Casitas then supplies potable water to its customers. Protecting this supply from potential contamination by fine sediment released from behind Matilija Dam is a significant concern (D. Chitwood, personal communication, 12/15/09). In an effort to protect downstream water supply, and the project management team's inability to secure downstream disposal sites, the Corps developed a conceptual upstream sediment disposal plan. Casitas recently refused to grant approval of the conceptual plan, which was necessary for the Corps to receive additional project funding to complete detailed studies (Kelley, 2010). Casitas Board members who did not vote in favor of the conceptual plan expressed the need for more information before they could approve such a plan (Kelley, 2010). This vote demonstrated the significant amount of power Casitas gained in later planning phases despite their lack of presence in earlier phases.

PROCESS

The eventual decision to remove Matilija was arrived at after two unsuccessful attempts to alleviate structural instability through notching the dam. Safety concerns guided dam modification in 1965 and 1978, in support of objectives to maintain the flood control and water supply function. However, these attempts to relieve strain on the dam were not as successful as anticipated, and additional studies indicated that sediment yield from the upstream watershed would lead to eventual filling of the reservoir (USBoR, 2000). Despite increased evidence of the ecological impacts, dam removal was still not thoroughly investigated as a permanent solution to ongoing loss of reservoir capacity and safety concerns.

The process which led to the decision to remove the dam began in 1998 following the revelation of mounting evidence on the ecological impacts of the dam (Capelli, 2007). Local environmental organizations, including Cal Trout and the local chapter of the Surfrider Foundation, formed the Southern Steelhead Reform Coalition and conducted several studies on the declining populations of southern steelhead trout throughout its historic range (N. Knite, Cal Trout, personal communication, 12/15/09). This information galvanized efforts to install a fish passage facility at the Robles Diversion Dam (completed in 2004), and to initiate contact with the Bureau of Reclamation regarding performing a dam removal appraisal study for Matilija Dam. The newly formed Matilija Coalition worked with the Bureau of Reclamation to politically engage the Ventura County Board of Supervisors and Congressman Elliot Gallegly to address several major issues of concern by removing Matilija Dam. These included restoring steelhead access to historic habitat throughout the Ventura River Ecosystem, restoring sediment supply to downstream reaches and beaches, and permanently addressing the safety hazard posed by structural instability (J. Hutchison, USACE, personal communication, 12/15/09, N. Knite, Cal Trout, personal communication, 12/15/09; USBoR, 2000). The dam removal related objectives were presented with supporting studies conducted during previous considerations of methods to address dam-related concerns, and more recent studies about ecological impacts (Capelli, 2007).

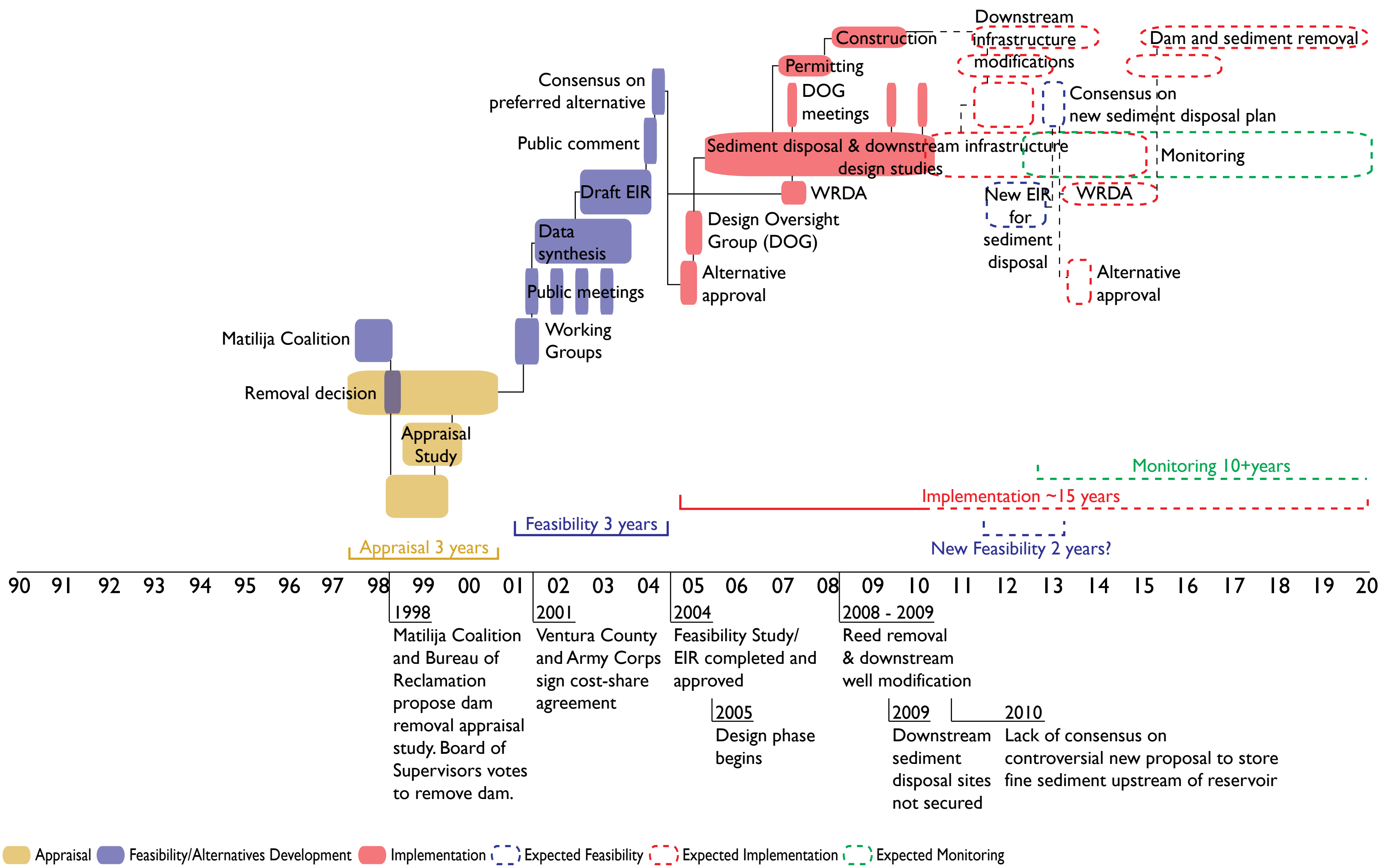


Figure 4-35. Matilija process steps and events.

Figure 4-36. Structural removal demonstration during then Secretary of the Interior Bruce Babbitt's visit, October 12, 2000. (Matilija Coalition, 2002).

In 1998, the Board of Supervisors voted to engage the Bureau in a formal dam removal appraisal study (USBoR, 2000). The role of politics in the decision making process is difficult to incorporate into a conceptual process model, but the strength of the scientific information presented by the Matilija Coalition and the Bureau provided significant political leverage, contributing to the decision to remove the dam and carefully evaluate dam removal options (N. Knite, Cal Trout, personal communication, 12/15/09).

The Bureau assembled the Matilija Dam Technical Task Force Committee, a multi-stakeholder group of federal, state and local entities, to complete the appraisal report (USBoR, 2000). Committee members completed various technical parts of the study, with oversight and technical investigation of sediment volume analysis by the Bureau (USBoR, 2000). The appraisal study outlined several removal and sediment management alternatives, and determined that removal is technically feasible, but did not go in depth regarding environmental impacts of the dam removal (USBoR, 2000). When the study was completed, a "demolition demonstration project" was held at the dam with then Secretary of the Interior Bruce Babbitt, who visited the dam during a test of the diamond wire saw cutting technique to remove the dam structure (Figure 4-36) (Matilija Coalition, 2002; J. Hutchison, USACE, personal communication, 12/15/09). The appraisal study did not select an alternative to proceed with, but recommended that additional studies and investigations should

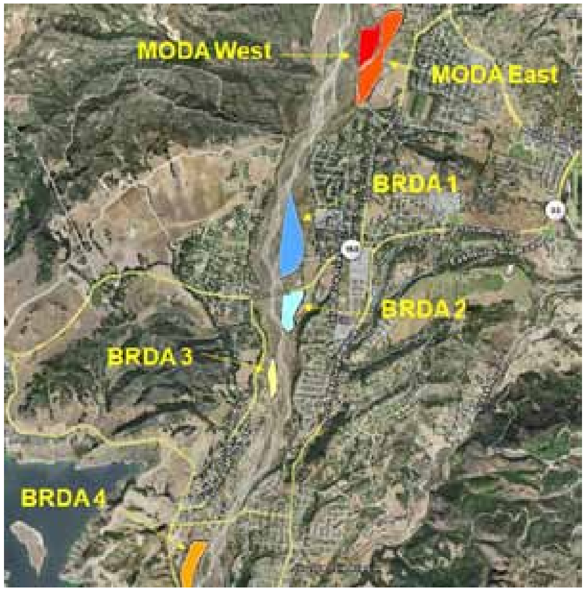


Figure 4-37. Proposed downstream sediment disposal sites. (USACE & VCWPD, 2010)

progress to determine an appropriate combination of alternative scenarios.

Following completion of the appraisal study, the Corps and VCWPD engaged in a partnership in 2001 to conduct a feasibility study and EIR/EIS, guided by topical work groups (Capelli, 2007). After several political negotiations, the Board of Supervisors worked with Congressman Gallegly to gain a Congressional appropriation for the Corps to conduct a reconnaissance study, which resulted in the determination that removing Matilija Dam was in the interest of the federal government (USACE & VCWPD, 2004; J. Hutchison, personal communication, 12/15/09). A cost share agreement was signed between VCWPD and the Corps, with additional financial support from the Coastal Conservancy and the Bureau as a contracted technical support agency as requested by the Board of Supervisors (USACE & VCWPD, 2004; J. Hutchison, USACE, 12/15/09, personal communication).

Through a working group, consensus-driven process led by the Corps and VCWPD, joint-fact finding led to alternatives development for the final feasibility study and subsequent EIR/EIS. The proposed alternatives primarily focused on sediment management in recognition that critical downstream infrastructure and sensitive aquatic ecosystems would be adversely impacted by an uncontrolled release of sediment from behind the dam (USACE & VCWPD, 2004). The preferred alternative identified in the EIR/EIS involves slurrying approximately 2.1 million cubic yards of fine sediment downstream to temporary disposal sites (Figure 4-37), excavating a channel through stabilized coarse sediments, enlarging downstream levees to off-set any temporary reduction in channel capacity, retrofitting bridges to accommodate increased flood elevations, reconfiguring downstream water supply infrastructure, and finally removing Matilija Dam (USACE & VCWPD, 2004). Public comment was solicited on the draft versions of the feasibility study and EIR/EIS, and a final report was drafted (USACE & VCWPD, 2004).

Approval of the preferred alternative was granted by the Secretary of the Army in 2005, moving the project into the design phase (USACE & VCWPD, 2005). Funding for implementation was secured in the 2007 WRDA. Members of the topical working groups remained involved as part of the Design Oversight Group (DOG). Several project components are underway, including a completed arundo removal project to minimize invasive species impacts on restored habitat along a 17 mile stretch of the river, and progress on downstream levee protection and infrastructure retrofitting (USACE, 2009; D. Chitwood, personal communication, 12/15/09). It is not clear if there is a monitoring plan that was developed to follow the implementation process, or if there is any possibility of re-initiating the planning process if additional efforts are needed to address arundo impacts on steelhead habitat restoration (K. Hockstedler, VCWPD, 12/14/09, personal communication).

Sediment management remains the greatest challenge in the design phase. Downstream disposal sites identified in the feasibility study were not able to be secured, significantly delaying project progress. The Corps recently presented a proposal to permanently stabilize fine and coarse sediment upstream of the reservoir at sites previously identified as temporary storage locations (Figures 4-38 & 4-39) (USACE & VCWPD, 2010). This would prevent sediment transport to downstream reaches, and from potentially entering downstream water supply at Lake Casitas (USACE & VCWPD, 2010). The Matilija Coalition has publicly stated their lack of support for the current proposal, saying that the "proposal to permanently sequester the fine sediments upstream of the dam in the manner described undermines the basic objectives of the Matilija Dam Ecosystem Restoration Project" (Jenkin et al, 2010). This statement is likely to influence efforts by elected officials to maintain project funding, and may result in returning to earlier steps in the planning process (B. Cluer, personal communication, 3/9/10).

The Matilija Dam removal planning process demonstrates the iterative nature of feasibility and alternatives development, and the importance of continued public consultation throughout planning phases. Integration of organized dam removal advocates throughout this process proved to be a key driver for moving the process forward while carefully crafting and developing alternatives. It also eliminated the threat of litigation by these groups during the feasibility study phase because they were included in a consensus based decision making process.

However, achieving consensus during the design and implementation phase has proven challenging, particularly in the refinement of studies dealing with sediment management, which requires complex modeling inputs and careful science. Engineering studies required for construction documentation has limited continued joint-fact finding in later phases of the project. New

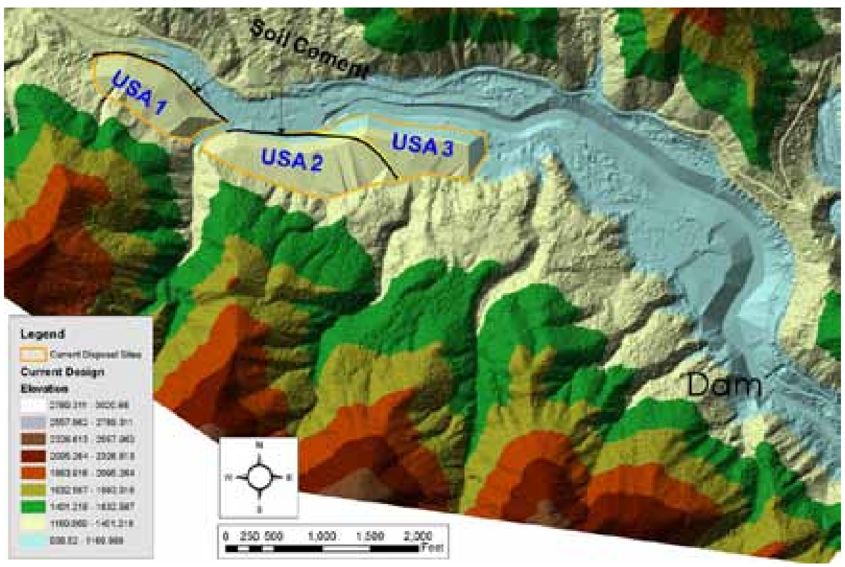


Figure 4-38. Upstream storage area proposal for permanently stabilizing fine sediments excavated from Matilija reservoir. (USACE & VCWPD, 2010)

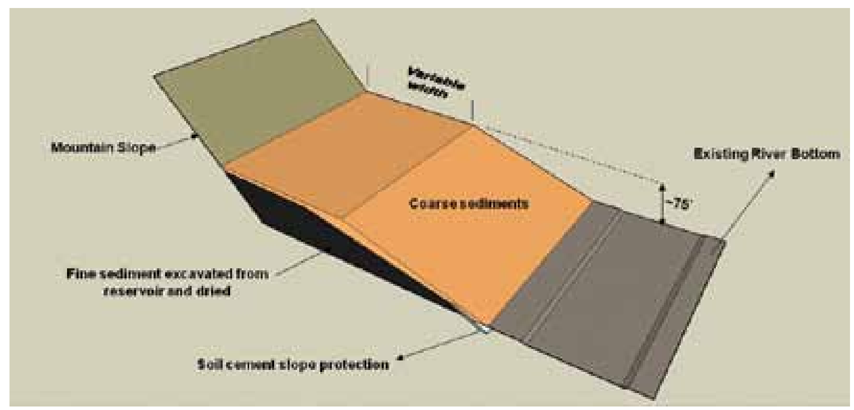


Figure 4-39. Cross section of sediment stabilization proposal. (USACE & VCWPD, 2010)

alternatives proposed by the Project Management Team from these study results were developed with limited input from the DOG, and their displeasure with the new proposal has been publicly voiced.

The lack of an evolving monitoring plan for this removal is a missed opportunity to conduct significant scientific research on dam removal. A dam of this scale has never been removed in the United States, and several theories and modeling results will be put to test in the real-world when the dam is removed. Therefore, significant support for monitoring should be a project management priority, regardless of which sediment management option is implemented. Actual structural removal renders application of adaptive management principles nearly impossible, but certain project components, such as sediment slurrying and arundo removal, should be carefully monitored in the event that adjustments to plan implementation are necessary. Post-project monitoring necessitates a feedback loop between implementation and monitoring to inform not only the project at hand, but also future projects.

RISKS

The new proposal to permanently stabilize fine sediments in place will potentially result in several undesired consequences compared to the original desired benefits established during the feasibility phase of the project. While dam removal will still result in increased fish passage, the quality of the habitat above the dam is likely not ideal if substantial portions of the upstream channel are hardened as suggested by the conceptual design for stabilizing fine sediments. Upstream sediment disposal sites are proposed in a popular recreation area, therefore decreasing recreation opportunities upstream of the dam (Jenkin et al, 2010).

Coarse sediment will be mobilized downstream in storm events, but re-establishing a more natural sediment transport regime to supply sand to downstream beaches will not be realized under the new proposal. Beach nourishment for downstream beaches subject to erosion was originally identified by stakeholders as one of the project's objectives. Increased sand deposition on Ventura County's shoreline will increase recreational opportunities in the area. The new upstream sediment stabilization proposal diminishes the likelihood of achieving this benefit.

The new proposal also has the undesired consequence of undermining the previously successful consensus based decision making process established during the feasibility phase. The upstream sediment stabilization proposal selectively draws upon elements of the consensus approved alternative, but is for the most part a new proposal developed by the Corps without consultation from other engaged stakeholders. Trust among planning partners is compromised by introduction of this new proposal, and will likely result in significant delays in implementation progress.

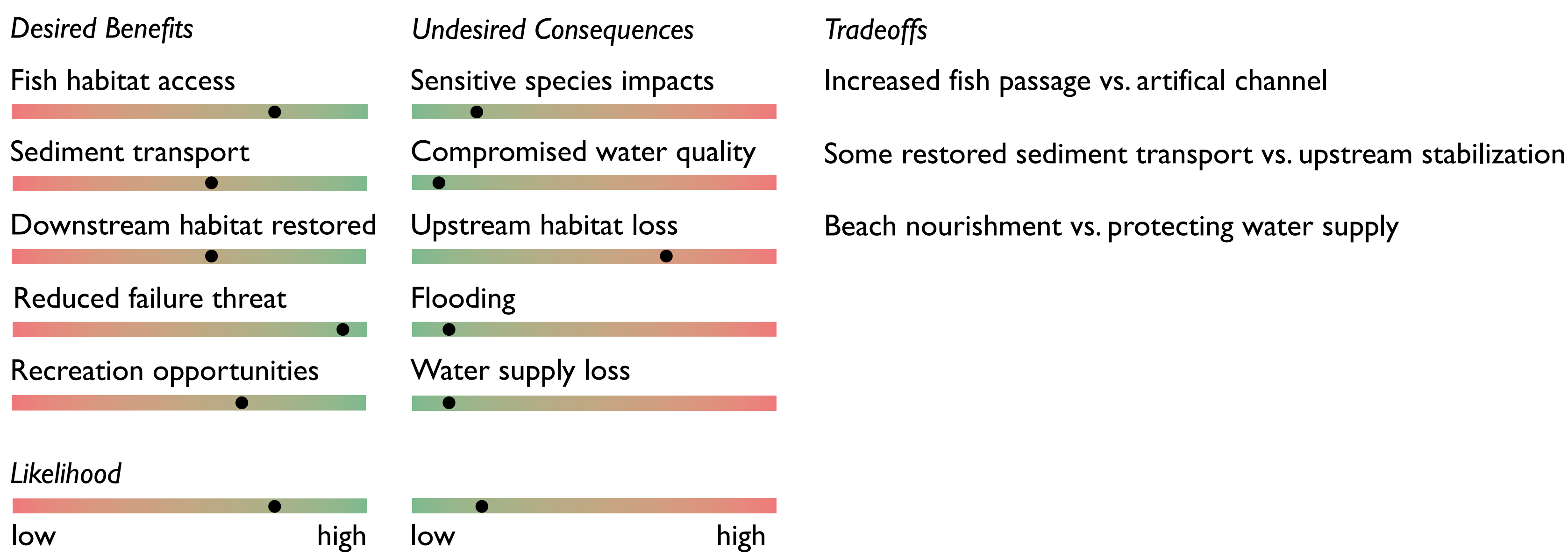


Figure 4-40. Matilija risks & tradeoffs.

Rindge Dam

BACKGROUND INFORMATION

Rindge Dam (Figure 4-41) is located on Malibu Creek in Malibu Creek State Park in Los Angeles County, approximately 2.6 miles upstream of the Pacific Ocean (Figure 4-42) (Dallman and Edmondson, 2002). The dam is 102 foot high and 140 foot wide, and is constructed of steel-reinforced concrete, with its maximum thickness at its base measuring 30 foot (USACE, 2006b). It was originally constructed by the Rindge family in 1926 for agricultural water supply (Dallman and Edmondson, 2002). Initial reservoir storage capacity was 574 AF, but the reservoir quickly filled with sediment due to storms in the late 1930s that contributed significant runoff from the upstream watershed, and damaged the spillway structure (Taylor, 1945 in Dallman and Edmondson, 2002). The

Figure 4-41. Rindge Dam.

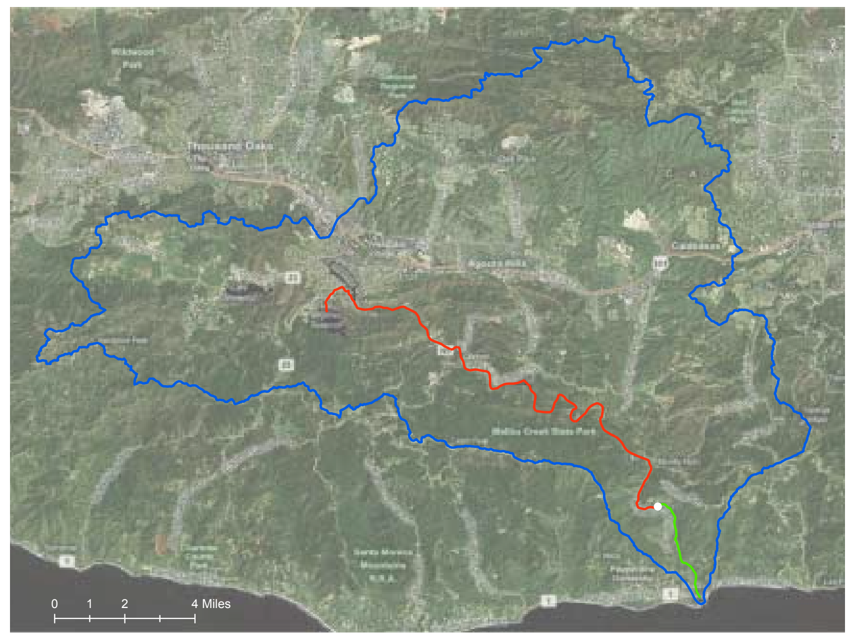


Figure 4-42. Rindge Dam and Malibu Creek watershed.
Downstream of dam   Upstream of dam

reservoir completely filled with sediment by 1955, and DSOD decommissioned the dam in 1967, ending its useful lifetime (USACE, 2006b; Dallman & Edmondson, 2002). The dam impounds approximately 780,000 cubic yards of sediment, and no longer provides flood storage or water supply (USACE, 2006b; Dallman & Edmondson, 2002).

Malibu Creek drains the southern slopes of the Santa Monica Mountains, and is a tributary to Santa Monica Bay (Dallman & Edmondson, 2002). Most of the upstream watershed is within the Santa Monica Mountains National Recreation Area, and erosion from the upstream watershed has contributed sediment to the now infilled reservoir (Dallman & Edmondson, 2002). At the mouth of Malibu Creek is Malibu Lagoon, a sensitive estuary that is home to the endangered tidewater goby (*Eucyclogobius newberryi*) (USACE, 2006b; Dallman & Edmondson, 2002). In addition to preventing fish passage, Rindge Dam also prevents transport of fine sediment and sand to downstream beaches. (Dallman and Edmondson, 2002).

Malibu Creek is also home to the southern steelhead, and historically supported approximately 1,000 steelhead (Nehlsen et al, 1991 in Dallman & Edmondson, 2002). Steelhead runs have been drastically reduced partially due to their inability to migrate to almost six miles of high quality spawning grounds above the dam (Abramson & Grimmer, 2005; Franklin and Dobush, 1989 in Dallman & Edmondson, 2002). CDFG determined that if the dam is not removed, recovery of the steelhead population is unlikely (McEwan and Jackson, 1996 in Dallman & Edmondson, 2002). The dam currently impacts water temperatures in the downstream portion of Malibu Creek, which threatens steelhead populations (Dallman & Edmondson, 2002).

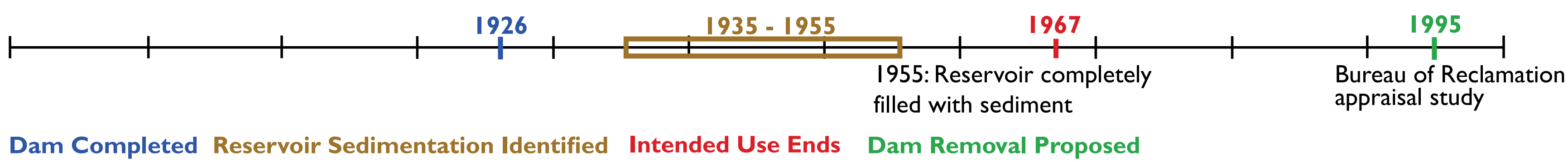


Figure 4-43. Rindge Dam timeline.

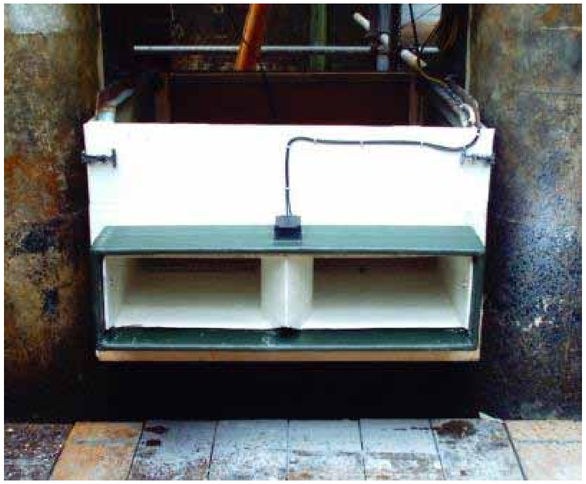


Figure 4-44. Example of a Borland fish lift. Fish swim into the lift, which transports them over the barrier. (Wyre Micro Designs, 2007)

Increasing steelhead access to upstream spawning areas motivated discussions regarding removing Rindge Dam. Previously, Cal Trout, the Santa Monica Mountains Conservancy and California State Parks (State Parks) investigated installing a Borland style fish lock device (Figure 4-44) to transport fish over the dam (Dallman & Edmondson, 2002; M. Capelli, personal communication, 12/17/09). However, this was deemed infeasible due to maintenance access issues (Dallman & Edmondson, 2002). In 1995, the Bureau and CDFG conducted a study to examine possible alternatives for fish passage, including three dam removal scenarios (USBoR, 1995). Following completion of this study, State Parks sought support from the Corps to initiate an ecosystem restoration project for providing fish passage within the watershed. In 1998, Congress appropriated funds for a Corps reconnaissance study, which determined that the federal government has an interest in restoring the Malibu Creek watershed and protecting its associated shoreline. The Corps and State Parks (CA Parks), the current dam owner, agreed to participate in a cost share study to determine feasibility of a restoration and watershed management study, including exploration of dam removal and sediment management alternatives. A baseline conditions report was prepared, and additional portions of the feasibility study are still underway pending available funding.

ACTORS

Local environmental groups and resource agencies provided much of the information used by project planners and managers in preparing the necessary studies as part of their planning process (M. Abramson, personal communication, 12/14/09). Studies conducted by the Southern Steelhead Restoration Coalition on available steelhead habitat, fish population size, and sediment characteristics initiated the removal consideration process (Dallman & Edmondson, 2002). Heal the Bay performed a comprehensive evaluation of steelhead habitat quality and fish passage barriers in the Malibu Creek watershed (Abramson & Grimmer, 2005). Heal the Bay also runs an extensive water quality monitoring program on Malibu Creek through its Stream Team program that provides information about habitat quality for steelhead (Heal the Bay, 2010). The Resource Conservation District of the Santa Monica

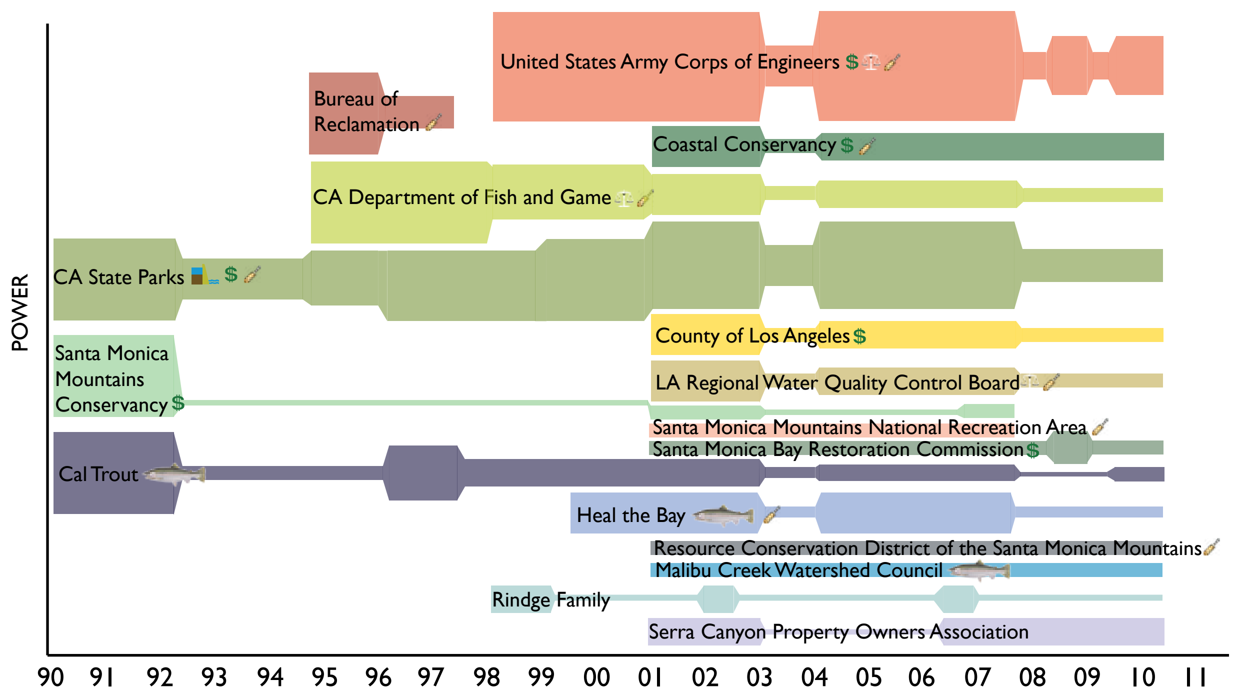


Figure 4-45. Rindge power map. Dam Owner Regulator $ Funder Technical Supporter Advocate

Mountains conducts stream monitoring for endangered fish species within the Santa Monica Mountains National Recreation Area, including steelhead populations in Malibu Creek (Resource Conservation District of the Santa Monica Mountains, 2010). Several of these data collecting groups are also proponents of removing Rindge dam, citing a wealth of information that indicates presence of valuable upstream habitat in the Santa Monica Mountains National Recreation Area and potential for beach nourishment (Dallman & Edmondson, 2002). Additional information specific to evaluating technical feasibility of removal and reservoir sediment characteristics was collected and refined through a working group approach similar to the Matilija planning process, which included some similar members on the project planning team (USACE, 2006b; J. Hutchison, personal communication, 12/15/09).

Despite the significant amount of information collected to characterize the watershed and evaluate feasibility of dam removal, the Corps and State Parks are still working on completing baseline conditions reports as part of the feasibility study. Funding for feasibility study tasks is sporadic depending upon annual appropriations from Congress and State Parks' annual budget, which decreased significantly during the recent state fiscal crisis. Other local government entities, such as the Santa Monica Bay Restoration Commission, have provided funding at times to keep the process moving.

Local constituencies have expressed their concerns about potential undesired consequences resulting from removing Rindge Dam, including the wealthy downstream community of Serra Retreat who are wary of potential increased flood risk, despite the lack of flood control currently provided by the dam (N. Knite, personal communication, 12/15/09). Additionally, Ron Rindge of the Rindge family, original owners of the dam and surrounding area, is at times a vocal proponent of keeping the dam in place, claiming its historic value (USACE, 2006b). The dam meets criteria established by the National Register of Historic Places for listing in their registry (USACE, 2006b).

PROCESS

Despite decommissioning the dam in 1967, the process to formally investigate increasing fish passage did not begin until State Parks, the Santa Monica Mountains Conservancy, and Cal Trout conducted their initial study in the early 1990s. The Bureau's appraisal study that followed conceptually explored removal alternatives, but the scope of the report did not include a detailed analysis of issues and concerns. The favored alternative identified in this plan was mechanical removal of sediment, and transporting the sediment out of Malibu Canyon via trucks (Dallman & Edmondson, 2002). This option raised concerns about increasing traffic on Malibu Canyon Road and Pacific Coast Highway (Dallman & Edmondson, 2002). Cal Trans restricts the size of trucks and hours during which they can travel on Malibu Canyon Road, which would lead to significant slowing of traffic likely to anger local residents (Dallman & Edmondson, 2002).

The Corps planning process provides an attractive funding mechanism to local partners, in this case State Parks, to develop and refine alternatives. However, consistent funding is dependent on annual budget cycles, resulting in several starts and stops in the feasibility phase. Local partners have contributed funding at times in an effort to maintain progress. A draft baseline conditions report was completed in 2006, and the feasibility study has moved into alternatives development. Selecting a preferred alternative to pursue has yet to be finalized due to funding delays to support additional research. Differences in the Corps and State Parks budget cycles have contributed to these delays - when one party receives some money, the other may not have funding available at that time, and the need for partner progress at equal paces complicates how and when money can be spent (M. Abramson, personal communication, 12/14/09; J. Hutchison, personal communication, 12/15/09). State Parks has not been able to provide funding for the past two fiscal years, significantly limiting the amount of progress than can be done on completing the feasibility study (M. Abellera, personal communication, 12/15/09).

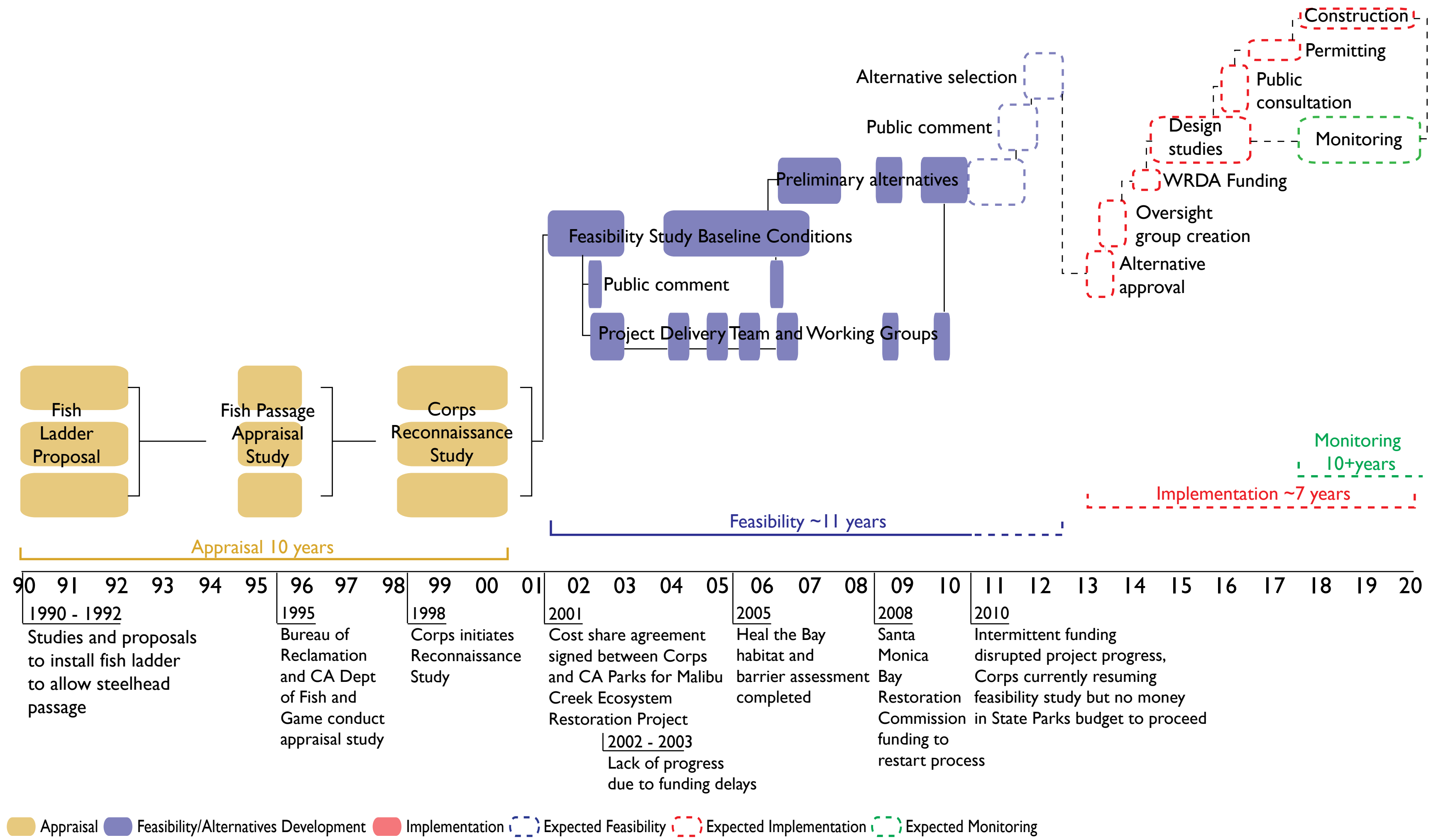


Figure 4-46. Rindge process steps and events.

When funding is received to re-activate project planning, re-establishing contact among stakeholders take some time, as well as building trust among these stakeholders to facilitate progress (M. Abellera, personal communication, 12/15/09; J. Hutchison, personal communication, 12/15/09). Re-establishing group process each time substantial funding is received, combined with long periods of no progress when funding is unavailable, contribute to the overall lack of project progress.

RISKS

As in the other case studies, sediment management is a significant challenge. Because the dam and reservoir are located in a narrow canyon, it is difficult to bring construction equipment into the former reservoir area (USACE, 2006b). Equipment for previous studies on sediment characteristics was brought down to the reservoir using helicopters (Figure 4-48) (USACE, 2006b). The proposal to truck out sediment has significant limitations due to traffic restrictions in the area, and downstream disposal sites immediately

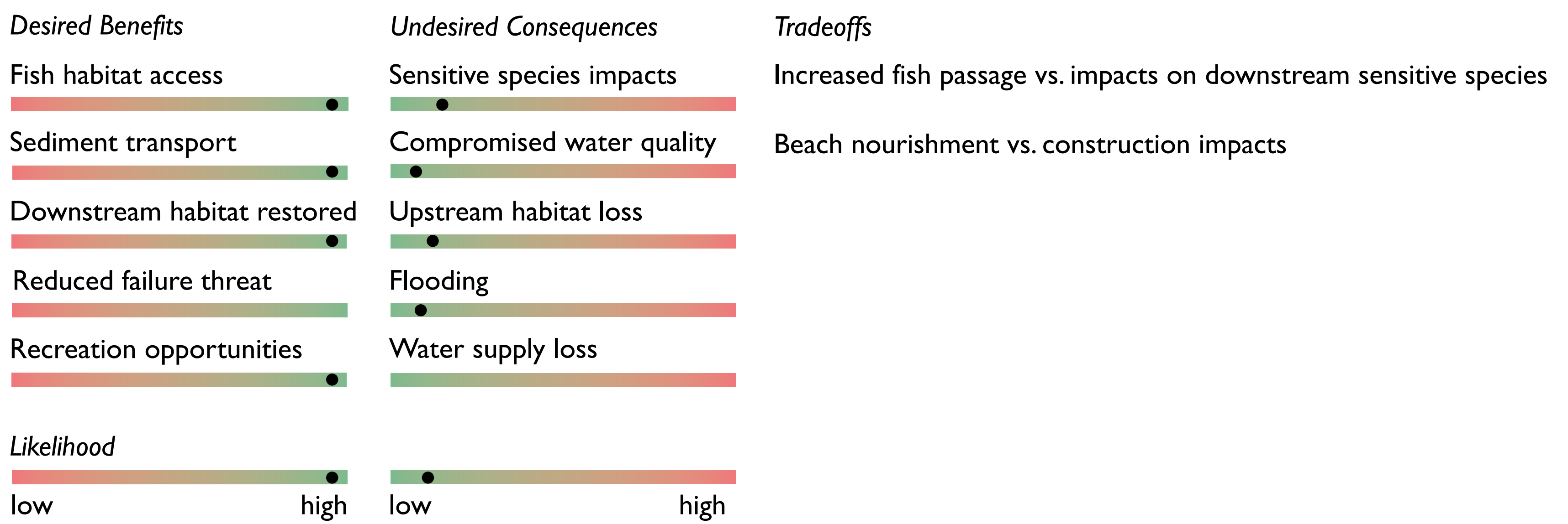


Figure 4-47. Rindge risks & tradeoffs.

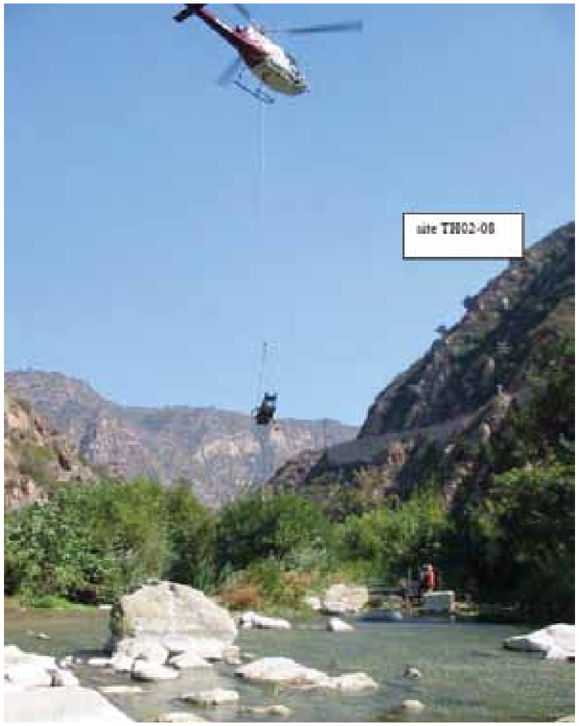


Figure 4-48. Helicopter transporting equipment into former reservoir area to use in sediment drilling. (USACE, 2006b)

below the dam are not available because of the canyon's form and residential development (USACE, 2006b). Approximately half of the material behind the dam is suitable for beach nourishment (Law Crandall, 1994). However, determining a method to transport this sediment without causing undesired traffic consequences has yet to be determined. Removal through incremental notching of the dam structure, and reliance on periodic flooding to flush sediments out of the former reservoir area has also been considered (Capelli, 1999). However, this has the potential to adversely impact downstream properties as a result of elevated sedimentation (Capelli, 1999). Determining an appropriate and feasible sediment transport scenario, along with a dam demolition plan for the steel reinforced concrete structure, that will not harm other sensitive species in Malibu Canyon and in downstream reaches are the greatest challenges in the Rindge removal planning process.

Synthesis of case study findings and recommendations for future dam removal planning efforts are presented in the following chapter.

CHAPTER 5: Synthesis & Recommendations

The "Big Five" case studies reveal several important lessons about planning for dam removal. As dams continue to age and removal becomes a more seriously considered option to address safety and ecosystem related concerns, new policies should be developed for dam removal planning based on recommendations discerned from the case study analysis. Recommendations should be applied to future dam removal projects with reference to the case studies as precedent examples.

Case Study Synthesis

ACTORS

Comparison of roles and power dynamics among actors involved in each case study highlights several key points (Figure 5-1):

1. The case studies demonstrate the value of coordination among multiple interested parties to produce a well informed plan for removal.
2. This coordination is dependent upon trust among involved actors, without which it is difficult to reach consensus on important decisions.
3. Individual personalities can make or break group dynamics, which can change significantly depending upon which step in the process the group has achieved.

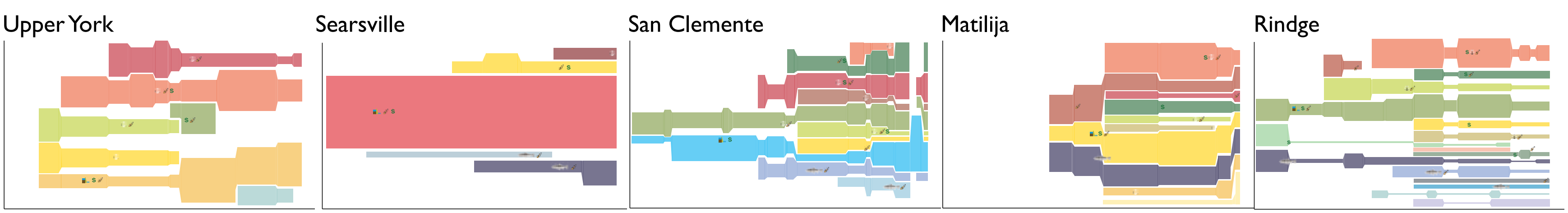


Figure 5-1. Case study comparison of actors' roles and power dynamics. Dam Owner Regulator $ Funder Technical Supporter Advocate

4. As power changes among actors, accessing resources can become difficult depending upon who has the most influence at a given time.
5. Assigning a particular entity oversight and coordination during the lengthy planning process is necessary to maintain an institutional memory and bring new players up to speed as the process evolves. This includes individuals or community groups, and fresh blood can at times reinvigorate a process.
6. Community organizations can help push a stalled process forward by holding government entities accountable for maintaining project progress.

PROCESS

The differences between planning processes in each of these case studies indicates that a single, optimal process does not exist for dam removal planning (Figure 5-2). However, there are key parts of the process that should be incorporated in future dam removals:

1. Collecting adequate baseline data to inform a dam removal decision is also important for supporting future steps in the process.
2. Care should be taken in the feasibility phase to inventory work that has already be completed in the appraisal phase, even if work was done by a different lead agency, to avoid redundancy.

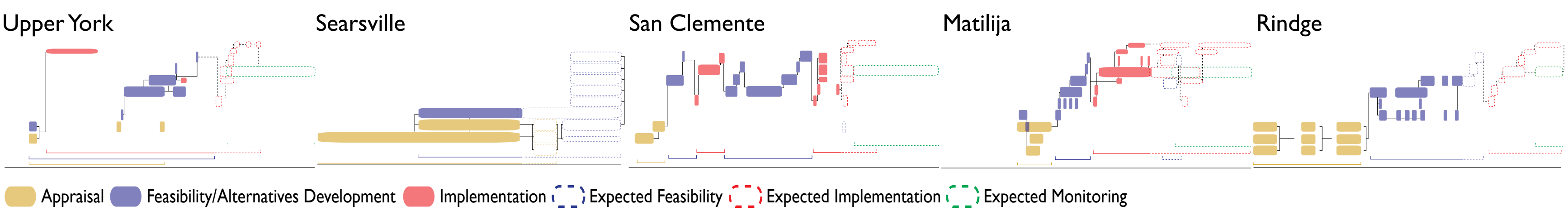


Figure 5-2. Case study comparison of process steps.

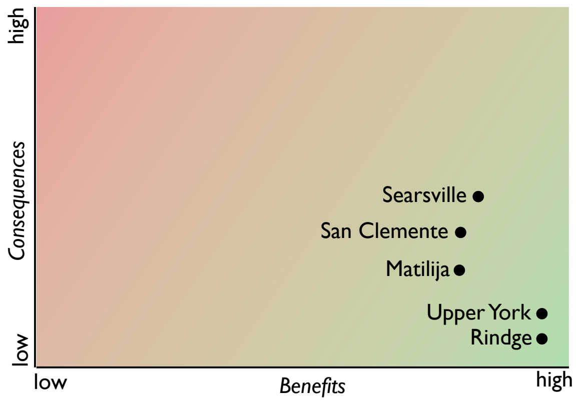


Figure 5-3. Comparison of case study risks.

3. Monitoring is necessary to add to a growing knowledge base about dam removal. None of the case studies have a clear monitoring plan at this time. One may emerge as planning moves forward, but it does not appear to be a priority among project managers.
4. Entities involved in removal planning should clearly explain to other partners what their internal processes are at the outset of removal appraisal to avoid future frustrations.
5. Maintaining secure funding throughout the removal process is critical for consistent project progress.

RISKS

Dam removal risks vary depending upon the local context, but comparing the likelihood of desired benefits and undesired consequences highlights common tradeoffs:

1. Re-establishing fluvial transport by removing a dam will change downstream reaches, and the severity of this change needs to be balanced with the potential for damage. Consistent monitoring is one tool to predict when and if events that endanger human life and safety will occur.

2. Increasing fish passage through dam removal will likely result in some loss of wetland habitat in the reservoir area. Evaluating if habitat availability is a limiting factor to sensitive species may require project design to include mitigation elements.

3. Determining who will assume long-term liability post-removal requires systematic negotiation of tradeoffs.

The following recommendations elaborate on these key points with examples from the case studies, and additional observations based on review of dam removal literature.

Recommendations

TAKE ADVANTAGE OF CHANGED ATTITUDES

The federal government's support of removal, notably during Bruce Babbitt's service as Secretary of the Interior, creates opportunities for removal by providing resources to state and local agencies. Federal support for small dam removal projects through grant programs, such as the Open Rivers Initiative, indicates continued willingness on the federal government's part to implement dam removal, in contrast to historical resistance to dam removal. Funding mechanisms should be established for larger dams, and to support the planning process, not just "shovel ready" projects.

In the case of Matilija, Rindge, and Upper York dams, federal financial and technical support through the Army Corps and Bureau of Reclamation were critical for getting these removal projects off the ground. Demonstrated political support for dam removal from the federal government contributed to a change in attitudes regarding dam removal that was previously not present when dam removal was first proposed. For example, removal of the Matilija dam was previously suggested but did not become a politically attractive idea until the federal government lent its support for evaluating dam removal through an appraisal study led by the Bureau. Dam removal was first proposed in a 1964 study conducted by the Bechtel Corporation evaluating at the safety of the Matilija Dam, but the Ventura County Board of Supervisors elected instead to notch the dam to relieve strain (USACE & VCWPD, 2004). Changes in the political acceptability of removal at that time may have led to more serious consideration of the option.

COLLECT RESERVOIR SEDIMENTATION AND DAM DATA

Although reservoir sedimentation modeling at a state-wide scale suggests that the Coast Ranges are particularly susceptible to reservoir sedimentation, it is still unclear how many reservoirs are infilling and at what rate (Minear & Kondolf, 2009). The number of reservoir sediment surveys has declined over the past twenty years (Figure 5-4) (Minear & Kondolf, 2009). Therefore, it is difficult to direct efforts to alleviating this problem to specific dams and reservoirs. Additional research needs to be done at a finer scale to prioritize where removal should be more seriously considered. While DSOD does annually inspect dams that meet the size and capacity threshold, often these are visual examinations that do not include in depth structural engineering studies, or investigation of reservoir sedimentation. Thus, reservoir capacity and its impacts on structural safety are not tracked on a regular basis. Periodic studies of reservoir sedimentation (every 5-10 years) should be done using sediment cores or analysis of historical bathymetry

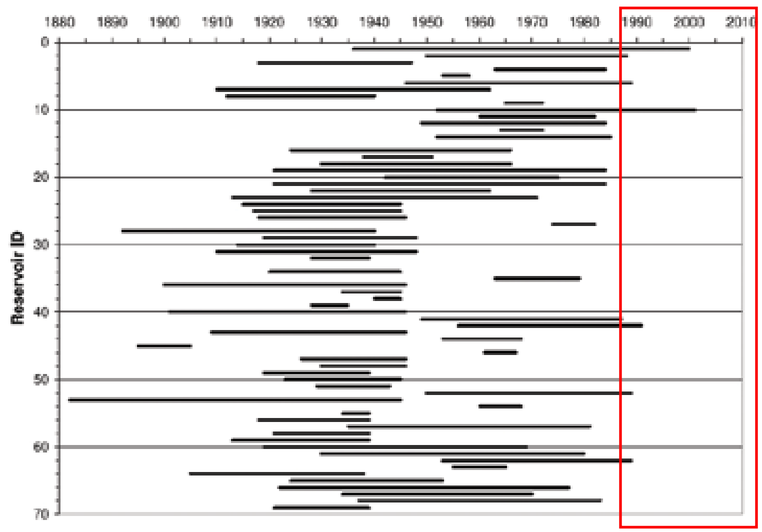


Figure 5-4. Decline in reservoir sediment surveys over the past 20 years. (Minear & Kondolf, 2009)

(Morris & Fan, 1998). Results should be incorporated into predictive modeling to estimate reservoir lifetime, thus management options can be evaluated early on. Understanding when a reservoir is likely to completely infill can spur planning for removal not as a reactive solution, but as a proactive measure. Therefore, budgeting and allocation of resources for eventual removal can be preemptively set aside. Although funding for dam removal is subject to political and economic forces, some early budgeting can take place in advance if an approximate date is determined for when a reservoirs usefulness will end.

In order to begin this kind of investigation, it is necessary to first establish how many dams are in the Coast Ranges (Figure 5-5). Discrepancies between records kept by the National Inventory of Dams and the DSOD should be more thoroughly investigated. Additionally, many small dams are not included in these databases because they do not meet the height or reservoir capacity thresholds. Therefore, smaller dams with compromised structural integrity may not be noticed until they fail. A thorough accounting of dams should be done before a removal potential or priority evaluation is done for the Coast Ranges.

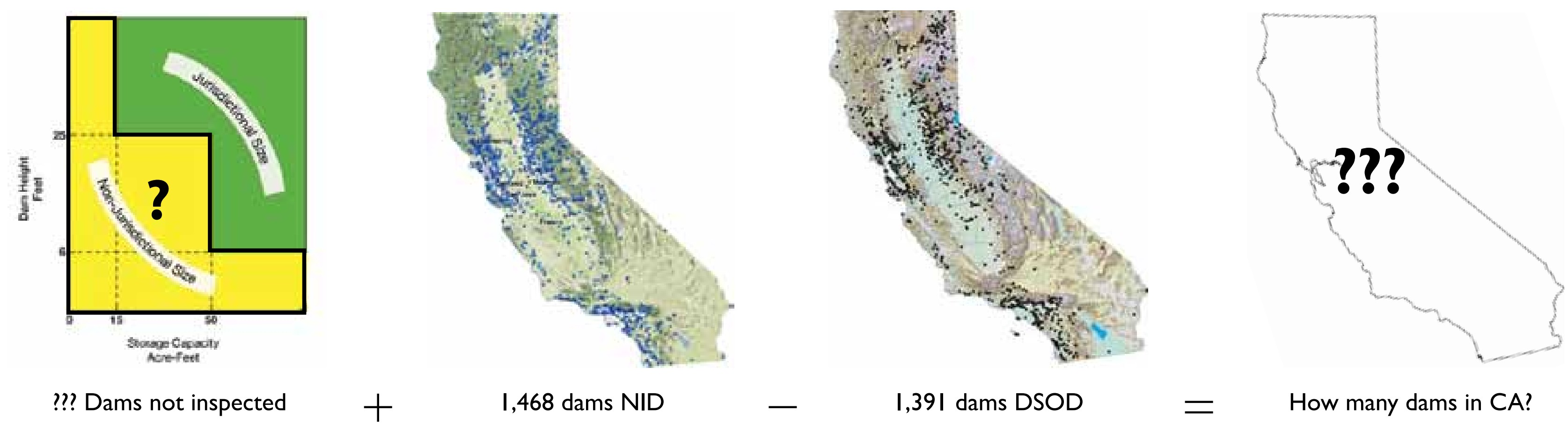


Figure 5-5. Contributing factors to uncertainty about number of dams in California (USACE, 2009; DSOD, 2009).

Figure 5-6. Los Padres Dam, upstream of San Clemente, is also filling with sediment and blocks steelhead passage.

PLAN IN A WATERSHED CONTEXT

Dam removal must be conducted in a watershed context in order to achieve the greatest ecological benefits. In addition to considering what potential downstream ecological impacts will result from removal, maximizing ecological restoration potential upstream of the removal site should be evaluated during the project planning phase. In the case studies, providing increased access to steelhead habitat is a common project goal. However, not all project removal proposals are designed with the greater watershed context in mind. For example, Los Padres Dam is seven miles upstream of San Clemente Dam, and is not currently considered for removal despite the fact that it limits access to an additional 18 miles of potential spawning habitat, and the reservoir is also filling with sediment from the upstream watershed (Figure 5-6) (MPWMD & Carmel River Watershed Conservancy, 2004). Cal-Am is mandated to stabilize or remove San Clemente for safety reasons, and the lack of emphasis on ecological restoration as a project motivation led to a lack of consideration for removing Los Padres.

An assessment of all barriers in a watershed must be conducted as part of dam removal planning. Downstream barriers, such as impassable weirs, eroded pipeline crossings, and culverts, should be addressed prior to removing a dam because dam removal is often a more expensive and resource intensive effort than removing smaller downstream barriers. Habitat quality should also be evaluated as part of dam removal projects that are attempting to improve anadromous fish passage. For example, barrier and habitat quality assessment in the Malibu Creek watershed as part of Rindge Dam removal planning led to prioritization of barrier mitigation projects within the watershed (Abramson & Grimmer, 2005). Assessment should also consider impacts to sensitive species habitat. California red-legged frog habitat is compromised to a degree in all of these projects, and investigation should be done of a watershed scale to determine where suitable habitat can be located to mitigate for loss of habitat that may occur from the removal project.

CREATE A COORDINATING ENTITY

As the case studies' timelines show, dam removal projects of this scale take a long time (Figure 5-7). Therefore, it is important to identify a coordinating entity that will remain involved throughout the process and can serve as a point person for tasks such as keeping an institutional memory, contract management, organizing a working group process structure, and securing funding (Figure 5-8). This entity should maintain oversight as individuals and agencies enter and exit the process, and keep the project going even if other agencies drop out. This role should be assigned in a written, legally binding project partner agreement that lays out ground rules for the planning process. The power maps show that the case studies are complicated jurisdictionally, and therefore having one oversight entity would be useful to facilitate progress among the various agencies.

In some cases, the Coastal Conservancy has stepped into this role when asked to serve as a coordinator. Through their mission to protect coastal watersheds, they have appropriately been incorporated into the Matilija, Rindge, and San Clemente projects to identify additional funding sources, serve on project management teams, and manage contracts among other project partners. However, the Coastal Conservancy does not have the regulatory authority to bring about dam removal through legally mandated means, although other common actors in dam removal planning such as NMFS do have enforceable legal mechanisms. The Coastal Conservancy's demonstrated experience in project management has helped move projects along, notably in the case of San

Clemente, but they lack tools like biological opinions or permitting authority held by other agencies involved in dam removal. As seen in the San Clemente planning process, the Coastal Conservancy was brought in to remedy a process on the brink of collapse to make sure that all interests were being considered, which was not happening in the previously disjointed process. In addition, the Conservancy was assigned the task of identifying funding sources to match Cal-Am's promise of funds of buttressing the dam.

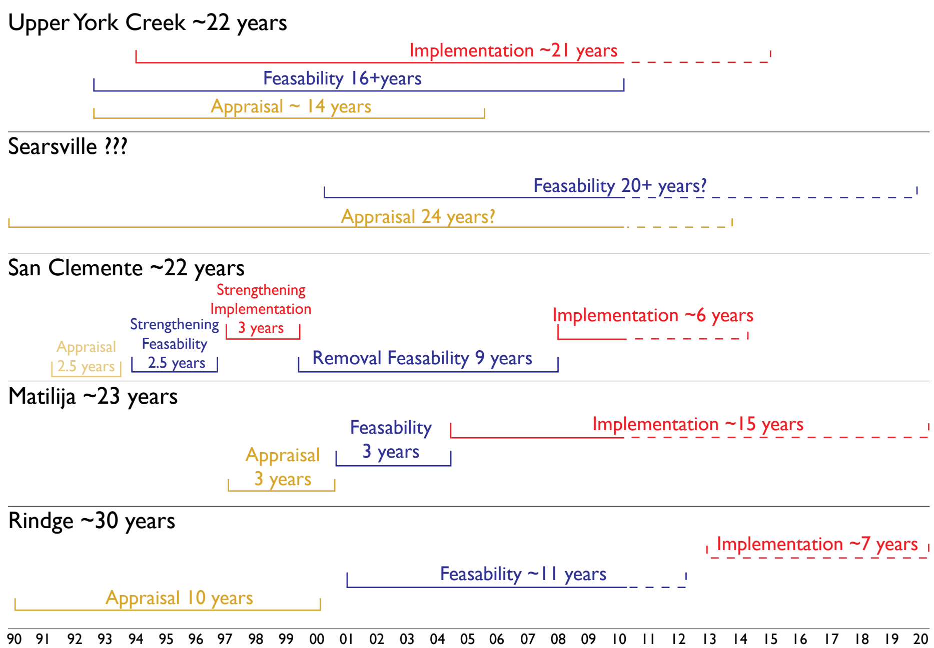


Figure 5-7. Case study timelines from appraisal to implementation.

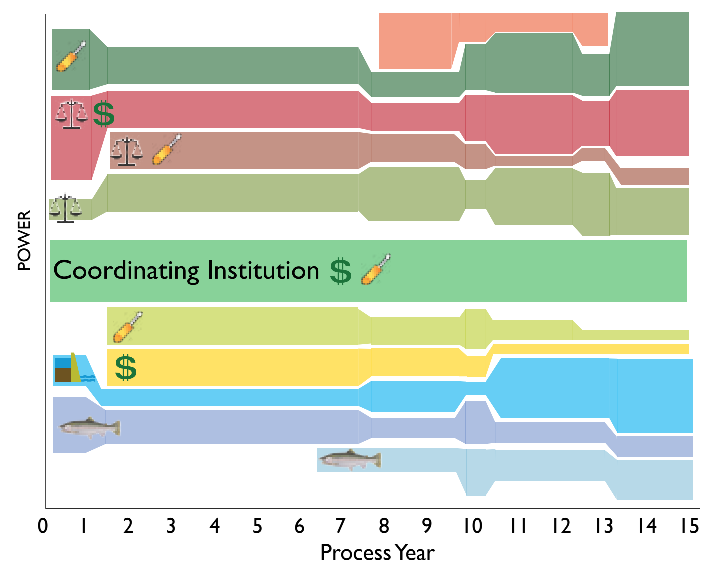


Figure 5-8. A coordinating entity is necessary among partners.

ENGAGE LOCAL COMMUNITIES AND RESIDENTS

Early involvement of non-governmental stakeholders in reaching the decision to remove a dam is vital for progression of the project, and policy should mandate opportunities for public involvement early in planning stages. Residents of the watershed and those who previously relied on reservoir storage for water supply or recreational access should be engaged early in the dam removal discussion. Dam removal provides a valuable learning opportunity regarding ecological restoration opportunities that should be shared with communities, not just experts who conduct studies related to removal. Local communities often possess knowledge of the area or river itself that can inform studies that need to be conducted as part of the appraisal phase, such ecological resources assessments. For example, several studies regarding steelhead populations in the Malibu Creek watershed were used in the Army Corps' development of the baseline conditions report for removing Rindge Dam.

Engaged residents can also help in politically driving the process forward. In the case of York Creek, the process appears to have stalled because of a shift in the City of St. Helena's priorities. Residents do not appear to be well aware of the removal proposal, given the lack of attendance at public comment meetings held regarding the draft EIR in 2006. Since then, changes in project leadership at the local level and focus on downstream flood control have left many of the City's obligations unfilled. Without the local community putting pressure on the Board of Supervisors to approve the draft EIR or direct the Department of Public Works to develop a sediment removal strategy, the project is unlikely to move forward.

Watershed residents hold political leverage through their participation in the democratic process. Local community engagement regarding San Clemente helped galvanize local elected officials to push for reconsideration of dam removal. Following Cal-Am's statement in February 2009 that they were not going to continue exploring the "re-route and removal" option, local groups such as the Carmel River Steelhead Association contacted their local officials, notably Congressman Sam Farr, to re-engage Cal-Am in dam removal discussions. This pressure from watershed residents helped keep removal on the table as a seriously considered option, and eventually led to crafting the new legal agreement signed in January 2010. Local residents were engaged in several public meetings during 2008 through efforts by the Coastal Conservancy and PCLF, and raising this awareness during earlier phases of the planning process helped contribute to later movements to keep removal on the table.

OUTLINE AGENCY AND GROUP PROCESS

Confusion about how to move forward with dam removal planning can arise if the various agency processes are not clearly explained from the very beginning. Collaboration is important for information and idea exchange, but the various agencies across levels of government have their own internal processes that are usually not well understood by other agencies or non-government entities. These need to be clearly outlined, as well as what the actors' roles and responsibilities are throughout dam removal planning to prevent the process from falling apart.

These case studies demonstrate government agencies across multiple levels are involved in dam removal planning, thus strategic coordination among these entities is critical. The Corps is the lead in the Upper York, Rindge, and Matilija processes, and their requirement to conduct work at an equal pace as project partners as funding is allocated has resulted in project delays at various points in time. Adapting a new interagency process with secure funding from the federal government is one potential way to ensure that dam removal planning continues unimpeded by interrupted funding streams. Development of such a process through the Bureau or the Corps, the largest owners of dams nationwide, will be useful to facilitate dam removal planning across levels of government.

CRITICAL STEPS IN EARLY PHASES PREVENT DELAYS LATER ON

The interagency process could be designed to expedite permitting if certain key early steps are taken (Figure 5-9). These should include a thorough appraisal assessment, including the identification of measurable goals, comprehensive review of issues of concern, and collection and evaluation of baseline data. Building a coalition of relevant government agencies, non-government organizations, and watershed residents that meets early and often is important to establish a process for the feasibility phase and a public engagement strategy. Joint fact finding and data collection that is subject to peer review within the coalition and public comment will help identify uncertainties and discrepancies early.

Figuring out a sediment management strategy is critical for dam removal projects of this nature. This should be done in the feasibility phase, and not left until the design development phase because funding allocation for implementation may be based on decisions made in the feasibility phase. Sediment is supposed to move from upstream to downstream, and a significant benefit of

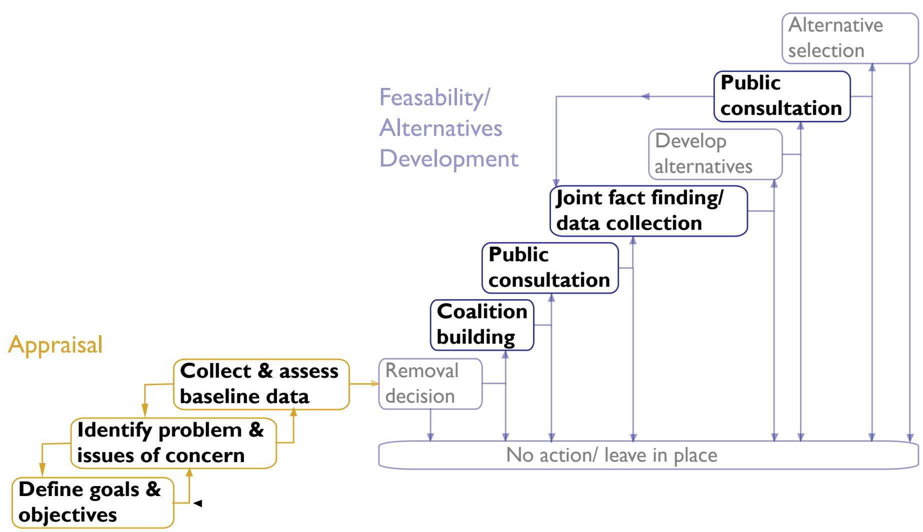


Figure 5-9. Key steps in the appraisal and feasibility phases.

dam removal is restoring sediment transport without compromising the safety of downstream communities, both for humans and wildlife. Sediment transport is an important function of rivers to maintain ecological integrity. Opportunities for storing that sediment somewhere else or allowing it to partially transport downstream via natural processes were investigated in all of the case studies, yet identification of a successful solution is a contributing factor to why none of the dams are removed yet.

In the case of planning for Matilija Dam, downstream sediment disposal sites were not secured during the feasibility process, and instead trust was placed in local politicians to secure these sites, which they were unsuccessful in acquiring. The Corps planning process leaves real estate acquisition towards the end of project planning after construction plans are approved (USACE, _____a). In dam removal scenarios where project implementation will depend upon where to put the sediment, disposal site acquisition should be incorporated into the planning phase to secure these locations sooner rather than later. This can help bridge the gap between the planning and construction phases, and avoid replacing big engineering projects, (i.e. dams), with other big engineering projects (i.e. hardened channels). Sediment management guidelines under development by federal agencies are promising for providing suggested methods to be used in future dam removal projects.

COMMUNICATE RISKS AND EVALUATE TRADEOFFS

Clarity about risks and tradeoffs is important to maintain while considering alternatives for achieving project goals and objectives. As removal proposals evolve, it is necessary to clearly communicate uncertainties and risks are posed by scenarios, and address those as needed. Complex science should be distilled for non-scientists in a manner that is understandable without undermining key results. Sediment transport and changes in channel form can be modeled with varying degrees of certainty, and current policies have limited tolerance for this range. Risks posed to human health and safety should of course be considered in the context of these model output ranges. Information about risk and uncertainty should also be shared with the public on a regular basis, rather than being left until the end when it may spark significant opposition, potentially requiring the process to start all over again.

Downstream infrastructure improvements related to mitigating human health and safety impacts from dam removal should also be conducted with restoration goals in mind. If bed aggradation is likely due to release of sediment, restoring floodplains to handle this increased flood risk should at least be considered before default options like reinforcing levees are implemented. Removing a dam creates opportunities for restoring ecological functions throughout the river, not just where the dam is proposed to be removed.

MONITOR

Removing dams of similar size as the case studies are essentially very large experiments because of the lack of precedent removals. While there are current obstacles for moving the process forward, the Upper York, San Clemente, Matilija and Rindge dams are likely to come out before several other large dam removal project that are at the beginning of their planning phases, namely Searsville Dam or the Klamath River dams. Therefore, monitoring should be conducted throughout the planning process – in establishing baseline conditions, during construction, and extensively post-removal to determine how successful implemented dam removals and sediment management scenarios were in achieving project objectives. If increased steelhead access to upstream spawning habitat is an objective, as it is in all of these case studies, it is important to monitor how these populations respond to removal. Project management should tap into existing monitoring programs, such as the Malibu Creek Stream Team, to use local resources and engage citizens in monitoring. These projects are often without precedent and therefore will provide a great deal of information to other projects in the future.

DEVELOP COST EFFECTIVE REMOVAL METHODS

When compared with the cost of increasing reservoir storage capacity or damage caused by dam failure, the removal proposal should provide substantially greater benefits over the long term, with maintenance and monitoring of the project factored in. The Corps' cost benefit analysis for Corps-sponsored projects accomplishes this under the auspices of the National Economic Development Plan and its Principles and Guidelines (Whitelaw & MacMullan, 2002). However, this traditional method is lacking in certain factors, such as an accurate assessment method of "passive use" values resulting from re-establishing a free flowing river (Whitelaw & MacMullan, 2002). The dynamic nature of dam removal planning leads to approved cost benefit analyses becoming quickly inaccurate, especially as market forces fluctuate.

SECURE FUNDING WITH PROJECT LIFETIME IN MIND

Like most major civil works projects, costs rise beyond original projections in dam removal planning. The lengthy nature of projects and involvement of multiple agencies makes budgeting for dam removal a particularly tricky task. Because various agencies operate on different budget year cycles, there may be times of the year when fully committed funds are not available from all partners, whereas there are other times of the year when one agency's budget can somewhat make up for another's when funds are not available. The Corps offers a significant source of funding to local governments, but incompatibility of the Corps' budget cycle with other entities' budget cycles makes consistent project progress difficult to achieve. Under the Corps' cost-share program, the local agency working in partnership with the Corps must make progress at an equal pace as the Corps' as demonstrated through spending funds associated with the project tasks and milestones. Inability to do so can stall project progress while one entity is waiting for the other to catch up, as is the current case in the York Creek and Rindge Dam Removal projects.

Public funding is necessary to support dam removal. In light of the fact that no dam will remain in place forever, it would behoove federal, state, and local governments to consider creating a dam decommissioning fund to support future dam removal projects. This fund should also support monitoring activities to develop accurate estimates of remaining dams' lifetimes on a continuing basis, not just when the dam is constructed.

As demonstrated by the San Clemente case study, private dam owners face significant funding obstacles (Klein et al, 2007). It is unrealistic to expect private dam owners to fund the entire dam removal project. Therefore, public-private funding partnerships for dam removal should be available at least during the planning phase to fund necessary studies for meeting regulatory and permitting requirements. A grant program similar to the Open Rivers Initiative should be developed for larger dams, and made available to both private and public dam owners.

Conclusion

Dam removal planning is a highly complex and unpredictable environmental planning situation. While subject to variations in political and economic winds, dam removal is also heavily reliant upon accurate scientific information to inform actors' decisions that allow the removal planning process forward. As these case studies show, at times it is not the quality, quantity, or source of information that matters most in moving the process forward, but the politics surrounding actors involved in advancing the removal option. While many small dam removal projects have been successfully completed over the past 20 years, larger dams in the California Coast Ranges present a unique set of circumstances to learn from. Policy specifically oriented towards removal of large dams previously constructed for water supply function should be developed with consideration of the aforementioned recommendations. It is possible that the task of removing the "Big Five" dams may be left to future generations, but the wheels should be set in motion to prepare the next generation for dealing with large dam removals by developing solid planning policy.

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APPENDICES

APPENDIX A: Interviewee List

Interviewees are listed with their name, affiliation, and date interviewed under the case study they are primarily associated with. In some cases, individuals were familiar with other case studies and provided information about them, but to eliminate redundancy, they are listed here under the case study they are most engaged with.

General dam removal experts
Steve Rothert, American Rivers, 10/19/09
Marcin Whitman, CDFG, 2/10/10
Brian Cluer, NMFS, 3/10/10

Upper York Creek
Eileen Nixdorf, USACE, 1/13/10
Joel Benegar, USACE, 1/20/10
Jonathan Koehler, Napa Resource Conservation District, 1/27/10
Laurel Marcus, California Land Stewardship Institute, 1/29/10

Searsville
David Freyberg, Stanford University, 9/28/09
Tom Zigterman, Stanford University, 2/1/10
Philippe Cohen, Stanford University, 2/1/10
Trish Mulvey, community volunteer and watershed advocate, 2/1/10
Matt Stoecker, Beyond Searsville Dam, 2/3/10
Kevin Murray, San Francisquito Creek Joint Powers Authority, 2/3/10

San Clemente
John Williams, Sierra Club, 1/13/10
Larry Hampson, Monterey Peninsula Water Management District, 1/14/10
Joyce Ambrosius, NMFS, 1/20/10
Trish Chapman, California State Coastal Conservancy, 1/20/10
John Klein, California American Water Company, 1/25/10
Frank Emerson, Carmel River Steelhead Association, 1/25/10
Monica Hunter, Planning and Conservation League Foundation, 2/3/10
Mike Burke, Interfluve, Inc., 2/3/10

Matilija
Kevin Hockstedler, VCWPD, 12/14/09
Doug Chitwood, USACE, 12/15/09
Jim Hutchison, USACE, 12/15/09
Mark Capelli, NMFS, 12/17/09

Rindge
Mark Abramson, Santa Monica Baykeeper, 12/14/09
Nica Knite, Cal Trout, 12/15/09
Marriah Abellera, USACE, 12/15/09

APPENDIX B: Evaluative Criteria for Dam Removal from Pejchar & Warner

Ecological Criteria

Is the dam currently degrading habitat quality and quantity?

Does the dam slow or alter natural flow patterns temporally or spatially?

Does the dam increase the temperature of the water?

Does it cause changes in natural nutrient load?

Does it cause changes in natural sediment load?

Does the dam result in the release of oxygen deprived water, suffocating organisms?

Does the dam obstruct access to spawning grounds for threatened and endangered fish?

Does the dam cause immediate death to organisms: do turbines kill fish and do fish ladders, if present, stun and stress fish, making them more vulnerable to predators?

Is the dam contributing to the degradation of wetlands by reducing available freshwater and leading to saltwater intrusion?

Are data for the above impacts on habitat quality available for this dam? If not, are they obtainable at an acceptable cost and over a reasonable time?

Will the removal of the dam restore habitat quality and quantity?

Will dam removal renew access to spawning grounds for threatened and endangered fish?

Will dam removal restore natural flow patterns, channel morphology, water temperature, nutrient and sediment load?

Would dam removal impact sensitive or endangered species that benefit from habitat alterations brought about by the dam and reservoir?

Can dam removal be accomplished safely so as to minimize harm to aquatic organisms?

Can potentially contaminated sediment be removed safely and can we identify and manage the uncertainty associated with sediment removal?

Are there other dams, diversions or activities in the watershed that could compromise fish recovery and habitat restoration despite removal of this dam?

Are data for predicting the effectiveness of dam removal available? If not, are they obtainable at an acceptable cost and over a reasonable time?

Dam function and safety

Is the dam still fulfilling its original intended function?

How much longer is the dam expected to be functional? What are the existing benefits to society? i.e., kilowatts of electricity, flood control, recreation.

Do the costs associated with operating and maintaining the facility outweigh costs of enforcing laws for safe fish passage and human safety?

If the dam provides critical flood control, are there alternatives?

If the dam still provides hydroelectric power, how much does it provide, and are there alternatives?

Could water storage and diversion be reconfigured if they are affected by dam removal?

Does the dam pose a current or potential safety hazard to human lives and property?

Is the dam inspected regularly?

Has maintenance been deferred?

Was the dam built to "low hazard" specifications but due to development now needs to be upgraded to "high hazard"?

Would dam failure result in a significant loss of life, property, and/or services?

What are the expenses associated with dam maintenance now and in the future?

What are the expenses associated with potential emergency removal and potential dam and downstream repair costs resulting from failure?

Political process

Is there stakeholder support for dam removal?

Are there local economic opportunities tied to dam removal?

Are there advocacy organizations in support of dam removal?

Are regulatory agencies addressing or recommending dam removal?

Who are the principal opponents to dam removal and what is their political capacity to block consideration of removal? Can their interests, such electricity generation or reservoir-based-recreation, be shifted elsewhere within the watershed?

Would the Endangered Species Act play a role in dam removal?

Would dam removal reduce the economic and/or regulatory burden of the agencies responsible for enforcing the ESA?

Is funding available?

Would the dam owner absorb the costs of removal?

Would costs of removal be shared within the watershed?

Would organizations such as CalFed or other divisions of the state or federal government contribute to removal costs?