Napa County Resource Conservation District · 1303 Jefferson Street, Suite 500B · Napa, CA 94559 · (707) 252-4188 · www.naparcd.org

Carneros Creek Watershed Management Plan

REFERENCE DOCUMENT

prepared for
Carneros Creek Stewardship
And Bay-Delta Authority Watershed Program

by
Napa County Resource Conservation District
with
San Francisco Estuary Institute
Pacific Watershed Associates

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Introduction

This Reference Document was developed as a companion document to the Carneros Creek Watershed Management Plan. To a large degree, the Reference Document synthesizes the information contained in the technical reports that were conducted as part of the watershed assessment that was completed in 2002 and provides the reader with information that is beyond the scope of the Management Plan. Specifically, the Reference Document provides a more thorough discussion of existing watershed conditions and recommended actions and monitoring. Much of the information contained in this document may be useful if a specific project is being considered or if a specific topic is of particular interest. However, the document is not meant to be a "stand alone" document. It is meant to be used in conjunction with the Watershed Management Plan, which is available on the Watershed Information Center and Conservancy WebCenter at www.napawatersheds.org

Existing Watershed Conditions

In the following discussion and throughout the Watershed Management Plan and this Reference Document, the term *lower* reach refers to the portion of Carneros Creek from the Napa River to Old Sonoma Road Bridge, the *middle* reach is the portion from the Old Sonoma Road Bridge to the end of the public portion of Henry Road, and the *upper* reach is the portion from there to the headwaters (Figure 5 in the Management Plan).

This section, like the Management Plan is broken down into several resource topics including riparian function, upland ecology, salmonid habitat, soil erosion, excess sediment, flood hazards, and water supply. Note that the topic of soil erosion and excess sediment where combined in the Management Plan and are separated here to allow for further detail. Additional information on each of these topics is available in the technical reports that were prepared in the process of completing the watershed assessment. These reports are available on the Watershed Information Center and Conservancy WebCenter at www.napawatersheds.org or can be provided as a CD from the Napa County Resource Conservation District.

Riparian Function

Vegetation along the creek is important to the function and health of the creek. Benefits of riparian vegetation include bank stabilization and erosion control provided by vegetation roots, water temperature regulation through shading of the creek, a source of food for the base of the food web (aquatic insects), recruitment of large woody debris (tree limbs, trunks and root wads) for fostering pool formation and channel complexity, protective cover for fish species, and a means of filtering runoff (trapping sediment and contaminants) before it enters the creek. In addition, riparian vegetation provides habitat, food, and a migration corridor for wildlife including birds, mammals, reptiles, and amphibians.

Currently in Carneros Creek:

- The riparian corridor is fairly continuous and well-developed. It provides shade essential for maintaining adequate water temperatures for cold-water fish and provides a mechanism for pool formation through potential recruitment of large woody debris. 45% of all pools in Carneros Creek are at least partially formed by scour around large woody debris. Canopy cover is generally high (averaging 91%) and is comprised of 74% evergreen tree species and 26% deciduous tree species. Tree species include: bay, eucalyptus, willow, oak, maple and alder. Some of the trees found today are non-native but still provide many of the functions that native riparian trees provide. Since historical times, significant portions of the corridor have been maintained.
- Mapping reveals that the total area of riparian vegetation along Carneros Creek and its tributaries has increased by 28% during the period from 1940 to 1993, possibly representing a re-establishment of historically present habitat, or possibly reflecting the establishment of a new condition in the watershed. It should be noted that increased vegetation along many of the tributaries to Carneros Creek account for this substantial increase in area. Average riparian corridor widths range from 26 to 65.5 feet (8-20 meters).
- Current observations show that the width of the riparian corridor is narrow along the lower reach of creek, downstream of the Old Sonoma Road Bridge. In this reach, a single row of mature bay and oak trees, many greater than 2.5 feet in diameter at the base of the trunk, comprise the majority of riparian vegetation along both sides of the creek. Some contradictory conclusions regarding riparian width along the lower reach exist. The narrow width could be due to thinning and removal. However, many Bay Area creeks historically had narrow riparian corridors and historical evidence suggests that the width has not changed significantly, despite potential width decreases associated with channel down cutting, streambank modifications, and/or clearing for land uses.
- The length of the riparian corridor along the lower reach has increased since 1858. The canopy extended 4,000 feet further downstream in 1942 than it did in 1858, and slightly further by 1999.
- Streambank erosion is threatening existing riparian vegetation. In the lower reach, bank erosion has caused many of the mature bay trees to become severely undercut, putting them at risk for falling into the channel in the near future. Normally, this type of large woody debris in the creek is viewed as a benefit; however, a single storm event could topple many of these trees. Loss of these trees would not only create a large gap in canopy cover, but also potential flood hazards, decreased bank stability, and negative effects on water temperature and quality.
- Some evidence of bank erosion and channel down cutting (incision) exists, especially in the lower and middle reaches. Evidence includes undercut trees and preserved terraces from previous channel bed elevation. Multiple terrace elevations are observed, however conclusive evidence regarding the timing of down cutting is not observed. Down cutting could have occurred as recently as during the past 50 years, or could have occurred over a much longer time frame. Tree coring in a few select locations would help clarify the timing of down cutting. Despite the evidence of potentially recent down cutting, evidence also exists that suggests that the channel has not significantly changed its form. The channel appears to be incised on the 1858 USCS map, has not undermined the bridge at

Old Sonoma Road built in 1896, and remains unchanged in the memories of local residents.

- In all three reaches, land uses have created localized gaps in the riparian corridor. Suburban and vineyard development, road crossings, other agriculture, and reservoirs are all examples of land uses creating these gaps. Naturally occurring landslides may be a contributing factor as well; 39% of all landslides mapped were adjacent to the stream channel. In addition, 11% of all blue line channels were identified as “disturbed,” which includes damage to riparian vegetation caused by channel migration, erosion, or flood events.
- Historical over-grazing and bank trampling have damaged riparian vegetation along Carneros Creek, particularly in the middle reach These past practices may be contributing to current high levels of bank erosion. At several locations in the upper reach, there is no exclusionary fencing or other management practice in place to keep cattle away from steep banks and the channel. Although livestock are not completely fenced out, some fencing efforts show improvements in vegetation growth and bank stability, when compared to non-fenced areas.
- Sudden oak death (caused by the pathogen *Phytophthora ramorum*) has killed or damaged trees along the riparian corridor as well as on the hillsides. In addition, Pierce’s disease, hosted by several trees and plants common to the riparian area, is a concern to many landowners because of its potential to harm surrounding vineyards.

The limiting factors to maintaining a healthy, functioning riparian corridor are development and land use practices combined with the possibility of many trees being catastrophically uprooted along eroding banks. In the lower reach, once the single row of mature trees has been recruited into the channel, very few other trees will remain on the banks to provide riparian vegetation functions. Depending upon future land management decisions, land uses such as vineyard management and development, grazing, rural housing, road crossings, etc. may continue to threaten the width and continuity of the riparian corridor.

Upland Ecology

Watershed health and function includes more than just the creek and its riparian corridor; many important physical processes occur in the surrounding upland landscape. Surrounding areas provide habitat for plant and animal species that are vital to maintaining the function and diversity of the natural ecosystem. Increased development, intensive land use, fire suppression, and altered hydrology of the watershed can all affect the functioning of terrestrial ecology. Potential watershed wide impacts include changes in vegetation patterns, amount and/or quality of habitat provided, and introduction of invasive species.

Currently in Carneros Creek:

- The watershed is currently described as supporting annual grasses and forbs and mixed hardwoods with smaller areas of California Bay and Pacific Douglas fir. Historically, the lower watershed was open grassland with seasonal wetlands, while the middle and upper watershed was a mix of grassland, brush, shrub, and woodland under native management (burning), that supported native grazing mammals (deer, elk, antelope). Native people likely had a significant influence on the composition, distribution, abundance, and productivity of most habitats in the watershed.

- The upper watershed has experienced expansion of woody vegetation into the grasslands, revegetation of previously cleared areas, increases in stand density of brush, shrub and woodlands, and decreases of native grass areas. Recent increases in impervious surfaces (e.g. roads, rooftops and parking lots) and residential and vineyard development have altered or removed native vegetation communities, affecting precipitation interception, infiltration and groundwater recharge.
- Compared with historical records, a greater number and larger extent of invasive plant species are now found in the watershed. Currently, the grasslands are predominantly exotic Mediterranean annuals, which are tolerant of grazing and drought and are able to suppress the growth of native perennial grasses. However, remnants of native grassland still exist. With proper expansion and restoration, possibly including careful application of grazing and fire, native grassland could provide benefits to the chemical and physical make-up of the soil and the infiltration capacity of the hillslopes. Native perennial grasses provide the benefit of maintaining a large living root mass through time, thus increasing soil stability and precipitation infiltration, whereas exotic annuals reproduce by seed and do not maintain the same beneficial living mass of roots.
- Available habitat has diminished for some species, and expanded for others. For example, the open grasslands in the lower watershed historically supported Western burrowing owls and waterfowl. Development and vineyards have since replaced a majority of the grasslands, removing most of the habitat. In addition, the increased number of trees in the lower watershed, compared to pre-European contact, has provided more roosting locations for predatory birds to prey upon burrowing owls and waterfowl. But for species dependent upon riparian or chaparral (brush and shrub land) and woodland habitats, the change is less dramatic. Although natural habitat areas are generally decreasing, riparian, chaparral and woodland areas in the upper watershed are experiencing expansion. However, because the riparian corridor in the lower reach is dominated by a single row of mature bay trees, in the future, when these severely undercut trees fall into the channel, gaps in the habitat will be created.
- Physical conditions, such as soil type, have an effect on watershed ecology. For example, the Haire loam found primarily in the lower reach restricts drainage, limits deep-rooted crops, and fosters seasonal wetlands, making this soil unsuitable for valley oak savanna habitat. Also, much of the watershed contains soils with a shallow clay pan that limits rooting depth of plants.
- The groundwater table is sensitive to withdrawals. Regional reports state that the groundwater levels are susceptible to pumping. Within the watershed, some residents report recent decreases in well water levels. A lowered groundwater table would reduce the amount of water provided to the creek from groundwater storage, reducing the amount of water available for animal and riparian plant species, especially during the late summer and fall.

The factors limiting the maintenance of a healthy, functioning terrestrial ecology are historic and current development and land management practices. Changes from natural vegetation patterns and densities have occurred with the advent of suburban residential development, vineyards, agriculture and grazing. Remaining habitat is fragmented and altered by non-native tree and grass species. Important land management practices that have significant effects on terrestrial ecology include the volume of water diverted from the creek, active fire suppression, and riparian corridor management.

Salmonid Habitat

The Carneros Creek watershed currently supports salmonids, specifically steelhead trout, which is a federally listed threatened species. Historical records go back as far as the mid-19th century, when Menefee (1873: 36), described Carneros: "The writer has caught several [trout] that weighed from 7 to 10 ½ pounds, in the Carneros, five miles from its mouth, where the water was not a foot deep."

Many physical processes combine to create adequate aquatic habitat. Different life stages of salmonids require various habitat elements, but several elements are universal to the different stages and will benefit many other aquatic species. Steelhead trout require adequate water temperatures and quality, access to the ocean, year-round water, a source of food, channel complexity, pools and velocity shelters, cover from predators, adequately sized spawning gravels, and a healthy riparian corridor, amongst other factors. An analysis of the current status of these elements reveals the factors most likely limiting the success of steelhead in Carneros Creek.

Currently in Carneros Creek:

- Year-round flow is not present in all reaches. This condition is similar to documented historic patterns, but probably more extreme. In general, essentially no surface flow exists from September to November, with the upper reach often being completely dry and the lower reach often containing only isolated pools. The September 2002 stream survey revealed 47% of the total surveyed habitat was dry. With more on-stream reservoirs recently built on tributaries, surface flow may be further reduced because water historically contributed by smaller tributaries is now being held within reservoirs.
- Water temperatures are appropriate for supporting cold-water fish, such as steelhead trout, in some reaches of Carneros Creek. Steelhead have a low tolerance for elevated water temperatures. However, in general, water temperatures are below stress levels (68°F, 20° C) in Carneros Creek. From July to October 2002, potential rearing pools had a temperature range of 47.5°F to 70.9°F (8.6° C to 21.6° C). Pools in the lowest reach have the warmest measured water temperatures, sometimes exceeding 68°F (20° C), and typically experiencing major water level declines. Pools in the middle reach have less variation in temperature due to shading and groundwater contributions.
- Water quality may be affected by land use in the watershed. Quality may be affected by sediment, nutrients and chemicals. Excessive sediment can have negative effects on local fish populations and the function of the creek. Direct runoff from grazing can introduce sediment, organic particulate matter, and excess nutrients, particularly ammonia. Runoff from viticulture or other agriculture and residential areas can contain chemical fertilizers and pesticides, sediment, and nutrients. Although not explicitly included in this study, many sources of runoff were observed entering the creek at different locations and from

varying land uses. Water quality has a significant impact on pools in the lower reach. Once they become isolated, removed from all surface water flow, water quality quickly degrades below levels required for successful steelhead rearing.

- Obstacles to fish migration exist in several reaches of Carneros Creek. The most extensive barrier is the dry lower reach, where reduced flow during late spring and early summer limits the movement of young steelhead out of the creek and into the Bay and ocean (outmigration). In the middle reach of the creek, three dams and a small bedrock cascade are identified as likely barriers during low flows, limiting both up and downstream migration. Nineteen on-stream reservoirs were also identified on tributaries to Carneros Creek, each acting as a migration barrier to upstream migration. A single poured concrete cattle crossing exists in the upper reach. These crossings are designed to limit bank erosion, but they also may act as barriers during low-flow conditions. This particular barrier likely does not have a significant impact on aquatic habitat due to other unfavorable conditions in this reach. Despite the several partial barriers, the creek still maintains a direct path from the upper watershed to the Napa River, with no complete barriers.
- The lower reach is characterized by limited channel complexity. Except in the short tidal reach, it has experienced very little straightening or simplification. However, available habitat in the lower reach is severely limited by low summertime flows, minimal instream cover due to bank stabilization efforts, limited shelter for fish during periods of high water flow, deficient pool frequency, lack of vegetative cover, and deficient water quality.
- Pool frequency and depth is adequate for steelhead rearing in the middle and upper reaches of Carneros Creek. Throughout the surveyed reaches, many pools were observed and the spacing of these pools averaged one pool every 5 bankfull widths, with most occurring more frequently, typically less than 3 bankfull widths. Many pools are deeper than 2 feet and associated or formed by large woody debris.
- Large woody debris is providing many benefits for the aquatic ecosystem. It provides shade, instream cover and velocity shelters for steelhead, trapping of spawning gravels, regulation of organic material movement, and a mechanism for pool development through scour. Despite a single large debris jam in the lower reach, additional wood cover would greatly enhance aquatic habitat quality. Unlike the lower reach, the middle and upper reaches contain a greater number of woody debris pieces and large boulders that provide shelter and cover for juvenile steelhead.
- Excess fine sediment deposits affect pool volumes in the lower reach. These sediment deposits are due to the low-gradient of the reach, lack of adequate flow, and the resultant inability of the creek to move the fine sediment further downstream. Excessive fine sediment is not favorable for steelhead spawning. Pools in other reaches are not as affected by sediment deposits. Natural creek processes and hillslope mass-movements provide sediment to the creek. In addition, some fine sediment is provided directly from vineyard plots and drainage pipes, sometimes causing the deposition of a small sediment fan downstream of the drainage outlet.
- As discussed above, portions of the riparian corridor are at risk, particularly along the lower reach of Carneros Creek, below the Old Sonoma Bridge. In this reach, a single row of mature trees comprises the only riparian corridor, and is severely undercut and in

danger of toppling into the creek. Bank erosion and associated channel widening are the cause of this riparian instability. Although limited, the riparian corridor in this reach does provide many benefits, including shade for the maintenance of cool water temperatures. The riparian corridor in the middle and upper reaches are not nearly as at risk. But, some creek reaches in the upper watershed, where cattle are not fully fenced out, are showing damage to banks and riparian vegetation along the channel. In general, the riparian area has slightly expanded, with tributary areas contributing to most of the expansion. Overall, the riparian corridor is not presently a limiting factor for steelhead success.

- Appropriate spawning gravels exist in several areas of the creek. Overall, the size and distribution of spawning gravel are acceptable for steelhead. Gravel does not appear to be significantly affected by excess fine sediment. However, moderate levels of gravel embeddedness (where gravel becomes smothered by finer sediment) are observed and the amount of fine sediment is near the threshold at which negative impacts will begin, particularly in the lower reach. Based upon analysis of bulk sediment samples, current levels of fine sediment (<1 mm and <6.35 mm) do not excessively impact steelhead egg incubation or emergence. Further, larger gravels are within the documented range for successful salmonid spawning. However, the 19 on-stream reservoirs (located on tributaries) trap sediment that would otherwise be transported downstream, limiting the supply of coarse sediment available for spawning. Over time, this may create a shortage of adequate spawning gravels.
- A limited food supply may be affecting steelhead survival and success in the summer months, however there is little data available to assess this factor properly. Summertime low flows are limiting downstream transport of the primary food source for young steelhead, including aquatic insects and other invertebrates.
- The middle reach is the best overall reach for steelhead spawning and rearing. This reach contains multiple areas for spawning with appropriately sized gravels, relatively high amounts of large woody debris, suitable channel complexity, the highest number of pools, the closest average pool spacing, consistently cool water temperatures, good cover, and relatively low volumes sediment within pools. Comparatively, the lower reach acts primarily as a migration corridor and provides only very limited year-round habitat due to lack of surface flow. The upper reach may support spawning but, because it is completely dry in the summer, does not support rearing.

Although it is likely that Carneros Creek never supported an exceptionally large steelhead population, its relative importance, compared to other streams of similar size in the North Bay, has probably increased. This is due to the maintenance of fairly rural land uses, lack of complete migration barriers, and direct connection and relative proximity to the Bay.

Multiple factors are limiting the success of steelhead in Carneros Creek. The most important factor is decreased water flow. Although the middle reach maintains year-round flow, the upper and lower reaches do not, and therefore, do not provide adequate salmonid habitat. Evidence suggests that Carneros Creek did not maintain year-round flow during historic times and that flow was historically negligible or intermittent in the summer. However, there is evidence that in the past several decades the amount of intermittent flow and persistent pools has decreased. A number of residents independently describe a reduction in the extent of pools and seasonal flow, reporting that: "it ran more" and "used to visibly run ... enough to get over the rocks, when I came here." Secondary limiting factors are lack of channel complexity in the lower reach, important for shelter during migration and cover from predators, as well as some partial migration barriers limiting the extent of available habitat.

Soil Erosion

Soil erosion is a process that can take many forms including: bank erosion, gully erosion, sheet and rill erosion, and landsliding; all of which are currently occurring in the Carneros Creek watershed to varying degrees and can lead to costly property loss and resource degradation. Although erosion is a natural process that helps the stream achieve or maintain equilibrium, much of the erosion occurring on Carneros Creek is caused or aggravated by land use management practices such as drainage rerouting, altered or removed vegetation cover, man-made structures, or poorly installed bank stabilization structures. Finding solutions to minimize erosion induced by human disturbance is essential because property and soil resources are valuable and because excess erosion and the resultant sediment input to the creek can have negative impacts on channel functioning and aquatic habitat.

Erosion is a natural process that acts to keep the landscape and stream channel in equilibrium. Some erosion is beneficial and essential to the watershed; for example, landslides and bank erosion provide sources of fresh sediment and gravel to the channel that can be utilized by spawning fish. However, intensive use of the land has the potential to increase rates of erosion and tends to supply more sediment to the creek than the system can handle, thus altering the natural balance. In the lower watershed, the change from grasslands, hay/grain production, and orchards to vineyards has, in some cases, led to more intensive soil disturbance and therefore increased the potential for surface erosion. Vineyard and road runoff controls such as pipelines and ditches concentrate runoff and provide ready transport of any surface erosion to the channel system. In addition, drainage pipes that discharge concentrated runoff onto channel banks without proper energy dissipation often cause bank collapse or gullying. Most of the lower watershed has been subject to some type of agricultural activity for well over a century, increasing the erosion potential. In the middle and upper reaches, both historic and recent grazing practices cause the largest impacts to the hillslopes and banks. Early grazing effects in combination with the 1862 flood could have mobilized a large amount of sediment from the hillslopes into the channel.

Currently in Carneros Creek:

- Accelerated bank erosion caused by changes in land use and management is contributing substantial amounts of sediment to the creek. Localized areas in the middle reach, upstream from the Old Sonoma Road Bridge, are contributing the largest volume of sediment per unit channel length, with half occurring in the past 20 years. Although the following volumes are merely estimates, they illustrate that accelerated bank erosion due to past and present land use is one of the largest sources of sediment supply to the channel. A total of 3,009 yd^3 (2,300 m^3) of bank erosion was measured along 0.93 miles (1.5 km) of surveyed mainstem channel. This erosion has occurred over approximately the past 150 years in the 10 sample reaches, which measure 9% of the total mainstem channel length. If this rate is extrapolated to cover the entire 11 miles (17.8 km) of mainstem channel length, approximately 35,320 yd^3 (27,000 m^3) of erosion could be measured. Tributary banks are also experiencing erosion but at a much slower rate; supplying 1,966 yd^3 (1,503 m^3) of sediment from 3.7 miles (6 km) of surveyed channel. A total of approximately 10.5 miles (17.0 km) of USGS blue line tributary channel length exists in the watershed; extrapolating would yield 5,625 yd^3 (4,300 m^3) of sediment supplied from tributary bank erosion. Erosion in the tributaries is associated with: no active management (lands managed in the past, but not currently actively managed; for example, previously grazed land) (49%), grazing (27%), reservoirs (13%), viticulture (9%), and roads (2%). Most measured erosion is chronic, occurring over the past 50 to 100 years. However, erosion rates appear to have increased in the past 10 years.

- Bank material and vegetation cover determine the stability of channel banks in the watershed. Although bank material along the mainstem and tributaries is variable (ranging from bedrock to silt/clay), nearly the entire channel bank length contains at least some vegetation, including areas of dense vegetation. Some locations, especially in the lower reach, contain bare banks with only exposed roots from the trees growing on the top of the bank. Areas with silt/sand banks and/or banks with minimal vegetation are at higher risk of eroding.
- Landslides and other hillslope mass movements also contribute sediment to the creek. There are 120 current and historic landslides mapped that have occurred since 1942, contributing approximately13,000 yd^3 (9,938 m^3) of sediment to the creek system. Due to different underlying rock types, the east side of the watershed is more prone to hillslope failures. Most slides occur in the grasslands, while few occur in oak woodlands. Most slides appear to be associated with the underlying geology, rather than changes in land use. Large storm events or prolonged, above-normal seasonal rains that saturate the soil are the likely triggering mechanisms. Landslides decrease hillslope stability, which in turn may threaten structures, improvements, roads, and reservoirs. Seven sites are recommended for erosion control and erosion prevention treatments, to prevent an additional 314 yd^3 (240 m^3) of sediment from entering the stream network. These sites are all associated with road building and maintenance and are identified as sites that are likely to deliver sediment to the channel system.
- Sheet and gully erosion is occurring. The largest gullies are forming downstream of poorly designed outlets of existing reservoirs. Rilling and gullying are observed in vineyards planted perpendicular to contour before cover crop growth in the fall and especially on hillslopes steeper than 10%. However, most vineyards have existing cover crop growth, significantly reducing the amount of observed erosion. Gullies are also observed in areas grazed by cattle, on hillslopes receiving road runoff, and on stream bank slopes below culverted drainage outlets. Sheet erosion occurs primarily on bare soil areas throughout the watershed and on long stretches of unpaved rural road with poorly designed drainage and ditches that are connected with, and flow into streams.
- Over 11 miles (17.7 km) of road surface in the watershed drains directly to the channel system, delivering runoff and fine sediment from unsurfaced roads and ditches. Undersized or plugged culverts and diverted streams also have the potential to contribute eroded sediment. Erosion control efforts are recommended for 10.3 miles (16.6 km) of road, 16 of 23 ditch relief culverts, and 90 of 101 stream crossings. The erosion- and

storm-proofing recommendations include a combination of such preventative treatments as re-grading roads to include rolling dips or insloped ditches; installing wet crossings; removing or replacing undersized or damaged culverts; realigning culverts to the channel gradient; retrofitting pipes with a downspout, trash rack and/or flared inlet; and rock armoring outlets. An estimated 18,324 yds^3 of sediment could be prevented from entering the stream system through implementation of road-related erosion control.

Observed and measured erosion is due to many different physical processes and land uses. The most important factors contributing to soil loss in the Carneros watershed include:

- Natural stream processes and channel entrenchment. In highly entrenched channels, bank and terrace erosion produce large volumes of sediment because destabilization at the bottom of the bank (the toe) causes erosion of the entire bank height. Scour around in-channel large woody debris pieces and localized bed incision (down cutting) also contribute.
- Grazing. Currently, only a small number of cattle are grazed in the upper watershed limiting the cumulative negative effects. Grazing reduces vegetation cover, often creates patches of compacted bare soil, and reduces the capacity of the soil to absorb water, ultimately increasing runoff and therefore erosion, especially in conditions of overgrazing or drought. The existing high rate of bank erosion in the middle reach is likely due to bank trampling and extreme vegetation removal associated with past major cattle operations.
- Hydromodification. Increased subsurface and surface drainage for agricultural and rural residential land uses and increased impervious surface area associated with roads and rural residential development are increasing the volume and speed of surface runoff reaching the channel. This, in turn, is increasing surface erosion and the channel's erosive ability. However, the number of reservoirs, which temporarily hold water and slowly release it over the growing season, dampens the effects of hydromodification.
- Limited or altered vegetation cover. Although the watershed is no longer experiencing cultural burning, intensive land use generally decreases the density and extent of native vegetation, thus increasing the potential for surface erosion.
- Drainage from roads, ditch relief culverts, or undersized culverts at stream crossings.
- Viticulture and other agriculture. Currently 20% (1,850 acres) of the watershed is planted in vineyards. In 1993, 58 of these acres were used for other agriculture. Tilling, cultivation and soil aeration contribute to soil loss if soils are exposed during rainfall and runoff events. Many of the vineyard developments are located on the eastern side of the watershed, which is prone to landslides and mass movements. Bank collapses, rilling, gullying, and fine sediment delivery result from some vineyard drainage pipes and avenues.
- Bank revetment/stabilization. Typically designed to control bank erosion, poorly-planned or failing bank revetments in a few areas, primarily in the lower reach, contribute to increased amounts of localized erosion.

Many locations and types of erosion are observed throughout the watershed. Although some is attributable to natural physical conditions and processes, a portion is due to human modifications or land uses. Of the identified erosion causes, grazing practices (both historic and current), altered runoff patterns created by intensive land use, road drainage and viticulture appear to be the critical causes.

Excess Sediment

Increased sediment volumes supplied to the creek system can cause decreases in water quality, increases in sediment storage (bars, pool deposits) and/or even raise the level of the channel bed along certain reaches (aggradation). Many negative impacts can result from increased sediment storage, including flood hazards due to the decreased channel capacity for water routing, property loss through bank erosion and increased channel widths, and habitat degradation through decreased channel depth, decreased pool volumes, general decreases in bed grain size distribution, and decreases in summer surface flows. Controlling sources of excess erosion and sediment supply is important for protecting, maintaining, and restoring channel form and function for human benefits, safety, and aquatic habitat quality. Sources of erosion and the existing condition of the watershed relative to erosion sites are discussed above. This section will focus on other aspects of sediment in the watershed.

Currently in Carneros Creek:

- Overall, a large amount of sediment is currently stored in the creek and available for transport. Sediment is being stored in deposits of accumulated gravel and sand in pools and along the banks of the creek. Overall, pool deposits, with most located in the lower reach, comprise the largest number of deposits, but the middle reach stores the greatest total volume of sediment, mostly in the form of accumulations at the meanders in the creek (point bars). As described above, volumes and size distributions of sediment in the middle reach currently appear to be adequate for successful salmonid spawning. However, the lower reach appears to be temporarily storing large volumes of fine sediment. These fine grain sizes are not adequate for utilization by salmonids. Analyses suggests that these deposits are easily mobilized and transported, but are likely redeposited during waning flood flows.
- Approximately 2.7 mi (4,300 m, or 11% of the total mainstem and tributary channel length) of channel is identified as “disturbed,” including riparian vegetation removal and channel aggradation, with over half occurring in tributary channels. Most of the sediment supplied from tributary channels is from bank erosion or debris slide locations. Most of the “disturbed” sites are associated with underlying geology, flood events, bank erosion or channel migration rather than directly caused by identifiable man-related actions.
- Because the watershed no longer experiences regular burning (either natural or cultural), the potential for a large wildfire exists. A wildfire, when paired with the right climatic conditions has the potential to release/mobilize large volumes of sediment into the channel.
- Many sediment-related negative impacts on salmonid habitat are observed. These include: deficient pool frequency and quality, moderate sediment embeddedness, and low summertime surface flow. Additional sediment will exacerbate these problems.

The factors most responsible for causing excess sedimentation are high rates of bank erosion and ongoing increases in land use intensity. Although the channel is not significantly aggrading (raising its bed elevation), the lower reach does contain many pool deposits and locations of decreased surface flow and increased subsurface flow.

Flood hazards

Channel shape and many fluvial, biological and ecological processes are dependent upon periodic flooding. However, floods can also damage property adjacent to the creek, damage bridges and other structures that cross the creek, and cause large amounts of bank erosion and sediment transport. Addressing current management practices that increase the likelihood of flood hazards is critical. Potential causes of flooding include: undersized bridges, backup associated with large woody debris caught on bridge pilings and culverted crossings, undersized culverts at road crossings, channel modification or simplification, channel aggradation (buildup), and other types of modifications that influence water movement. Specifically, human actions that confine creek flow and land use changes that alter the rate at which water enters the creek can exacerbate localized flooding beyond that which is beneficial to the functioning of the watershed. Changing the hydrologic regime in this way can cause excess erosion and scour of the channel bed and banks, increase water velocity, and decrease water quality. Clearly, this type of flood occurrence can have negative impacts on surrounding property and aquatic habitat.

Currently in the Carneros Creek watershed:

- Land use intensity is increasing. Although historic cultural burning had some effect upon infiltration and evapotranspiration, recent changes in land use are having a larger impact by routing more water to the channel system in less time and increasing the likelihood of localized flooding. These changes include increases in agriculture, increases in impervious surface area, an increase in vineyard-related engineered subsurface and surface water drainage systems, and increased road density.
- Multiple channel crossings and constrictions exist. The mainstem of Carneros Creek has eight major crossings, either bridges or culverts, which appear to be large enough to accommodate flood flow. In addition, there are many crossings located on tributaries. Many of these smaller crossings and culverts have been identified as undersized and have the potential to constrict high water flows and cause localized flooding. Because the potential for wood recruitment to the creek is high and because the channel already contains many large woody debris pieces, plenty of debris is available to catch on bridge pilings and culvert inlets, causing a backup of flood waters. Also, the potential for major wood recruitment exists in the lower reach; numerous large trees are severely undercut, many of which could enter the channel in a single large storm event. Both the hazards and benefits of in-channel large woody debris should be considered when making decisions about what to do with “downed” trees that fall into the creek.
- Channel modifications, including reservoirs, bank stabilization projects, and storm and subsurface drainage systems, are altering runoff patterns and timing. The watershed currently contains 57 on- and off-stream reservoirs, which intercept and retain storm flow, acting to reduce the peak of the hydrograph, at least during the early part of the rainy season. However, some of these reservoirs were found to have the potential to

overflow, which would cause either severe erosion or catastrophic failure of the dam and associated flooding. Bank stabilization efforts, particularly in the lower reach may also influence the likelihood of localized flooding. These hardscape revetments typically encroach upon the natural channel cross sectional area, decreasing the volume of flood flow that can pass at that location. Increases in storm and subsurface drainage systems and impervious surfaces from residential development, roads, and vineyards in the watershed decreases the amount of time it takes for rainfall to enter the creek, thus causing water levels in the creek to rise and fall more rapidly, increasing the potential for flash flooding.

- Overall, flood conveyance appears to be effective. Recent floods have not topped the terrace banks, especially in the lower entrenched reaches. Future limitations on building structures within flood-prone areas of the creek will prevent additional damages caused by flooding.

The factors most responsible for increasing flood hazards are increased surface and subsurface drainage and time to peak flow associated with high intensity land use, a large number of inadequate culverted stream crossings, and the large amount of woody debris in the creek and/or available for recruitment to the creek. The catastrophic failure of an on-channel reservoir could potentially cause flooding, property damage, downstream sedimentation, bank erosion, habitat loss and widespread channel morphology changes.

Water Supply

Water is essential for all aspects of life, including agriculture and viticulture, grazing, human habitation, aquatic and terrestrial habitat, and vegetation communities. Water availability is generally limited in the Carneros Creek watershed. The many competing uses for the finite amount of water available include flows for environmental benefits, diversion for storage, diversion for land uses or residential needs, and extraction from wells. Without continued maintenance of and/or increases in seasonal water flow in Carneros Creek, continued challenges for all water users will likely occur.

Currently in Carneros Creek:

- Precipitation is the primary source of surface water in the watershed and is driven by the natural regional flood/drought regime. Many large storms and notable droughts have occurred historically in the Napa Valley region (e.g., *floods*: 1852, 1890, 1940, 1942, 1958, 1983, 1986, 1995, 1997, and 2003; *droughts*: early 1860's, 1900 to 1930 and 1986-1990). Average annual precipitation in the watershed is 28 inches (710 mm). It is estimated that approximately 52% of rainfall in an average year enters the creek as runoff; wetter and drier years have proportionally greater and less runoff, respectively.
- The rate at which the creek flows (discharge) is seasonally dependent; water levels in the creek begin to rise in December and closely follow precipitation events, frequently ceasing to flow from September to November. While discharge varies from year to year depending upon annual precipitation and intensity, discharge with a recurrence interval of 1.5 years is approximately 530 cubic feet per second (cfs). The 1.5-year recurrence interval is commonly used because it represents the flow occurrence that accounts for

much of the way the creek transports and stores sediment and gravel. There is a 73% chance of experiencing this rate of flow in any given year.

- Surface flow and groundwater is generally limited. Few natural springs and seasonal creeks exist and surface flow in creeks has been and is currently limited. In addition, based upon historic studies and current landowner observations, the groundwater table appears to be sensitive to overdraft. The incised nature of the lower reach of Carneros Creek contributes to a localized drop in groundwater levels.
- Changing vegetation patterns are altering the infiltration/transpiration capacity of the watershed. Expansion of chaparral/woody vegetation into grasslands, lengthening and expansion of riparian vegetation, and change from native to more drought-resistant grass communities all influence the amount of precipitation that reaches the creek.
- The overall low levels of seasonal flow are likely the historical norm and are typical of many Napa region creeks. Historic stream surveys have noted lack of channel flow. However, there is evidence for recent decreases in flow. The entire channel has essentially no flow from September to November. The upper reach is completely dry throughout the summer and fall, the middle reach has perennial (year-round) surface flow that slows to a trickle in the late summer, and the lower reach contains only isolated pools, which quickly decrease in volume and quality throughout the summer. Aquatic habitat for cold-water fish is impacted by the naturally low summertime flows and exacerbated by additional decreases.
- Large volumes of water are being stored in reservoirs. A total of 57 on- and off-stream reservoirs exist, all having been built since 1940. Reservoir surface area ranges from 1,600 square feet to 31 acres. On-stream reservoirs intercept and retain storm flow, slowly releasing water over the growing season.
- A large portion of water is diverted/extracted for human uses. Although agricultural land was typically dry farmed historically, many diversions are noted in historic channel surveys, presumably for grazing and household needs. Currently, over 30% of the average surface discharge is allocated for diversion. Wells currently supply water for residential uses and some vineyards, many of which are located on the eastern side of the watershed because of a relatively higher groundwater table. The amount of groundwater being extracted and the effect that extraction is having on surface flows are unknown; groundwater pumping is not frequently monitored and permits are not needed for extraction.

The factor most responsible for a limited water supply in Carneros Creek is the natural climatic character of the watershed. The secondary factor is the increased population of the watershed and greater diversion and extraction associated with more water-intensive land uses. Balancing the increasing demands for land uses with flows necessary to support environmental amenities is becoming more difficult.

Watershed Management Recommendations

The Carneros Creek Stewardship group has recognized a set of five goals as fundamental to their activities. These goals guided the watershed assessment completed in 2002 and also provided the implicit framework for recommendations made in management plan and expanded upon in this reference document. The goals of the stewardship group are as follows:

GOAL 1: Assess the physical features of the watershed on an ongoing basis
GOAL 2: Provide education about the watershed
GOAL 3: Protect and restore natural resources, including native fish and wildlife species
GOAL 4: Protect and enhance economic and human resources
GOAL 5: Create a sustainable and enduring watershed stewardship

In order to attain these goals and in response to existing and historic watershed conditions, seven specific objectives have been identified by the Stewardship group. This section expands upon the recommendation matrices in the Watershed Management Plan, providing more specific detail and identifying sources of assistance and additional information, where available. The numbering of recommended actions is the same in both documents for ease in cross-referencing (e.g. recommendation A-1 in the Management Plan is the same as A-1 in the Reference Document).

Objective A: Establish and maintain an uninterrupted riparian corridor along Carneros Creek and its major tributaries, emphasizing the use of native plants which are not primary hosts for Pierce's disease. A healthy riparian corridor will function as naturally as possible and perpetuate itself. There may be areas along the lowest portion of the lower creek reach where the riparian corridor may be naturally interrupted.

Linkages: In some ways this is the most fundamental objective, since actions taken in support of it will also indirectly support all the others; further, many of the actions will directly contribute to stream stability, terrestrial habitat, and in-stream habitat.

A-1: Manage existing riparian corridor to maximize riparian canopy width by "stepping back" from creek where and when possible. A good general rule is to allow the creek an overall meander belt width of four times the *bankfull width*, counting the channel itself and both sides of the stream; note that bankfull width is *not* measured at the top of bank. Check with the RCD or NRCS for help in estimating the bankfull width at your site. In the headwaters of Carneros Creek, the riparian corridor will probably be narrower. This recommendation is derived from the Napa Green Farm Certification Program.

A-1-1: Where the riparian corridor is thin or overmature, especially along the lower reach, plant the top of bank in native trees and shrubs that support a diverse and mature plant community. This will provide for bank stabilization and tree cover for creek shading. Consult the RCD or NRCS for examples of what species to plant.

A-1-2: Where residential development is close to the creek, limit clearing of vegetation and landscaping unless restoring native vegetation.
A-1-3: Avoid constructing homes or permanent structures within the 100-year floodplain zone of all stream channels.
Setbacks are addressed under A-1 above
A-1-4: Design and implement revegetation projects in areas of bank erosion in the middle reach of the creek.

A-2: "Close" gaps along the riparian corridor by developing and implementing riparian revegetation plans that utilize native trees, shrubs, and grasses.
A-2-1: Minimize continued development of stream crossings, in-stream reservoirs, or use of agricultural practices that create riparian discontinuities.
A-2-2: Decommission or upgrade old creek crossings and remove partial migration barriers.
A-2-3: Manage existing in-stream ponds and ditches as wildlife habitat by encouraging native plant growth.
A-2-4: Especially in vineyard settings, select native plant species that are not vectors or act as host plants for Pierce's Disease. Use guidelines from Riparian Vegetation Management Information Manual, or seek advice from the RCD or NRCS for selection of native non-PD host plants.
A-2-5: For all revegetation projects, include a 5-year minimum maintenance plan including water conserving irrigation schedules to ensure the survival of new seedlings.

A-3: Incorporate exclusionary livestock fencing in such a way as to allow for native mammal migration and access to the creek while keeping domestic grazing animals out of the riparian corridor. Provide alternate dispersed, shaded watering sites away from the riparian zone. Refer to the California Department of Fish and Games *"Wildlife Friendly Fencing Guidelines"* for specific fencing suggestions.

A-4: Explore opportunities for conservation easements along the riparian corridor in exchange for property tax reductions with organizations such as the Land Trust of Napa County.

A-5: Ensure that future planning of rural residential areas include stream side areas that enhance and emphasize natural riparian zones.

A-6: Continue to conduct education and outreach to promote a functioning riparian corridor.
A-6-1: Provide a forum to discuss and clarify issues related to riparian buffer areas.
A-6-2: Encourage current efforts to manage PD in the middle and upper reaches of the creek in a way that increases the diversity and complexity of riparian understory and overstory.
A-6-3: Utilize the demonstration site developed under Action **G-2** as an outreach tool to encourage riparian corridor reestablishment.

A-6-4: Support vineyard participation in the Napa Green Farm Certification Program.

Objective B: Promote contiguous upland habitat and biodiversity

Linkages: many actions taken in support of other objectives will also support this objective, particularly actions which increase the extent of riparian corridor along the creek and tributaries. Water management will ensure/increase year-round water supply for wildlife.

B-1: Develop new upland migration habitats for birds and small mammals through native planting and hedgerows along fences, fields and property borders.

B-2: Provide terrestrial wildlife habitat enhancements such as birdhouses, raptor roosts, and bat boxes.

B-3: Continue to enhance and implement grazing, range, and grassland management plans to maximize native grassland revegetation and exotic invasive plant management. Consider prescribed burns, as appropriate.

B-4: Maintain and encourage development of continuous east-west habitat corridors across the valley into other watersheds through cooperative efforts with neighboring landowners.

B-5: "Step back" from sensitive upland areas such as slides whenever possible.

B-6: "Close" gaps along the riparian corridor by developing and implementing riparian revegetation plans that utilize native trees, shrubs, and grasses. See action **A-2** above.

B-7: Continue watershed education activities including guest speakers to discuss wildlife habitat and sudden oak death.

B-7-1: Recruit wildlife speakers for presentations at Stewardship meetings.

B-7-2: Provide landowners with information on how to identify sudden oak death and care for affected trees

B-7-3: Identify key wildlife corridors within the watershed and educate landowners on the value of conserving and protecting these as continuous habitat

B-7-4: Provide landowners with information and assistance in creating new upland habitat (specifically, recommended actions B-1 and B-2 above.)

B-8: Collaborate with youth education programs such as Acorn Soupe to conduct education and outreach to promote contiguous habitat and biodiversity.

Objective C: Maintain and improve in-stream habitat

Linkages: many actions taken under this objective will promote streambank stability. Actions taken under objectives A, D, E, and F will also improve in-stream habitat, especially in the lower reach. Maintaining the riparian corridor stabilizes water temperature and traps sediments and pollutants; reducing soil erosion and preventing bank failures reduces sediment deposition in the lower reach; increasing late season flows provides water for fish habitat.

C-1: Remove barriers to fish migration on the main stem of the creek.

C-1-1: Modify bridge crossings, culverts, and concrete crossings to allow full access to available stream habitat under a wider range of flows.

C-1-2: Minimize continued development of stream crossings.

C-1-3: Decommission or upgrade old crossings and remove or modify partial migration barriers when possible.

C-2: Encourage formation of pools via large woody debris (LWD) in ways that do not increase the risk of flooding.

C-2-1: For fallen trees that do not present an immediate flood hazard, practice minimal interventions acceptable to regulatory agencies. Encourage modification rather than complete removal of LWD jams that pose erosion and flood risks (i.e. leave select pieces of LWD within the stream system, and consider anchoring them in place).

C-2-2: Create favorable rearing/spawning pools using LWD and boulder habitat enhancement structures in reaches with suitable flow.

C-3: Limit low water crossings to only those that are necessary, with a preference for designs that minimize channel disturbance. Refer to NOAA Fisheries Guidelines for Salmonid Passage at Stream Crossings.

C-3-1: Where a crossing is necessary in an active salmonid spawning area (middle and upper reaches) install full span bridges or bottomless arches to allow for natural stream processes within the crossing.

C-3-2: To minimize stream impacts, limit crossing to occur during dry seasons, and reduce or eliminate cattle movement through the channel during winter.

C-3-3: Maintain seasonal crossings to allow fish passage during high flows. Seasonally installed cattle exclusion fencing that crosses the stream should be removed or modified before high winter flows.

C-4: Continue to enhance and implement grazing management plans with an emphasis on intensive management systems that reduce grazing impacts on upland and riparian landscapes.

C-5: Protect and improve water quality.

C-5-1: Inspect and maintain septic systems for leaks and limit development near watercourses.

C-5-2: Minimize use of pesticides and fertilizers in agricultural, residential, industrial, public, and recreational, areas.
C-5-3: Capture and appropriately discard winery and industrial waste to prevent discharge into storm water system.
C-5-4: Store any chemicals, fertilizers, fuel, and debris in areas away from riparian zones and floodplains.
C-5-5: Use fencing and riparian buffer strips to help dampen the impact of nutrients from livestock.

C-6: **Implement stream restoration using 'soft' bio-engineered techniques, incorporating live plant material whenever possible Also consider "stepping back" development from the creek to provide for natural meandering.** Refer to DFG California Salmonid Habitat Restoration Manual. Utilize stream restoration design and permitting assistance from the NRCS, DFG, the RCD and other local agencies. This style of restoration is particularly recommended for bare eroding banks in the middle reach of the creek. It is also important in the lower reach, where any hard revetment could aggravate erosion on adjacent banks. Because of the degree of entrenchment in the lower reach, and risk of failure or causing aggravated erosion, ensure that restoration projects are professionally designed.

C-7: Conduct education and outreach regarding actions that can help improve water quality and in-stream habitat.
C-7-1: Educate landowners on the impacts of dumping trash, organic debris, and agricultural waste into streams.
C-7-2: Support vineyard participation in Napa Green Farm Certification Program.
C-7-3: Educate rural residential landowners and others on LWD via tours and workshops.

Objective D: Reduce soil erosion.

The primary concern of this objective is with the accelerated soil erosion caused by human activities, and specifically with the transport and supply of eroded material to the stream. *Linkages: Actions to reduce soil erosion from upland surfaces have the potential to improve in-stream habitat and improve water quality in general, as do actions to prevent streambank erosion.*

D-1: Use sustainable agricultural practices to minimize soil erosion, as recommended in the Napa River Watershed Owners Manual and the Fish Friendly Farming (Napa Green) Manuals.
D-1-1: Maintain permanent, non-tilled cover crops in vineyards; where tillage is necessary, use annually-seeded cover crops.
D-1-2: Leave vineyard perimeter avenues untilled. Where traffic prevents maintenance of strong vegetative cover, fill in bare spots with post-harvest straw mulch and seed applications. Protect very high traffic routes with a permanent, crushed rock surface.

D-1-3: Install water bars to divert concentrated flows from vineyard avenues and roads to protected outfalls, or use road shaping or other means to disperse flows.

D-2: Limit use of and abandon existing low water crossings and access points to minimize bank degradation at those sites. Where possible, exclude livestock from the creek.

D-3: Maintain and improve roadways, and minimize new road construction.

D-3-1: Reduce sediment delivery from public and private roads, culverts and other improvements associated with human land use by implementing the recommendations made by Pacific Watershed Associates over the next 15 years.

D-3-2: Decommission abandoned roads by removing old crossings and eroding fill slopes and revegetating them.

D-3-3: Maintain and clear debris from culverts prior to and during the rainy season and monitor for plugging during heavy rainfalls.

D-3-4: Design roadway maintenance systems and erosion control practices for existing private roads using the Handbook for Forest and Ranch Roads in conjunction with USDA NRCS assistance.

D-4: Explore and where preferable utilize alternatives to engineered storm drains (to disperse, rather than concentrate, water).

D-4-1: When subsurface drainage is used, route drainage into settling or infiltration basins or install adequate energy dissipaters and downspouts at outlets.

D-4-2: Design drainage to disperse runoff and encourage groundwater recharge by using vegetated swales, rolling dips, and other methods.

D-4-3: Minimize soil disturbance on stream banks, such as when it is required by such activities as utility installation. Seed and revegetate all disturbed areas.

D-5: Consider "stepping back" development from the creek to provide for natural meandering. Where appropriate, implement streambank stability using "soft" bioengineered techniques. See A-1 and C-5 above.

D-6: Maintain and improve reservoir outlets to ensure that they are operating properly.

D-7: Conduct education and outreach regarding roads, vineyard practices, and bio-engineered streambank protection.

D-7-1: Hold a rural roads workshop in the watershed.

D-7-2: Encourage vineyard participation in the Napa Green Farm Certification Program.

D-7-3: Encourage landowners to allow access for future road assessment in areas not assessed to date.

D-7-4: Encourage Napa County Roads Department to apply for grants and implement road improvements recommended for public roads.

D-7-5: Establish a demonstration site for road-related erosion control, including road decommissioning and upgrading.

Objective E: Protect property and habitat using natural processes to promote streambank stability

Linkages: many actions taken under this objective will improve in-stream habitat and the health and continuity of the riparian corridor.

E-1: Protect property and natural resources by managing channel bank erosion.

E-1-1: Where the riparian corridor is narrow or missing, add vegetated buffer strips to help stabilize stream banks and prevent bank failures.

E-1-2: When bank failures threaten improvements to property, make repairs using bio-engineered methods which foster revegetation of the bank. Be sure to coordinate bank stabilization efforts with adjacent property owners.

E-1-3: Wherever possible, exclude livestock from the creek and correct any culverts that drain directly onto the bank.

E-2: Protect property from flood damage through culvert and bridge abutement clearing, in-channel vegetation management, and where possible providing the creek with access to its floodplain.

E-2-1: Maintain and clear debris from culverts prior to rainy season and monitor for plugging during heavy rainfalls.

E-2-2: Coordinate with Napa County Flood Control and DFG to control excess in-channel vegetation while limiting removal of LWD. See objective **C-2**.

E-2-3: Where possible, plant tree cover along flood control channels and drainage ditches, to maintain water quality and discourage in-channel vegetation while protecting against bank failure.

E-2-4: Provide the creek with access to its floodplain where possible. Where the stream is heavily incised, the incised stream will try to reestablish its floodplain by eroding banks. Where this has begun to happen and the landowner is willing to step back, a floodplain can be created at a lowered elevation appropriate for the incised stream. This process can be assisted by careful grading in the context of restoration work. Do this only on the basis of a thorough site analysis and professional design.

E-2-5: Avoid development within the 100-year floodplain. When opportunity arises, move existing structures and/or vines out of the floodplain.

E-3: Conduct education and outreach regarding bio-engineered streambank protection, floodplain functions, culvert maintenance, and management of large woody debris.

E-3-1: Educate landowners on bio-engineered streambank repairs via the demonstration site under G-2, if appropriate

E-3-2: Educate rural residential landowners and others on LWD via tours and workshops.

Objective F: Improve water management for the benefit of human, plant and animal communities

Linkages: this objective addresses not only the quality of in-stream and riparian habitat, which depends to some degree on water quantity, but also the needs of landowners for water for domestic use.

F-1: Plan individual water use (both surface and groundwater use) to minimize environmental disruption. Environmental values may be threatened by the timing of water withdrawals and the mechanisms used to pump and store water.

F-1-1: Design pump intakes to avoid harming fish, following the NMFS Fish Screen Criteria.

F-1-2: Register and upgrade or eliminate illegal or non-permitted water diversions.

F-2: Maintain desirable low flows for fish, using the telephone connection to the RCD-maintained streamgage at Old Sonoma Road Bridge to schedule withdrawals from streams.

F-2-1: Maintain a depth of one foot during adult steelhead migration (November - March) and six inches during smolt outmigration (April – June). NMFS cites seven inches (0.6 feet) as the bare minimum water depth to allow for adult steelhead passage.

F-2-2: In reaches that have flow during summer rearing periods, maintain flowing water over riffles to support invertebrates and improve water quality.

F-3: Explore opportunities to use recycled water for agriculture and landscape irrigation.

F-4: Use water conservation fixtures and equipment in and around homes and for agricultural uses of water

F-5: Use low-water-consuming and fire-retardant native plant materials for landscaping and habitat restoration.

F-6: Explore and where preferable utilize alternatives to engineered storm drains (to disperse, rather than concentrate, water).

F-7: Improve communication among water appropriators and among appropriators and the community.

F-7-1: Establish a communication network among water appropriators to discuss bypass requirements and best management practices for water withdrawal.

F-7-2: Establish a communication link between appropriators and the community to discuss surface water use.

F-7-3: Conduct field tours to demonstrate water use practices and procedures.

F-8: Support continued monitoring and research regarding local water conditions.

F-9: Conduct education and outreach to promote water use efficiency practices.

F-7-1: Encourage vineyard participation in Napa Green Farm Certification Program.

F-7-2: Continue to invite guest speakers to Stewardship meetings to cover topics related to water use efficiency, in-stream flows, and groundwater management.

Objective G: Encourage land stewardship and sustainable land use

The goal of this objective is to recruit active watershed management participants, so that every property owner takes responsibility for actions that affect the watershed.

Linkages: actions which educate land users about stewardship and sustainability tend to support the whole range of objectives identified in this plan, because informed land users are more likely to consider the environmental consequences of management decisions.

G-1: Organize community events and develop other mechanisms to increase awareness of this plan and support for its implementation.

G-2: Develop a creek restoration demonstration site on Carneros Creek and utilize it for community events.

G-3: Develop and distribute a "creek care guide" to landowners and managers.

G-4: Develop and implement a means to discuss this plan with neighbors and receive feedback from the community.

G-5: Facilitate permitting for environmental restoration projects. Support DFG and NRCS efforts to develop a local consolidated permit program.

G-6: Obtain funding for watershed work done under this plan.

Future Research and Recommended Monitoring

Although a great effort was made to assess existing watershed conditions in 2002 as part of the extensive watershed assessment, some additional research needs were discovered. They include the following:

- Identify wildlife species and habitat diversity
- Identify key wildlife corridors
- Gather data to improve water budget
  - Multi-year records of monthly rainfall
  - Establish creek flow measurement stations at several locations and maintain for 5 years
  - Gather information on permitted surface water withdrawal volumes (identify those with & without bypass requirements)
  - Improve information on ground water extraction – meter as many wells in the watershed as possible
  - Identify where aquifer is recharged
  - Estimate water use for vineyard, residential, and other irrigation, and rural domestic use
- Conduct groundwater monitoring to better characterize the groundwater basin and better understand locations of recharge and connectivity with surface water

Beyond additional research, watershed conditions should be monitored over time to allow the community to track changes within the watershed and adapt their land management strategies accordingly. Several recommendations for on-going and future watershed monitoring resulted from the watershed assessment and are summarized in matrix format in the Management Plan. The information that follows provides additional information regarding recommended monitoring. The numbering of recommended monitoring activities is the same in both documents for ease in cross-referencing (e.g. recommendation A-1 in the Management Plan is the same as A-1 in the Reference Document).

Objective A: Establish an uninterrupted riparian corridor along Carneros Creek and its major tributaries, emphasizing the use of native plants that are not primary hosts for Pierce's disease

A-1: Monitor vegetation growth and continuity and width of riparian corridor
Riparian continuity is one of the keystones for improving the channel condition and functioning. Wildlife habitat, channel stability, water quality, water temperature and aquatic habitat will all improve with established riparian vegetation. Monitoring vegetation growth over multiple growing seasons will provide a relatively quick indicator of success. Riparian continuity data should be collected for the entire reach annually for the first three years, and then once every five years following.

- Monitoring of the corridor should be based on the three defined reaches. Information should be recorded for each bank. Channel reaches longer than 15 m (50 ft) that are devoid of canopy should be considered riparian gaps, and areas of potential restoration. Locations of these gaps should be noted and photographed.

- Data collection should be keyed into channel length distances, working successively upstream. Data should be segregated by bank, and should include dominant riparian species/dominant composition, approximate age/age class, and condition. Secondary species should be noted. Notes should include approximate riparian corridor width, degree of undercut (if applicable) under individual trees, and potential for recruitment into the channel. Percent canopy cover (as measured in the centerline of the creek using a spherical densiometer) is a good quantitative metric.
- Success is reached when the corridor is 95% continuous, with no single gap larger than 20 m (66 ft) in length.

A-2: Monitor vegetation growth at restoration sites
At restoration project sites, initial baseline data should be collected followed by post-project data collected annually for five years following project completion. After the first three years of data collection, trends will be observable. Longer-term data collection will serve as checkups, and will identify new problem locations due to development, vegetation disease, or bank instability.

A-3: Observations of vines infected with Pierce's Disease should be recorded
Pierce's disease (caused by the bacterium *Xylella fastidiosa*) is hosted by many common riparian plant species, including: California grape, periwinkle, Himalayan and California blackberry, stinging nettle, mugwort, mulefat, and blue elderberry (http://www.cnr.berkeley.edu/xylella/hostptable.html). Vectors include the blue-green sharpshooter and the glassy-winged sharpshooter. Observations of infected vines will be important in slowing the spread of the disease. Data should be collected from vineyards throughout the watershed once every other year, with more frequent inspections during epidemics. Monitoring for the disease is primarily intended to slow the spread of the disease and should continue until Pierce's disease is not a significant problem/issue in the Napa Valley region.
Restoration sites in proximity to vineyards should choose plants that are not hosts for Pierce's disease.

Objective B: Promote contiguous upland habitat and biodiversity

B-1: Measure and record shape, area, and connectivity of wildlife habitat and migration corridors including riparian corridors and east-west corridors connecting habitat to adjacent watersheds.

Areas should be measured following the same schedule as the riparian corridor monitoring (annually for the first three years, once every five years thereafter). Trends should be apparent during the first three years of data collection. Methods should use the most recent aerial photographs available, in concert with field measurement.

B-2: Document number of wildlife species present in the watershed
Monitoring the watershed area available for wildlife habitat will help in understanding the status and condition of wildlife. Consider working with a wildlife biologist to document numbers and species of wildlife currently present in the watershed.

B-3: Monitor grazed areas, specifically grazing related erosion; grass species composition, condition, and density; percent area composed of exotic invasive species; and effectiveness of best management practices.

- Working with the NRCS or other resource professionals, develop a monitoring plan for grazed areas of the watershed. Monitoring should be field-based, and the following observations should be recorded: grazing-related erosion (bank trampling, gully and headcut development, etc); grass species composition, condition, and density; percent of area composed of exotic invasive species; and effectiveness of employed best management practices.
- Monitoring should occur annually for the first five years, and once every three years thereafter. Work with agencies/local experts to create a plan to eradicate non-native invasive species and replace them with native species, ultimately reducing problematic invasives by 75 %. Possible other goals: reduce grazing-related erosion (total number of erosion sites or total volume of erosion by 50%).

Objective C: Maintain and improve in-stream habitat

C-1: Conduct a survey of complete and partial migration barriers for salmonids and other species.
An initial survey of the main stem creek observing both complete and partial migration barriers for salmonids and other fish species was completed in 2002. Similar surveys should be completed once every three years. Landowners should work with the RCD and the Department of Fish and Game in designing and implementing the removal of any barriers. For future surveys, photographic records of the barriers at low- and high-flow; information on the height of the barrier, the depth of the pool, if any, beneath the barrier; and monthly estimates of the amount of flow over the barrier should be collected. Success is reached when anadromous fish are able to access the portions of the creek that provide appropriate habitat value. Significant improvements to fish migration would occur with the removal of 50% of the partial barriers. Prioritization should be given to the removal of barriers in the lower and middle reaches.

C-2: Monitor the number, depth, volume, complexity, and location of pools.
Monitoring the number, depth, volume, complexity, and location of pools will provide important data on channel function, available aquatic habitat, and the outcome of any restoration projects or changes in land management. The dataset collected for this project (see Channel Geomorphology Technical Report) can serve as baseline data for pools in the 10 sample reaches. Continued monitoring in these same reaches will provide information on pool trends through time. Monitoring should occur during the dry season, once every three years, or during the dry season following an unusually large flood event (5 year recurrence

interval or greater). Success will be reached when pool habitat quality and quantity is stable for two consecutive monitoring periods.

C-3: Monitor restoration projects – inventory of pools and channel form.
For specific reaches with projects planned, an inventory of pools and other channel features (e.g., gradient, sediment storage, large woody debris, channel bed grainsize) should be completed before and after the restoration project, as well as annually for five years after the project. Monitoring at project locations will provide data on the level of success of the project for meeting its habitat and physical processes goals.

C-4: Document the location and condition of cattle crossings.
Landowners should develop a monitoring program to document the location and condition of cattle crossings across tributaries and the mainstem of Carneros Creek. Monitoring should occur annually, and could utilize photographic records and/or bank pins to document the extent of erosion.

- Measures of channel bed grainsize distribution downstream of major crossings could also be employed to quantify any effects of management efforts enacted.
- Management plans to reduce the total number of crossings by 50% and/or to improve all of the major crossings to reduce the impact upon the stream should be enacted. Landowners should work with the appropriate permitting agencies during planning of removal/upgrade of any crossings. RCD and NRCS may be available to assist.

C-5: Conduct snorkel surveys of fish species during the summer.
Conduct annual snorkel surveys of fish species during the summer. The data would be used to describe what fish species are present, which age classes of steelhead are found, and the distribution of juvenile steelhead throughout the creek. Annual results could be compared with successive years to refine understanding of long and short-term variability and impacts of water levels on the population. Surveys should also focus upon other habitat requirements and factors affecting the success of fish in the watershed. These other factors may include: availability and transport of fish food (macroinvertebrates), water levels, water temperature, etc.

C-6: Conduct steelhead spawning surveys during adult migration season (December – March).

C-7: Monitor all projects that potentially impact in-stream habitat.
Monitoring of bank erosion on the adjacent bank, upstream and downstream of a restoration project would provide data on the success of the project. Baseline data should be collected in the proposed reach before a project begins. Monitoring could include photographic records and bank pins/scour chains to document erosion. Success is reached when the restoration proves to limit erosion in the project reach, does not induce erosion adjacent to the project, encourages natural channel processes without negatively affecting water or sediment transport, and encourages growth of native vegetation in the project area.

C-8: Monitor water quality, particularly temperature, dissolved oxygen, pH, and conductance.

The group should continue to monitor water temperature in key reaches, particularly the middle reach, which is important for providing aquatic habitat. Water temperature monitoring with continuous dataloggers in reaches with seasonal drying would reveal the relative importance of elevated stream temperatures, especially in the middle and lower reaches. Year-round monitoring could be implemented to document stream temperatures during salmonid spawning, egg incubation, rearing, and migration. This would identify important seasonal variations and allow the group to isolate those periods during the year that are most critical to maintaining water levels sufficient for healthy cold-water fish populations. The goal would be to maintain year-round temperatures below 68° F (20° C) for juvenile steelhead, currently found in the middle reaches. Hobo brand temperature loggers should be used, anchored in place, in a pool that will not completely dry up over the summer/fall. Data loggers should collect at least one data point every hour, potentially every 15 minutes during the summer and fall. Data should be downloaded once every month. Data should be collected for two consecutive years, in the same locations, with a decision to continue or to modify the methods at that point.

- Monitor water quality under supervision of the Napa County RCD's volunteer monitoring program. Data should be collected at three established sites at least monthly and include: dissolved oxygen (DO), temperature, pH, specific conductance, and other physical observations. One established monitoring site is located at the Old Sonoma Rd Bridge, and two more sites should be established upstream.

C-9: Measure turbidity.

Sampling should be conducted during high flow periods.

C-10: Sample benthic macroinvertebrates.

Sampling should be conducted in the spring and/or fall.

Objective D: Reduce soil erosion

D-1: Monitor vineyard plots and avenues for rill and gully development throughout the wet season.

Monitoring should occur annually, and should utilize photographic records and quantitative measures of erosion.

D-2: Monitor and remove debris from bridges and culverts to prevent the buildup of debris.

Preceding and throughout the wet season, monitoring of bridges and culverts should occur to prevent the buildup of debris. Work with the Napa County Flood Control and Water Conservation District to coordinate debris removal. RCD may also be available to assist.

D-3: Conduct physical and biological monitoring at outlets that drain to the creek and reservoir outlets.

Utilizing the work of Pacific Watershed Associates (see Hillslope Geomorphology / Sediment Budget Technical Report) the number of culverts/ditches/roads that are contributing or have the potential to contribute significant amounts of sediment to the fluvial system should be reduced by 50% over the next five years. Success will be reached with a significant decrease in the amount of road-related erosion that is routed into the fluvial system. This can be assessed by conducting physical and biological monitoring, including measures of ditch, culvert, and bank erosion; measures of bed sediment grainsize distribution at locations of drainage input; and measures of the benthic macroinvertebrate community composition and health. Additionally, increased awareness and education regarding the potential impacts of road-related drainage will increase the likelihood of success.

Objective E: Protect property and habitat using natural processes that promote streambank stability.

E-1: Monitor bank erosion and measure channel cross sections.
Utilizing the data collected in this study as a baseline (see Channel Geomorphology Technical Report), biennial monitoring of bank erosion and measurement of channel cross sections in the 10 sample reaches will provide data on the trend of bank erosion. In addition, in high-erosion locations, bank pins can be installed to monitor erosion on an event or annual basis. Success is reached when the volume of bank erosion caused by human sources (road, vineyard, or residential drainage, channel modifications, vegetation removal, etc) is reduced by 50% over the next five years.

E-2: Map locations of debris jams. Monitor locations with excess in-channel vegetation and amount of in-channel woody debris.
As described above, monitoring and maintaining culvert and bridge locations for debris during the wet season will help prevent flood damages. Monitoring of locations with excess in-channel vegetation as well as monitoring of volumes of in-channel LWD should also occur on an annual basis. Success will be reached when the maximum amount of vegetation and LWD can remain in-channel without causing significant flood hazards and damage.

E-3: Monitor effectiveness of bank stabilization projects.
See C-7 above.

Objective F: Improve water management for the benefit of human, plant and animal communities

F-1: Document locations of all diversions from the stream and make sure diversions are properly screened.

F-2: Work with RCD to continue monitoring water level and discharge, making the information available to those who divert water.
The stream gage will allow calculation of the total annual streamflow and will provide water level data so that even with water withdrawals, minimum flow depths for fish are maintained. For specific seasonal depth requirements see Objective F-1-2. The gage records data

continuously, and can be accessed via telephone. Data should be collected for a minimum of five full water years. Success will be reached when minimum stream flow requirements for salmonids are met throughout the year and sufficient water is available for plant and animal species and human uses.

Objective G: Encourage land stewardship and sustainable land use

G-1: Document number of watershed community events that support watershed awareness and implementation of actions suggested in this plan.
Watershed community events might include project work days, stewardship meetings, demonstration workshops, etc. Success will be met in years when 8 events are held and attendance goals for each event are met.

G-2: Track progress of development of creek-care guide.
A creek-care guide and restoration demonstration site should be developed within 5 years. The creek-care guide will be successful when it is available on-line and distributed to 100 property owners or managers within the watershed. Greater success will be achieved when practices or suggestions in the care-guide are implemented by several landowners or managers (a survey instrument could be used to evaluate implementation).

G-3: Track progress of establishing a restoration demonstration site and once completed, track its use.
The restoration demonstration site will be successful when it is utilized annually for community events and possibly for monitoring.

G-4: Document, to the extent feasible, implementation of the recommendations in this management plan.
Tracking could be accomplished through surveys and/or direct communication & coordination with resource professionals and landowners/managers involved in implementation.

G-5: Document efforts to obtain funding and funding received to implement actions suggested in this management plan.
Success will be met when sufficient funding is available to landowners who choose to implement suggested actions.