SALMONID HABITAT ASSESSMENT

SOLANO HABITAT CONSERVATION PLAN

LSA

June 30, 2008

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1.0 INTRODUCTION

1.1 BACKGROUND AND PURPOSE

In 2003, the Solano County Water Agency (SCWA) received an Endangered Species Act (ESA) Section 6 grant from the U.S. Fish and Wildlife Service to address specific data gaps identified in the Solano Habitat Conservation Plan's (HCP) *Report of Science Advisors* (Noss 2002). For anadromous salmonids, the report recommended evaluating the factors affecting the survival and growth rate of juvenile salmonids. Before this type of evaluation can take place, it is necessary to understand factors affecting spawning; most importantly, the location and availability of potentially suitable spawning and rearing habitat within Solano County streams. Studies to determine if potential salmonid habitat is available (or could be made available through restoration actions) are critical since it is estimated that greater than 82% of steelhead spawning and rearing habitat in the Central Valley has been lost (Yoshiyama et al. 1996). In addition, the presence and distribution of salmonid species and habitat in Solano County is poorly documented.

The ultimate goal of this salmonid habitat assessment is to provide background information on the location of suitable/potentially suitable salmonid habitat to landowners, agencies, and other entities who may become involved in salmonid habitat restoration projects. Plan Participants can use the information provided in this report to help evaluate applicable conservations measures for the Solano HCP. This study also helps address proposed conservation measures directed at species recovery contained in Working Draft 2.0 of the Solano HCP:

> **Conservation Measure RSM 21 – Salmonid Stream Surveys.** This measure requires Solano HCP Plan Participants to conduct surveys within their jurisdiction to assess barriers within public rights-of-way and at public facilities along streams known or suspected to support important populations of steelhead and other native fishes. Creeks specifically identified in this conservation measure are Jameson Canyon, American Canyon, Ledgewood, Suisun, and Green Valley creeks and their tributaries that contain suitable breeding and rearing habitat for steelhead.
>
> **Conservation Measure RSM 22 – Removal of In-Stream Barriers.** Plan Participants will also work to remove or minimize existing barriers at existing facilities and to prevent creation of barriers on private lands as new development occurs on the creeks identified in Conservation Measure RSM 21. This conservation measures requires that all barriers within Plan Participants' rights-of-way be removed or corrected within 10 years of the adoption of the HCP. Plan Participants will also work with, and provide technical assistance to, landowners to remove or minimize barriers on private lands.

1.2 SCOPE OF ASSESSMENT

This report focuses on two salmonid species found in Solano County, Chinook salmon (*Oncorhynchus tshawytscha*) and the federally-threatened steelhead trout (*Oncorhynchus mykiss iredeus*). This report provides an overview of available information for selected streams in Solano

County in order to assess the potential for these streams to support Chinook salmon and steelhead trout. This habitat assessment focuses on the Central California Coast and Central Valley steelhead Evolutionarily Significant Units (ESUs), and one Chinook salmon ESU (Central Valley fall and late-fall run). This report is not intended to present an exhaustive summary of literature related to Solano County fisheries but focuses on key factors affecting salmonids. This report provides recommendations for prioritizing streams where habitat enhancement projects have better potential to improve or increase steelhead habitat in Solano County's streams.

This assessment focuses on the following streams located within two main hydrologic units: the Suisun Bay watershed (hydrologic unit code [HUC] 18050001) and Lower Sacramento watershed (HUC 18020109). The Suisun Bay watershed includes the range of the steelhead Central California Coast ESU and includes the following waterways: American Canyon Creek, Jameson Canyon Creek, Green Valley Creek, Suisun Valley Creek, Ledgewood Creek, and Laurel Creek. Figure 1 (Appendix A) shows the locations of these streams within Solano County. The Lower Sacramento watershed lies within the designated range of Central Valley ESU and includes two primary waterways and their associated tributaries: Alamo Creek and Ulatis Creek. The streams listed above are included in this assessment because limited information is available for these streams and they are known or suspected to have potential salmonid habitat.

Two other major waterways, the Napa River and Putah Creek, are not addressed in this assessment. Within Solano County, none of the Napa River tributaries contain suitable steelhead breeding habitat and the Napa River itself provides primarily passage habitat. Putah Creek is not included because it is beyond the scope of the Solano HCP and salmonid habitat issues have been thoroughly addressed by the Solano Project Contract Renewal. Also, the California Department of Fish and Game (CDFG) conducted a study (the Fish Passage Improvement Project) that includes major streams and rivers (including Putah Creek) but does not include smaller creeks or creeks with "potential" or unconfirmed salmonid habitat or populations (CDFG et al. 2005).

2.0 METHODS

2.1 REVIEW OF EXISTING INFORMATION

LSA reviewed a variety of sources for information regarding historic and current conditions of Solano County streams and salmonid populations in the region. The following types of sources were consulted or reviewed:

1. Documents produced by LSA, including:

    - The *Solano Multispecies Habitat Conservation Plan (HCP), Working Draft 2.2* (LSA 2007)
    - A Riparian Habitat Assessment of Solano County Streams (LSA 2008)
    - A freshwater shrimp survey of Jameson Canyon Creek in Solano and Napa counties (LSA 2006)

2. Various sources providing previous records or studies of streams and salmonids in Solano County and the Central Valley

3. Government agency memos and guidance on fish passage, water rights and other issues

4. Government databases related to fisheries (CDFG 2007 and 2008; NMFS 2008)

5. Air temperature model database (Daly and Gibson 2006)

6. Aerial imagery provided by the Solano County Water Agency (2004)

7. Various published species accounts and field guides

2.2 HABITAT SUITABILITY MODEL

In the absence of sufficient stream temperature and flow data for most Solano County streams, potentially suitable habitat for anadromous salmonid spawning and rearing was predicted with a model utilizing air temperature and stream gradient. This model is based on a comparable habitat suitability model used for identifying streams in the Central Valley that were likely to support steelhead during summer months (Lindley et al. 2006).

The model used in the Central Valley stream assessment identified suitable stream reaches that met the following parameters: mean annual discharge >0.028 m^3s^{-1} (1 ft^3s^{-1}), gradient <12%, and mean August air temperature <24° C (75.2° F). The Central Valley assessment selected these habitat parameters based on previously published data indicating that (1) stream temperature is linearly related to air temperature between 0 and 24° C (32 and 75.2° F), (2) the highest reported maximum air temperature for steelhead rearing was determined to be 24° C (75.2° F), and (3) steelhead are commonly found in stream reaches with gradients less than 6% but in some systems they are not uncommon in reaches with gradients of up to 12% and occasionally higher. Air temperature of 24° C is correlated with stream temperature of 22° C (71.6° F).

The monthly air temperature model results for Solano County show that the highest mean air temperatures occur in July rather than August; therefore, our model utilizes mean temperature data from July. The model was developed using interpolated from data collected at climate stations for the period from 1971 to 2000 to provide four-hundred-meter resolution grids of temperature data (Daly and Gibson 2006) for the County. These grids were used to determine zones within Solano County where the monthly mean air temperature is either above or below 24° C (75.2° F) during July. Streams were segmented into 100- to 200-meter reaches. Segments were compared to the climate data and were classified based upon their position within the watershed relative to the high temperature zones. Stream gradient was modeled by first converting the segments to 3D features and then by overlaying them onto 10-meter resolution NED digital elevation data (USDA Edition 1). Mean percent slope was calculated for each segment and the resulting segments were classified by gradient into three categories: 0-6% slope, 6-12% slope, and >12% slope.

2.3 FIELD ASSESSMENT

A field assessment of the eight streams was conducted in spring of 2008 in an attempt to fill data gaps identified during the review of existing information. The field component focused on (1) locating potential barriers to fish passage, and (2) evaluating which stream reaches support riparian canopy that provides shade over the channel during the afternoon, when air temperatures are highest.

Data collection in the field was limited to locations where the streams could be accessed by public roads. In many areas, there is no public access to the streams. Data collected during this field assessment were added to data previously collected for the Riparian Habitat Assessment (LSA 2008). All assessment locations were recorded using GPS technology.

3.0 SALMONID LIFE HISTORY AND HABITAT REQUIREMENTS

3.1 LIFE HISTORY

Salmonids share general characteristics such as basic life history traits and habitat preferences. Salmonid life history generally follows an anadromous cycle, spawning in streams and rivers and then migrating to the sea to mature. Timing of migration and spawning varies between and within species (see discussion below). Adults migrate to the streams of their birth by using their olfactory memory of a specific creek's organic molecular compounds (McGinnis 2006). Once they have arrived in the upper reaches of the creek, the adult salmon spawn in gravel beds in the upper reaches of streams. The eggs are laid and fertilized in the redd (a depression created by the female salmonid) after which time they are lightly buried. The adult Chinook salmon die following spawning, whereas adult steelhead may spawn multiple times (Moyle 2002). The eggs take a month or more to hatch, and the alevins (newly emerged fry) then remain in the gravel beds maturing and subsisting on large yolk sacs. Once the fry emerge from the gravel layer and become free-swimming, they develop dark vertical bands called parr marks. These juvenile fish reside in freshwater for a variable length of time, dependent on species, before beginning their migration to the ocean. During their ocean-bound migration, the young spend time in the estuarine ecosystem, where they develop the silvery coloration of adults and adapt to the physiological demands of living in salt water in a process known as smoltification (McGinnis 2006).

Chinook Salmon. Chinook salmon show a wide array of life histories, probably as an adaptation to highly variable river conditions. Spawning Chinook salmon generally are confined to perennial, lower reaches of larger watersheds (Leidy 2007).

Steelhead Trout. Central valley steelhead migrate upstream in the fall, beginning in August and peaking in late September-October. They spawn several months later, when flows in tributary streams are high enough. Steelhead spawn in headwater reaches with deep pools. These fish exhibit highly variable juvenile rearing times with 1-3 years being spent in fresh water followed by 1-4 years at sea.

3.2 STATUS AND DESCRIPTION

3.2.1 Steelhead Trout

Steelhead are the anadromous (sea-run) form of rainbow trout. Steelhead in California are classified as the coastal subspecies, *Oncorhynchus mykiss irideus* (Behnke 1992). The Central Valley steelhead ESU was listed as a threatened species on March 19, 1998 (63 FR 13347). This ESU includes all naturally spawned populations of steelhead (and their progeny) in the Sacramento and San Joaquin Rivers and their tributaries, including Ulatis and Alamo creeks and their tributaries. Historically, the Central Valley ESU steelhead were well-distributed throughout the Sacramento and San Joaquin river systems: from the upper Sacramento/Pit river systems south to the Kings and possibly Kern river systems in wet years (Yoshiyama et al. 1996).

Steelhead in the western portions of the County are classified as being in the Central California Coast ESU. The Central Valley steelhead ESU was listed as a threatened species on March 19, 1998 (63 FR 13347). This ESU includes all naturally spawned populations of steelhead (and their progeny) in the San Francisco, San Pablo, and Suisun Bays and their tributaries. Steelhead from the Central California Coast ESU would be expected to spawn in the streams of western Solano County such as American Canyon, Jameson Canyon, Green Valley, Suisun Valley, Ledgewood, and Laurel creeks.

3.2.2 Chinook Salmon

The Central Valley fall and late fall-run Chinook salmon ESU was designated as a candidate for listing on September 16, 1999. This ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin River Basins and their tributaries, east of the Carquinez Strait, California (NOAA Fisheries 1999).

Historically, it is estimated that fall and late fall-run Chinook salmon occurred at elevations up to 1,000 feet based on known records from the McCloud River (NOAA Fisheries 2003). This run was historically the most abundant in the Central Valley. The fall and late fall run occurred in all the major tributaries in the Sacramento-San Joaquin drainage, however it is unclear how far upstream Chinook salmon reached (Moyle 2002). Currently, hatchery fish are believed to augment this run by 10 to 65 percent (Behnke 2002).

In the late nineteenth century, many fish hatcheries were established in northern California in response to the decline of the commercial salmon fishery of the Sacramento River. No hatcheries were based in Solano County (JRP 2001). It has been suggested that the small natural population of Chinook salmon in the Solano HCP area contributes to the natural production of the Central Valley fall/late-fall ESU, which is currently heavily subsidized by hatchery production in the Sacramento River watershed (Noss et al. 2002).

3.3 HABITAT REQUIREMENTS

Both Chinook salmon and steelhead require riparian river and stream habitat, with spawning and rearing habitat characterized by perennial streams with clear, cool to cold, fast flowing water with a high dissolved oxygen content (near 100 percent for spawning), and abundant gravels and riffles. Both salmonids require sufficient flow and appropriate habitat for spawning, rearing, and migration, including shallow riffles for spawning and deep pools with well-developed riparian cover for rearing (Leidy 2000). In addition, water quality is important for both species; they prefer water with low suspended sediment and contamination loads, and minimal pollution levels.

3.3.1 Steelhead Trout

A summary of habitat requirements for steelhead is provided in Table A (Appendix B). Optimal water temperatures for steelhead range from 39° F to 50° F depending on habitat use. Although eggs can die at 56° F and fish can experience difficulty in extracting oxygen from the water when temperatures exceed 70° F (Hooper 1973), steelhead are adapted to survive conditions where preferred temperatures are exceeded for long periods of time (McEwan and Jackson 1996). Preferred water depth for spawning is 6-24 inches, for fry rearing is 2-14 inches, and for parr rearing is 10-

20 inches (Bovee 1978). The preferred water velocity for spawning is approximately two feet per second (ft/s) (Barnhart 1986). Steelhead can survive low oxygen concentrations at low temperatures, but require oxygen concentrations near saturation for growth (Moyle 2002).

3.3.2 Chinook Salmon

Chinook salmon generally are confined to perennial, lower reaches of larger watersheds. Table B (Appendix B) provides a summary of Chinook salmon habitat requirements. The upper range of thermal tolerance for Chinook salmon is 71.6-73.4° F (stream temperature), with an upper lethal level of 77 °F (Moyle 2002). The Chinook salmon's optimal migratory temperature is 60.8 °F, although a range of temperatures is tolerated (Torgersen et al. 1999). Spawning temperatures of 50-59° F are preferred. Optimal juvenile growth occurs at temperatures of 55.4-64.4° F, although positive growth occurs in a wider range of temperatures, from 41-66.2° F (Moyle 2002).

Chinook salmon primarily spawn at depths between 9.8 and 39.4 inches and velocities of 1.0-2.6 feet per second (Behnke 2002). Optimal conditions for embryo survival include water temperatures between 41 and 55.4° F and oxygen levels must be close to saturation (Behnke 2002). Optimal rearing temperatures for juvenile fall-run Chinook salmon are between 55.4 and 64.4° F. Juvenile Chinook salmon remain in freshwater for 1-7 months (Leidy 2007).

4.0 RESULTS

4.1 WATERSHED SUMMARIES AND BACKGROUND INFORMATION

4.1.1 Land Use

Data related to land use in Solano County watersheds are available from mapping conducted previously for preparation of the Solano HCP (LSA 2007). Land use data provide broad information regarding the potential of individual streams to provide habitat for salmonids. Land use data can provide clues for assessing water quality, potential for water withdrawals (and subsequent lowered depth and velocity), impacts to riparian habitat, and other factors that have the potential to impact salmonid habitat or migration potential. Existing land use data for each stream are summarized in Table C (Appendix B) and discussed below.

The American Canyon and Jameson Canyon watersheds are both located in areas with relatively low agricultural development and low urban development (Table C). Vegetative cover in the American Canyon and Jameson Canyon watersheds is primarily inner coast grassland with some oak woodland and other riparian vegetation. The lower reaches of these creeks (east of Interstate 80 [I-80], along Interstate 680 [I-680]) are in developed areas but these areas are much less developed than the lower reaches of other creeks covered in this assessment. American Canyon and Jameson Canyon, along with Laurel Creek, have the smallest watersheds of all those considered in this assessment.

The upper reaches of Green Valley Creek have relatively low agricultural and urban development; however, the lower reaches of this creek have higher agricultural development and urban development than American Canyon Creek or Jameson Canyon Creek. The Green Valley Creek watershed within Solano County is located in areas with vegetative cover consisting of inner coast range grassland, oak woodland, scrub/chaparral, and agriculture (LSA 2007). This watershed, along with the Ulatis Creek watersheds, is one of the largest watersheds in the county, after the Suisun Creek watershed.

Vegetative cover in the Suisun Creek watershed is predominantly agriculture with oak woodland and inner coast range grassland in the upper reaches and relatively low urban development. The Suisun Creek watershed is by far the largest of all of the watersheds (approximately 49 sq. mi) included in this assessment. Although the watershed has a relatively high amount of agriculture, it has a low percentage of development relatively to watershed size.

The vegetative cover within the Ledgewood Creek watershed is similar to that of Suisun Valley Creek except that the lower reaches are much more developed (LSA 2007). This is a mid-sized watershed, comparatively speaking, and is similar in size to the Alamo Creek watershed. The lower portion of this creek has been channelized for flood control.

The upper reaches of Laurel Creek (west of I-80) are located in areas with low percent development and low agriculture with vegetative cover consisting of oak woodland and inner coast range grassland. However, a significant portion of this small (approximately 8-square-mile) watershed is located in highly urbanized areas and lacks riparian vegetation. Much of the lower length of Laurel Creek has been channelized for flood control.

The uppermost portions of the Ulatis Creek and Alamo Creek watersheds are located in areas of relatively low development with vegetation consisting of scrub/chaparral, oak woodland, inner coast range grassland, and agriculture. The lower reaches of these creeks are predominantly located in developed areas (near the I-80 corridor) and within agriculture lands (further east of I-80 and closer to the Delta). Some reaches of Lower Ulatis Creek are located adjacent to vernal pool grassland areas.

4.1.2 Beneficial Uses of Streams

The Regional Water Quality Control Boards (Regional Boards) established beneficial uses (i.e., "uses that benefit the people of the state") for major streams within their jurisdiction. One of the purposes of the Regional Boards is to protect these uses from waste discharges. Beneficial uses established for some of the Solano County streams are listed in Table D in Appendix B and discussed further in the paragraphs that follow. Uses were specifically established by the San Francisco Bay Regional Board for Green Valley Creek, Suisun Valley Creek, Ledgewood Creek, and Laurel Creek. Beneficial uses for other creeks within the SF Bay Region were not specifically designated; therefore, the beneficial uses for these creeks (American Canyon Creek and Jameson Canyon Creek) are based on those listed for Suisun Slough (SFRWQCB 2007). Likewise, the Central Valley Regional Board does not specifically identify beneficial uses for Alamo Creek or Ulatis Creek (the only drainages in this assessment that fall under the jurisdiction of the Central Valley Regional Board). These drainages are located within the Sacramento-San Joaquin Delta. Beneficial uses vary throughout the Delta and are evaluated on a case-by-case basis (CVRWQCB 2007).

Three beneficial uses relate to the ability of a stream to support salmonid habitat. These beneficial uses are cold freshwater habitat (COLD), fish migration (MIGR), and fish spawning (SPWN). These beneficial uses are described briefly below. Full definitions of beneficial uses are provided in Appendix C.

Coldwater habitat is listed as a beneficial use for Green Valley Creek, Laurel Creek, Ledgewood Creek, and Suisun Valley Creek. Cold freshwater habitats are well-oxygenated and generally support trout and may support anadromous salmonids (SFRWQCB 2007). These habitats typically support species less tolerant to poor water quality. Although Jameson Canyon Creek and American Canyon Creek are not included, this does not necessarily reflect the ability of these streams to provide coldwater habitat because beneficial uses for these streams are based on the greater watershed (i.e., Suisun Slough). Beneficial uses for Ulatis Creek and Alamo Creek are also based on the greater watershed (i.e., Sacramento-San Joaquin Delta) and most likely do not support coldwater habitat.

Laurel Creek, Ledgewood Creek, Suisun Valley Creek, and Ulatis Creek are designated as supporting fish migration. As defined by the Regional Board, the beneficial use of fish migration implies similar water quality as streams supporting cold water fisheries but adds provisions for maintaining fish passage whether it be a physical, thermal, chemical, or other water quality barrier (SFRWQCB 2007).

The same creeks that support fish migration, plus American Canyon Creek, Jameson Canyon Creek, and Green Valley Creek have a designated beneficial use for fish spawning. This beneficial use focuses on maintenance of high dissolved oxygen levels (near saturation) and un-obstructed flow and notes that size distribution and organic content of sediments, water depth, and velocity also affect the ability of a stream to provide suitable spawning habitat (SFRWQCB 2007 and CVRWQCB 2007).

Although it is uncertain what background information or research was used to make these decisions about beneficial uses, they can add to the need to preserve or restore salmonid habitat. If there is an activity or a barrier that threatens the health or survival of the salmonids, then the Regional Board could prohibit that activity/barrier (or potentially require mitigation/restoration) based on the established beneficial uses (SFRWQCB 2007). The intended uses of these streams add to the impetus to restore passage in creeks where these uses (i.e., COLD, MIGR, and SPWN) are established.

4.1.3 Historical and Current Distribution of Salmonids in Solano County Streams

American Canyon Creek and Jameson Canyon Creek. A preliminary search did not yield data or reports related to the historical presence of fisheries in American Canyon Creek or Jameson Canyon Creek. However, a winter steelhead distribution map produced by CDFG in June 2007 indicates that anadromous steelhead were observed in 2004 in Jameson Canyon Creek (CDFG 2007). Steelhead were reportedly observed in American Canyon Creek within the last ten years in association with a spill of well-drilling clay from a slide repair project on I-80 near Lynch Canyon (Greg Martinelli, personal communication); however, specific information is lacking.

Green Valley Creek. Steelhead have been observed in Green Valley Creek from the 1950s to at least as recently as 2002. Observations have been made at several locations upstream of I-80 (Leidy et al. 2005). Chinook salmon have been observed upstream to the base of Green Valley Falls and redds have been observed at Mankas Corner (Edwards, personal communication *In* National Marine Fisheries Service [NMFS] 2008). The winter steelhead distribution map produced by CDFG in June 2007 indicates that anadromous steelhead were observed in 2004 in Green Valley Creek (CDFG 2007).

Suisun Valley Creek. Steelhead have been observed in Suisun Valley Creek and its tributaries since the 1950s and as recently as June 2002 (Leidy et al. 2005). It is unclear whether spawning steelhead have been observed in recent years. The winter steelhead distribution map produced by CDFG in June 2007 indicates that anadromous steelhead were observed in 2004 in Suisun Valley Creek (CDFG 2007). Steelhead runs have diminished primarily due to the construction of the dam at Lake Curry in 1926 and subsequent issues related to inadequate surface water flows (Leidy et al. 2005). A 1969 memo from CDFG indicated that the greatest concentration of steelhead juveniles in the Suisun Creek watershed was in Wooden Valley Creek (Greenwald 1969 *In* Leidy et al. 2005). This same report noted that lack of nursery habitat was limiting steelhead populations in Suisun Creek. In 1980, a CDFG report recommended removing barriers, improving agricultural practices, and preventing dumping to improve steelhead habitat (Cox 1980 *In* Leidy et al. 2005).

Chinook salmon have been observed over multiple years upstream to the Napa/Solano County line. These individual were possibly strays (Edwards, personal communication *In* NMFS 2008).

Ledgewood Creek. Chinook salmon have been found upstream of I-80 in multiple years, it is unknown whether they spawn in the creek (Edwards 1998, personal communication *In* NMFS 2008). Additional information provided in the *Historic Record of Salmon and Steelhead in Solano County Streams: Final Progress and Findings Report* (JRP 2001) suggests that Ledgewood Creek historically supported steelhead, at least until the mid-1970s. However, no specific observations of steelhead are noted.

Laurel Creek. Chinook salmon have been found in Laurel Creek from upstream to Travis Boulevard, possibly strays; it is unknown whether they spawn in the creek (Edwards 1998, personal communication *In* NMFS 2008). Additional information provided in the *Historic Record of Salmon and Steelhead in Solano County Streams: Final Progress and Findings Report* (JRP 2001) suggests that Laurel Creek also historically supported steelhead, at least up until the mid-1970s. However, no specific observations of steelhead were noted.

Alamo Creek and Ulatis Creek. A preliminary search did not yield data or reports related to the historical presence of fisheries in Alamo Creek or Ulatis Creek. However, CDFG's winter steelhead distribution map indicates that anadromous steelhead were observed in 2005 in both Alamo Creek and Ulatis Creek (CDFG 2007). Fall-run Chinook salmon have been observed periodically in Ulatis Creek, at Nut Tree Road between the mid 1970s and late 1990s (Steve Foreman, personal observation).

4.2 HABITAT SUITABILITY

4.2.1 Stream Gradient/Temperature Model

Upper Alamo and Ulatis Creeks. These are two of the northernmost streams in Solano County and are shown on Figure 2 (Appendix A). These creeks originate in the Vaca Mountains, just west of the Napa/Solano County line. For the purposes of this assessment, the downstream limit of "upper" Alamo and Ulatis Creeks is located roughly where the creeks enter the densely developed limits of the City of Vacaville (see assessment locations AC02 and UC02 in Figure 2). Upper Alamo and Ulatis Creeks are well shaded by riparian vegetation that forms a closed to partially-closed canopy. The most typical substrates occurring in upper Alamo and Ulatis Creeks are gravel, cobble, and boulder (LSA 2008).

Within upper Alamo and Ulatis Creeks, the majority of stream reaches with the most suitable gradient (<6%) for salmonid habitat are located in the region that exceeds the temperature threshold for salmonid habitat (i.e., too hot to provide suitable rearing habitat in summer). These segments also tend to dry during many summers.

The uppermost reaches of these watersheds are located in areas within the suitable temperature threshold; however, the topography of the area results in steeper stream gradients. In the upper reaches of Alamo and Ulatis creeks, only 13% and 19%, respectively, of the stream reaches are of low to moderate gradient (<6%; $\geq$6% to $\leq$12%). The majority of the stream reaches in the upper watersheds are characterized by gradients of >12%. The low to moderate gradient stream reaches are interspersed among the higher gradient stream reaches, thus likely making these sections inaccessible to steelhead.

Lower Alamo and Ulatis Creeks. Lower Alamo and Ulatis Creeks are located in heavily developed or agricultural bottomlands. These are entirely low gradient (<6%) streams that have been channelized and rerouted in several locations. Where riparian vegetation does occur along the two creeks, the canopy is more open than along upper Alamo and Ulatis Creeks. Riparian canopy is sparse or absent from many of the channelized reaches farther east.

Because the lower gradient reaches receive runoff from the upper watersheds and also pass through portions of diked baylands, the most typical substrates occurring in lower Alamo and Ulatis Creeks are silt/clay/mud and cobble (LSA 2008). Approximately 90% of the lower reaches of Ulatis Creek, and 65% of the lower reaches of Alamo Creek, are located in areas within the suitable monthly temperature threshold for salmonid habitat (Figure 2); however, these sections of creek can typically experience several continuous weeks of unsuitable temperatures in most years. Old Alamo Creek meets the gradient and temperature criteria for salmonid habitat, but is not considered suitable because of dewatering and other passage barriers.

Laurel Creek. Laurel Creek, another stream in the central/northern portion of the county, is shown on Figure 2. This creek originates in the Vaca Mountains and terminates at Hill Slough. The entire length of this creek is located within the suitable temperature threshold for salmonid habitat and approximately 96% of this creek is characterized by a low gradient (<6%). Low, moderate and steep gradient stream reaches are fairly evenly interspersed along the uppermost reaches in the hills, where closed canopy riparian vegetation is common. South of Cement Hill Road and Laurel Creek Park the stream is channelized for flood control and supports little or no riparian canopy.

American Canyon Creek. American Canyon Creek, the southernmost creek in Solano County, originates in the low hills southeast of I-80 and approximately one-half of a mile northeast of the Napa/Solano County line (Figure 3, Appendix A). This creek is channelized for flood control through the flat agricultural fields before it drains to Cordelia Slough. Two tributaries in Lynch Canyon, northwest of I-80, are included in the assessment of American Canyon Creek. The entire creek is located within the suitable temperature threshold for salmonid habitat and approximately 95% of this creek is characterized by low to moderate gradients. The most typical substrates occurring in this creek are silt/clay/mud and gravel (LSA 2008).

The upper reaches of American Canyon Creek support a nearly continuous corridor of closed-canopy riparian vegetation. Along the lower, easternmost reaches, riparian vegetation cover is less dense and more patchily distributed along the channel.

Jameson Canyon Creek. The headwaters of Jameson Canyon Creek are located in Jameson Canyon, just east of the Napa/Solano County line (Figure 3). The lower reaches of Jameson Canyon Creek are channelized through agricultural fields before it drains to Cordelia Slough through a flapgate. Five small, unnamed tributaries in the canyon are included in the assessment. The entire creek is located within the suitable temperature threshold for salmonid habitat and approximately 99% of this creek is characterized by low to moderate gradients. The most typical substrate occurring in this creek is silt/clay/mud and many reaches are concrete-lined (LSA 2008).

Riparian canopy is sparse where the upper reaches of Jameson Canyon Creek are located in grazed pastures. As the creek makes its way eastward, the stream corridor is dominated by closed-canopy riparian vegetation until the channel is culverted underneath I-80. Riparian canopy is patchily distributed along the channel where it passes through industrial development southeast of Cordelia Junction and becomes sparse, then absent, once the channel is diverted through agricultural fields and toward Cordelia Slough.

Green Valley Creek. Green Valley Creek originates in Green Valley, northwest of Rockville Hills Regional Park, and drains into Cordelia Slough via flood control channels southeast of Cordelia Junction. Several unnamed tributaries and one major tributary (Dug Road Creek) are included in the assessment of Green Valley Creek (as shown on Figures 1 and 3). All reaches of Green Valley Creek and its tributaries are located in areas within the suitable temperature threshold and 84% of the stream reaches assessed (i.e., as mapped on Figure 3) are characterized by low to moderate gradients. The most typical substrates occurring in the upper reaches of Green Valley Creek are boulders and cobble and silt/clay/mud is the dominant substrate in the lower, wider reaches (LSA 2008).

The uppermost reach of the mainstem of Green Valley Creek is located in an open, low-gradient valley where riparian canopy is absent. The mainstem and the tributaries in the surrounding hills become steeper and support closed-canopy riparian vegetation as they drain toward Green Valley. Closed-canopy riparian vegetation remains nearly continuous until the creek enters residential development and the Green Valley Golf Course. Here the creek is mostly channelized, with the exception of a portion of the golf course, where the stream channel is less confined, with natural braids and meanders and patchily distributed riparian vegetation. Closed-canopy riparian vegetation is again dominant along the channel south of the golf course until the creek reaches South Putah Canal. From that point until it drains to Cordelia Slough, riparian vegetation is sparse and provides little shade over the wetted channel.

Suisun Valley Creek. Suisun Valley Creek originates in Napa County. It enters Solano County as a low-gradient stream that meanders through Suisun Valley before draining to Cordelia Slough southeast of Cordelia Junction. Two unnamed tributaries originating in the hills west of Suisun Valley Creek are included in the assessment. Approximately 88% of Suisun Valley Creek within Solano County is located in areas within the suitable temperature threshold for salmonid habitat and 88% of the stream reaches assessed are characterized by low to moderate gradients. The most typical substrate occurring in Suisun Valley Creek are cobble, silt/clay/mud, and gravel.

North of I-80 this creek is characterized by partially-closed riparian canopy. South of I-80, the channel becomes gradually wider and the riparian canopy is much more open, providing less shade over the creek.

Ledgewood Creek. Ledgewood Creek originates in the Vaca Mountains north of the Solano/Napa County line and drains into Paytonia Slough southwest of Suisun City. The entire length of this Creek within Solano County is located within the suitable temperature threshold for salmonid habitat and is characterized by a low gradient. The most typical substrate occurring in this creek is silt/clay/mud (LSA 2008).

The upper reaches of this creek (within Solano County) flow between agricultural fields and low-density residential areas where the naturally sinuous path of the creek has been maintained for the most part. These upper reaches support closed to partially-closed riparian canopy. Between the Putah South Canal and Paytonia Slough, some reaches of Ledgewood Creek are sinuous and shaded by riparian vegetation, while others are channelized for flood control and lacking riparian canopy.

4.2.2 Fish Passage Barriers

Potential barriers to fish passage occur in six of the eight streams that were included in this assessment. Potential fish passage barriers were identified by reviewing existing literature, interviewing Solano County residents, and by direct field observation where possible. Potential fish passage barriers may include culverts, large headcuts or drops in streambed elevation greater than three vertical feet, debris dams, and agriculture/irrigation diversions. Twenty-one potential fish passage barriers identified by this assessment are summarized in Table E (Appendix B) and their approximate locations are depicted in Figures 2 and 3 (Appendix A).

Ulatis Creek. Five potential fish passage barriers were identified in Ulatis Creek or its tributaries (Figure 3, Appendix A). Salmonids entering this creek from the bay would first encounter a pair of water control structures that create 6-foot vertical drops in the concrete-lined portions of the flood control channel (see assessment locations UC11 and UC10). One of these structures is shown in Photo #1 in Appendix D. Approximately three miles further upstream, between assessment locations UC04 and UC03, a debris dam of wood and riprap creates a potential barrier to passage during seasons of low flow. The debris dam is shown in Photo #2 (Appendix D). Approximately five miles further upstream, in the Vaca Mountains (see assessment location UC13), a concrete box culvert under a road creates a 5-foot vertical drop in the channel. The culvert outlet is shown in Photo #3 (Appendix D). Approximately one quarter mile further upstream, at assessment location UC12, another culvert creates a 4-foot vertical drop in the channel.

Alamo Creek. Six potential fish passage barriers were identified in Alamo Creek or its tributaries. Four of these barriers occur in Old Alamo Creek (see Photo #4 in Appendix D), which is cut off from New Alamo Creek (a channelized flood control channel) by flapgates. Salmonids entering this creek from the bay would be directed upstream via New Alamo Creek. Approximately three miles upstream from the New Alamo Creek diversion (see assessment location AC03), a beaver dam creates a potential barrier to passage during low flow. Approximately three miles further upstream, in the Vaca Mountains (between assessment locations AC14 and AC13), fish passage to a tributary entering the mainstem of Alamo Creek is potentially blocked by a culvert that creates a 4-foot drop (see Photo #5).

Laurel Creek. Two potential fish passage barriers were identified in Laurel Creek: small double culverts underneath Nelson Road (assessment location LRLC02), and a culvert under Lyon Road (assessment location LRLC01) with a grade control structure or trash grate across the outlet. The creek also passes underneath I-80 between Lyon Road and Nelson Road.

American Canyon Creek. Three potential fish passage barriers were identified in American Canyon Creek or its tributaries (Figure 3, Appendix A). Salmonids are most likely prevented from entering this creek from the bay by a levee and flapgate at Cordelia Slough. Approximately five miles upstream, just below the confluence with a tributary from Lynch Canyon, a break in the channel's concrete lining creates a 5-foot drop. This potential barrier is shown in Photo #6 (Appendix D). Approximately one-half mile further upstream, an old asphalt road has eroded creating a 3-foot drop above the channel bottom.

Jameson Canyon Creek. Two potential fish passage barriers were identified in Jameson Canyon Creek or its tributaries. As with American Canyon Creek, salmonids are most likely prevented from entering this creek from the bay by a levee and flapgate at Cordelia Slough. Approximately three miles upstream a tributary entering Jameson Canyon Creek is most likely impassible where it is culverted underneath Highway 12 because the 24-inch culvert is clogged with sediment.

Green Valley Creek. Four potential fish passage barriers were identified in Green Valley Creek or its tributaries. Salmonids entering this creek from the bay would travel through Cordelia Slough, where there appears to be no flapgate or other barrier preventing passage upstream. Approximately one mile upstream from the Cordelia Slough/Green Valley Creek confluence, between Green Valley Road and I-80 (see assessment location GRNV07), a large beaver dam creates a potential barrier to passage during seasons of low flow. Another mile further upstream, at assessment location GRNV04, a potential high velocity barrier exists where the Putah South Canal discharges into Green Valley Creek at Reservoir Lane. In the upper reaches of Green Valley Creek, the Green Valley Falls below Lake Frey create an impassible, natural 50-foot drop.

Suisun Valley Creek. No potential barriers to fish passage were identified in Suisun Valley Creek.

Ledgewood Creek. No potential barriers to fish passage were identified in Ledgewood Creek. Fish passage structures (i.e., baffles) were installed where the creek is channelized and lined with concrete underneath I-80.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Overall, the greatest potential for enhancing salmonid habitat in Solano County exists in the southern streams. All five of the southern streams included in this assessment (American Canyon Creek, Jameson Canyon Creek, Green Valley Creek, and Suisun Valley Creek), plus Laurel Creek, have extensive lengths of potentially suitable habitat based on gradient and temperature thresholds included in our model. The northern streams (Ulatis Creek, Alamo Creek) generally appear to be too hot and inaccessible to merit much effort in restoration. Air temperature (and, thus, water temperature) of the northern streams is influenced by the hot summers of the Central Valley, whereas summer temperatures of the southern streams are moderated by the coastal fog that spreads north from the bay, typically no farther than Jameson Canyon or Green Valley.

In the absence of long-term field data, the gradient and temperature model provided a starting point for determining which streams have potentially suitable habitat for salmonid spawning and/or rearing. Temperature/stream gradient assessment at this broader scale cannot (or does not necessarily) account for localized temperature fluctuations. Other factors that can affect temperature on a reach or pool/riffle scale are the presence or condition of riparian vegetation, the amount of water (discharge and depth), and the length of time that a given stream holds water. This assessment did not include stream discharge (minimum requirement < 1 cfs), as the Lindley et al. (2006) study did. Other considerations besides temperature are the presence of adequate gravel substrate for redds, water quality, including sediment loads (type and amount of sediment), and the uses of the creek. Still other considerations relate to urbanization and flood control. For example, Laurel Creek and Ledgewood Creek, though they meet the temperature/gradient criteria, are maintained as flood control channels for at least a portion of their lengths. Therefore, they have limited riparian vegetation and habitat diversity (gravel/cobble, woody debris, etc.).

Based on a qualitative analysis of land use and other watershed characteristics, the ability of a stream to support salmonids is not necessarily related to watershed size, percent irrigated agriculture, or percent developed land. Three of the southern streams (American Canyon, Jameson Canyon, and Suisun Valley Creek) are different from the northern streams in that they have low percent development throughout their reaches. The lower reaches of the remaining southern creeks (Green Valley Creek, Ledgewood) as well as the northern streams Alamo Creek, Ulatis Creek, and Laurel Creek have a high percentage of development in their lower reaches. However, Green Valley Creek still has strong potential to support steelhead, partly because its upper reaches have a low percentage of development. The smaller watersheds of American Canyon, Jameson Canyon, and Laurel Creek could mean lower water quantity, fewer pools, and potentially flows below the threshold for salmonids. Some of the upper portions of Jameson Canyon and some of the upper and lower portions of American Canyon, where steelhead have been reported, were dry during field surveys in June 2008 (note: 2008 was the second consecutive year of substantially below normal rainfall for this region). However, long-term discharge studies are necessary to make determinations regarding adequate water supply for salmonids (e.g., the ability of a stream to provide pools throughout the summer).

The above conclusions summarize the potential of streams to provide steelhead spawning and rearing habitat. More information about water temperature, substrate, and flow would be necessary to make conclusions regarding the *actual* suitability of each stream as salmonid habitat. Studies of this nature are costly and labor intensive; therefore, the results of this assessment can be used to prioritize or direct future research and restoration efforts in Solano County.

5.1 RESTORATION PRIORITIES

Among the southern streams, the highest priority for salmonid habitat restoration efforts should be given to Green Valley Creek and Suisun Valley Creek. These two creeks are known to support salmonids and, compared to other creeks in Solano County, their watersheds are much less impacted by development. These two creeks also have established beneficial uses of coldwater habitat and spawning, and Suisun Valley Creek has an established beneficial use of fish migration. There are no major fish passage barriers known to occur in Suisun Valley Creek and the potential barriers identified in the mainstem of Green Valley Creek are potentially restorable. The next highest priority for restoration efforts could be given to Jameson Canyon and American Canyon Creeks. Ledgewood Creek appears to have sufficient summer flow for juvenile salmonid rearing and no known barriers to fish passage; however, the watershed of this creek is more developed than the other two streams. Much of Ledgewood Creek is channelized for flood control and/or degraded by adjacent land uses. The watersheds of Jameson Canyon Creek and American Canyon Creek are relatively undeveloped and support robust riparian vegetation, but uncertainty remains as to whether there is sufficient flow in summer for rearing of juvenile salmonids. Access to these two creeks by anadromous salmonids is another factor that needs to be addressed. We were not able to access the mouths of these two creeks to determine if fish passage is possible via Cordelia Slough. Aerial photo imagery indicates that fish passage is likely restricted by one-way flow flap gates and the potential for restoring passage is unknown.

5.2 RECOMMENDED ACTIONS

5.2.1 Fish Passage

Potential barriers to fish passage identified in the southern streams should be analyzed using established/approved methods to determine the degree to which passage is actually restricted and the feasibility of restoring passage. If possible, more extensive field surveys or polling of property owners should be conducted to identify other potential passage barriers that may have been overlooked by this assessment. Wherever feasible, barriers should be removed or altered to restore fish passage. Further research and/or restoration should focus on those streams that are, or could be made, passable to salmonids. For some of the creeks, this will require research on streamflow. If flow in a creek is not sufficient to sustain a population of steelhead, efforts to remove fish passage barriers may not be appropriate. In other locations, especially urban areas, culverts may not be removable but could be made more amenable to fish passage (e.g., by installing baffles or fish ladders).

5.2.2 Research and Restoration

Within each passable stream, additional field surveys and data collection should be conducted to identify and prioritize sites where spawning and rearing habitat can be expanded, enhanced or restored.

Research actions may include the following:

- Installing water and air temperature data loggers to obtain annual or seasonal temperature data, capture diurnal variation in temperature, and obtain temperature data on a reach scale. These data may help determine if shade cast by riparian vegetation keeps water temperatures sufficiently low for salmonids.
- Conducting substrate/pool-riffle mapping (full habitat assessment).
- Conducting basic water quality studies that would begin with analyzing pH, dissolved oxygen, and conductivity. Depending on the results of these initial analyses, other potential water quality studies may include sediment (total suspended solids), pesticides, and/or heavy metals, depending on adjacent land uses and suspected pollutants.
- Utilizing an established procedure for analyzing fish passage barriers, such as the USDA-Forest Service Inventory and Assessment Procedure for Fish Passage Barriers (USDA 2005).
- Obtaining streamflow and water level data, including an assessment of water withdrawal locations and amounts of water withdrawn seasonally. Flow measurements and stream gauging (installing permanent staff plates and water level monitors at a stable location in the channel) would be useful.

Restoration actions may include the following:

- Planting riparian vegetation to provide afternoon shade over the channel.
- Adding woody debris to the channel to provide shelter.
- Excavating deeper pools where fish can retreat from predators or high surface water temperature.
- Addressing sources of sediment (e.g., stabilize a landslide).
- Addressing water withdrawal issues.

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APPENDIX A

FIGURES

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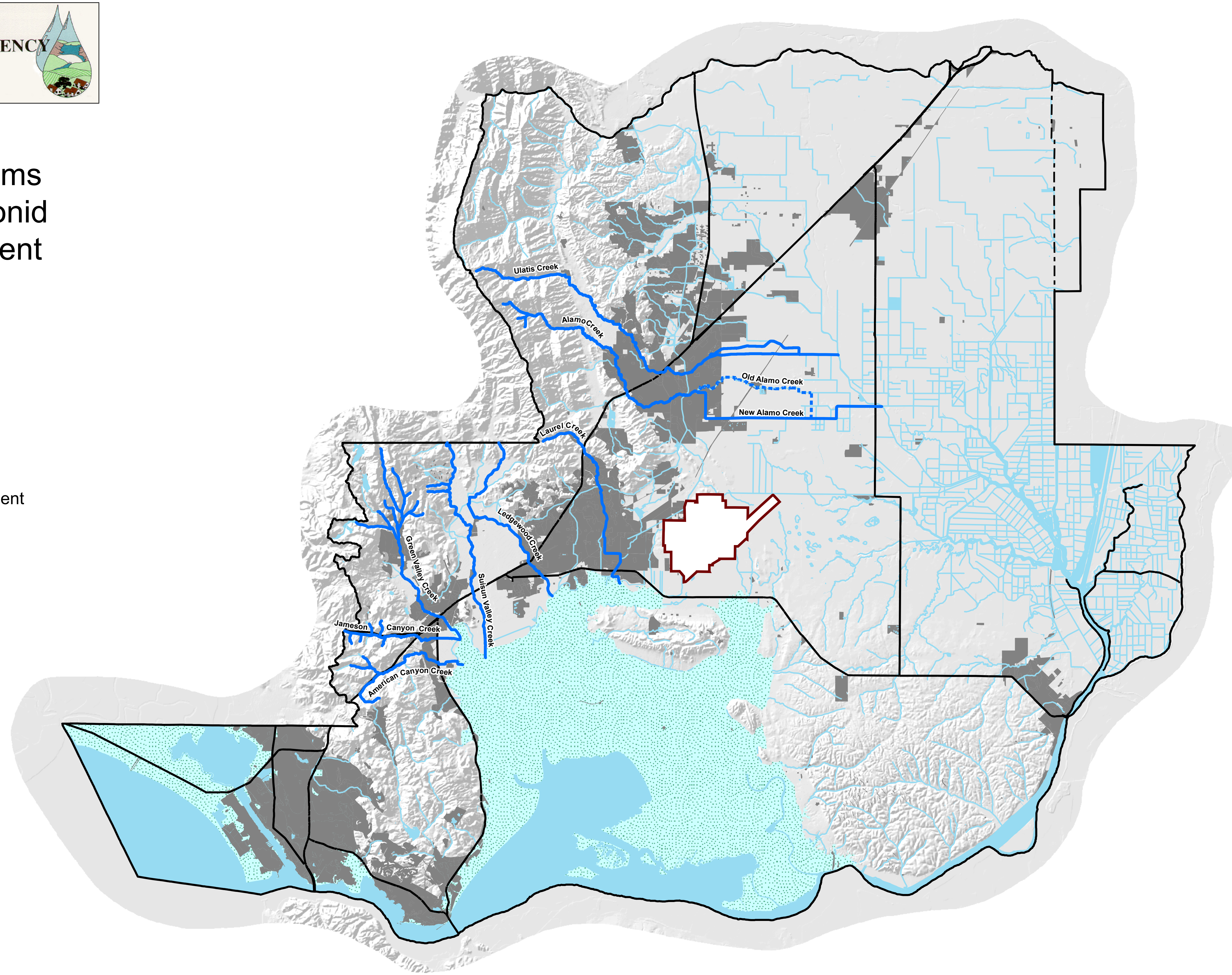
Solano County Water Agency

Figure 1
Location of Streams Included in Salmonid Habitat Assessment

- Major Roads
- Waterways
- Marsh
- Travis Air Force Base
- Developed
- Open Water Habitats
- Streams Included in Salmonid Habitat Assessment



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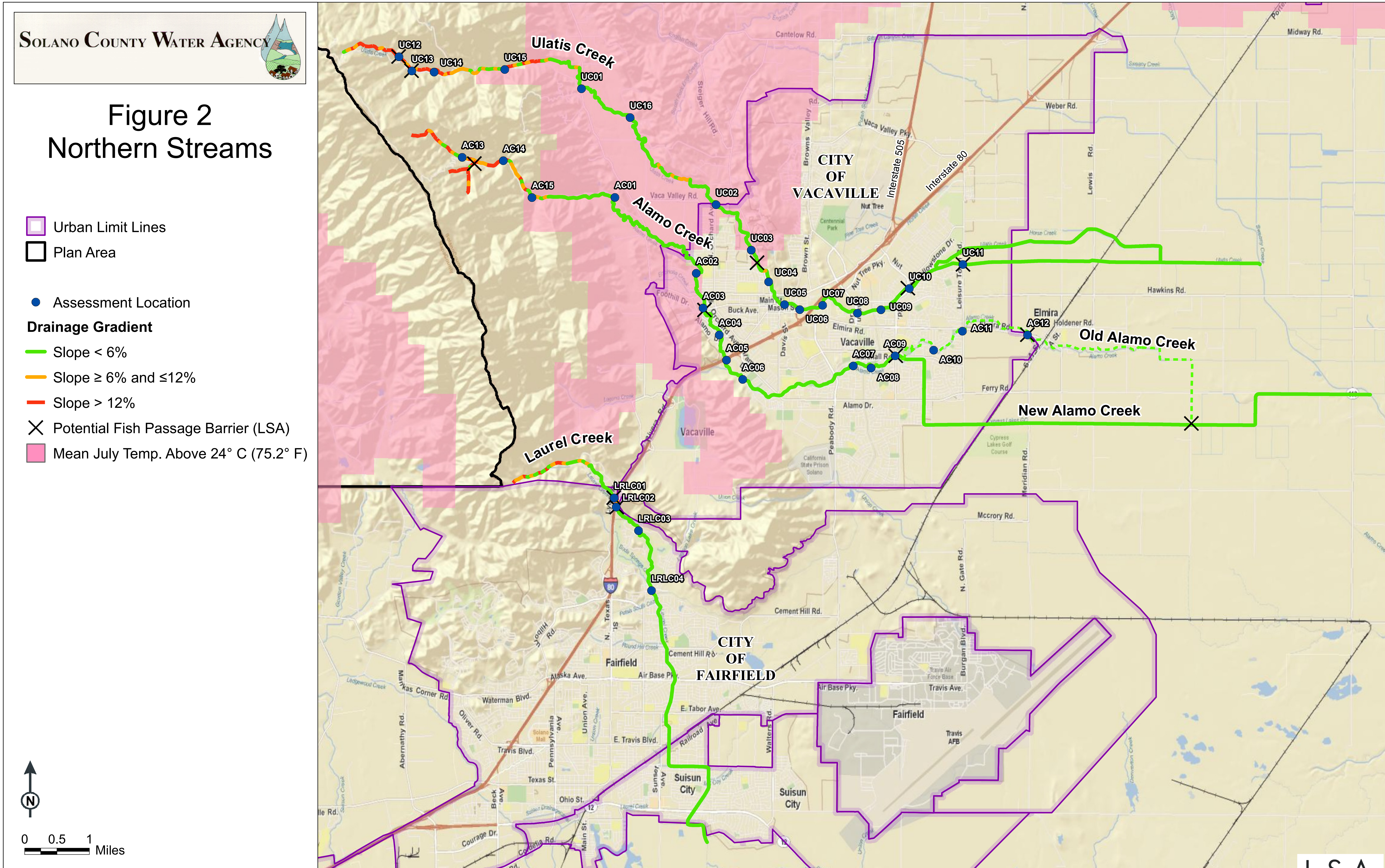

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SOLANO COUNTY WATER AGENCY

Figure 3
Southern Streams

Urban Limit Lines

Plan Area

Assessment Location

Drainage Gradient

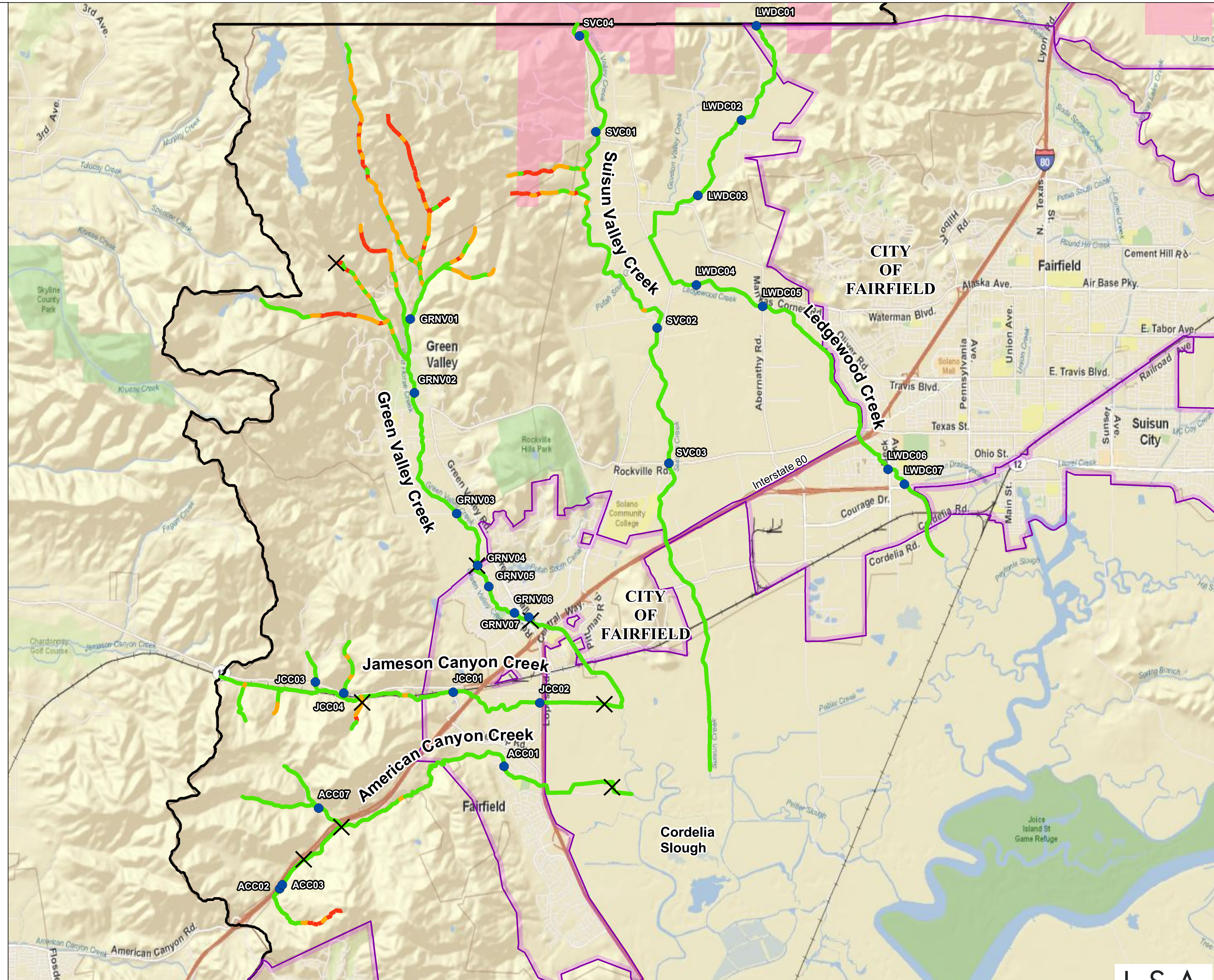
Slope < 6%

Slope ≥ 6% and ≤12%

Slope > 12%

Potential Fish Passage Barrier (LSA)

Mean July Temp. Above 24° C (75.2° F)



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APPENDIX B

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Table B. Chinook Salmon Stream Temperature Requirements
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Table A. Steelhead Trout Stream Temperature Requirements

Habitat Use	Stream Temperature (°F)[1]
Migration	46-52
Spawning	39-52
Incubation/emergence	48-52
Rearing	45-60
Smoltification	< 57

[1] Bovee 1978, Reiser and Bjornn 1979, Bell 1986
[2] Depending on size of fish.
[3] Barnhart 1986
[4] Bovee 1978

Table B. Chinook Salmon Stream Temperature Requirements

Habitat Use	Stream Temperature (°F)
Migration	60.8[2]
Spawning	50-59[3]
Incubation/emergence	41-55.4
Rearing	55.4-64.4[4]
Smoltification	Fall Run: 59-79.2 (June- August)[5]

[1] Behnke 2002
[2] Torgersen et al. 1999
[3] Moyle 2002
[4] Leidy 2007
[5] Sauter et al. 2001

Table C. Drainage Area and Land Use[1]

Watershed	Approximate Drainage Area (square miles)[2]	Percent Irrigated Agriculture	Percent Developed
Alamo Creek (Upper)	9.39	0-8%	0-8%
Alamo Creek (Lower)	8.97	28-56%	25-50%
American Canyon Creek	6.82	0-8%	0-8%
Green Valley Creek (Upper)	11.47	0-8%	0-8%
Green Valley Creek (Lower)	10.65	9-27%	25-50%
Jameson Canyon Creek	3.90	0-8%	0-8%
Laurel Creek (Upper)	2.38	0-8%	0-8%
Laurel Creek (Lower)	5.66	0-8%	51-80%
Ledgewood Creek (Upper)	16.26	28-56%	0-8%
Ledgewood Creek (Lower)	1.39	9-27%	51-80%
Suisun Valley Creek	48.85	28-56%	0-8%
Ulatis Creek (Upper)	10.61	9-27%	0-8%
Ulatis Creek (Lower)	16.32	28-56%	25-50%

[1] Source = Figures 4-11 and 4-12 in the Solano HCP (LSA 2007)
[2] One square mile = 640 acres

Table D. Beneficial Uses[1,2]

WATERBODY	AGR	MUN	FRSH	IND	PROC	COLD	MIGR	SPWN	WARM	WILD	REC-1	REC-2
Alamo Creek (Old)[3] (from Sacramento-San Joaquin Delta info)	E	-		E	E	-	-	-		E	E	E
American Canyon Creek (from Suisun Slough info)								E	E	E	E	E
Green Valley Creek			E			E		E	E	E	E	E
Jameson Canyon Creek (from Suisun Slough info)								E	E	E	E	E
Laurel Creek			E			E	E	E	E	E	E	E
Ledgewood Creek			E			E	E	E	E	E	E	E
Suisun Valley Creek			E			E	E	E	E	E	P	P
Ulatis Creek (from Sacramento-San Joaquin Delta info)	E	E		E	E		E	E		E	E	E

E: Existing beneficial use

[1] From the San Francisco Bay Regional Water Quality Control Board Water Quality Control Plan (Basin Plan) (SFRWQCB2007) and the Central Valley Regional Water Quality Control Board Water Quality Control Plan (Basin Plan) (CVRWQCB 2007).
[2] The beneficial uses of any specifically identified water body generally apply to its tributary streams (San Francisco Bay RWQCB Basin Plan, 2007).
[3] On April 28, 2005, the Central Valley Water Board adopted Resolution No. R5-2005-0053, that amended the basin plan to remove (i.e., "dedesignate") MUN, COLD, MIGR and SPWN as beneficial uses for Old Alamo Creek.

Table E: Potential Fish Passage Barrier (PFPB) Locations[1] and Descriptions

Drainage	PFPB No.	Site ID[2]	Location	Description of Barrier	Potential for Removal or Alteration of Barrier to Allow for Passage
Alamo Creek	1	None	Old Alamo Creek at junction with flood control channel (aka New Alamo Creek)	Flapgates	Unknown.
	2	None	Long reach of Old Alamo Creek between Eleanor Nelson Park and South A St. (not labeled on Figure 3)	Channel is dewatered because all streamflow is diverted into New Alamo Creek flood control channel; Old Alamo Creek carries water again below this point due to discharges from EWWTP, groundwater remediation projects, and SID return water[3]	Passage potentially restorable if compatible with flood control.
	3	AC12	Bridge on Elmira Rd. near Meridian Rd. - downstream	Irrigation diversion	Potential for fish passage structures to be added is unknown.
	4	Between AC09 and AC11	Reach of Old Alamo Creek between Nut Tree Rd. and Leisure Town Rd.	36-inch CMP culvert with 2 to 3-foot drop (depending on water level)	Passage potentially restorable.
	5	AC03	Alamo Creek Park in Vacaville, corner of Buck Ave. and Alamo Dr.	Beaver dam (seasonal barrier)	Passage potentially restorable.
	6	Between AC13 and AC14	Uppermost tributary entering Alamo Creek from south of Gates Canyon Rd, approximately 1 mile east of Solano/Napa County lines	4-foot culvert under road with 4-foot drop to channel bottom; potential barrier to tributary, not mainstem of Alamo Creek	Passage potentially restorable.
American Canyon Creek	1	None	East of I-680, southeast of Cordelia	Levee/flapgate at Cordelia Slough[4]	Unknown.
	2	None	Southeast of McGary Rd. and Lynch Rd. junction, downstream of Lynch Canyon tributary	5-foot drop from broken concrete-lined channel to streambed below	Passage potentially restorable.
	3	None	Southeast side of McGary Rd/I-80.	An old asphalt road has eroded creating a 3-foot drop to channel bottom.	Passage potentially restorable.
Green Valley Creek	1	Near GRNV07	Just downstream of Green Valley Road (above I-80)	Large beaver dam[3] (seasonal barrier)	Passage potentially restorable.
	2	GRNV04	South Putah Canal discharge point at Reservoir Lane bridge	Potential high velocity barrier at discharge into Green Valley Creek	Unknown.

Drainage	PFPB No.	Site ID[2]	Location	Description of Barrier	Potential for Removal or Alteration of Barrier to Allow for Passage
Green Valley Creek	3	None	Green Valley Falls below Lake Frey	Approximately 50-foot drop[4]	No potential for passage.
Jameson Canyon Creek	1	None	East of I-680, Southeast of Cordelia	Flapgate at confluence with Green Valley Creek/Cordelia Slough[4] (same feature as Green Valley Creek PFPB#1)	Unknown.
	2	JCC04	Downstream-most tributary entering mainstem from north side of Hwy 12	24-inch culvert under Hwy 12 is half buried in sediment	Passage potentially restorable.
Laurel Creek	1	LRLC02	Nelson Rd.	Culvert	Passage potentially restorable.
	2	LRLC01	Lyon Rd.	Culverts	Passage potentially restorable.
Ulatis Creek	1	UC11	New Ulatis Creek Bridge 23C0137	Water control structure with 6-foot drop	Potential for fish passage structures to be added is unknown.
	2	UC10	Nut Tree Rd. bridge	Water control structure with 6-foot drop	Potential for fish passage structures to be added is unknown.
	3	Between UC03 and UC04	Reach of Ulatis Creek between Fruitvale Rd. and 97 Dobbins Rd.	Wood and riprap debris dam; approximately 1 foot tall; probably not a barrier in high flows; could either be washed out or could divert water depending on flow	Passage potentially restorable.
	4	UC13	Vaca mountains, approximately 1.5 mile east of Solano/Napa County lines; across from 2778 Mix Canyon Rd, below culvert	Sloped concrete slab with 25- to 30° angle; 8-foot wide concrete box culvert with approximately 5-foot drop	Passage potentially restorable.
	5	UC12	Vaca mountains, approximately 1 mile east of Solano/Napa County lines and approximately 200 feet upstream from 2751 Mix Canyon Rd.	6-foot culvert with 4-foot drop to channel bottom	Passage potentially restorable.

[1] Listed downstream to upstream, where applicable.
[2] Refer to Assessment Locations in Figures 2 and 3 and Datasheet Locations in the Riparian Habitat Assessment (LSA 2008).
[3] Tetra Tech, Inc. (2004).
[4] Steve Foreman, personal observation.

APPENDIX C

DEFINITIONS OF STREAM BENEFICIAL USES

DEFINITIONS OF BENEFICIAL USES

The following definitions are taken from the San Francisco Bay and Central Valley Regional Water Control Boards Basin Plans (SFRWQCB 2007 and CVRWQCB 2007).

AGRICULTURAL SUPPLY (AGR)
Uses of water for farming, horticulture, or ranching, including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing. The criteria discussed under municipal and domestic water supply (MUN) also effectively protect farmstead uses. To establish water quality criteria for livestock water supply, the Regional Board must consider the relationship of water to the total diet, including water freely drunk, moisture content of feed, and interactions between irrigation water quality and feed quality. The University of California Cooperative Extension has developed threshold and limiting concentrations for livestock and irrigation water. Continued irrigation often leads to one or more of four types of hazards related to water quality and the nature of soils and crops. These hazards are (1) soluble salt accumulations, (2) chemical changes in the soil, (3) toxicity to crops, and (4) potential disease transmission to humans through reclaimed water use. Irrigation water classification systems, arable soil classification systems, and public health criteria related to reuse of wastewater have been developed with consideration given to these hazards.

COLD FRESHWATER HABITAT (COLD)
Uses of water that support cold water ecosystems, including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. Cold freshwater habitats generally support trout and may support the anadromous salmon and steelhead fisheries as well. Cold water habitats are commonly well-oxygenated. Life within these waters is relatively intolerant to environmental stresses. Often, soft waters feed cold water habitats. These waters render fish more susceptible to toxic metals, such as copper, because of their lower buffering capacity.

FRESHWATER REPLENISHMENT (FRSH)
Uses of water for natural or artificial maintenance of surface water quantity or quality.

INDUSTRIAL SERVICE SUPPLY (IND)
Uses of water for industrial activities that do not depend primarily on water quality, including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization. Most industrial service supplies have essentially no water quality limitations except for gross constraints, such as freedom from unusual debris.

FISH MIGRATION (MIGR)
Uses of water that support habitats necessary for migration, acclimatization between fresh water and salt water, and protection of aquatic organisms that are temporary inhabitants of waters within the region. The water quality provisions acceptable to cold water fish generally protect anadromous fish as well. However, particular attention must be paid to maintaining zones of passage. Any barrier to

migration or free movement of migratory fish is harmful. Natural tidal movement in estuaries and unimpeded river flows are necessary to sustain migratory fish and their offspring. A water quality barrier, whether thermal, physical, or chemical, can destroy the integrity of the migration route and lead to the rapid decline of dependent fisheries. Water quality may vary through a zone of passage as a result of natural or human- induced activities. Fresh water entering estuaries may float on the surface of the denser salt water or hug one shore as a result of density differences related to water temperature, salinity, or suspended matter.

MUNICIPAL AND DOMESTIC SUPPLY (MUN)
Uses of water for community, military, or individual water supply systems, including, but not limited to, drinking water supply. The principal issues involving municipal water supply quality are (1) protection of public health; (2) aesthetic acceptability of the water; and (3) the economic impacts associated with treatment or quality-related damages. The health aspects broadly relate to: direct disease transmission, such as the possibility of contracting typhoid fever or cholera from contaminated water; toxic effects, such as links between nitrate and methemoglobinemia (blue babies); and increased susceptibility to disease, such as links between halogenated organic compounds and cancer. Aesthetic acceptance varies widely depending on the nature of the supply source to which people have become accustomed. However, the parameters of general concern are excessive hardness, unpleasant odor or taste, turbidity, and color. In each case, treatment can improve acceptability although its cost may not be economically justified when alternative water supply sources of suitable quality are available. Published water quality objectives give limits for known health-related constituents and most properties affecting public acceptance. These objectives for drinking water include the U.S.Environmental Protection Agency Drinking Water Standards and the California State Department of Health Services criteria.

INDUSTRIAL PROCESS SUPPLY (PRO)
Uses of water for industrial activities that depend primarily on water quality. Water quality requirements differ widely for the many industrial processes in use today. So many specific industrial processes exist with differing water quality requirements that no meaningful criteria can be established generally for quality of raw water supplies. Fortunately, this is not a serious shortcoming, since current water treatment technology can create desired product waters tailored for specific uses.

WATER CONTACT RECREATION (REC1)
Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, whitewater activities, fishing, and uses of natural hot springs. Water contact implies a risk of waterborne disease transmission and involves human health; accordingly, criteria required to protect this use are more stringent than those for more casual water-oriented recreation. Excessive algal growth has reduced the value of shoreline recreation areas in some cases, particularly for swimming. Where algal growths exist in nuisance proportions, particularly bluegreen algae, all recreational water uses, including fishing, tend to suffer. One criterion to protect the aesthetic quality of waters used for recreation from excessive algal growth is based on chlorophyll a.

NONCONTACT WATER RECREATION (REC2)

Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where water ingestion is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities. Water quality considerations relevant to noncontact water recreation, such as hiking, camping, or boating, and those activities related to tide pool or other nature studies require protection of habitats and aesthetic features. In some cases, preservation of a natural wilderness condition is justified, particularly when nature study is a major dedicated use. One criterion to protect the aesthetic quality of waters used for recreation from excessive algal growth is based on chlorophyll a.

FISH SPAWNING (SPWN)

Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish. Dissolved oxygen levels in spawning areas should ideally approach saturation levels. Free movement of water is essential to maintain well-oxygenated conditions around eggs deposited in sediments. Water temperature, size distribution and organic content of sediments, water depth, and current velocity are also important determinants of spawning area adequacy.

WARM FRESHWATER HABITAT (WARM)

Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. The warm freshwater habitats supporting bass, bluegill, perch, and other panfish are generally lakes and reservoirs, although some minor streams will serve this purpose where streamflow is sufficient to sustain the fishery. The habitat is also important to a variety of nonfish species, such as frogs, crayfish, and insects, which provide food for fish and small mammals. This habitat is less sensitive to environmental changes, but more diverse than the cold freshwater habitat, and natural fluctuations in temperature, dissolved oxygen, pH, and turbidity are usually greater.

WILDLIFE HABITAT (WILD)

Uses of waters that support wildlife habitats, including, but not limited to, the preservation and enhancement of vegetation and prey species used by wildlife, such as waterfowl. The two most important types of wildlife habitat are riparian and wetland habitats. These habitats can be threatened by development, erosion, and sedimentation, as well as by poor water quality. The water quality requirements of wildlife pertain to the water directly ingested, the aquatic habitat itself, and the effect of water quality on the production of food materials. Waterfowl habitat is particularly sensitive to changes in water quality. Dissolved oxygen, pH, alkalinity, salinity, turbidity, settleable matter, oil, toxicants, and specific disease organisms are water quality characteristics particularly important to waterfowl habitat. Dissolved oxygen is needed in waterfowl habitats to suppress development of botulism organisms; botulism has killed millions of waterfowl. It is particularly important to maintain adequate circulation and aerobic conditions in shallow fringe areas of ponds or reservoirs where botulism has caused problems.

APPENDIX D

PHOTOGRAPHS OF POTENTIAL FISH PASSAGE BARRIERS


Photo 1: Ulatis Creek (UC010) (05-18-08)


Photo 2: Ulatis Creek (UC03) (05-14-07)

LSA

Solano County HCP Salmonid Assessment

Potential Fish Passage Barriers

Photos 1 and 2

Photo 3: Ulatis Creek (UC13) (06-20-08)

Photo 4: Alamo Creek (AC12) Irrigation Diversion (05-18-07)

LSA

Solano County HCP Salmonid Assessment

Potential Fish Passage Barriers

Photos 3 and 4

Photo 5: Alamo Creek (between AC13 and AC14) (6-20-08)

Photo 6: American Canyon below Lynch Canyon (06-20-08)

LSA

Solano County HCP Salmonid Assessment

Potential Fish Passage Barriers

Photos 5 and 6