GALLINAS CREEK RESTORATION FEASIBILITY STUDY AND CONCEPTUAL DESIGN REPORT MARIN COUNTY, CALIFORNIA

Prepared For:
San Pablo Bay Watershed Restoration Program Partners:
U.S. Army Corps of Engineers, San Francisco District
California Coastal Conservancy

In cooperation with:
The Friends of Gallinas Creek
The Bay Institute
Marin County Stormwater Pollution Prevention Program

Prepared by:
Kamman Hydrology & Engineering, Inc.
101 Lucas Valley Road, Suite 120
San Rafael, CA 94903
(415) 491-9600
info@KHE-INC.com

Contributing Authors:
Sharon Farrell – Restoration Ecologist
Lisa Hug – Wildlife Biologist
Camp Dresser & McKee, Inc.

December 2004

Services provided pursuant to this Agreement are intended for the sole use and benefit of: the San Pablo Bay Watershed Restoration Program Partners(U.S. Army Corps of Engineers, San Francisco District, and California Coastal Conservancy);CDM Federal Programs; The Bay Institute; Marin County Stormwater Pollution Prevention Program; and Friends of Gallinas Creek. No other person or entity shall be entitled to rely on the services, opinions, recommendations, plans or specifications provided pursuant to this agreement without express written consent of Kamman Hydrology & Engineering, Inc. *101 Lucas Valley Road, Suite 120, San Rafael, CA 94903*

This report should be referenced as:

Kamman Hydrology & Engineering, Inc. (eds.), 2004. Gallinas Creek Restoration Feasibility Study and Conceptual Design Report, Marin County, California. Prepared for San Pablo Bay Watershed Restoration Program Partners (U.S. Army Corps of Engineers, San Francisco District and California Coastal Conservancy), in cooperation with The Friends of Gallinas Creek, The Bay Institute, and Marin County Stormwater Pollution Prevention Program, December, 47p.

ACKNOWLEDGEMENTS

This study was completed under the direction of The Friends of Gallinas Creek. Funding for this study and document was provided by the San Pablo Bay Watershed Restoration Program Partners (U.S. Army Corps of Engineers, San Francisco District and California Coastal Conservancy), administered through CDM Federal under subcontract agreement number 6135-004-001-F1 with Kamman Hydrology & Engineering, Inc. This report was prepared and edited by Kamman Hydrology & Engineering, Inc., with the following contributions:

- Section 2.3: Property Ownership, prepared by Camp Dresser & McKee, Inc.;
- Section 3.5: Vegetation, prepared by Sharon Farrell – Restoration Ecologist; and
- Section 3.6: Wildlife, prepared by Lisa Hug – Wildlife Biologist.

Sharon Farrell and Lisa Hug also contributed to the preparation of Chapter 5.0: Conceptual Alternatives and Feasibility.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION AND PROJECT GOALS

The Friends of Gallinas Creek, a local public interest group in northern San Rafael, California, is investigating the feasibility of stream restoration along the 5.6-mile Gallinas Creek corridor (see Figure 1) with the support of the San Pablo Bay Watershed Restoration Program Partners (U.S. Army Corps of Engineers, San Francisco District, and the California Coastal Conservancy), the Bay Institute and the Marin County Stormwater Pollution Prevention Program (MCSTPPP). The group's overall goals are to improve the creeks ecological function and value, and to integrate stream and riparian corridor restoration consistent with the City of San Rafael's ongoing planning and community improvement efforts. In addition, San Rafael's City Engineer agreed that the water quality benefits associated with creek restoration would be valuable to the City in helping them to meet anticipated water quality limits for urban discharges to San Pablo Bay. Specific natural resource goals and actions stipulated in the City's North San Rafael (2010) Vision Statement include:

- Protect, restore and enhance surrounding hillsides, bay front wetlands and creeks.
- Increase wetland habitats.
- Wherever feasible, restore and enhance the natural wildlife habitat, particularly habitat for endangered species, by providing wildlife corridors, adequate buffers along wetlands and creeks and other environmental protections.
- Whenever feasible, seek out opportunities to protect, restore and increase wetlands habitat.
- Restore creeks and incorporate sound flood control practices and riparian vegetation, such as at the large meadow site next to the transit line, the San Rafael Meadows neighborhood and the Valley Baptist Church (the PG&E site).
- Provide opportunities for people to enjoy the natural environment.
- Work Collaboratively with Marin County and environmental organizations to provide access and interpretive center(s) to facilitate the public's enjoyment of wetland areas, where appropriate.
- Protect hillsides from erosion with emphasis on large eroded ravines off fire roads.
- Remove invasive plants from open space and other public and private lands.

This restoration feasibility study focuses on the reach west of Highway 101 (Freitas Parkway and Del Ganado Road; see Figure 2). This segment of the corridor was prioritized because the City of San Rafael is currently developing conceptual plans for infrastructural improvements along this reach as part of a "North San Rafael Vision Promenade Conceptual Plan." The concepts brought forth by the City to date do not incorporate any creek enhancement efforts. Such efforts were considered outside of the City of San Rafael's scope. This study is intended to provide the preliminary information necessary to characterize the creek corridor, and evaluate the feasibility of a range of restoration alternatives to be considered and incorporated in the City's ongoing planning efforts.

In this report, Kamman Hydrology & Engineering, Inc. (KHE), with assistance from Sharon Farrell - Consulting Restoration Ecologist, Lisa Hug - Wildlife Biologist, and Camp, Dresser, & McKee, Inc. (CDM), has gathered and summarized background information about the watershed, the stream corridor and local hydrology. The feasibility of stream restoration is evaluated from the standpoint of channel hydraulics and biological value. The preliminary hydraulic assessment characterizes existing conditions, and defines the change in cross-sectional flow area required to accommodate a less hydraulically efficient (subcritical flow regime), but more ecologically friendly channel design. We evaluate baseline restoration feasibility by comparing the size of channel required to pass flood flows under a "restored" condition within the space available along the study reach. The underlying assumption to this study is that restoration is feasible if it does not pose an increase flood risk when compared to the existing condition. In summary, the main objectives of this study include conducting the necessary scientific and engineering studies needed to evaluate:

a) Existing habitat values, potential habitat values and restoration opportunities and constraints;

b) The feasibility for creek restoration alternatives that represent varying degrees of habitat value and community investment.

2.0 STUDY AREA DESCRIPTION

2.1 Physiographic Setting

Las Gallinas Creek, located in the City of San Rafael, is a highly impacted watercourse originating in county-owned open space hills above the community of Terra Linda (see Figure 1). Upstream (west) of Highway 101, the stream runs through rectangular and trapezoidal concrete channels down the centerline of Freitas Parkway. Downstream of the Highway 101 crossing, the tidally influenced portion of the creek discharges to San Pablo Bay via a dredged channel surrounded by leveed marsh. The existing channel conditions, typical of 1950's flood control engineering, significantly reduced the ecological value of the creek.

The Gallinas Creek watershed is conveniently broken into an upper- and lower-watershed – the upper watershed is located west of Highway 101 while the lower watershed is located east of the Highway (see Figure 2). Highway 101 also marks the approximate upstream extent of tidal marsh although the influence of high tides in the main stem extend upstream of the Highway to approximately Freitas Parkway. The upper Gallinas Creek watershed is contained in Santa Margarita Valley (SMV), which widens to the east. The headwaters of the valley consist of two spur ridges emanating from Loma Alta. Loma Alta, rising to over 1500-feet in elevation, lies approximately two miles west-northwest of SMV and is the prominent western peak visible to residents of Terra Linda. The southwest margins of the watershed consist of the ridge that separates Sleepy Hollow and SMV while the northern upper watershed boundary is defined by the ridge (referred to locally and historically as “Springs Hill”) that rises between Lucas Valley and SMV (Figure 2). The Sleepy Hollow-SMV ridge (also referred to as the Terra Linda-Sleepy Hollow Divide) actually extends to the southeast in transitioning to the more commonly referred to “San Rafael Hill.” This ridge continues due east from Highway 101 as “San Pedro Ridge.” The highest elevations in the watershed exceed 650-feet at several locations along the Sleepy Hollow-SMV ridge.

Ridge flanks are steep-sloped with gentler slopes extending across and down the valley bottom of the upper watershed. Apart from locally isolated bedrock knobs, the lower watershed is essentially flat lying. The boundary between the upper and lower watersheds roughly coincides with a ground surface elevation of 10-feet above mean sea level. This boundary also marks the approximate extent of tidal influence in the lower creek-slough channel system. The lower watershed is bounded on the south by San Pedro Ridge and to the north by the Gallinas Hills that run parallel and north of Smith Ranch Road between Highway 101 and the Gallinas Valley Sanitary District wastewater treatment facility (see Figure 2).

The main Gallinas Creek channel in the upper watershed follows the alignment of Del Ganado Road down to the intersection with Freitas Parkway, and then along Freitas Parkway to Highway 101. There is an additional 800 feet of open concrete lined channel along Freitas Parkway upstream (west) of the confluence with the Del Ganado Road. The main channel consists of a concrete trapezoid flood control channel. Smaller tributary channels, now contained in underground storm drains that drain the surrounding ridges, are directed into the main stem Gallinas Creek floodway at regular intervals along its course from Del Ganado Road to Highway 101. The width and cross-sectional area of the trapezoidal channel increases intermittently in a down stream direction to accommodate increased runoff contributions from the watershed. Between Las Gallinas Road and North Gate Drive, the open channel is rectangular in cross-section and transitions back into a wide trapezoid channel downstream of North Gate Drive. Leaving Freitas Parkway, the channel makes a sharp turn to the north for approximately 1500-feet where it is directed under Highway 101 in a series of box culverts. Between Highway 101 and San Pablo Bay, the main-stem Gallinas Creek occupies a tidally influenced earthen and leveed channel.

Its important to note that the Southern Gallinas Creek Slough channel and contributing drainage area, (i.e., the area including the Civic Center and urbanized area east of Highway 101 including the Las Ranchitos subdivision) were not included as part of this study area for reasons described in Section 4.2 of this report.

2.2 Historic Changes in Land-Use

In order to better understand the historic landscape, and the timing and sequence of development in the Gallinas Creek watershed, a review of historic maps (USGS topographic maps, U.S. Coast and Geodetic Survey maps, and other archival maps), aerial photographs, and articles was undertaken. Interviews with long-time local residents were also conducted. Research was initiated at the Marin Civic Center California History Archives (the Archives). Aerial photographs were researched at, and selected images (1950, 1963, 1970, 1990, 2000) purchased from, Pacific Aerial Surveys in Oakland, California. Together, these sources show the changes in landscape and progression of development over the last century in the Gallinas Creek watershed. A chronological description of these changes follows.

The oldest map obtained and reviewed for this study included what appears to be a crude 1871 parcel map (Map #465 from the Archives) that only included coverage of the lower watershed (east of what is now Highway 101). This map indicates that the Gallinas Creek tidal marsh was virtually undisturbed. A proposed “San Francisco and North Pacific Railroad” alignment appeared on the map along what is roughly the current Highway 101 corridor. The main Gallinas Creek tidal slough channels are labeled “North Fork” and “South Fork”.

An 1873 map (A.L. Bancroft & Co. Lit.) of Marin County (this is about the time that San Rafael became incorporated) was found showing the entire Santa Margarita Valley and the Gallinas Creek Slough. The only resident in the SMV was the “Lucas Home Ranch” (2340 acres). The main County Road was located in essentially the same alignment as today’s Highway 101. The “Patent Brick Company”[1] was located at the east end of the Gallinas Hills (near what is today McGinnis Park) with other scattered structures in the upland areas of these same hills. The tidal marsh in the lower watershed displayed an elaborate and extensive network of dendritic slough channels through what was likely upper salt marsh plain. The County Road bordered the tidal marsh on the west. The North Pacific Rail Road alignment/berm is present through the Gallinas Slough tidal marsh and appears to be the only human encroachment into the marsh. The 1898 U.S. Coast and Geodetic Survey Nautical Chart of San Pablo Bay only display the far eastern edge of the shoreline and marsh – conditions were consistent with those displayed on the 1873 County map.

[1] The 1871 map labels this facility as the Blamonhery and Ohms Brickyard.

Few changes to the 1873 land use and physiographic setting are observed in the USGS 15-minute quadrangle map of 1914. Dashed blue lines delineate the alignment of the main stem and large tributary channels of Gallinas Creek in the upper watershed. This suggests that flow in Gallinas Creek through the upper watershed was intermittent (seasonal) at the time this map was created. This map, along with a Rand McNally & Company map, published circa. 1926, shows the historic alignment of Gallinas Creek following what is modern-day Freitas Parkway up to Del Ganado Road, then up to the end Del Ganado Road (basically, the same principal drainage alignment that is found today; see Figure 2). Four main tributary reaches are also indicated: two coming off the Sleepy Hollow-SMV ridge; a third directing runoff from the southern portion of the upper watershed through a channel aligned along what is today Nova Albion Way south of Las Gallinas Avenue; and the forth tributary flowing southward along what is now the Las Gallinas Avenue valley north of Freitas Parkway.

The 1914 map indicates that "Freitas Ranch" occupies the location of what was labeled the "Lucas Home Ranch" on the 1873 map. Manuel Freitas purchased approximately 1200 acres of the ranch from John Lucas in 1896 (Starkweather, 1972). Although not certain, it appears the remaining approximately 1140 acres, including the upper SMV watershed west of what is now Los Ojevas Avenue and extending into Lucas Valley[2], was sold to the Beherns family around this same time (Starkweather, 1974). The Beherns estate, in turn, sold this parcel to Thomas Nunes in the 1940's[3]. According to Walter Freitas (Starkweather, 1972), the Freitas ranch was very productive for cattle grazing because it was natural grassland. The Freitas family operated the property as a dairy ranch. In addition, Freitas also planted several fields of oat hay in SMV along what is now Del Ganado Road.

The homestead structures of the former Freitas ranch are located at what in now St. Isabella's Church and School (this 10-acre parcel was donated to the Catholic Church by the Freitas family; Starkweather, 1972). There was a long driveway up to the ranch from the former County road/Highway. The drive was lined with eucalyptus trees. To the north of the eucalyptus-lined drive, there were marshy areas, some buckeye trees, and a "lake" at what is now Northgate I (the lake was not identified on the 1950 aerial photograph). The character of this area changed dramatically with the advent of the Terra Linda housing development in the mid-1950's (Starkweather, 1972).

Walter Freitas also indicated that Gallinas Creek dried up in the summer. When it contained water during the winter rainy season, large steelhead swam up it from the Bay at least as far as the main ranch buildings located at what is now St. Isabella's church (Starkweather, 1972). Starkweather also reports that Walter Freitas indicated there was not much vegetation along the creek bank except "wire grass"; there were no blackberries along the bank except further west in the valley.

Numerous maps from the 1940's indicate the majority of the main Gallinas Creek and South Gallinas Creek tidal slough channels are leveed and the majority of the interior area and slough channels are filled and drained. Small areas of remnant salt marsh remain near the western

[2] The 1914-though-current USGS topographic maps label what is now Lucas Valley as Gallinas Valley, which is drained by Miller Creek.
[3] Alternatively, this land may have been sold to Freitas, who in turn sold it to the Beherns family shortly thereafter.

termini of these two channels. The USGS maps now indicate Gallinas Creek as a solid blue-line creek upstream of the County Road to the confluence of two tributary channels at what is now the Freitas Parkway-Las Gallinas Avenue intersection. A solid blue-line creek suggests perennial flow. The southern of these tributary channels, aligned along what is now Nova Albion Way, is also indicated as a solid blue-line creek. No development is evident in the upper Gallinas Creek watershed at this time. It's also worth noting that by the 1940's, the USGS had introduced green shading on their maps to represent forested areas. No green shading, most notably along Gallinas Creek, was mapped in the upper watershed.

Maps and an aerial photograph from the 1950's indicate the first housing development in the watershed (labeled "Venetia Harbor on the 1958 U.S. Coast and Geodetic Survey Nautical Chart) – located along the south bank of South Gallinas Creek slough channel, east of Highway 101 (Highway 101 is first observed in 1950 aerial photograph). A new development is also being constructed in the Los Ranchitos subdivision across (west) from what is now the Marin Civic Center. Much of the diked and drained former marshland east of Highway 101 is now agricultural fields. Much of the Gallinas Hills marking the northern boundary of the lower watershed are undergoing active quarrying and a lot of industrial facilities occupy the area north between the hills and the main leveed Gallinas Creek slough channel.

The 1950 aerial also indicates that apart from scattered brush or trees, the vast majority of the main stem Gallinas Creek and tributary channels in the upper watershed (west of Highway 101) are devoid of riparian vegetation and deeply incised. These features are commonly the result of heavily grazed watersheds. A large concrete lined reservoir, likely supplying the Freitas Ranch, also appears just uphill of what is now the intersection of Las Collindas and Wintergreen Terrace on the south face of the Lucas Valley-SMV ridge. According to Walter Freitas, the concrete lined reservoir was approximately 70-feet long by 40-feet wide and 22-feet deep. This reservoir, used for domestic water supply, and another small reservoir located near the main ranch buildings for stock watering, were supplied by an elaborate collection and pipe system, fed by as many as 17 springs on the south face of the adjacent Lucas Valley-SMV ridge (i.e. Springs Hill; Starkweather, 1972). According to Freitas, the large concrete reservoir was likely constructed around 1922 and never went dry; it was always half full.

By 1963, the majority of the valley bottom of the upper watershed (Terra Linda) was covered in newly constructed suburban housing. The Freitas family sold 400 acres of the mid- to lower-valley ranch to developers in July 1954 and the remaining 800-acres in May 1955 (Starkweather, 1972). Thomas Nunes sold the valley bottom portion of SMV and Lucas Valley to Joseph Eichler in the early 1960's. Nunes built his current home on the ridge between Lucas Valley and SMV in 1964. Although not captured on historic maps and aerial photographs, interviews with local residents revealed that the large Eichler subdivision centered on Del Ganado Road was initiated in 1955. As indicated on the 1963 aerial photograph, construction of Northgate Mall was started and a portion of the Civic Center has been built. An interesting article (Independent Journal, March 6, 1965) was also found that shows two pictures from the same vantage point (i.e., looking northwest out across the entire Santa Margarita Valley and portions of the lower Gallinas Creek watershed), one taken in 1954 and the other taken in 1965. The purpose of the contrasting photographs was to document the vast development the occurred in the intervening 11-year period.

During the development of the watershed in the mid-1950's and early 1960's, the entire upper Gallinas Creek system was directed into or converted into a storm drain system, as described in Section 1.0. By the late 1960's and early 1970's most roads and neighborhoods, including new homes encroaching further up the surrounding hills, were completed and the urban character of the area appears very similar to that of today. In the 1960's, the Terra Linda valley was annexed to the City of San Rafael. Nautical charts from this period indicate that the South Gallinas Creek channel was dredged and maintained to 6-feet. Also during this time, the Marin County Open Space District acquired 1,168 acres of ridge-top open space that encompasses the Sleepy Hollow-SMV, Lucas Valley-SMV, and San Rafael Hill ridges from Thomas Nunes (Starkweather, 1974). This preserve, called the Terra Linda-Sleepy Hollow Divide Open Space Preserve, protects the ridges from further development and supports a mixture of open grassland and broadleaf forests crisscrossed with fire roads and trails. With creation of the preserve, many of the north-facing slopes and drainages have been recolonized by thick stands of forest. Abundant native and non-native riparian vegetation was also observed in the 1963 through 2000 aerial photographs, establishing and thickening at the outfall of numerous springs draining the south face of the Lucas Valley-SMV ridge (a.k.a. Springs Hill).

2.3 Property Ownership

West of Highway 101, Las Gallinas Creek is located between two lanes of roadway that service Del Ganado Road and Freitas Parkway. Directly adjacent to both sides of the creek is a small strip of City-owned land, which is part of the roadway median. Privately owned parcels border both sides of Del Ganado Road. City-owned land (public park) borders the majority of Freitas Parkway to the north, between Los Gamos Road and Del Ganado Road. The remainder of the land north of Freitas Parkway includes individual privately owned parcels. Privately owned parcels border Freitas Parkway to the south.

East of Highway 101, approximately 29-percent of the property bordering the mainstem creek channel is privately owned. The remaining 61-percent of property is owned and maintained by the State of California, Las Gallinas Sanitary District, Golden Gate Bridge and Highway and Transportation District, the County of Marin, and City of San Rafael. As discussed later in Section 4.2, the urbanized area east of Highway 101 that contains South Gallinas Creek Slough, was not included as part of the study area.

3.0 EXISTING CONDITIONS

3.1 Geology

Santa Margarita Valley and Gallinas Creek watershed lie within the Coast Range physiographic province of California, resting on a large structural block bounded to the west by the San Andres Fault and by the Hayward Fault to the east. The topography between these fault zones consists of alternating, northwest-trending mountains and hills separated by valleys and lowlands. The bedrock in the region consists of the Franciscan Mélange, which was deposited during the Jurassic through early Tertiary periods in association with subduction of the oceanic Pacific Plate beneath the continental North American plate. The Franciscan Mélange consists of a wide variety of highly deformed rock types that were deposited along the margin of the subducting and overriding plates. Texturally, the Franciscan Mélange ranges from large coherent blocks of rock (up to tens of kilometers in length) to a jumbled assemblage of small coherent rock masses floating in a fine-grained matrix of intensely sheared and crushed rock material, ergo the term "mélange" (Rice et al., 1976 and Page, 1979). Typical rock-types found in the Franciscan Mélange consist of greenstone, chert, serpentine, schists, meta-volcanics, sandstone, shale and mudstone. The origin of these rock materials ranges from oceanic crust and deep marine siliceous oozes to submarine volcanics and well-sorted flows of land-born sand, gravel, and clay.

The sediments overlying the Franciscan Mélange in the Bay Area are undeformed and were deposited during the more recent Holocene and Pleistocene Epochs. Upland valleys are commonly filled with alluvium and colluvium[4] eroded off the surrounding hills, while areas fringing San Francisco Bay are composed of broad flats of fine-grained sediments deposited in an estuarine environment. In general, these relatively young Bay margin alluvial and estuarine sediments were deposited during cycles of sea-level rise and fall associated with periods of Pleistocene glaciation. Deposits associated with the two most recent glaciations are well represented in Bay Area sediments.

The thick accumulations of Quaternary sediments along the margins and beneath San Pablo Bay have been referred to by Treasher (1963) as Younger Bay mud. The Holocene surficial deposits of the Younger bay mud found throughout the Bay Area are considered to be estuarine deposits, formed over the last 10,000 years in association with approximately 100 meters of sea level rise since the end of the Wisconsin glaciation (Atwater, 1977). These estuarine deposits are characterized as soft, organic-rich clay and silt while alluvial deposits, which are locally characteristic of low stands in sea-level, typically consist of a much higher percentage of coarser grained material like sand, gravel, and interbedded clay layers.

The bedrock hills exposed along the upland margins of the Gallinas Creek watershed consist of the Cretaceous aged Franciscan Mélange (Rice and Strand, 1971; Rice et al., 1976). The rocks that makeup the Sleepy Hollow-SMV ridge consist of relatively weak Franciscan mélange containing masses of more resistant rock (knockers) enclosed in the sheared mélange matrix

[4] For purposes of this report, colluvium refers to deposits of unsorted and unconsolidated soil material and weathered rock fragments that accumulate on or at the base of slopes by gravitational or slope wash processes. Soil and rock debris in colluvium were derived by weathering and decomposition of the bedrock materials underlying the slopes on which they are found.

material. The matrix is unstable and the majority of the ridge is covered in landslide deposits – mostly rotational blocks of failed material in or immediately below the landslide scar. A thick cover of vegetation camouflages many of the historic landslides.

The Lucas Valley-SMV ridge is comprised primarily of the same Franciscan mélange material bisected by a relatively continuous and persistent band of serpentine bedrock. Based on extensive field observations of the serpenitine-melange association, the zone of serpentine contained in this ridge was likely tectonically emplaced as a flat thrust sheet. The mélange matrix located both above and below the band of serpentine is easily eroded and has failed by land sliding at numerous localities (Rice and Strand, 1971). The serpentine appears to be relatively stable although some slides originating in the mélange above the serpentine have passed over the serpentine on their downward path.

Unconsolidated sediments of clay, silt, sand, and gravel underlie the SMV bottom upgradient (west) of approximately Highway 101. These deposits are all of Quaternary to Holocene (recent) age and were eroded from the surrounding steep slopes and transported to the gently sloping alluvial fans and valley floor by flooding streams. In general, surficial soils are coarser-grained at the toe of slopes and fine towards the valley center. Typically, these deposits consist of interbedded lenses of silt, sand, and gravel that interfinger bay ward with the shallow Bay mud estuarine deposits.

The bulk of San Pedro Ridge, which forms the southern boundary of the lower watershed, is composed of sandstone with lesser amounts of shale and mudstone. The sandstone is mostly strong and well cemented and relatively stable on natural slopes – even steep slopes that exceed 40 degrees. The Gallinas Hills, which form the northern boundary of the lower watershed, are composed of a wide variety of materials including large thicknesses of sandstone, Franciscan mélange, and large localized outcrops of erosion resistant greenstone.

The lowland areas east of Highway 101 are underlain by a considerable thickness of Bay mud deposits. Denby (1978) and Bonaparte and Mitchell (1979) have characterized the shallow (younger) Bay mud as a soft, fine-grained unit composed primarily of clays, some of which are easily hydrated and expandable. The Bay mud is notorious for its poor engineering properties, mostly a result of its high water content (typically above 90%) and extremely low unconfined compressible strength. To the north of the Gallinas Creek tidal marsh, at the former Hamilton Army Airfield site, Woodward-Clyde (WWC) indicates that the upper 5 to 10 feet of Bay mud is desiccated - mud that contains a compositional and structural signature indicative of seasonal wetting and drying. Beneath the desiccated zone, the Bay mud is “softer, a result of being perennially saturated and display lower permeabilities than the Desiccated Bay mud (WWC, 1996 and 1997). The older units beneath the shallow Bay mud display a wider range of textural variability, including interbedded clay, sand, and gravel horizons (Trask and Ralston, 1951).

3.2 Soil

Much, if not all, of the ground surface within the watershed has been altered by grazing, agriculture, and housing development since European settlement. The soil units mapped within the Gallinas Creek watershed reflect a highly disturbed urban setting. The former Soil Conservation Service (U.S. Department of Agriculture) completed and published a soil survey of

Marin County in 1985 (Soil Conservation Service, 1985). The following descriptions of soil in the Gallinas Creek watershed are keyed to the soil unit numbers presented in the County's soil survey.

Upland Soil

184 and 185 – Tocaloma-Saurin association (very steep to extremely steep slopes)
The 184 series is found on very steep (30 to 50 percent) upland slopes and the 185 series is found on the extremely steep (50 to 75 percent) upland slopes. The Tocaloma soil is on the north- and east-facing slopes and in drainageways, and the Saurin soil is on ridge tops and side slopes. Both soil types are moderately deep and well drained (depth to bedrock ranges from 20 to 40 inches). Runoff is rapid and the hazard of water erosion is high.

142 and 143 – Los Osos-Bonnydoon complex (15 to 50 percent slopes)
The 142 series is found on 30 to 50 percent upland slopes and the 143 series is found on 15 to 30 percent upland and urbanized slopes. The unit varies in relative percentages of each soil type. The Los Osos loam is mainly located on concave to planar side slopes and Bonnydoon gravely loam is mainly on convex side slopes and ridges. Both soils form from sandstone or shale with depth to bedrock ranging from 10 to 40 inches. Although the permeability of the Los Osos soil is slow, and moderate for the Bonnydoon soil, both display rapid runoff and have a high water erosion hazard.

146 – Montara clay loam (15 to 30 percent slopes)
This soil is shallow (10 to 20 inches to bedrock) and well drained. The soil is derived from serpentine exposed in uplands. Due to low permeability, runoff is rapid and the soil displays a high hazard of water erosion.

162, 163, and 166 – Saurin-Bonnydoon complex (15 to 50 percent slopes)
The 162 series is found on 15 to 30 percent slopes, the 163 series is found on 30 to 50 percent upland slopes, and the 166 series is also found on 30 to 50 percent partially urbanized slopes. The soil types are as described above with each soil series displaying a 20 to 40 inch depth to bedrock and rapid runoff (high water erosion hazard).

180 – Tocaloma-McMullin complex (50 to 75 percent slopes)
This soil complex is found underlying the San Pedro Ridge and is derived from the underlying sandstone. Even though soil permeability is moderately rapid, the steep slopes occupied by this soil lead to very rapid runoff and an associated very high erosion hazard.

Valley Bottom Soil

202, 203, and 204 – Xerorthents-Urban land complex (0 to 9 percent slopes)
These soil complexes dominate the heavily urbanized valley bottomland in the upper watershed and lower watershed. Xerorthents consist of cut or fill areas (areas affected by urban construction) and vary greatly in depth and drainage. Urban lands consist of areas covered by roads, driveways, houses, parking lots, and other structures. The specific soil series or complex listed is dependant on the relative percentage of contributing series. Regardless of series or complex and because the ground is covered or stabilized, runoff is rapid and the hazard from water erosion is slight.

147 – Novato Clay (0 to 2 percent slopes)
This thick, poorly drained soil forms in the salt marshes along the edges of San Pablo Bay. Permeability is low due to the high relative content of clay. Throughout the year, this soil displays a high water table at or near the surface.

3.3 Climate and Rainfall

The San Francisco-San Pablo Bay area climate is commonly referred to as Mediterranean with wet winters and dry summers. The climate along the North Bay coast is moderated by the Pacific Ocean and usually experiences even temperatures, frequent heavy fog, and prevailing winds from the west to northwest. There are also winds that develop in local valleys due to differential heating between adjacent land and water bodies on a seasonal basis. Temperatures display a wider range inland, away from the moderating effects of the Ocean and San Francisco-San Pablo Bay. Temperatures and rainfall are also influenced by elevation and local topography.

The long-term median annual[5] precipitation total for the valley bottom and marsh plain portions of the project site is approximately 31.9 inches. This long-term average is based on a 97-year (1907 through 2003) record of precipitation at the Marin Civic Center rain gauge[6], located in the southeast corner of the Gallinas Creek watershed. Isohyet (lines of equal annual rainfall totals) maps prepared by the USGS (Rantz, 1971) indicate a maximum mean average annual rainfall of 35-inches along the Sleepy Hollow-Santa Margarita Valley ridge, which marks the western boundary of the watershed.

Precipitation in the San Francisco-San Pablo Bay area is seasonal with over 80-percent of the total annual rainfall occurring between the months of November and March. Very little, if any, precipitation occurs from June through September. This seasonal rainfall distribution as median monthly flow for the period 1907-2003 at Marin Civic Center is illustrated in Figure 3.

A plot of annual precipitation totals provides a picture of the long-term climatic conditions for the study area for the period 1907 through 2003 (see Figure 4). This time-series plot indicates that annual precipitation amounts range widely, from 226- to 42-percent of the median annual precipitation total (long term minimum and maximum derived totals are 72.1 and 13.3 inches, respectively). In order to identify and characterize long-term wet and dry periods, the cumulative departure from the mean annual precipitation was tabulated[7] for the long-term rainfall record. Figure 5 presents the results of this analysis and clearly identifies long-term wet

[5] Annual precipitation totals are typically calculated for the periods starting on July 1st and ending on June 30th of the named year. However, for the purposes of this study, annual precipitation totals were calculated to be consistent with annual flow and runoff records, which are calculated according to "water years", which start on October 1st and end on September 30th of the named year.

[6] Monthly rainfall totals for the Marin Civic Center (record 1947 to 2003) were estimated back to 1907 by correlation to monthly rainfall totals at Kentfield.

[7] Annual departures from the mean are calculated by subtracting the long-term average rainfall from each annual rainfall total. Positive results indicate that the year experienced above average rainfall while the negative results indicate that year was drier than average. Keeping track of the chronological sum of annual departures from the mean identify prolonged wet and dry periods. A positive slope to the cumulative departure curve indicates extended we periods while a negative slope indicates an extended dry period.

and dry periods. The recent intense droughts of 1976/77 and 1984-1992 and wet period from 1995-1998 provide some context for identifying and appreciating the historical cycles. For example, the long-term drought that occurred over the 1916 through 1934 period displays a similar intensity to recent droughts but is of longer duration.

3.4 Hydrology

3.4.1 Surface Water Runoff

A combination of precipitation, geology, and impervious cover are the dominant controls over seasonal urban runoff patterns in California coastal basins. As would be expected from seasonal rainfall patterns, approximately 80 percent of the total annual runoff in the Gallinas Creek watershed occurs during the months of December through March. Typically, early season rains that fall on permeable surfaces in October and November quickly infiltrate into dry ground and contribute little to runoff. Based on a regional study of long-term runoff volumes in the San Francisco Bay region, Rantz (1974) identified strong correlations between mean annual precipitation and runoff for areas at similar latitude, distance from the ocean, altitude and orientation of slopes. Low permeable soil and rock, and a low capacity for subsurface storage will impede infiltration and lead to higher runoff rates. These natural influences result in a short lag-time between the occurrence of rainfall and initiation of runoff.

Prior to this study, no known historic stream flow monitoring has been completed on Gallinas Creek. The nearest stream gauge locations are on Novato Creek (USGS 11459500, peak and mean daily flows, 1947-2003) and Corte Madera Creek (USGS 1146000, peak flows, 1951-1997; mean daily flows, 1951-1993). Novato Creek, lying approximately six miles to the north, is closest to the Gallinas Creek watershed; furthermore, Novato Creek is an active station and flow data is available through the present (personal communication, Tom Haltom, USGS). However, stream flow in the Novato watershed is heavily regulated by local reservoirs.

Regional runoff studies completed by the USGS (Rantz, 1974) indicate an annual runoff rate ranging from near 16-inches annually off the upland ridges to 8-inches in the lower elevations of the watershed near San Pablo Bay. These estimates are based on natural ground cover and land use conditions. Based on existing aerial photographs and GIS data, a large percentage of the basin is covered by impervious surfaces. Available literature suggests that impervious cover and the introduction of an extensive storm drain system will significantly increase storm runoff rates over those that would occur under natural conditions.

As part of this investigation, a stream flow-monitoring gauge was installed in the Gallinas Creek channel immediately downstream of the Las Pavadas Avenue bridge crossing on January 22, 2003 (see Figure 2). This gauge consisted of a staff plate and stilling well (secured to the concrete box culvert walls) housing an electronic water level recorder. Periodic discharge measurements were completed over a broad range of flows and a rating curve developed to convert hourly water level measurements to corresponding flow estimates. Continuous and accurate flow records were obtained for the January 22 through July 11 period during WY2003 and between January 1 and July 21 during WY 2004. Calculated mean daily flow values for these monitoring periods are plotted on Figure 6. Hydrographs indicate storm flows are very flashy in nature, displaying a rapid rise and fall in response to rainfall events. The intervening base flows, between winter storm events, are typically less than 1.0-cubic feet per second (cfs)[8]. To better illustrate the flashy nature of storm flows in the Gallinas Creek system, selected storm hydrographs for the February 15-16, 2003 and February 25, 2004 events are presented in Figures 7 and 8, respectively. These flow hydrographs plots the actual hourly flows measured at the Las Pavadas Avenue gauge along with the cumulative rainfall totals for each storm event. The February 25, 2004 storm was the largest storm event during the monitoring period with rainfall intensities at the Marin Civic Center exceeding 1.5-inches per hour (in/hr) for over a six-hour period (see Figure 9). It's worth noting that the rainfall intensity-duration experienced during this storm approached and exceed a 100-year recurrence interval (i.e. 100-year storm) for 1- and 2-hour rainfall durations (Rantz, 1971). The 2003 storm is representative of a less intense, more normal winter rainfall event, displaying a steady rainfall intensity of about 0.25-in/hr for over 9 hours. Both of these flood hydrographs display an almost immediate response in runoff to the onset of rainfall, followed by waning flows as soon as rainfall ceases.

Based on several years of recent field observations, perennial flows exist along the entire length of concrete lined channel. These flows are only on the order of a tenth to hundredth of a cfs and are likely sustained by "grey-water" runoff originating mainly from excess lawn watering. The flow hydrographs presented in Figure 6 indicate that the storm drain system that conveys Gallinas Creek is very effective at evacuating water out of the basin. The lack of significant increases in post-flood and seasonal baseflow rates indicate that there is little off-channel storage available to the creek system, either as flood plain storage or groundwater storage. In short, flow patterns in Gallinas Creek are representative of a heavily urbanized system and have been significantly altered from historic conditions.

3.4.2 Flood Frequency

There is no long-term flow record for Gallinas Creek. A FEMA Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) have been completed for the watershed (FEMA, 1997b and 1997c). Although Gallinas Creek is indicated as a "detailed study reach" in the FIS, flood peak flow values are not presented nor are there any flood profiles. According to the FIRM, a large expanse of the lower watershed falls in the 100-year flood zone (esp. the mobile home park serviced by Smith Ranch and Yosemite Roads) and the area surrounding the South Fork Gallinas Creek slough channel immediately north of the Civic Center Auditorium. A wider band of area between the 100 and 500-year flood zone (flood hazard Zone B) surrounds the 100-year flood zone. The FIRM also indicates a narrow finger of the 100-year flood zone extending up Gallinas Creek, west of Highway 101 to approximately Los Gamos Road. The zone does not extend for significant distance from the main channel. A wider Zone B area extends much further up the Gallinas Creek channel to the Las Pavadas Avenue with the potential for flooding 100 to 500-year covering the entire Freitas Parkway corridor and extending in many locations to adjacent properties.

The only other flood studies found for the Gallinas Creek watershed focused on the San Rafael Meadows development located in the south-central portion of the watershed (Oberkamper & Associates, 1999, 2000, 2001, and 2001b; MCFC&WCD, 1998; and Marin County Department

[8] One cubic foot per second (cfs) is the rate of discharge representing a volume of 1 cubic foot passing a given point in 1 second. It is equivalent to approximately 7.48 gallons per second, 449 gallons per minute, or 0.0283 cubic meters per second.

of Public Works, 1973). This study area drains to the South Fork of Gallinas Creek, again, a portion of the watershed not included as part of this investigation. However, Flood Control's study does provide a unit-area runoff estimate for a 100-year flood (Q_{100}) of 0.84-cfs per acre of drainage area.

In order to estimate the 2- through 500-year flood flows (Q_2 through Q_{500}) on the main stem Gallinas Creek, two flood frequency analysis methods were employed. One set of estimates was made using the USGS regional flood-frequency correlation equations developed for the San Francisco Bay Area (Rantz, 1971b). These available relationships, based on mean annual precipitation totals and drainage area, provide peak flow estimates for the 2- through 50-year floods (Q_2 through Q_{50}). Flood flow estimates for the Las Pavadas Avenue gauge location are presented in Table 1. It is important to note that these flood flow estimates are representative of natural (i.e. unurbanized) conditions, flows that are noticeably less than those off of an urbanized area.

A second and independent set of flood flow estimates were derived from analysis of FEMA and County flood studies for surrounding watersheds/communities (FEMA 1977, 1989, 1997, and 1997b). This analysis included selecting and tabulating available peak flow estimates for representative floods on area creeks and completing regression analyses between tabulated flow and drainage area. The selected study creeks and flood flow data are presented in Table 2 while results of the regression analysis (trend lines, corresponding correlation equations, and squared correlation coefficients) are presented in Figure 10. Flood flow estimates for Gallinas Creek at the Las Pavadas Avenue bridge using these study-derived equations are also presented on Table 1.

Table 1: Summary of Flood Flow Estimates
Gallinas Creek at Las Pavadas Avenue

Event	Recurrence Interval	Peak Flow Rate (cfs)	Estimate Method
Q_2	2-years	98	(a)
Q_5	5-years	187	(a)
Q_{10}	10-years	254/372	(a)/(b)
Q_{25}	25-years	353	(a)
Q_{50}	50-years	525/559	(a)/(b)
Q_{100}	100-years	649	(b)
Q_{500}	500-years	843	(b)

Table Notes: Estimate Method: (a)=USGS regional flood-frequency correlation equations (Rantz, 1971b); and (b) = estimates derived (this study) by development of area/flow correlation using FEMA flood estimates for surrounding watersheds (see Figure 9).

The peak flow recorded at the Las Pavadas Avenue stream gage during the 2003-2004 study period was 501-cfs on February 25, 2004 (see Figure 1). Based on the estimates presented in Table 1, this flow fell slightly below a 50-year event. Observations of flow conditions and high water marks during and immediately after this event indicate that the culvert connecting the Del

Ganado Road reach to the Freitas Parkway channel was flowing at full capacity and some water was piling up onto the road deck for a short duration on the upstream side of the culvert. Although the channel flowed very full along the Freitas reaches, especially downstream of Las Gallinas Avenue, no significant out-of-bank flooding was observed in the system. Interviews of several long-term residents indicate that this level of flow at the Freitas Parkway-Del Ganado Road intersection had never been seen before and many suggested this was the highest flow they ever observed in the system. These anecdotal accounts, combined with the 100-year recurrence rainfall intensity-duration experienced during the storm, suggest that it is not unreasonable that this event equated to a 50-year flood flow. Its also worth noting that hydraulic calculations completed as part of this study on the Del Ganado Avenue to Freitas Parkway culvert yielded a culvert capacity of 388-cfs and that the estimated 50-year flood flow entering the culvert is 381-cfs. These estimates suggest the culvert would experience full capacity flow during the 50-year event, as occurred during the February 2004 storm.

3.4.3 Hydraulic Analyses of Existing Conditions

Probably the most significant constraint on ecological restoration in the watershed is the potential for a project-induced increase in flood hazard. Therefore, KHE completed preliminary stream hydraulic analyses of existing conditions to characterize flood hazards for portions of the creek upstream of Highway 101. This analysis was completed by developing a one-dimensional, steady state hydraulic model (HEC-RAS) for a portion of the Gallinas Creek floodway and simulating resultant water level and hydraulic parameters for selected floods. This model was then used to characterize the likely flow conditions and define the necessary hydraulic geometry requirements (i.e. channel dimensions) for proposed conceptual restoration alternatives.

In order to create a hydraulic model of the Gallinas Creek floodway, information regarding channel dimension, slope, and conditions were collected. Relevant engineering plans and drawings were obtained, or copied, from the San Rafael Department of Public Works (SRDPW). Three plans of the Freitas Parkway Channelization Project (1959-1960) were found, covering Freitas Parkway from the intersection at Las Pavadas Avenue to just west of the Highway 101 undercrossing. These plans have cross-section dimensions and profile elevation data for the Gallinas Creek concrete channel, however, it is not clear to what datum the elevation data is referenced. Two plans (both 1970) were found for the alteration of the culvert at the Freitas Parkway and Las Gallinas Avenue intersection. One plan (1975) was found for construction of the sidewalk, adjacent to Gallinas Creek, east of the Freitas Parkway and Las Gallinas Avenue intersection. Copies of SRDPW storm drain maps were acquired for the majority of the watershed. These copies cover the extent of the Gallinas Creek and Santa Margarita Creek channels. Sanitary sewer maps for the Gallinas Creek watershed were obtained from the Las Gallinas Valley Sanitary District (LGVSD) in paper form (digital file copies have been requested and are pending). In addition to these plans, a series of site reconnaissance walks were completed to confirm and collect additional channel, culvert, and bridge crossing measurements.

Based on available plans and information, a HEC-RAS model of the open channel sections of Gallinas Creek along Freitas Parkway (Monticello downstream to Highway 101) and Del Ganado Road (Las Raposas to Freitas Parkway) was developed. The model captures all changes in channel dimension, culverts, and bridge crossings. A longitudinal profile of the modeled channel is presented in Figure 11. The locations of all sections and bridges are indicated along with channel bed and top of bank elevations. A Manning's roughness value (n) of 0.013 was used for concrete lined sections (Chow, 1959).

Simulations were completed for the 2-, 10-, 50-, and 100-year floods, with flow additions incorporated at boundaries/nodes corresponding to: the upstream ends of the Del Ganado Road and Freitas Parkway reaches; Las Pavadas Avenue; Las Gallinas Avenue; and Las Gamos Avenue. Flood flow estimates were made by calculating contributing drainage areas and using the correlation equations presented in Figure 10 to estimate the corresponding peak flow value. The main calibration check of the model included comparing the 50-year flood water levels to those experienced during the February 25, 2004 storm flows, measured at the Las Pavadas Avenue bridge and qualitatively observed throughout the remainder of the watershed.

The most significant findings to come from the hydraulic modeling exercise were that floods in the Gallinas Creek floodway are dominated by supercritical flow as compared to subcritical flow, which is the dominant flow regime in natural, earth-lined channels. In very simple terms, subcritical flow is a state of flow where the role of gravity dominates and flow has a low velocity and is often described as tranquil or streaming. Supercritical flow is a physical state where the inertial forces become dominant and flow has a high velocity and is commonly described as rapid. The finding that the Gallinas Creek floodway is a supercritical flow system is not surprising given that concrete channel floodways built in the 1950's and 1960's were commonly designed to take advantage of this flow regime and minimize flood water travel-time through the system. The significance of this finding is that replacing a concrete channel with an earth-lined, vegetated channel will cause a transition in the flow regime from supercritical to subcritical flow, requiring the earth-lined channel to have a significantly larger capacity (cross-sectional area) to accommodate the same volume of water moving at a slower velocity.

Existing condition water surface profiles of the 2- through 100-year floods in the modeled reach are illustrated on Figure 12. These results assume supercritical flow throughout the entire reach. Analyses of subcritical and mixed subcritical/supercritical flow through the creek resulted in water levels at or above the top-of-bank at numerous locations (e.g., between Las Gallinas and Los Gamos Way) for flows equal to or in excess of the 10-year flood. As indicated in Figure 12, water levels for the 50- and 100-year floods remain in the channels only under supercritical flow conditions.

3.5 Vegetation

3.5.1 Historic Changes in Vegetation

The Gallinas Creek Watershed once supported a vibrant riparian system that fed the lower watershed's tidal salt marsh habitats. Dense willow, oak, bay and buckeye canopies would have provided habitat for numerous neo-tropical migrant bird species, as well as feeding raptors, spawning steelhead, and a diversity of mammal species. Today, however the upper reaches of this creek system is mostly contained in lined concrete channels.

Historically, stands of native evergreen forests dominated by coast live oak, valley oak, California bay, and California buckeye trees would have flourished within the drainages, and protected slopes of the Gallinas Creek watershed. Diverse and ecologically rich wetland habitats within the watershed would have ranged up its arroyos and edged its lowland floodplains. A vibrant mosaic of upland grassland and coastal scrub habitats, often supporting unique floral assemblages such as those found on Franciscan-derived soils such as serpentine, would have also flourished atop the ridges and amid the slopes of the watershed.

Grazing, building construction and timber harvesting dramatically altered the native plant communities during the early European settlement periods. Following the Mexican American War in 1848 many larger ranchos in Marin, such as Rancho Saucelito, were subdivided into smaller ranches, with some being subdivided and sold to farmers, dairymen, and timber outfits. Dairy farming began in Marin in 1857 and, by 1880, a census counted 32,449 cattle (mostly dairy cows). This changed the pattern and types of disturbance and vegetation composition across the landscape as fences went up, fertile marine terraces and creek valleys were tilled, and forests were logged on a large scale (Stanger 1967, Hynding 1982, Fairley 1987). As the Central Valley became the primary cattle producer, the coastal cattle industry began to fade (Burcham 1957, Toogood 1980) but many of the grazing practices decreased in size and scale by the 1960s. The increased pressures from grazing, development, logging and other management practices further changed the landscape by increasing the presence and persistence of invasive non-native plant species. For example, eucalyptus was first planted in San Francisco Bay Area in 1856 (McClatchie 1902). Extolled for its qualities as a fast-growing timber species, eucalyptus became a widely planted for ornamental use, timber, and windbreaks. Many non-native annual grasses were introduced in soils transported in ship ballasts, and through lifestock feed. Additionally, French broom (*Genista monspessulana*) and Scotch broom (*Cytisus scoparius*) were introduced into California in the mid-1800s for landscaping and to control roadside erosion.

More than 90-percent of tidal wetlands in the Bay Area have been lost to reclamation by diking, filling, and draining vast sections of marsh for agriculture, urbanization, and salt production (Goals Project 1999). Continued urban development, channelization, water quality degradation, and the expansion of invasive non-native plant infestations have significantly altered natural stream processes (surface water flow, groundwater recharge, etc.), converted and fragmented remnant native habitats, and limited wildlife corridors and movement.

3.5.2 Existing Vegetation Communities

The following is a description of the vegetation communities found within the watershed. While riparian vegetation represents only a small percentage of that vegetation, this report describes it in greater detail than other communities, as it will be the primary vegetation type subject to future restoration efforts.

3.5.2.1 Riparian Communities

Riparian Woodlands develop in the wettest zones of perennial (i.e., year-round) and intermittent creeks. This streamside community is dominated by broad-leaved deciduous trees and shrubs, most commonly willows (*Salix lasiolepis*, *S. lucida* ssp. *lasiandra*), California bay laurel (*Umbellularia californica*), Coast live oak (*Quercus agrifolia*) and occasionally red alder (*Alnus rubra*). The understory is usually extremely dense because of the thicket-forming growth habit of this species. A variety of shrubs including berries – thimbleberry (*Rubus parviflorus*), California blackberry (*R. ursinus*), ninebark (*Physocarpus capitatus*), and wood rose (*Rosa gymnocarpa*) are most commonly woven through the understory. Wax myrtle (*Myrica californica*) or poison oak (*Toxicodendron diversilobum*) may be present. Numerous herbaceous species including ferns, rushes, and sedges dominate the shrub understory. Nonnative trees including eucalypts (*Eucalyptus* spp.) and Monterey pine (*Pinus radiata*) have also become successfully established within the restricted zones of riparian forest habitat within the watershed.

Riparian habitats are considered valuable wildlife habitats, providing critical wildlife resources (water, food, movement corridors, and cover for escape, breeding, nesting, and foraging). The complexity of microhabitats created by the layering of trees, shrubs, vines, and herbaceous and aquatic vegetation promotes high wildlife species diversity (Goals Project, 2000). The complex structure and diversity of vegetation within riparian areas, as well as their close proximity to water, creates an extremely productive habitat for numerous mammal, bird, and reptile species (see *Section* 3.6 below).

Riparian habitat also enhances the value of adjacent fish and wildlife habitats. When adjacent to grasslands or agricultural land, riparian habitats provide nest sites for raptors and cover for upland species that use them for foraging. Riparian vegetation typically extends over water and shades the aquatic environment, thereby improving fish and macroinvertebrate habitat by reducing water temperatures. Dropping leaves and insects provide food and other essential nutrients to the aquatic ecosystem. Riparian habitat also provides nesting habitat for migratory, neo-tropical song birds (Goals Project, 2000).

3.5.2.2 Wetland Communities

Wetlands throughout Marin County are associated with creeks, streams, ponds, lakes, or occur as isolated fresh water seeps or vernal pools. Wetland Communities grow within perennially or seasonally saturated soils. Wetlands provide a rich species diversity and important foraging habitat for wildlife. Herbaceous wetlands are known as emergent wetlands in the Cowardin wetlands classification (Cowardin et al., 1979). They consist of a mix of low-growing species of sedges (*Carex* spp.), rushes (*Juncus* spp.), and other wetland-dependent species (*Scirpus microcarpus*, *Typha* spp. *Cyperus eragrostis*, *Equisetum* spp.), as well as some nonnative species of grasses (especially velvet grass (*Holcus lanatus*) and Harding grass (*phalaris aquatica*)). The Gallinas Creek watershed supports tidal marsh, freshwater seep and freshwater wet meadow vegetation habitats. Descriptions of these wetland types follow.

Freshwater seep – These are composed of vegetation similar to that of a freshwater marsh. Freshwater seep vegetation occurs in areas where groundwater seepage creates permanently or periodically saturated soils. Seeps within the study area emerge from serpentinite fractures and contacts between geologic formations. Freshwater seep vegetation typically includes willows (*salix sp*.), rushes (e.g., *Juncus patens, J. bufonius, J. effusus, Luzula comosa*), carex (*Carex densa*) and sedges (*Eleocharis* sp., *Cyperus eragrostis*), and other plants adapted to moist or wet growing conditions. Small to moderately sized (1-acre) freshwater seeps are located throughout the upper watershed and headwaters, most notably along the Lucas Valley-SMV Ridge (see Figure 2).

Freshwater wet meadow (wet meadow) - A wet meadow habitat is different from a freshwater seep in the depth and duration of inundation. It can be defined as an area adjacent to a perennial or a seasonal creek or other places where groundwater remains relatively close to the surface and the soil is seasonally saturated. Although this type of habitat is not officially classified as a vegetation community, it is a habitat type that is referred to in local floras and exists within the watershed area. Wet meadows support specific plant species that can be extremely diverse. Wet meadow habitat within the upper watershed typically includes the following species: meadow barley (*Hordeum brachyantherum*), buttercups (*Ranunculus californicus*), *Juncus phaeocephalus*, and *J. phaeocephalus* var. *paniculatus*. This habitat type typically occupies the flat or low-lying portion of landslide scars within the headwater ridge areas.

Tidal marsh (saltwater and brackish water marshlands) – This habitat type is characterized by exceptionally high productivity and biomass, but typically supports low species diversity. Relatively few plant species can tolerate the natural variations in water levels and salinity. Vegetation is generally low growing and herbaceous, either forming a low dense mat or dominated by clumps of emergent species. The tidal marsh system in the lower watershed is somewhat brackish because of the influx of fresh water from Gallinas Creek and managed flooding and irrigation of surrounding lands. This salt-fresh water mix results in increased plants species richness over what is typically associated with true salt marshes found in the San Francisco Bay.

Pickleweed (*Salicornia virginica*) is a common dominant, as well as saltgrass (*Distichlis spicata*); these species often co-dominate. Jaumea (*Jaumea carnosa*) is the most common associate. Sea lavender (*Limonium californicum*), arrow-grass (*Triglochin concinna*), alkali heath (*Frankenia salina*) and bird's beak (*Cordylanthus maritimus*) are often associates as well.

Tidal brackish marsh communities are divided into three distinct elevation zones - lower, middle, and upper tidal marsh. *Lower tidal marsh* (lower marsh) typically occurs above mudflats and below the mean high water (MHW tidal datum) along stream and slough channels. This habitat is within the range of daily tidal fluctuations, and low growing plants are exposed at low tides and completely inundated at higher tides and during periods of high creek flow. This community is typically dominated by species of cord grass, including California cord grass (*Spartina foliosa*). Other common species include pickleweed (*Salicornia virginica*), annual pickleweed (*S. europea*), fleshy jaumea (*Jaumea carnosa*), and curly dock (*Rumex crispus*).

Middle tidal marsh (middle marsh) occurs between MHW and Mean High High Water (MHHW) tidal datums and is inundated only during higher high tides. Pickleweed is typically the dominant species. Other typical species include frankenia (*Frankenia salina*), fat hen (*Atriplex triangularis*), Baltic rush (*Juncus balticus*), and saltmarsh dodder (*Cuscuta salina*). *Upper tidal marsh* (upper marsh) occurs from MHHW and to the maximum elevation of tidal effects. This habitat is inundated only during extreme high tides. Salt grass (*Distichlis spicata*), gum plant (*Grindelia stricta* var. *angustifolia*) and pickleweed are typical dominant species, and can also be is locally dominant. Other species include sea lavender (*Limonium californicum*), mugwort (*Artemisia douglasiana*), frankenia, fat hen, arrow grass, goldenrod (*Solidagooccidentalis*), aster (*Aster chilensis*), and sedges (*Carex* spp.).

3.5.2.3 Uplands

Both native and non-native grassland habitats form a mosaic with the coastal scrub community and mixed evergreen forests in the upper Gallinas Creek watershed. One or more of the following factors probably maintains the boundary between grassland and coastal scrub: allelopathy, herbivory, limited seed dispersal, and differential use of soil moisture (Davis and

Mooney 1985). Native California grasslands however have had the greatest disturbance of any natural habitat in this region (Savage 1974). Four main factors have contributed to this disturbance: (1) an increase in grazing pressures, (2) the introduction of highly competitive nonnative plants, (3) cultivation, and (4) the elimination of fire. Descriptions of the distinct plant communities that occupy upland areas follow.

The majority of the grassland habitat within the watershed however is dominated by ***Non-native Annual Grassland*** habitat that is adapted to Mediterranean conditions. Non-native grasses within the watershed include: ripgut brome (*Bromus diandrus*), soft chess (*Bromus mollis*), rat-tail fescue (*Vulpia bromoides*), Italian ryegrass (*Lolium multiflorm*), tall fescue (*Festuca arundinacea*), and Harding grass (*Phalaris aquatica*).
Valley Grassland and ***Coastal Prairie*** habitats within the watershed are include the following native grasses: purple needlegrass (*Nasella pulchra)* – the California state grass, Torrey's melic (Melica torreyana), California oatgrass (Danthonia californica), California brome (Bromus carinatus), blue wild rye (Elymus glaucus), and red fescue (Festuca rubra). Other herbaceous plant species found within the grassy slopes of headwater ridges include soap plant (*Chlorogalum pomeridianum*), a number of lupine species (*Lupinus bicolor, L. nanus, L. formosus*), morning glory (*Calystegia subcaulus*), gold fields (*Lasthenia californica*), and brownie thistle (*Cirsium quercetorum*).

Additionally, small, disturbed ***serpentine grassland*** is located in the northern part of the upper watershed on the Lucas Valley-SMV Ridge. The chemical nature of serpentine soils inhibits many plants from growing on it, therefore creating habitat for unique vegetation assemblages. These assemblages are often limited to serpentine soils and isolated genetically from others, due to the patchy distribution of serpentine outcrops throughout the region. Many of Marin's threatened or endangered plants are serpentine endemics.

Mixed Evergreen Forest - This variable community typically extends from 200 to 2,500 feet in elevation (Munz and Keck 1968), and is typically dominated by oak *(Quercus* spp.)*,* California bay laurel and/or tanbark oak *(Lithocarpus densiflorus).* In the Marin County region it is typical to find redwood/Douglas-fir community along the mesic boundary of mixed evergreen forest and coastal scrub and grasslands along the xeric boundary (Sawyer et al. 1977).
Coastal live oak and California bay trees dominate this community within the watershed. These species thrive in the cool, foggy, coastal climate. Oak species found within the watershed include coast live oak, valley oak, and California black oak (*Q. kelloggii*). Understory plants found within this vegetation community in the Gallinas Creek watershed include snowberry (*Symphoricarpus mollis, S. rivularis*), hound's tongue (*Cynoglossum grande*), Western bracken fern (*Pteridium aquilinum* var. *pubescens*), toyon (*Heteromeles arbutifolia*), poison oak (*Toxicodendron diversilobum*), hedge nettle (*Stachys rigida var. quercetorum*), yerba buena (Satureja douglasii), bedstraw (*Gallium nuttallii*), red larkspur (*Delphinium nudicaule*), wild cucumber (*Marah fabaceus*), and milkmaids (*Cardamine californica*).

Northern Coastal Scrub is dominated by coyote brush (*Baccharis pilularis*), California sagebrush (*Artemisia californica*), bush lupine (*Lupinus arboreus*), and poison-oak (*Toxicodendron diversilobum*), with variations in dominant species based on moisture levels, soil types and slopes, and past land use history (Howell 1970). This community intergrades and creates a mosaic with the grassland community, and is found throughout the coastal region from near sea level to 2,500 feet. Other species that are found within this community in the upper watershed includes: cow parsnip (*Heracleum lanatum*), yarrow (*Achillea millefollium*), poison oak (*Toxicodendron diversilobum*), Douglas' iris (*Iris douglasiana*).

Ruderal vegetation appears where disturbance, such as off-road vehicular traffic, alters the natural ecosystem. Ruderal species are typically aggressively growing, colonizing disturbed areas rapidly. Non-native plants such as black mustard (*Brassica nigra*), field mustard (*Brassica campestris*), Italian thistle (*Carduus pycnocephalus*), Hairy cat's-ear (*Hypochoeris radiata*), yellow star-thistle (*Centaurea solstitialis*), poison hemlock (*Conium maculatum*), sweet fennel (*Foeniculum vulgare*), and wild radish (*Raphnus sativus*) are within pockets of ruderal vegetation within the watershed.

Urban landscaped areas are concentrated along the edges of development, roadways, parks and neighborhoods. Over the past century, urban landscapes have replaced and fragmented riparian and evergreen woodland habitats within the watershed, as well as other wetlands, grassland and coastal scrub communities. Landscaped areas typically support non-native trees, (including a number of eucalypts (*Eucalyptus* spp.), acacia (*Acacia* spp.), Monterey pine (*Pinus radiata*), and Monterey cypress (*Cupressus macrocarpa*)), shrubs (including cotoneaster (cotoneaster spp.), *oleander* sp. and *pyrachantha* sp.), flowers, and vegetables. Propagules from these species can be easily dispersed by birds, people, landscape practices and water (e.g. if the seeds fall in a creek and float downstream).

Non-native ornamental plants make up the majority of the roadside landscaping (adjacent to Gallinas Creek) along both Freitas Parkway and Del Ganado Road. Some native plant species, including coyote brush, toyon, and ceanothus species were included in a recent planting effort along the lower section of Del Ganado Road, however the majority do not appear to be locally native.

3.5.3.4 Special Status Plant Species

Several sources were consulted to develop a list of special-status plant species that may occur in the project area or vicinity and that may be affected by ecological enhancement and restoration activities in the watershed. Sources consulted include the documents listed above and the following:

- *Species List provided within the* <u>*San Rafael General Plan 2020 Draft EIR*</u> (City of San Rafael, 2002);
- *Marinwood/Terra Linda Divide Plant Species List (*Doreen Smith, California Native Plant Society, Marin County Chapter, 1992);
- *Rarefind2: California Natural Diversity Database* (California Department of Fish and Game 2001); and
- Electronic Inventory of Rare and Endangered Vascular Plants of California, 6th Edition (California Native Plant Society 2001).

The DFG California Natural Diversity Database (CNDDB) and the California Native Plant Society (CNPS) Electronic Inventory are databases of reported occurrences of special-status plants and sensitive communities. To enable development of a list of species that may occur in the project area, a search of the latest versions of each database was conducted for reported species occurrences in the USGS 7.5-minute topographic quadrangles.

Several special-status plant species associated with tidal marsh habitats either occur or have a high potential to occur in suitable habitat types in the watershed, including:

- Soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*) – Potential habitat present in lower Gallinas Creek watershed, however no documented occurrences [Federal Species of

Concern, CNPS – List 1B][9];

- Marin knotweed (*Polygonum marinense*) - Potential habitat present in lower Gallinas Creek watershed, however no documented occurrences [Federal Species of Local Concern, CNPS – List 3]; and

- California cord grass (*Spartina foliosa*) – located in low tidal marsh habitat in lower watershed [Federal Species of Local Concern]

3.6 Wildlife

Despite habitat fragmentation, increased urbanization, and invasive non-native plant species, the Gallinas Creek watershed provides valuable wildlife habitat for amphibians, reptiles, invertebrates, birds, and mammals in Marin County. Habitats located near water sources (e.g. riparian and wetland habitats) and those supporting large areas of multistoried (of varied heights) vegetation typically support the highest diversity and abundance of wildlife. Below is a discussion about species currently using the habitats found within the watershed. A discussion about which species would likely benefit from the proposed riparian corridor restoration activities is found in Section 5.5.

3.6.1 Birds

Located along the Pacific Migratory Flyway, a route heavily used by spring and fall migrant bird species, habitats within the Gallinas Creek watershed provide valuable resting places, as well as food and water sources for migrating and overwintering bird species. There are approximately 86 species of breeding birds within the Gallinas Creek watershed (see Table 3). This is a rough estimate based on the information available in the Marin County Breeding Bird Atlas (Shuford,

---

[9] **Status definitions:**
Federal: U.S. Fish and Wildlife Service (50 CFR 17.12, 61 FR 40:7596-7613, February 28, 1996).
CNPS: California Native Plant Society (Skinner and Pavlik 1994).
1B = List 1B species: rare, threatened, or endangered in California and elsewhere.
4 = List 4 species: a "watch-list" of plants of limited distribution.

1993). Using the grid system set up in the atlas, all of the breeding bird records in the watershed grids plus some records from nearby grids with similar habitat were used to construct Table 3.

Of these 86 breeding species, there are 21 species recognized as having special population status. Table 4 identifies special status wildlife populations found within the Gallinas Creek watershed. California clapper rail (*Rallus longirostris obsoletus*) is both Federally and State-endangered. California black rail (*Latirallus jamaicensis coturniculus*) is State-threatened. Osprey (*Pandeon haliaetus)*, Northern harrier (*Circus cyanus*), Saltmarsh common yellowthroat (*Geothlyipus trichas sinuosa*), and San Pablo song sparrow (*Melospiza melodia samuelis*) are all Species of Special Concern in California. Band-tailed pigeon (*Columba fasciata*), Allen’s hummingbird (*Selasphorus sasin*), Nuttall’s woodpecker (*Picoides nuttallii*), and oak titmouse (*Baeolophus inornatus*) are on the 2002 Audubon Watchlist. In addition, there are eleven Breeding Bird Species of Special Concern in Marin County present in the watershed. These eleven species include four herons and egrets, three dabbling ducks, one diving duck, two shorebirds and one rail. All of these species use habitats found within the lower watershed. Invasive (non-native) bird species include the European starling, English house sparrow, and brown-headed cowbird. The lower watershed is also used by migratory and over-wintering species. Refer to Table 5 for species that would use the downstream marshes for migration stopovers and over-wintering grounds.

3.6.2 Mammals

Riparian habitat provides cover and breeding sites for Virginia opossum (*Didelphis virginiana)*, striped skunk (*Mephitis mephitis*), and raccoons (*Procyon lotor*), which may forage in woodland and grassland habitats. Table 6 presents a list of mammals known to occur in the watershed, which includes a number of other medium to small mammals that could also find shelter and den sites within riparian habitat. California voles (*Microtus californicus*), western harvest mice (*Reithrodontomys megalotis*), and a diversity of other mouse, mole, shrew and gopher species are found in a variety of upland habitats within the upper watershed (Marin County Open Space District, 2004). Both gray fox (*Urocyon cinereoargenteus*) and red fox (*Vulpes vulpes*) are also found in these habitats. Larger mammal species such as mule deer (*Odocoileus hemionus*) and coyote (*Canis latrans*) are also known to occur in the upper watershed.

Twelve bat species have been reported to occur in the upper watershed habitats (Marin County Open Space District, 2004). These include the California myotis (*Myotis californicus*), Yuma myotis (*Myotis yumanensis*), Townsend's Big-eared Bat (*Plecotus townsendii*), and the big brown bat (*Eptesicus fuscus*). The Yuma myotis bat is a Federal Species of Concern, and the Townsend’s big-eared bat is a State Species of Special Concern.

Mammals that live in the lower watershed east of Highway 101 in the marshes are river otter (*Lutra canadensis*)(Evens, pers. comm., 2004) and Salt marsh harvest mouse (*Reithrodontomys raviventris*). The salt marsh harvest mouse, also known as the "red-bellied harvest mouse," is a small federally endangered rodent in the Cricetidae family, which includes field mice, lemmings, muskrats, hamsters and gerbils. There are two subspecies: the northern (*R. r. halicoetes*) and the southern (*R. r. raviventris*). The northern subspecies lives in the marshes of the San Pablo and Suisun bays, the southern in the marshes of Corte Madera, Richmond and South San Francisco Bay. Salt marsh harvest mice are critically dependent on dense cover and their preferred habitat is pickleweed. In marshes with an upper zone of peripheral halophytes (salt-tolerant plants), mice use this vegetation to escape the higher tides, and may even spend a considerable portion of their lives there. Mice also move into the adjoining grasslands during the highest winter tides.

3.6.3 Amphibians, Reptiles and Fish

There have been few studies documenting the amphibians and reptiles occurring within the watershed. Table 7 includes species occurrences within the upper watershed habitats (Marin County Open Space District, 2004). Several additional species, including the federally threatened California red-legged frog (*Rana aurora draytonii*) were also included in Table 7 based upon personal communication with local experts (Fellers, pers. comm., 2004). Commonly observed species include California slender salamanders (*Batrachoseps attenuatus*), northwestern fence lizards (*Sceloporus occidentalis*), and California alligator lizards (*Gerrhonotus multicarinatus*).

3.6.4 Introduced Wildlife

Introduced mammal species that occur within the Gallinas Creek watershed include the red fox (*Vulpes vulpes*), feral cats (*Felis domesticus*) and Norway rat (*Rattus norvegicus*). Introduced bird species include the European starling (*Sturnus vulgaris*). These are aggressive species, which often out-compete native species for nesting sites and food. Non-native wildlife species often have a negative affect by preying on indigenous wildlife and reducing their populations.

4.0 RESTORATION OPPORTUNITIES AND CONSTRAINTS

During review of background material and implementation of study analyses, special attention was paid to identify potential opportunities and constraints for ecological enhancement of the project site. This independent analysis considered hydrologic, geomorphic, biologic, engineering, water quality, and geotechnical opportunities and constraints. KHE focused the opportunities and constraints analysis on the ability to establish a self-sustaining, natural riparian corridor system and enhance ecological processes that minimize long-term operation and maintenance requirements and costs. The assessment will entail reach specific evaluations, and address local site constraints and the impacts on restoration, relative to reference (unimpaired) conditions. A preliminary list of opportunities and constraints is presented below.

4.1 Opportunities

1. Gallinas Creek has been significantly altered from a natural and ecologically friendly state. There is potential to significantly improving upland, riparian and tidal marsh habitat in the watershed.

2. Unlike most Bay Area roadways, there is considerably more room for relocating and widening the creek channel along Freitas Parkway between Las Gallinas Avenue and Monticello Road – work that could be completed in association with the development of a green belt park and path (recreation) system, consistent with the City's "North San Rafael Promenade" concept.

3. The number of road crossings (i.e. bridges) across a restored creek channel between Las Gallinas Avenue and Monticello Avenue would be minimal as access to all homes bordering this reach is from surrounding neighborhood streets.

4. Much of the land in the lower watershed is at a suitable elevation and condition for tidal marsh restoration without the need for extensive grading and filling.

5. Restoration of tidal marsh in the lower watershed would provide the opportunity to expand habitat for sensitive, rare, and endangered plant and animal species.

6. Riparian and tidal restorations provide the opportunity to create/expand passive recreational activities.

7. Restoration projects provide the surrounding community with tremendous educational opportunities and a source of civic pride.

8. The natural and altered hydrologic characteristics of Gallinas Creek, including summer grey-water runoff, are such that it could support a healthy riparian vegetation corridor.

9. There is healthy and abundant open space in much of the headwater region of the Gallinas Creek watershed. Reconnecting this habitat to a valley bottom riparian and tidal marsh ecosystem would restore important wildlife corridors and lost diversity in all

ecological realms. These efforts would attempt to reverse the habitat fragmentation that has occurred, resulting in isolated, unconnected areas of existing habitat.

10. Restoring an earth-lined, vegetated channel would significantly improve water quality draining to San Pablo Bay.

11. Restoring an earth-lined, vegetated channel could create habitat for steelhead, which is now absent in the watershed.

12. The City is currently reviewing Master Plans and long-term planning strategies and efforts. It is a good opportunity to incorporate restoration/enhancement efforts along Gallinas Creek.

13. Restoration along any alignment would improve aesthetics in the neighborhoods.

14. Construction activities associated with restoration could incorporate the burial of overhead utility lines, further improving local aesthetics.

15. Current channel and restoration corridors in the upper watershed are mostly located on/along public property.

16. There currently exists a group of dedicated community members who support and are willing to commit resources to ecological enhancement and restoration efforts within the watershed.

4.2 Constraints

1. The current Gallinas Creek floodway system functions within a supercritical flow regime. Replacing the existing concreted lined channels with earthen and vegetated will require larger (i.e. wider) channels to maintain the existing level of flood protection. Depending on the degree of desired "restoration", traffic lanes in Freitas Parkway and/or Del Ganado Road may need to be narrowed and/or eliminated.

2. The vast majority of property bordering the South Gallinas Creek channel upstream of Highway 101 is privately owned and occupied by residential development. Downstream of Highway 101, a similar condition exists, especially along the south bank. The tidal portions of the creek are also regularly dredged. Because of these factors, it is likely that ecological enhancement along these reaches would require significantly more time and effort for coordination and planning than the mainstem reaches. Therefore, for purposes of this study, the South Gallinas Creek above the confluence with North Gallinas Creek channel was dropped from the study area.

3. Channel bank erosion during flood flows and natural channel migration would require long-term monitoring and maintenance of a restored creek system. Relocating the channel to one side of the Freitas Parkway corridor could introduce bank erosion and instability to private property.

4. Channels that would be the focus of restoration activities are located along major thoroughfares in the community. Any construction activities would be highly disruptive.

5. Creek channel restoration would require major earthwork activity, along with relocating utilities and infrastructure. These types of activities are very expensive.

6. Approximately 29-percent of the property bordering tidally influenced portion of the mainstem creek channel is under private ownership. State, County, City, and municipal agencies own the balance of the property. This constraint could be viewed as an opportunity pending the willingness of participants in contributing to restoration efforts.

7. Depth to groundwater in the upper watershed may not sustain riparian habitat - further study would be required.

5.0 CONCEPTUAL ALTERNATIVES AND FEASIBILITY

Based on findings of the hydraulic analysis of existing conditions and constraints on creek corridor expansion, KHE use a hydraulic modeling-based analysis to determine the minimum area and corridor width necessary to create a restored channel while maintaining the existing level of flood protection. The analysis undertaken assumed an earthen corridor with vegetated banks from Monticello Avenue down to Las Gallinas Avenue yielding a main channel Manning roughness coefficient of 0.055 and overbank roughness of 0.090 (Arcement and Schneider, 1989; Coon, 1998; and Limerinos, 1970). This analysis also assumed that the road crossings/culvert connections at Del Ganado Road and Las Gallinas Avenue would remain unchanged and the Los Pavadas Avenue crossing (currently a box culvert) would be converted to single span bridge, minimizing encroachment into the channel. These changes necessitated simulating the channel as a subcritical flow system. As such, simulated channel width/area was increased on an incremental basis until the earthen channel reach provided sufficient capacity to convey the 100-year flood. An increase in channel conveyance by increasing channel depth was determined to be unfeasible as the downstream limit of the study reach is controlled by tidal boundary conditions and not channel slope. In addition, any significant and rapid changes in channel slope would likely result in excessive bed and bank erosion or sediment deposition.

Results of this analysis indicate that channel cross-sectional area needed to be significantly increased, translating into a 28 to 103-percent increase in channel width. The minimum required increase in channel width for selected locations along with existing channel width is presented in column (B) of Table 8. The maximum corridor width at each selected location is also presented in column (D) of Table 8. Assuming the minimum four-lane roadway width for the existing condition is 60 feet, the remaining corridor width not associated with a restored creek channel or roadway that would exist at each selected location is also given in column (E) of Table 8. These values are a first order approximation of where maximum creek restoration is feasible along the study corridor. Based on these results, it appears that there is room for channel expansion and restoration along the study corridor.

Based on the cumulative findings presented and discussed above, a suite of conceptual creek and riparian corridor restoration designs were developed and are described below. A discussion of the rationale, design concept and feasibility are discussed for each conceptual design. Conceptual restoration alternatives are presented in order of minimum to maximum ecological restoration outcome. In general, the alternatives build on one another, with most key components or restoration concepts from lower ranked alternatives being incorporated into subsequent, or higher ranked, alternatives. Native plants are recommended in all revegetation efforts and a monitoring and maintenance program should accompany implementation, which would include a non-native plant removal component. A discussion about how the proposed alternatives could affect local wildlife is presented in Section 5.5 of this report.

5.1 Alternative A: Minimal Restoration for Receiving Water Quality Improvements

Alternative A Rationale:

This effort focuses on reducing the impacts of increased dry season flows on receiving waters in lower Gallinas Creek and San Pablo Bay. Historically the upper reaches of this system were dry during much of the year when small inflows returned to the groundwater as seepage into the bed. The existing concrete channel does not permit infiltration, and instead routes dry season flows downstream ultimately to San Pablo Bay. These impacts are exacerbated by increased flows due to runoff of residential irrigation, and poor water quality due to high temperatures and nutrient loading. This alternative is intended to provide infiltration zones along the corridor to minimize the volume of low quality dry season flows moving downstream. The result will be the re-establishment of an ephemeral seasonal flow pattern to the headwater reaches of Gallinas Creek. This minimum restoration scenario will also reduce the potential for mosquito breeding in stagnant water that can pond behind sediment and debris within the concrete lined channel. Channel maintenance efforts would also be reduced because a dry summer channel would not support algal mats and reduce or eliminate the establishment of emergent vegetation, which is currently removed by the City prior to the start of each rainy season.

Alternative A Design Concept:
Infiltration zones will be created downstream of inflow points in the channel corridor along Freitas Parkway and Del Ganado Road. These zones will require excavation of a thirty to fifty foot long section of channel bed. The excavated areas would be cut to a depth sufficient to provide the needed infiltration capacity based on estimated inflows and local geology. One excavated the area would be backfilled with course gravel and rock, and keyed into the existing channel bed to minimize the risk of channel scour during large flow events. A design criterion of the infiltration gallery is that it does not alter the existing (super-critical) flow regime during flood events. Based on a preliminary review of the existing storm drainage network, infiltration galleries will be required at two locations on Del Ganado Road, and five locations along Freitas Parkway.

Revegetation with riparian species would not occur within the channel corridor under this Alternative. However, current road-side plantings located adjacent to the cement channel, and possibly community park landscaping could be replaced over time with locally native tree and shrub species that would provide shade and possibly nesting and roosting habitat. Priority would be afforded to converting vegetation species that are known to be invasive to the natural habitats found within the larger watershed. Species such as cotoneaster, Monterey pine, pittosporum could be replaced by species including coast live and valley oaks, coffeberry, toyon, California sage, coyote brush, wax myrtle, sticky monkey flower and locally-appropriate manzanita species. These species would require less irrigation after establishment, and once established would provide a more habitat-friendly and complex vegetation structure, which could help suppress herbaceous weeds.

Alternative A Preliminary Feasibility Assessment:
This alternative is considered feasible because it will not alter the existing hydraulic flow structure during storm events. The long-term sustainability of the infiltration galleries is questionable as sediment and organic matter may accumulate over time, reducing the infiltration capacity. Design modifications to address this problem could include increasing the area of infiltration and/or routine maintenance.

The construction of the infiltration zones within the creek corridor could indirectly affect the tidal marsh habitat by reducing the year round freshwater flows. It is not anticipated that this would have a significant negative effect on the existing tidal marsh vegetation communities as the salinity of the system already varies seasonally and annually with fluctuations in precipitation and stream discharge. A reduction in summer freshwater base flow into the marsh system could have a greater impact if brackish water dependent plant species have not already established (Cannon, pers. comm., 2004).

5.2 Alternative B: Riparian Restoration in Existing Alignment

Alternative B Rationale:

This scenario entails improving habitat conditions within the creek corridor while maintaining the existing alignment at the center of Freitas Parkway. This design will provide the infiltration benefits of Alternative A, as well as an opportunity to establish a riparian vegetation zone along the banks, and upland vegetation atop the edges. Riparian vegetation will include trees to shade the channel. Additionally, a diverse understory of native plants would be included in the design, providing cover and possibly, food. This scenario will improve water quality both in the reach and downstream, and may allow local benthic organisms and birds to utilize the creek. In addition it will begin to re-establish a corridor between the tidal sections of the creek and its headwaters in the open space. Historical descriptions of the creek system (Starkweather, 1972) include observations of steelhead as far upstream as Las Pavadas Avenue. While the proposed efforts are not likely to yield a significant increase in fish usage, the fundamental features would create possible habitat for fish. This design would also create a large aesthetic benefit for the community.

Alternative B Design Concept:

This design scenario entails removing the existing concrete channel and replacing it with a channel that has a native bed composed of rock, sand and gravel, and terraced banks constructed of concrete blocks that permit vegetation planting. In order to accommodate the increased roughness associated with native bed and partially vegetated banks, the channel widths will need to be increased by varying amounts along the corridor. The existing channel includes 5 to 10 feet of planting bed on either side of the concrete channel. We assume this area is available for inclusion in the restored channel design. The required channel widths will be contingent on flow volume and channel resistance associated with the bank configuration and vegetation that would establish within the design limitations. Small pools would be created where feasible to maximize habitat for wildlife. The design will need to optimize channel geometry within this restricted width. A conceptual image of this alternative is provided in the photograph of the restored creek corridor through downtown Ashland, Oregon (see Figure 13).

Revegetation would occur within the terraced banks. The selection and success of riparian and upland plants species would be primarily contingent on soil texture and composition, summer depth to ground water, exposure, and space availability associated with the bank configuration. The design would maximize the size and continuity of the planting buffer, and to the greatest extent feasible allow for a high number of planting spaces within the rock boulder design to maximize both overstory and understory planting. It is anticipated however, that the majority of the species used for revegetation efforts would be trees and shrubs, with some wetland species planted at the toe-of-slope and lower bank. The design footprint would limit the width of the buffer habitat.

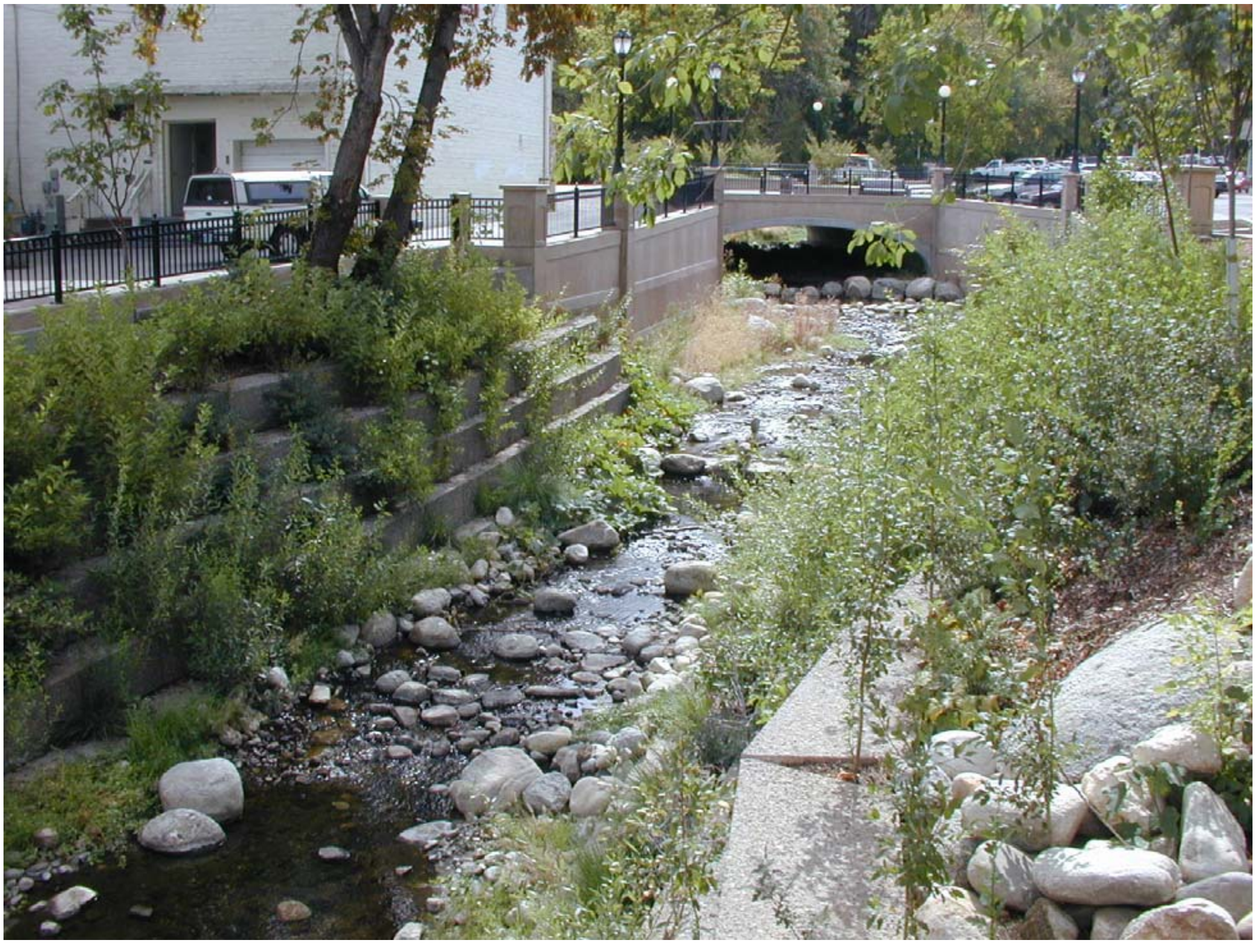


Figure 13: Urban Creek Restoration on Ashland Creek in downtown Ashland, Oregon

Table 9 lists recommended tree and shrub species (as well as their preferred location relative to the creek channel) for consideration during future design. The bank locations (toe-of-slope; lower-, mid-, or upper- bank; and upland) listed in Table 9 refer to where zones of riparian shrub and herbaceous species generally occur in urban creeks within this region.

- The Toe-of-Slope (TOE) zone occurs closest to the channel. Plant species chosen for this region of Gallinas Creek should be very tolerant of frequent inundation, wet soils, and varying levels of scouring.

- The Lower Bank (LB) zone occurs close to the channel just above the toe-of-slope. Plant species chosen for this site would generally be tolerant of occasional inundation and wet soil conditions.

- The Mid bank (MB) zone occurs roughly midway along the bank above the toe-of-slope. Plant species chosen for this site should be tolerant of occasionally moist soil conditions but posses some degree of drought tolerance.

Table 9: Plant Species for Consideration and Bank Locations – Alternative B

Common Name	Scientific name	Gallinas Creek – Potential Bank Location				
		TOE	LB	MB	UB	UP
Large Trees						
California bay	*Umbellularia californica*					●
Coast live oak	*Quercus agrifolia*					●
California buckeye	*Aesculus californica*					●
Small Tree:						
Arroyo willow	*Salix lasiolepsis*	●	●			
Western dogwood	*Cornus sericea*		●	●		
Shrubs:						
California blackberry	*Rubus ursinus*	●	●	●	●	
California coffeeberry	*Rhamnus califonica*			●	●	●
California rose	*Rosa californica*		●	●	●	
Coyote brush	*Baccharis pilularis*			●	●	●
Flowering current	*Ribes sanguineum*		●	●	●	
Snowberry	*Symphorocarpos albus*		●	●	●	●
Toyon	*Heteromeles arbutifolia*			●	●	●

Note: **TOE**: toe-of-slope; **LB**: lower bank; **MB**: middle bank; **UB**: upper bank; **UP:** upland

- The Upper Bank (UB) zone occurs above the mid bank. Plant species chosen for this site should be relatively drought tolerant since there would be little moisture input from the creek.

- The Upland (UP) zone occurs above the upper bank at the top-of-bank or beyond and is situated furthest from the channel. Plant species chosen for this zone should be drought tolerant and adapted to drier conditions.

An invasive non-native plant management plan should also be developed as a part of the restoration design phase. Targeted invasive species and control treatments would be identified. Management of these species following revegetation would be critical, as these species would not only directly compete with native plantings, they also can support several non-native bird species that compete directly and indirectly with native songbird populations. These invasive birds include the European starling, English house sparrow, and brown-headed cowbird.

Alternative B Preliminary Feasibility Assessment:
The feasibility of this alternative is contingent on the ability to maintain the existing flood conveyance capacity. Careful hydraulic analysis of localized transitions in flow regimes will be necessary. Preliminary hydraulic analyses did not simulate this intermediate alternative, but there is likely sufficient flexibility in the design of channel features to minimize channel

roughness and work within the allowable space. Additionally, the feasibility of establishing a contiguous and healthy riparian buffer is contingent on whether or not the summer groundwater depth is high enough. Based on existing conditions, it is anticipated that the summer ground water depth would be greater than 10-15 feet in a section of the restored creek in the upper watershed, limiting willow establishment. However, groundwater levels adjacent to the creek alignment may rise as a result of recharge along a restored earthen channel. Under these conditions, coast live oak, California bay and buckeye trees and a diversity of coastal scrub could be planted instead of willow and wax myrtles to create a vegetation buffer. The diversity of understory species, especially annual, biennial and short-lived herbaceous species would be limited under this Alternative, as there would be limited open soil and sediment deposition, and therefore limited recruitment opportunities.

The reduction in freshwater flow to the tidal marsh system would be greater than that anticipated under Alterative A. However, it is anticipated that the long-term effects on the marsh would be similar to those described above, as well as having benefits to wildlife as described later in this section.

5.3 Alternative C: Riparian Restoration with Realignment

Alternative C Rationale:

By separating the creek and roadway, and integrating the creek with a greenbelt, this alternative creates a closer connection between the community and the creek, and greater separation between the roadway and non-vehicular travelers. Unlike Alternative B, the roadway will not isolate the community from the creek/riparian corridor. Consolidation of the roadway will create more flexibility in the restoration design and increase the potential for diversity of habitats, wildlife use and user experience throughout the greenbelt. Added floodplain storage could ameliorate some of the impacts of development in the watershed. The existing channel, once decommissioned, could be used to dramatically reduce the costs associated with under-grounding utilities. Additional water quality benefits could be realized with the implementation of water quality management features like oil/water separators at appropriate inflow points.

Alternative C Design Concept:

This alternative entails the same bed and bank features described in Alternative B, with realignment of the creek channel to either side of the corridor. The creek/riparian zone would be integrated in a linear park or greenbelt. Where hydraulically necessary (or aesthetically desirable) the channel can be widened using broader terraces to provide increased flow conveyance, flood water storage, high flow cover for aquatic organisms, greater public access, and/or seasonal picnic or resting areas adjacent to creek-side plantings. Portions of existing triangular parks may be lowered to create floodplain storage if needed. The consolidation of the roadway affords greater opportunity to increase the size of the riparian buffer, the extent and diversity of the lower creek bank species, as well as the opportunity for creating a riparian/coastal scrub and woodland interface, extending into newly created pockets of upland habitat. The buffer size would be maximized so as to maximize wildlife habitat. Table 10 lists a number of recommended plant species (as well as their preferred location relative to the creek channel) for consideration during future design.

Table 10: Plant Species and Bank Locations – Alternatives C and D

Common Name	Scientific name	Gallinas Creek – Potential Bank Location				
		TOE	LB	MB	UB	UP
Large Trees						
California bay	*Umbellularia californica*					●
Coast live oak	*Quercus agrifolia*					●
California buckeye	*Aesculus californica*					●
Small Tree:						
Arroyo willow	*Salix lasiolepsis*	●	●			
Western dogwood	*Cornus sericea*		●	●		
Shrubs:						
California blackberry	*Rubus ursinus*	●	●	●	●	
California coffeeberry	*Rhamnus califonica*			●	●	●
California rose	*Rosa californica*		●	●	●	
Coyote brush	*Baccharis pilularis*			●	●	●
Mugwort	*Artemesia douglasiana*	●	●	●		
Flowering current	*Ribes sanguineum*		●	●	●	
Snowberry	*Symphorocarpos albus*		●	●	●	●
Toyon	*Heteromeles arbutifolia*			●	●	●
Sticky monkey flower	*Mimulus aurantiacus*			●	●	●
Herbs:						
Wild Strawberry	*Frageria vesca*		●	●	●	
Douglas iris	*Iris douglasiana*			●	●	
Maidenhair fern	*Adiantum jordanii*			●	●	
Lady fern	*Athyrium filex-femina*			●	●	
Wood fern	*Dryopteris arguta*			●	●	
Sword fern	*Polysticium munitun*			●	●	

Note: **TOE**: toe-of-slope; **LB**: lower bank; **MB**: middle bank; **UB**: upper bank; **UP:** upland

Similar to Alternative B, an Invasive Non-native Management Plan would be developed as a part of the project's design phase.

Alternative C Preliminary Feasibility Assessment:

The feasibility of this alternative is contingent on the ability to maintain existing flood conveyance capacity and infrastructural and traffic constraints within the corridor. The width constraints summarized in Table 8, as well as at other locations, will dictate the degree of channel and flood plain restoration that is feasible as well as the channel character in terms of degree of bank stabilization structures. Again, careful hydraulic analyses will be required to design a functional and sustainable corridor. Earlier habitat restoration, plant establishment discussions under Alternatives A and B apply.

5.4 Alternative D: Full Restoration with Realignment and High Flow Bypass

Alternative D Rationale:

This scenario follows the same rationale as Alternative C for relocating the channel to one side of the Freitas Parkway corridor. However, this concept incorporates a channel design comparable to the historical "natural" channel with earthen bed and banks. The design facilitates establishment of ecologically functional creek and riparian habitats. To provide a comparable level of flood protection to the community and minimize the potential for destructive channel scour and erosion during large storm events, the design includes bypassing high flows through a large diameter, buried storm drain. Bypassing high flows creates the most design flexibility in creating a linear green belt that serves non-vehicular transportation, recreation and stream restoration objectives.

This design would promote natural geomorphic processes and ecological functions within the corridor to the fullest extent possible. The result is a linear park where the public can travel and recreate along a stream channel, which runs as a unifying thread through the community, connecting the open space of the headwaters and the downstream tidal channel.

Alternative D Design Concept:

The design utilizes a two-stage channel, consisting of a small "low flow" earthen channel and higher broader terrace(s). Select sections of the Miller Creek channel serve as likely references for designing bed and bank features. Terraces will be construed in a variety of sizes and elevations, depending on hydraulics, site constraints, and public use and habitat objectives. The bypass channel, along with utilities and other necessary infrastructure can be located within the existing channel alignment and covered by the roadway. The geometry of the channel and terraces, as well as the elevation and size of the bypass storm drain should be determined through detailed hydraulic analyses. The greenbelt would be revegetated with native woodland trees, coastal scrub shrubs and riparian plants. The Alternative D design would allow for the greatest opportunity for natural recruitment of wetland and riparian species within the corridor, due to the more dynamic nature of the proposed system. This would allow for increased diversity of plants, to include a larger number of annual, biennial species, and disturbance favoring species. Multi-use pathways could be created on both high and low terraces to permit varying seasonal use. An earthen or decomposed granite pathway would be used on the lower terrace. A hard surface would be use don the upper terraces beyond the limit of seasonal flood impacts.

The design could be brought up Freitas Parkway. However, realignment of the creek is not recommended along Del Ganado Road where residential driveways line both the North and

South sides of the street. In this reach, increased channel width and aggressive planting efforts will be needed to create a riparian zone along the existing roadway alignment.

Alternative D Preliminary Feasibility Assessment:
The feasibility of this alternative is contingent on the ability to maintain existing flood conveyance capacity and infrastructural and traffic constraints within the corridor. The width constraints summarized in Table 8, as well as at other locations, are not as stringent in dictating the degree of channel and flood plain restoration that is feasible because of the additional floodwater conveyance associated with the buried high-flow bypass. Again, careful hydraulic analyses will be required to design a functional and sustainable corridor.

Earlier habitat restoration, plant establishment discussions under Alternatives A, B and C apply. Additionally, the plant species listed in Table 10 above could also be considered for future revegetation efforts under this Alternative.

5.5 Possible Effects on Wildlife Under Habitat and Future Design Considerations

5.5.1 Birds

The restoration efforts along Del Ganado Road and Freitas Parkway would have significantly beneficial impacts on breeding birds normally associated with riparian habitats. It is anticipated that birds would move into the newly provided habitat in stages as the habitat matures. Table 11 lists the birds that would most likely use the riparian corridor for breeding, and categorizes the species according to the estimated timing of their arrival as breeders to the restored habitat areas. It should be noted, that these estimates are dependent upon the size and quality of habitat restored within the corridor. The greatest benefits and species utilization of the restored habitats would be achieved under Alternative D, with similar but less benefits under Alternative C. It is anticipated that Alternative B would have less colonization and species richness.

Following restoration and planting efforts, bird species that might initially use the habitat would be mainly cup-nesting small species. After about 7 years, the vegetation may become mature enough to offer nesting sites for birds that require hollows - some larger species, requiring sturdier nest support may also move in. After about 15 years, the trees will become large enough to develop larger hollows for larger species and provide structural support for species that build large nests. Many bird species will use the habitat for foraging and as a sheltered transportation route long before the habitat is mature enough to provide nesting habitat.

All four of the species on the 2002 Audubon Watchlist would benefit from this increased availability of riparian habitat. The oak titmouse primarily breeds in oak woodland habitat but will use riparian habitat for feeding where it is adjacent to oak woodland habitat, as in this case. Oak titmice are cavity nesters so they most likely would not be able to use the habitat for nesting for several years. The Nuttall’s woodpecker also shares the same habitat requirements as the oak titmouse and likewise would use the riparian corridor for foraging in the early stages of maturation and would use nest hollows as the trees mature. Allen’s hummingbird would benefit most significantly from the restoration of riparian habitat along the creek because they are sparse breeders in oak woodland (adjacent habitat) and readily breed in riparian habitat in coastal counties. Allen’s hummingbird would be likely to move into the habitat almost immediately after restoration. Band-tailed Pigeons could benefit initially by the restoration because of increased foraging opportunities but would need mature trees for nesting.

As these Audubon Watchlist species and other species use the riparian corridor, individuals would move up and down the stream. Individuals would travel to areas otherwise unavailable, and this movement could facilitate genetic exchange among populations. This effect could be most significant in the song sparrow population. The restoration may create a narrow corridor of possible genetic exchange between the San Pablo song sparrow (*Melospiza melodia samuelis*) and the local upland song sparrow (*M. melodia gouldii*) that would likely use the riparian corridor.

There are also a number of birds that could use the riparian habitat as an over-wintering site. These birds would benefit almost immediately from the restored riparian habitat. These species include: Ruby-crowned Kinglet (*Regulis calendula)*, Hermit thrush (*Catharus guttatus*), varied thrush (*Ixoreus naevius)*, yellow-rumped Warbler (*Dendroica coronata*), Townsend's warbler (*Dendroica townsendi*), white-crowned sparrow (*Zonotrichia leucrophys*), golden-crowned sparrow (*Zonotrichia atricapilla*), white-throated sparrow (*Zonotrichia albicollis*), and the fox sparrow (*Passerella iliaca*).

It is possible that encouraging birds to use an urban habitat near a roadway may have deleterious effects on those populations. There could be some mortality due to traffic and predation by domestic and feral cats. There may also be some disturbance to nesting birds by innocent pedestrians and curious children recreating within the restored corridor. If the two lanes of the road are consolidated, as in restoration Alternatives C or D, and the creek is allowed to flow beside the road rather than between the two lanes, then the risk of the birds being injured or killed by traffic would be reduced. However, implementing these alternatives may increase the risks of being disturbed by domestic cats and humans. It is anticipated that these negative impacts would be offset by the advantage of providing additional breeding habitat for these species.

While the restored creek-side vegetation may not be as ideal as a large expanse of natural landscape, it could provide breeding territories for birds that get pushed out of ideal territories. Birds capable of breeding in less than ideal circumstances may provide hearty genetic stock for future generation of birds that very likely will be faced with decreasing habitat quality and increased urban existence.

Wildlife using the lower downstream tidal marsh section of the watershed, just east of Highway 101 (behind several industrial buildings by Mitchell Avenue and next to a housing complex along Yosemite Road) could be positively influenced by the restoration of the upper watershed to riparian habitat. California Clapper Rails (*Rallus longirostris obsoletus*) use this marsh sporadically for breeding, but it is not ideal habitat. It has been utilized at least once since the early 1990's and in 2004 there were four to five pairs using this marsh. It is probable that this area is used as a "spill-over" site from the substantial population downstream (Evens, pers. Comm.., 2004). It is likely that restoring the riparian habitat upstream of this marsh may reduce the amount of freshwater infiltration and allow for increased salinity in areas further upstream during high tides and increase the volume of this marsh, making it more ideal for California

Clapper Rails (Evens, pers. comm., 2004). Increasing the size of this marsh may also increase breeding populations of Saltmarsh common yellowthroat and San Pablo song sparrow which thrive in tidal marsh bordered by rank vegetation.

Moving further downstream to the junction of the North and South Forks of Gallinas Creek, there is a large brackish tidal marsh behind the McGinnis Golf Course. Upstream creek restoration could possibly improve conditions. This is the best habitat for the breeding ducks. Black-necked stilt and American avocet nest in this marsh. The riparian habitat restoration upstream may help these breeding species as the process will allow for the expansion of the salt-water habitat, possibly reducing the probability of nests being flooded and destroyed during high tides. Virginia rails fall victim to predation during high tides and the movement of salt water further upstream would leave more exposed vegetation available for cover. Northern harriers use this marsh for nesting and foraging. Therefore, the impact of the brackish water habitat moving further upstream could also decrease the chances of nest loss for this species. Ospreys feed on fish in the Bay and creek. The restored habitat upstream would have a positive impact for fish using the stream and therefore potentially increase prey availability for the Osprey. This marsh is also a significant foraging site for great blue heron, great egret, and snowy egret (Bajema, pers. comm., 2004).

The restoration of the upper watershed of Gallinas Creek to riparian could also somewhat influence the very lowest part of the watershed - the last 2 miles upstream from the mouth at San Pablo Bay. This area is an extensive salt marsh that supports a significant population of California clapper rails and a low-density population of California black rails (Evens, 2004; Spautz and Nur, 2002). Restoration of the upper watershed habitat would reduce fresh water flow into the marsh and allow for increased salinity in areas that are currently brackish, thereby extending the salt marsh habitat. This would be mainly beneficial for California black rails because they are currently impacted from a lack of vegetation for shelter when the tides are very high. Herons, egrets, and raptors will capture the small rails during high tides. The hydraulic changes may allow the salt water to move upstream more readily and therefore leaving more vegetation exposed for the California black rails to use as cover.

5.5.2 Mammals

All of the small mammal, reptile and amphibian species listed in Table 6 would benefit from the increased shelter of the vegetation near an accessible water source and increased food supply. The smallest mammals such as the Trowbridge shrew, shrew-mole, broad-footed Mole and deer mouse would most likely be the earliest colonizers of the site. They require very little in terms of cover. As the corridor vegetation matured, larger mammals such as brush rabbits, striped skunk and raccoons would most likely utilize the habitat. Western gray squirrel would only colonize the corridor after the trees became suitably tall enough for it to build a nest at least 20 feet above the ground (Whitaker, 1980).

In addition, there are several species of bats that would benefit from the corridor, especially as feeding grounds or as a transportation route between breeding and feeding sites. Several tree nesting species might use the corridor for foraging and eventually for breeding and roosting as the trees mature. Additionally, the bats residing in the Terra Linda/Sleepy Hollow Divide Open Space Preserve may use the corridor as a protective transportation route to feeding areas. The

Pallid bat feeds mainly on the ground and requires open areas for feeding so it is not likely to use the corridor for feeding. However, the Townsend's long-eared bat may use the corridor for feeding.

These mammals are subject to the same advantages and disadvantages as the bird populations. While these mammals risk being injured or dying because of the attraction to the narrow corridor in an urban environment, they also benefit from the increased availability of breeding and feeding habitat. They are more able to travel from area to area in a sheltered environment, and this advantage facilitates gene flow between otherwise isolated populations. This should outweigh the risks of being hit by a car, killed by a cat, or disturbed by humans.

River otters may also benefit from the upstream restoration by the increased tidal marsh size near the Yosemite Road housing development. If Alternative C or D is used in the restoration plan, providing still-water pools along the watercourse could encourage the river otter to move upstream into the upper watershed.

The salt marsh harvest mouse resides in many of the same areas as the California Clapper Rail. Most of the population would be located in the outer salt marshes near the mouth of Gallinas Creek. The restoration of riparian habitat in the upper watershed may have some positive influences for this mammal. The main threats to salt marsh harvest mouse populations are infiltration of freshwater into the saltwater marshes by sewage treatment plants and by the lack of sufficient escape habitat available to the mice during very high tides. Herons and raptors prey upon this species when they are forced from vegetation during very high tides. Increased fresh water inflow into the lower marshes and the greater ability for the salt water to move upstream may alleviate some of these stresses for the salt marsh harvest mouse.

5.5.3 Amphibians, Reptiles and Fish

There are some species of snakes and lizards that would inhabit the upper watershed in a restored riparian corridor. Below is a list of reptiles most likely to utilize the restored riparian habitat (Fellers, pers. comm., 2004):

- Western fence lizard (*Sceloporus occidentalis*)
- Western skink (*Eumeces skiltonianus*)
- Northern alligator lizard *(Elgaria coerulea*)
- Southern alligator lizard (*Elgaria multicarinata*)
- Sharp-tailed snake (*Contia tenuis*)
- California kingsnake (*Lampropeltis getula california*e)
- Gopher snake (*Pituophis catenifer*)
- Western terrestrial garter snake (*Thamnophis elegans*)
- Western aquatic garter snake (*Thamnophis atratus*)
- Red-sided garter snake (*Thamnophis sirtalis*)

Many of these animals would already exist either in the lower watershed or in the Marin County Open Space land adjacent to the headwaters of Gallinas Creek. Once the habitat was established, they could freely move in to the corridor.

Western pond turtle (*Clemmys marmorata*) may benefit from the restoration of Gallinas Creek. If the creek is restored in such a way that there are still-water pools along the watercourse, then the Turtle could inhabit the area. It might be necessary to recruit turtles from other sites to get them established (Fellers, pers. comm., 2004).

Below is a list of amphibians that would be likely to move in to the corridor from adjacent Marin County Open Space land, or from the lower watershed:

- Rough-skinned newt (*Taricha granulose*)
- California Slender Salamander (*Batrachoceps attenuatus*)
- Ensatina (*Ensatina eschscholzii*)
- Western toad (*Bufo boreas*)
- Pacific treefrog (*Hyla regilla*)

California red-legged frog (*Rana aurora draytonii*) and Foothill Yellow-legged Frog (Rana *boylii*) may also benefit from the restored corridor. California red-legged frogs breed in ponds, but they also use streams during the non-breeding season for feeding grounds (Fellers, pers. comm., 2004). The foothill yellow-legged Frogs would need sunny, still-water pools along the watercourse to be able to inhabit the area. They also may need to be recruited from other sites to become established (Fellers, pers. comm., 2004).

The reptiles and amphibians using the corridor would suffer the highest risks of disturbance or mortality by traffic, humans and pets. Reptiles tend to be slow when they are cold (especially turtles) and are very vulnerable to being captured by humans and their pets. Snakes are sometimes intentionally persecuted by humans and sometimes even deliberately killed.

Steelhead could benefit significantly from a restored riparian habitat in the upper Gallinas watershed. The adults swim upstream to spawn. The young usually remain in fresh water for 2-3 years before swimming downstream to reach the sea (Eschmeyer, Herald and Hammann, 1983) In 1997, the population of Steelhead in Miller Creek upstream of Highway 101 was estimated to be about 5 per 30 meters (Leidy et al., 2003). Restored habitat could present the potential for fish passage, however the design of the creek bed and its associated substrate would have to be compatible with essential fish habitat requirements. Because steelhead live in the water, they would not be as exposed to the direct risks associated with traffic, humans, and their pets, however protection of water quality would be essential.

7.0 LIMITATIONS

The hydrologic and hydraulic analyses presented in this report are intended solely to assist in characterizing site conditions and developing conceptual restoration alternatives. It should be recognized that the hydraulic modeling analyses were completed with a minimum number of cross-sectional profiles and with a simple hydrodynamic model that does not account for the dynamic (flood event duration) effects of scour, sediment transport, or sediment deposition in the channel and ocean outfall. Channel morphology conditions may be significantly different during storms than those simulated. This report should be considered an informational document and should not be used for the final design of creek/estuary restoration or flood control improvement projects. If the watershed undergoes significant change, the results of this analysis may be rendered unrepresentative of the altered conditions.

8.0 REFERENCES

Arcement, G.J., Jr., and Schneider, V.R., 1989, Guide for selecting Manning's roughness coefficients for natural channels and flood plains. U.S. Geological Survey Water Supply Paper 2339, prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration, 38p.

Atwater, B.F., Hedel, C.W., Helley, E.J., 1977, Late Quaternary Depositional History, Holocene Sea-Level Changes, and Vertical Crustal Movement, Southern San Francisco Bay, CA. U.S. Geological Survey Professional Paper 1014, 15p.

The 2002 Audubon Watchlist, 2002, National Audubon Society. http://audubon2.org/webapp/watchlist/viewwatchlist.jsp

Bajema, B., 2004, Personal Communication, Vice President. Marin Audubon Society. Mill Valley, CA.

Bonaparte, R., and Mitchell, J.K., 1979, The properties of San Francisco Bay mud at Hamilton Air Force Base, CA. Department of Civil Engineering, University of California, Berkeley, April, 1979, 179p.

Brown, Philip R., 1997, A Field Guide to Snakes of California. Gulf Publishing Co. Houston.

Burcham, L.T., 1957, California range land: a historic ecological study of the range resource of California. California Division of Forestry, Sacramento. 261 pages.

California Endangered and Threatened Species Lists. California Department of Fish and Game. www.dfg.ca.gov/hcpb/species/species/.shtml

California Natural Diversity Database. California Department of Fish and Game. www.dfg.ca.gov/whdab/html/cnddb.html

Chow, V.T., 1959, Open-channel hydraulics. McGraw-Hill, Inc., New York, 680p.

Coon, W.F., 1998, Estimation of roughness coefficients for natural stream channels with vegetated banks. U.S. Geological Survey Water Supply Paper 2441, prepared in cooperation with the New York State Department of Transportation, 133p.

Cowardin, L.M., Carter, V., Golet, F.C., and LaRoe, E.T., 1979, Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, FWS/OBS-79/31, December.

Davis, S. D., and H. A. Mooney., 1985, Comparative water relations of adjacent California shrub and grassland communities. Oecologia 66: 522–529.

Denby, G.M., 1978, Self-boring pressure meter study of the San Francisco Bay mud. A dissertation submitted to the Department of Civil Engineering, Stanford University, CA, in partial fulfillment of the degree of Doctor of Philosophy, July, 270p.

Eschmeyer, William N; Herald, Earl S; Hammann, Howard., 1983, A Field Guide to the Pacific Coast Fishes of North America. Houghton Mifflin Co. Boston.

Evens, Jules., 2004, California Clapper Rail (*Rallus longirostris obsoletus*) Breeding Season Survey, San Pablo Bay and Tributaries 2004. Final Report to Marin Audubon Society. Avocet Research Associates. Point Reyes, CA. 95956. May 28, 2004. revised June 9.

Evens, Jules., 2004, Personal Communication, Avocet Research Associates. Point Reyes, CA. 95956.

Fairley, L., 1987, Mount Tamalpias: a history. Scotwall Associates, San Francisco, California. 201 pages.

Fellers, Gary. 2004, Personal Communication. Research Biologist. Western Ecological Research Center USGS. Point Reyes National Seashore. Point Reyes, CA. 95956

FEMA, 1977, Flood Insurance Study, City of San Anselmo, CA, Marin County. Completed by precursor agency to FEMA – U.S. Department of Housing & Urban Development, Federal Insurance Administration, Community Number 060180, revised February, 1977, 12p.

FEMA, 1989, Flood Insurance Study, City of Novato, CA, Marin County. Community Number 060178, revised September 29, 1989, 17p.

FEMA, 1997, Flood Insurance Study, Marin County, California, unincorporated areas. Community Number 060173, revised May 5, 1997, 39p.

FEMA, 1997b, Flood Insurance Study, City of San Rafael, CA, Marin County. Community Number 065058, revised January 3, 1997, 25p.

FEMA, 1997c, Flood Insurance Rate Map, City of San Rafael, CA, Marin County. Community Number 065058 0005C, panel 5 of 20, map revised January 3, 1997.

Geomatrix Consultants, Inc., 1994, Draft report-geotechnical engineering study, Hamilton Field Phase I Development. April, 1994.

Goals Project, 1999, Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. First Reprint. U.S. Environmental Protection Agency, San Francisco, California/S.F. Bay Regional Water Quality Control Board, Oakland.

Goals Project, 2000, Baylands Ecosystem Species and Community Profiles. Life histories and environmental requirements of key plant, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P.R. Olofson, editor, San Francisco, California/S.F. Bay Regional Water Quality Control Board, Oakland.

Grinnell, Joseph and Miller, Alden H., 1986, The Distribution of the Birds of California. Cooper Ornithological Club. 1944. Reprinted by Artemisia Press.

Howell, J.T., 1970, Marin Flora. 2nd Edition. University of California Press, Berkeley, California. 366 pages.

Hynding, A., 1982, From frontier to suburb: the story of the San Mateo Peninsula. Star Publishing Company, Belmont, California.

Jameson, E.W.Jr. and Peeters, Hans J., 1988, California Mammals. University of California Press. Berkeley.

Leidy, Robert A; Becker Gordon S. and Havey, Brett N., 2003, Historical Distribution and Current Status of Steelhead (*Oncorhynchus mykiss*), Coho Salmon (*O.kisutch*) and Chinook Salmon (*O. tshawytscha*) in Streams of the San Francisco Bay Estuary, October. Robert A. Leahy, U.S. Environmental Protection Agency, Region 9, San Francisco, CA 94105; Gordon S. Becker and Brett N. Havey, Center for Ecosystem Management and Restoration. Oakland, CA. 94611.

Limerinos, J.T., 1970, Determination of the Manning coefficient from measured bed roughness in natural channels. U.S. Geological Survey Water Supply Paper 1898-B, 47p.

Marin County Department of Public Works, 1973, Master drainage plan for the San Rafael Meadows Flood Control Zone. Prepared for Marin County Flood Control & Water Conservation District, April, 18p.

Marin County Flood Control & Water Conservation District, 1998, 1998 Drainage report approved by Advisory Board for San Rafael Meadows Flood Control Zone 6. September, 10p.

Marin County Open Space District. http://enature.marinopenspace.org/openspace/mcosd/localguide_parkfinder_display.asp?rgn=PK_1062

McClatchie, A.J., 1902, Eucalyptus Cultivated in the United States. USDA Bureau of Forestry, Bulliten No. 35. Washington (D.C.) Government Printing Office.

Munz, P.A., and Keck, D.D., 1968, A California flora with supplement. University of California Press, Berkeley, CA. 1681, 224p.

Oberkamper & Associates, 2000, Storm Drainage Study, Ranchitos Park, San Rafael, CA. Prepared for Signature Properties, April, 6p.

Oberkamper & Associates, 2001, Storm Drainage Study, Ranchitos Park, San Rafael, CA. Prepared for Signature Properties, February, 5p.

Oberkamper & Associates, 2001b, Letter regarding Ranchitos Park Storm Drainage Study. Prepared for Signature Properties, January 18.

Oberkamper & Associates, 1999, Letter report regarding Drainage, Merrydale Road, and PG&E property (hydraulic analysis of the Merrydale Road drainage system). Prepared for Signature Properties, February 24.

Page, B.M., 1979, Effects of Late Jurassic-Early Tertiary subduction in CA. In: Franciscan Rock Types, Program and field guide for the National Association of Geology Teachers-Far Western Section, fall conference, October 27-28, 1979, pp. 1-10.

Rantz, S.E., 1971, Mean annual precipitation depth-duration-frequency data for the San Francisco Bay Region, California. United States Geological Survey, Water Resources Division open-file report, prepared in cooperation with the U.S. Department of Housing and Urban Development, 23p.

Rantz, S.E., 1971b, Suggested Criteria for Hydrologic Design of Storm-drainage Facilities in the San Francisco Bay Region, California. United States Geological Survey, Water Resources Division Open-file Report, prepared in cooperation with the U.S. Department of Housing and Urban Development, 69p.

Rantz, S.E., 1974, Mean annual runoff in the San Francisco Bay Region, California, 1931-70. United States Geological Survey, Water Resources Division Miscellaneous Field Studies Map (MF-613).

Rice, S.J., Smith, T.C., and Strand, R.G., 1976, Geology for planning, central and southeastern Marin County, CA. California Division of Mines and Geology open file report 76-02 (with geologic map), pp. 33-46.

Savage, S. M., 1974, Mechanism of fire-induced water repellency in soil. Soil Science Society or America Proceedings 38:652-657.

Sawyer, J.O., Thornburgh, D.A., and Griffin, J.R., 1977, Pages 359-382, In: M.G. Barbour and J. Major, eds. Terrestrial vegetation of California, John Wiley and Sons, New York.

Shuford, W. David., 1993, The Marin County breeding bird atlas: a distributional and natural history of coastal California birds. Bushtit Books, P.O. Box 233, Bolinas, CA 94924.

Sibley, David Allen., 2003, The Sibley Field Guide to Birds of Western North America. Alfred A. Knopf. New York.

Sokale, Jana., 2004, Personal communication. Principal Investigator. Bay Trail Project Wildlife Study. Oakland, CA.

Soil Conservation Service, 1985, Soil survey of Marin County, California. United States Department of Agriculture in cooperation with the Regents of the University of California (Agricultural Experiment Station), March, 229p.

Spautz, H. and Nur, N., 2002, Distribution and abundance in relation to habitat and landscape reatures and nest site characteristics of California Black Rail (Laterallus jamaicensis coturniculus) in the San Francisco Bay Estuary. Final report to the U.S. Fish and Wildlife Service, Point Reyes Bird Observatory, 4990 Shorline Highway, Stinson Beach, CA 94970.

Species Account: Salt Marsh Harvest Mouse (Reithrodontomys raviventris). Sacramento Fish and Wildlife Service Office, www.sacramento.fws.gov/es/animall_spp_acct/salt_marsh_harvest_mouse_.htm.

Stallcup, Rich., 2004, Field Checklist of Birds Point Reyes National Seashore. Point Reyes National Seashore Association. Point Reyes, Ca. 94956

Stanger, Frank M., 1967, Sawmills in the Redwoods: Logging on the San Francisco Peninsula, 1849-1967. San Mateo County Historical Society, San Mateo, California.

Starkweather, J., 1972, The natural history of Terra Linda as told by Water Freitas: a conversation with Jean Starkweather, December 18, 1972. Unpublished manuscript, 3p.

Starkweather, J., 1974, Conversation with Thomas Nunes, January 11, 1974. Unpublished manuscript, 1p.

Stebbins, Robert C., 2003, Western Reptiles and Amphibians. Houghton Mifflin Co. Boston. 2003.

Toogood, A.C., 1980, A civil history of the Golden Gate National Recreation Area and Point Reyes National Seashore, California. Denver: Historic Preservation Branch, Pacific Northwest Team, Denver Service Center, National Park Service, United States Dept. of the Interior. 2v.

Trask, P.D., and Rolston, J.W., 1951, Engineering geology of San Francisco Bay, California. in Bulletin of the Geological Society of America, vol. 32, pp. 1079-1110.

Treasher, R.C., 1963, Geology of the Sedimentary Deposits in San Francisco Bay, California. Bulletin of the Geological Society of America, v. 62, p. 1079-1110.

Whitaker, John O. Jr., 1980, The Audubon Society Field Guide to North American Mammals. Alfred A. Knopf Inc. New York.

Woodward-Clyde Consultants, 1996, Additional environmental investigation report, BRAC property, Hamilton Army Airfield. Prepared for U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA, February 1996.

Woodward-Clyde Consultants, 1997, Summary technical report for Landfill 26 at Hamilton Army Airfield: Geological and chemical data analysis. Prepared for U.S. Army Corps of Engineers, Sacramento District, Sacramento, CA, February 1997.

TABLES

TABLE 2: FEMA Flood Flow Estimates for Area Creeks

	Source[1] of Data	Drainage Area sq. mi.	Drainage Area acres	Q_{10} cfs	Q_{50} cfs	Q_{100} cfs	Q_{500} cfs
Sorich Drainage (San Anselmo)	SA	0.42	268.8	110	190	230	315
Ignacio Creek @ San Jose Cr	NO	1.3	832	400	650	800	1000
San Rafael @ 2nd St	SR	1.3	832	400	705	830	1100
Vineyard Cr us unnamed	NO	1.43	915.2	370	530	610	790
San Rafael @ D St	SR	1.5	960	725	1165	1350	1740
Vineyard Cr ds unnamed	NO	1.69	1081.6	490	700	810	1040
Pacheco Cr @ NWP R.R.	NO	1.69	1081.6	470	670	770	980
Arroyo Avichi @ Novato Cr.	NO	1.78	1139.2	550	770	890	1140
Wilson Cr. @ mouth	NO	1.88	1203.2	520	750	860	1100
San Rafael @ Ritter St	SR	2.3	1472	740	720	690	810
Vineyard Cr @ mouth	NO	2.6	1664	580	830	960	1230
Sleepy Hollow Cr	SA	3	1920	650	1050	1300	1800
San Rafael @ Grand Ave	SR	4.3	2752	1430	1865	1995	2500
Warner Cr ds of Wilson Cr.	NO	4.47	2860.8	1080	1540	1770	2280
Warner Cr u.s. Novato Cr	NO	5.18	3315.2	1260	1800	2080	2680
Arroyo San Jose @101	NO/UI	5.4	3456	1200	1900	2300	2900
Miller Creek @ mouth	UI	9.35	5984	1600	2540	2870	3395
San Anselmo Cr.	SA	10	6400	2200	3150	3950	4900

Notes:

1) Sources: FEMA Flood Insurance Studies; SA=San Anselmo, SR=San Rafael, NO=Novato, and UI=unicorporated Marin County.

TABLE 3:
BREEDING BIRD SPECIES OF LAS GALLINAS CREEK WATERSHED
(UPPER AND LOWER)

Species		Status
Common Name	**Scientific name**	
Pied-billed Grebe	*Podilymbus podiceps*	
Great Blue Heron	*Ardea herodias*	MCSC
Great Egret	*Ardea alba*	MCSC
Snowy Egret	*Egretta thula*	MCSC
Black-crowned Night-Heron	*Nycticorax nycticorax*	MCSC
Mallard	*Anas platythrynchos*	
Northern Pintail	*Anas acuta*	MCSC
Blue-winged Teal	*Anas discors*	
Cinnamon Teal	*Anas cyanoptera*	
Northern Shoveler	*Anas clypeata*	MCSC
Gadwall	*Anas strera*	MCSC
Ruddy Duck	*Oxyura jamaicensis*	MCSC
Turkey Vulture	*Cathartes aura*	
Osprey	*Pandeon haliaetus*	SSC
Black-shouldered Kite	*Elanus leucurus*	
Northern Harrier	*Circus cyaneus*	SSC
Red-shouldered Hawk	*Buteo lineatus*	
Red-tailed hawk	*Buteo jamaicensis*	
American Kestrel	*Falco sparverius*	
California Quail	*Oreotyx pictus*	
Californai Black Rail	*Latirallus jamaicensis coturniculus*	ST
California Clapper Rail	*Rallus longirostris obsoletus*	SE, FE
Virginia Rail	*Rallus limicola*	MCSC
American Coot	*Fulica americana*	
Killdeer	*Charadrius vociferus*	
Black-necked Stilt	*Himantopus mexicanus*	MCSC
American Avocet	*Recurvirostra americana*	MCSC
Band-tailed Pigeon	*Columba faxciata*	AWL
Mourning Dove	*Zenaida macroura*	
Barn Owl	*Tyto alba*	
Western Screech-Owl	*Otus kennicottii*	
Great Horned Owl	*Bubo virginianus*	
Anna's Hummingbird	*Calypte anna*	
Allen's Hummingbird	*Salasphorus sasin*	AWL
Belted Kingfisher	*Ceryle alcyon*	
Acorn Woodpecker	*Melanerpes formicivorus*	
Nuttall's Woodpecker	*Picoides nuttallii*	AWL
Downy Woodpecker	*Picoides pubescens*	
Hairy Woodpecker	*Picoides villosus*	
Northern Flicker	*Colaptes auratus*	
Western Wood-Pewee	*Cantopus sordidulis*	
Pacific-slope Flycatcher	*Empidonax difficilis*	
Black Phoebe	*Sayornis nigrcans*	
Ash-throated flycatcher	*Myiarchus cinierascens*	
Western Kingbird	*Tyrannus verticalis*	
Horned Lark	*Eremophila alpestris*	
Tree swallow	*Tachycineta bicolor*	

TABLE 3:
BREEDING BIRD SPECIES OF LAS GALLINAS CREEK WATERSHED
(UPPER AND LOWER)

Species		**Status**
Common Name	**Scientific name**	
Violet-green Swallow	*Tachycineta thallassina*	
Cliff Swallow	*Petrochelidon pyrrhonota*	
Barn Swallow	*Hirundo rustica*	
Steller's Jay	*Cyanocitta stelleri*	
Western Scrub Jay	*Aphelocoma californica*	
American Crow	*Corvus brachyrhychos*	
Common Raven	*Corvus corax*	
Chestnut-backed Chickadee	*Poecile rufescens*	
Oak Titmouse	*Baeolophus inornata*	AWL
Bushtit	*Psaltriparus minimus*	
White-breasted Nuthatch	*Sitta carolinensis*	
Bewick's Wren	*Thryomanes bewickii*	
Marsh Wren	*Cistothorus palustris*	
Western Bluebird	*Sialia mexicana*	
Swainson's Thrush	*Catharus ustulatus*	
American Robin	*Turdus migratorius*	
Wrentit	*Chamaea fasciata*	
Northern Mockingbird	*Mimus polyglottos*	
Loggerhead Shrike	*Lanius excubitor*	
Hutton's Vireo	*Vireo hutoni*	
Warbling Vireo	*Vireo gilvis*	
Orange-crowned Warbler	*Vermivora celata*	
Saltmarsh Common Yellowthroat	*Geothlypis trychas sinuosa*	SSC
Wilson's warbler	*Wilsonia pusilla*	
Black headed Grosbeak	*Phaeucticus melanocephalus*	
Spotted Towhee	*Pipilo erythrophthalmus*	
California Towhee	*Pipilo crissalis*	
Song Sparrow	*Melospiza melodia gouldii*	
San Pablo Song Sparrow	*Melospiza melodia samuelis*	SSC
Dark-eyed Junco	*Junco hyemalis*	
Red-winged Blackbird	*Agelaius phoeniceus*	
Western Meadowlark	*Sturnella neglecta*	
Brewer's Blackbird	*Euphagus cyanocephalus*	
Brown-headed Cowbird	*Molothrus ater*	
Hooded Oriole	*Icterus cucullatus*	
Bullock's Oriole	*Icterus bullockii*	
Purple Finch	*Carpodacus purpureus*	
House Finch	*Carpodacus mexicanus*	
Lesser Goldfinch	*Cardeulis psaltria*	

Legend
MCSS= Marin County Breeding Species of Special Concern
SSC=State Species of Special Concern
FE= Federally Threatened
SE = State Endangered
FT = Federally Threatened
SSC=State Species of Special Concern

TABLE 4:
Wildlife Species with Special Population Status in Gallinas Creek Watershed

species	status	habitat requirements	Potential Effect of Restoration Activity
Allen's Hummingbird, *Selasphorus sasin*	AWL	riparian forest	P provide nesting habitat
American Avocet, *Recurvirostra americana*	MCSS	marsh with open ground	O - P flooding of nests at high tides may occur less frequently
Band-tailed Pigeon, *Columba fasciata*	AWL	mature forest	P increase foraging and nesting availabilty
Black-crowned Night-heron, *Nycticorax nycticorax*	MCSS	large trees, open marsh	O - N Black Rails and Harvest Mice more concealed at high tides
Black-necked Stilt, *Himantopus mexicanus*	MCSS	marsh with open ground	O - P flooding of nests at high tides may occur less frequently
California Black Rail, *Latirallus jamaicensis coturniculus*	ST	tidal salt marsh	O - P may become less conspicuous to predators at high tide
California Clapper Rail, *Rallus longirostris obsoletus*	FE. SE	tidal salt marsh	O - P quantity of suitable habitat may increase
California Red-legged Frog, *Rana aurora draytonii*	SSC	ponds and streams	P would likely increase habitat availability
Foothill Yellow-legged Frog, *Rana boylii*	SSC	still water along streams	P would likely increase habitat availability
Gadwall, *Anas strepera*	MCSS	marsh with vegetation clumps	O - P flooding of nests at high tides may occur less frequently
Great Blue Heron, *Ardea herodias*	MCSS	large trees, open marsh	O Black Rails and Harvest Mice more concealed at high tides
Great Egret, *Ardea alba*	MCSS	large trees, open marsh	O Black Rails and Harvest Mice more concealed at high tides
Long-eared Myotis bat, *Myotis evotis*	SC	buildings, crevices, snages	O - P may become less conspicuous to predators at high tide
Long-legged Myotis bat, *Myotis volans*	SC	under bark or hollow trees	O - P would likely increase feeding habitat availability
Northern Harrier, *Circus cyaneus*	SSC	marsh or open grassland	O - P flooding of nests at high tides may occur less frequently
Northern Pintail, *Anas acuta*	MCSS	marsh with vegetation clumps	O - P flooding of nests at high tides may occur less frequently
Northern Shoveler, *Anas clypeata*	MCSS	marsh with vegetation clumps	O - P flooding of nests at high tides may occur less frequently
Nuttall's Woodpecker, *Picoides nutallii*	AWL	Oak woodland	P increase foraging and nesting availabilty
Oak Titmouse, *Baeolophus inornatus*	AWL	Oak woodland	P increase foraging and nesting availabilty
Osprey, *Pandeon haliaetus*	SSC	tall structures, open water	P prey would likely become more available as fish habitat improves
Ruddy Duck, *Oxyura jamaicensis*	MCSS	marsh with vegetation clumps	O - P flooding of nests at high tides may occur less frequently
Salt Marsh Harvest Mouse, *Reithrodontomys raviventris*	FE. SE	tidal salt marsh	O - P may become less conspicuous to predators at high tide
Saltmarsh Common Yellowthroat, *Geothlypis trychas sinuosa*	SSC	tidal salt marsh	O - P quantity of suitable habitat may increase
San Pablo Song Sparrow, *Melospiza melodia samuelis*	SSC	tidal salt marsh	O - P quantity of suitable habitat may increase
Snowy Egret, *Egretta thula*	MCSS	large trees, open marsh	O - N Black Rails and Harvest Mice more concealed at high tides
Steelhead, *Onchorhynchus mykiss*	FT	streams, salt to fresh water	O - P could provide unobstructed passage to freshwater habitat increasing habitat availability
Townsend's Big-eared bat, *Plecotus townsendii*	SSC	cavities, caves, attic spaces	O - P would likely increase feeding habitat availability
Virginia Rail, *Rallus limicola*	MCSS	marsh with vegetation clumps	O - P may become less conspicuous to predators at high tide
Western Pond Turtle, *Clemmys marmorata*	SSC	still water along streams	O - P would likely increase habitat availability
Yuma Myotis, *Myotis yumanensis*	SC	tree cavities and attic spaces	O - P would likely increase feeding habitat availability

Legend

MCSS= Marin County Breeding Species of Special Concern
SC=Federal Species of Special Concern
FE= Federally Threatened
SE = State Endangered
FT = Federally Threatened
SSC=State Species of Special Concern
AWL= Audubon Watchlist 2002
O = Neutral; N = Negative; P = Positive

The 2002 Audubon Watchlist. National Audubon Society. http://audubon2.org/webapp/watchlist/viewwatchlist.jsp

California Endangered and Threatened Species Lists. California Department of Fish and Game. www.dfg.ca.gov/hcpb/species/species/.shtml

Shuford, David W. The Marin County Breeding Bird Atlas. Bushtit Books. Point Reyes Bird Observatory. Bolinas. 1993

TABLE 5:
Bird Species that Utilize Lower Las Gallinas Watershed for Migration or Over Wintering (Breeding Species Not Included)

Common Name	Scientific Name
Double-creted Cormorant	*Phalacrocorax auritus*
Canada Goose	*Branta canadensis*
American Wigeon	*Anas americana*
Eurasian Wigeon	*Anas penelope*
Canvasback	*Aythya valisineria*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Bufflehead	*Bucephala albeola*
Sora	*Porzana carolina*
Black-bellied Plover	*Pluvialis squatarola*
Semipalmated Plover	*Charadrias semipalmatus*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa erythropus*
Willet	*Catotrophorus semipalmatus*
Whimbrel	*Numenius phaeopus*
Long-billed Curlew	*Numenius americanus*
Marbled Godwit	*Limosa fedoa*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
Pectoral Sandpiper	*Calidris melanotos*
Dunlin	*Calidris alpina*
Long-billed Dowitcher	*Limnodromus scalopaceus*
Short-billed Dowitcher	*Limnodromus griseus*
Wilson's Snipe	*Gallinago delicata*
Red-necked Phalarope	*Phalaropus lobatus*
Bonaparte's Gull	*Larus philadelphia*
Mew Gull	*Larus canus*
Ring-billed Gull	*Larus delawarensis*
California Gull	*Larus californicus*
Herring Gull	*Larus argentatus*
Thayer's Gull	*Larus thayeri*
Western Gull	*Larus occidentalis*
Glaucous-winged Gull	*Larus glaucescens*
Caspian Tern	*Sterna caspia*
Forster's Tern	*Sterna forsteri*

TABLE 6:
Mammal Occurrences in Gallinas Creek Watershed

Common Name	Scientific Name
American Badger	*Taxidea taxus*
Big Brown Bat	*Eptesicus fuscus*
Black Rat	*Rattus rattus*
Black-tailed Jackrabbit	*Lepus californicus*
Bobcat	*Lynx rufus*
Botta's Pocket Gopher	*Thomomys bottae*
Brazilian Free-tailed Bat	*Tadarida brasiliensis*
Broad-footed Mole	*Scapanus latimanus*
Brush Mouse	*Peromyscus boylii*
Brush Rabbit	*Sylvilagus bachmani*
California Ground Squirrel	*Spermophilus beecheyi*
California Myotis	*Myotis californicus*
California Vole	*Microtus californicus*
Common Gray Fox	*Urocyon cinereoargenteus*
Common Raccoon	*Procyon lotor*
Coyote	*Canis latrans*
Deer Mouse	*Peromyscus maniculatus*
Dusky-footed Woodrat	*Neotoma fuscipes*
Eastern Fox Squirrel	*Sciurus niger*
Fringed Myotis	*Myotis thysanodes*
Hoary Bat	*Lasiurus cinereus*
House Mouse	*Mus musculus*
Little Brown Bat	*Myotis lucifugus*
Long-eared Myotis	*Myotis evotis*
Long-legged Myotis	*Myotis volans*
Long-tailed Weasel	*Mustela frenata*
Mountain Lion	*Puma concolor*
Mule Deer	*Odocoileus hemionus*
Norway Rat	*Rattus norvegicus*
Ornate Shrew	*Sorex ornatus*
Pallid Bat	*Antrozous pallidus*
Red Bat	*Lasiurus borealis*
Red Fox	*Vulpes vulpes*
Ringtail	*Bassariscus astutus*
River Otter	
Salt Marsh Harvet Mouse	*Reithrodontomys raviventris*
Short-tailed Weasel	*Mustela erminea*
Shrew-mole	*Neurotrichus gibbsii*
Silver-haired Bat	*Lasionycteris noctivagans*
Striped Skunk	*Mephitis mephitis*
Townsend's Big-eared Bat	*Plecotus townsendii*
Trowbridge's Shrew	*Sorex trowbridgii*
Vagrant Shrew	*Sorex vagrans*
Virginia Opossum	*Didelphis virginiana*
Western Gray Squirrel	*Sciurus griseus*
Western Harvest Mouse	*Reithrodontomys megalotis*
Western Spotted Skunk	*Spilogale gracilis*
Yuma Myotis	*Myotis yumanensis*

Sources: Marin County Open Space District
(http://enature.marinopenspace.org/openspace/mcosd/localguide_parkfinder_display.asp?rgn=PK_1062)
CDFG, CNDDB, 2004

TABLE 7:
Amphibian and Reptile Occurrences in the Gallinas Creek Watershed

Common Name	Scientific Name
Arboreal Salamander	*Aneides lugubris*
California Giant Salamander	*Dicamptodon ensatus*
California Newt	*Taricha torosa*
California Red-legged Frog	*Rana aurora draytonii*
California Slender Salamander	*Batrachoseps attenuatus*
Common Garter Snake	*Thamnophis sirtalis*
Common Kingsnake	*Lampropeltis getula*
Foothill Yellow-legged Frog	*Rana boylii*
Gopher Snake	*Pituophis catenifer*
Night Snake	*Hypsiglena torquata*
Northern Alligator Lizard	*Elgaria coerulea*
Pacific Treefrog	*Pseudacris regilla*
Racer	*Coluber constrictor*
Ringneck Snake	*Diadophis punctatus*
Rough-skinned Newt	*Taricha granulosa*
Rubber Boa	*Charina bottae*
Sharp-tailed Snake	*Contia tenuis*
Southern Alligator Lizard	*Elgaria multicarinata*
Western Fence Lizard	*Sceloporus occidentalis*
Western Pond Turtle	*Clemmys marmorata*
Western Rattlesnake	*Crotalus oreganus*
Western Skink	*Eumeces skiltonianus*
Western Terrestrial Garter Snake	*Thamnophis elegans*
Western Toad	*Bufo boreas*

Source: Marin County Open Space District
(http://enature.marinopenspace.org/openspace/mcosd/localguide_parkfinder_display.asp?rgn=PK_1062)
CDFG, CNDDB, 2004

TABLE 8: SUMMARY OF HYDRAULIC FEASIBILITY ANALYSIS SIMULATION RESULTS

Location	(A) Existing Floodway Width (feet)	(B) Estimated Minimum Restorated Channel Width (feet)	(C) Minimum Restored Roadway Width (feet)	(D) Maximum Corridor Width (feet)	(E) Net Available Space (feet)
Downstream of Monticello Ave.	18	23	60	180	97
Upstream of Del Ganado Rd.	18	23	60	130	47
Downstream of Del Ganado Rd.	19.5	29.5	60	140	50.5
Ustpream of Las Pavadas Ave.	19.5	39.5	60	150	50.5
Downstream of Las Pavadas Ave.	28	43	60	240	137
Midway-Munson Park	33	56	60	125	9
Upstream of Las Gallinas Ave.	33	56	60	180	64

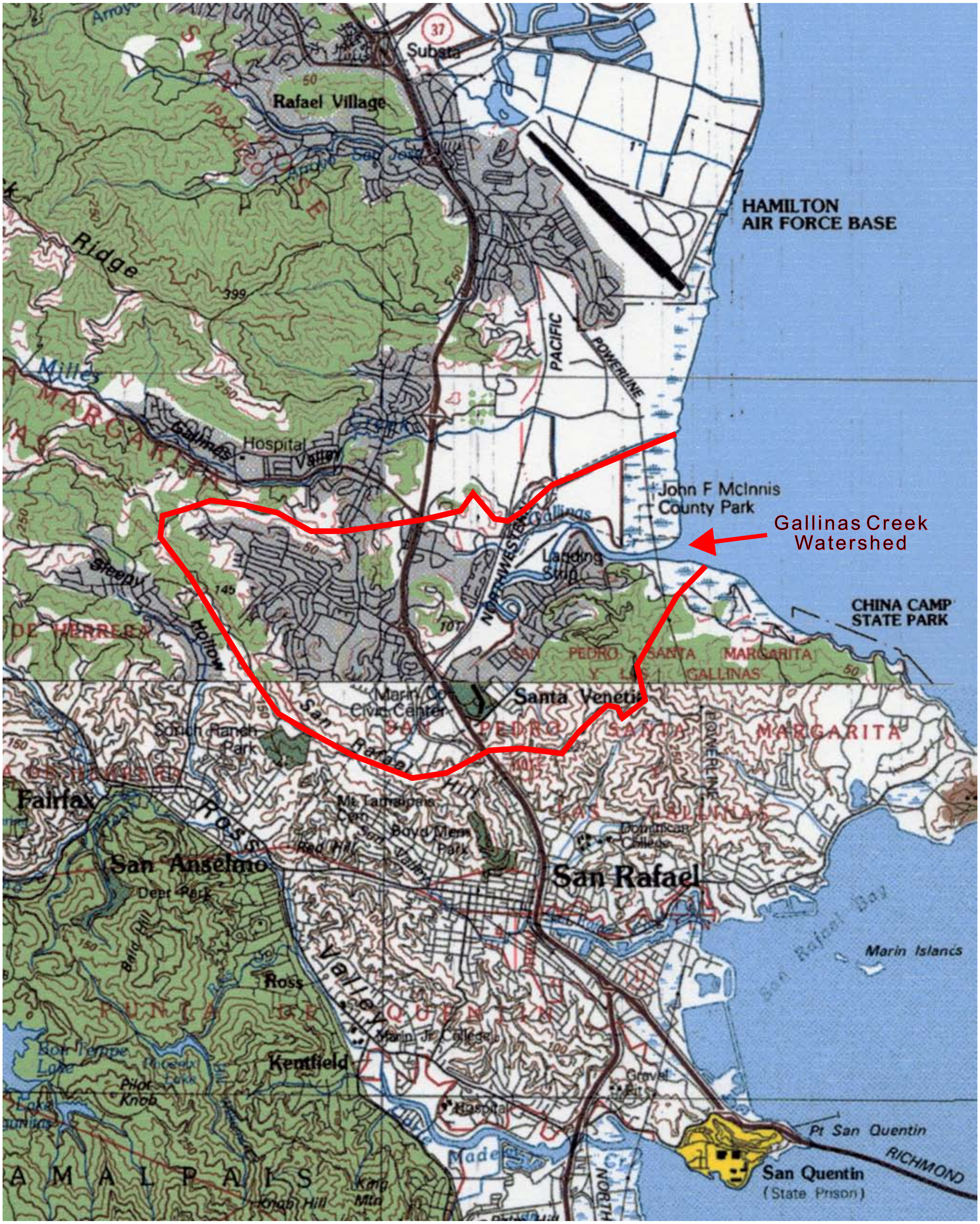
TABLE 11:
Approximate Time Frame for Potential Breeding Bird Utilization of Restored Riparian Habitat in Upper Watershed

1-7 years	7-15 years	>15 years
California Quail, *Callipepla californica*	Green Heron, *Butorides virescens*	Great Blue Heron, *Ardea herodias*
Anna's Hummingbird, *Calypte anna*	Mourning Dove, *Zenaida macrouta*	Greg Egret, *Ardea alba*
Allen's Hummingbird, *Selasphorus sasin*	Western Screech Owl, *Otus kennicottii*	Snowy Egret, *Egretta thula*
Western Wood-pewee, *Cantopus sordidulis*	Belted Kingfisher, *Ceryle alcyon*	Black-crowned Night-Heron, *Nycticorax nycticorax*
Pacific-slope Flycatcher, *Empidonax difficilis*	Downy Woodpecker, *Picoides pubescesn*	Osprey, *Pandeon haliaetus*
Black Phoebe, *Sayornis nigricans*	**Nuttall's Woodpecker, *Picoides nuttallii***	White-tailed Kite, *Elanus leucurus*
Ash-throated Flycatcher, *Myiarchus cinierascens*	American Crow, *Corvus brachyrhychos*	Red-shouldered Hawk, *Buteo lineatus*
Hutton's Vireo, *Vireo hutoni*	Tree Swallow, *Tachycineta bicolor*	Red-tailed Hawk, *Buteo jamaicensis*
Warbling Vireo, *Vireo gilvis*	Violet-green Swallow, *Tachycineta thallassina*	American Kestrel, *Falco sparverius*
Western Scrub Jay, *Aphelocoma californica*	**Oak Titmouse, *Baeolophus inornatus***	**Band-tailed Pigeon, *Columba fasciata***
Bushtit, *Psaltriparus minimus*	Chestnut-backed Chickadee, *Poecile rufescens*	Great Horned Owl, *Bubo virginianus*
Swainson's Thrush, *Catharus ustulatus*	Brown Creeper, *Certhia americana*	Northern Saw-whet Owl, *Aegolius acadicus*
American Robin, *Turdus migratorius*	Bewick's Wren, *Thryomanes bewickii*	Hairy Woodpecker, *Picoides villosus*
Wrentit, *Chamaea fasciata*	Purple Finch, *Carpodacus purpureus*	Northern Flicker, *Colaptes auratus*
Northern Mockingbird, *Mimus polyglottos*		
Orange-crowned Warbler, *Vermivora celata*		
Wilson's Warbler, *Wilsonia pusilla*		
Black-headed Grosbeak, *Pheucticus melanocephalus*		
California Towhee, *Pipilo crissalis*		
Spotted Towhee, *Pipilo erythrophthalmus*		
Song Sparow, *Maxima melodia gouldii*		
Dark-eyed Junco, *Junco hyemalis*		
Bullock's Oriole, *Icterus bullockii*		
Brown-headed Cowbird, *Molothrus ater*		
House Finch, *Carpocacus mexicanus*		
Lesser Goldfinch, *Cardeulis psaltria*		
American Goldfinch, *Cardeulis tristis*		

Bold Species = Audubon Watchlist 2002

* The actual utilization of the restored habitat by these species would be dependent upon the final restoration design - specifically the continuity of riparian buffer size and planting corridor width

FIGURES



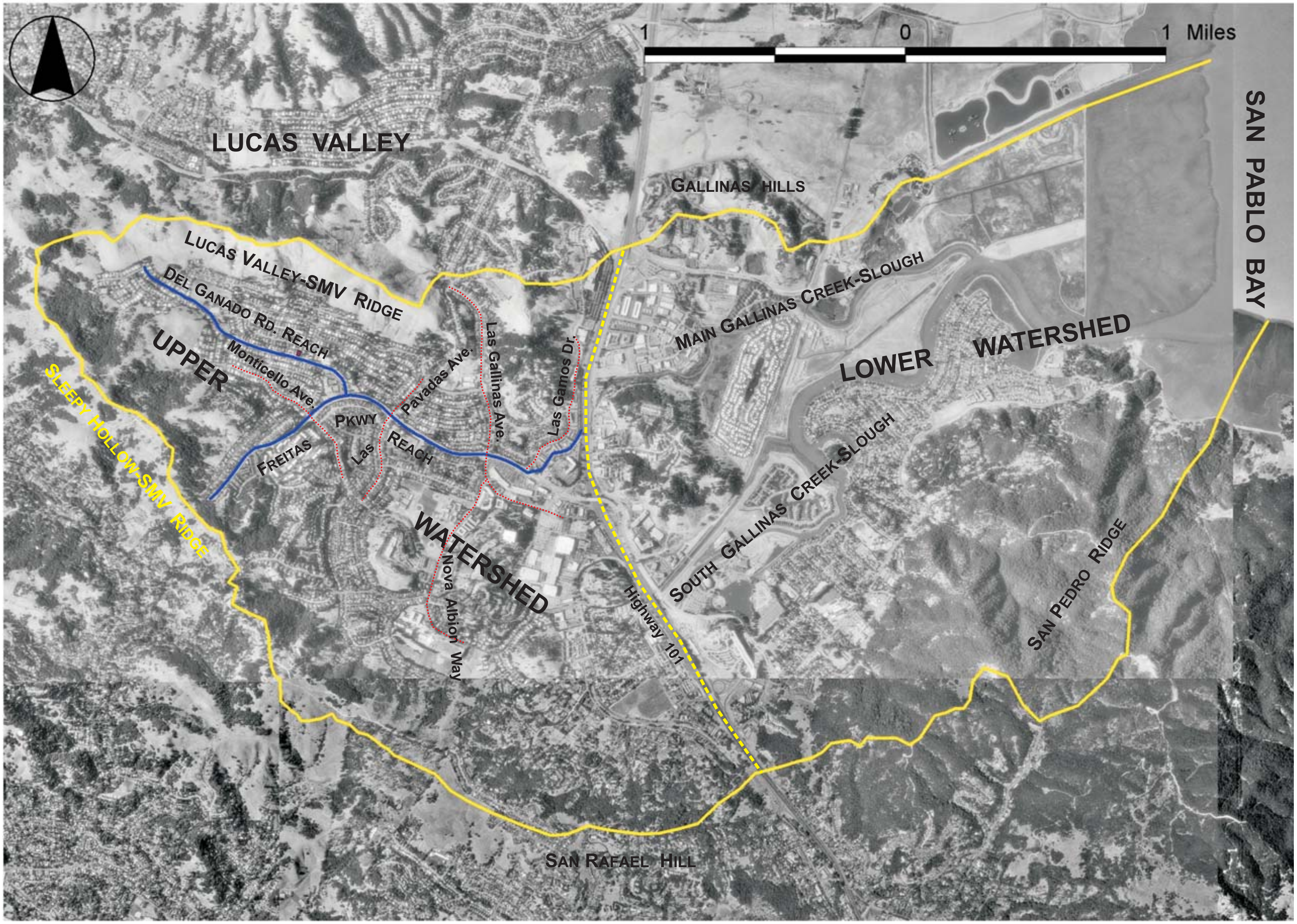
KAMMAN HYDROLOGY & ENGINEERING, INC.

Gallinas Cr. Restoration Hydrologic Feasibility and Conceptual Design Report

Site Location Map

FIGURE

1

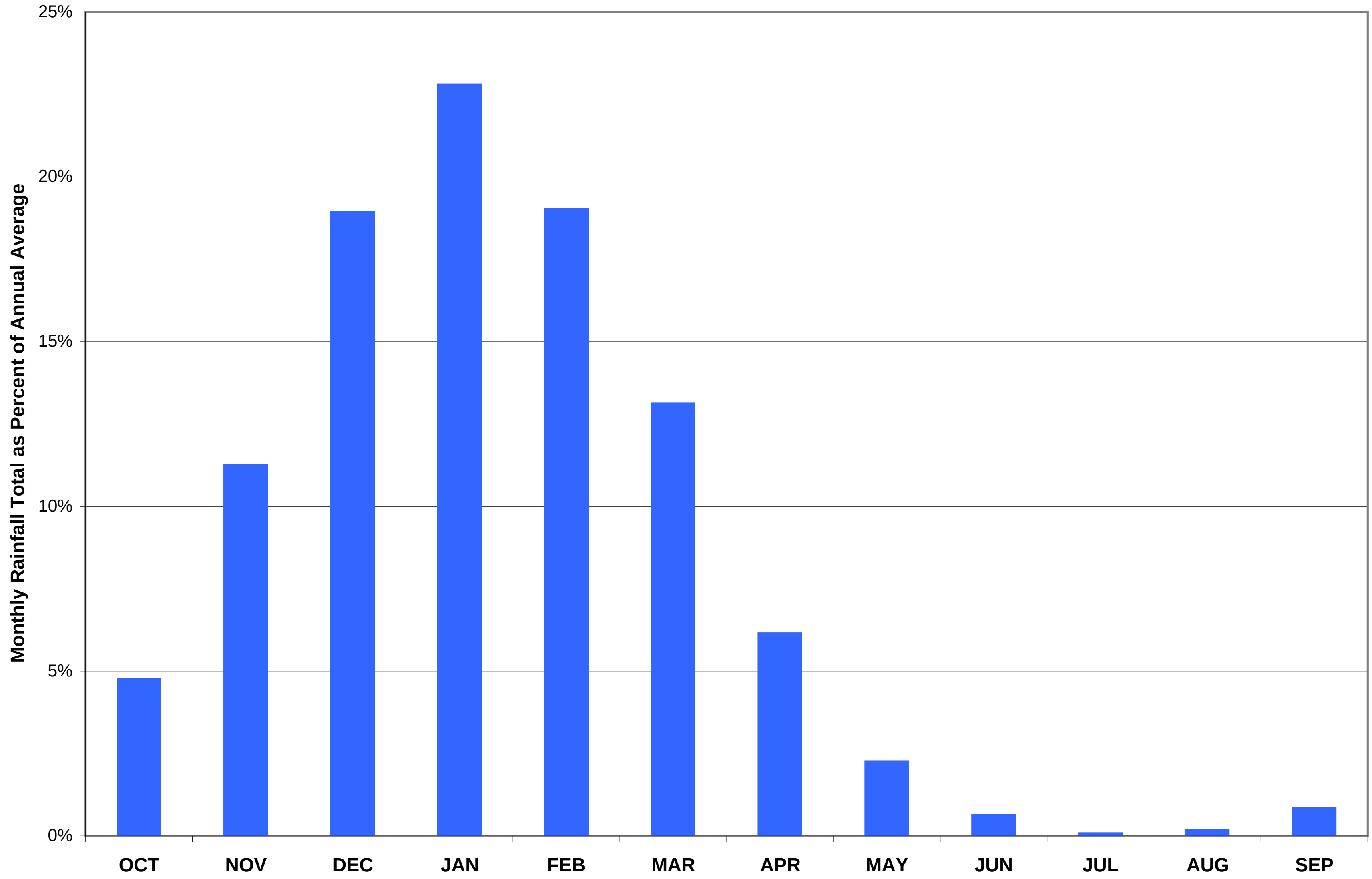


KAMMAN HYDROLOGY & ENGINEERING, INC.

Gallinas Cr. Restoration Hydrologic Feasibility and Conceptual Design Report

Gallinas Creek Watershed

FIGURE 2

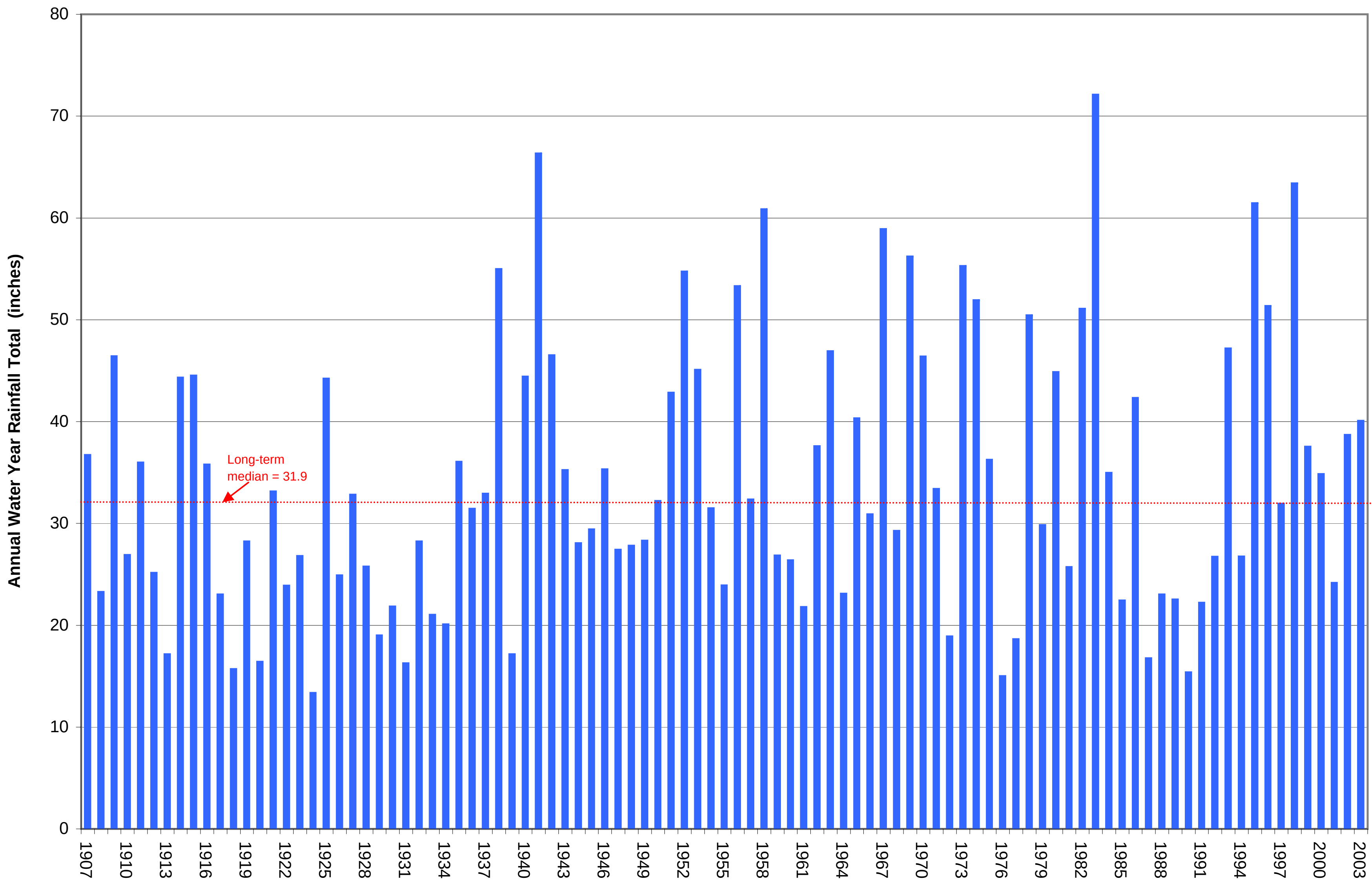


Kamman Hydrology
& Engineering, Inc.

Gallinas Creek Restoration Hydrologic Feasiblity and Conceptual Design Report
Median Monthly Total Rainfall at Marin County Civic Center: WY1907-2003

FIGURE
3

Mo Rainfall.xls,Figure 3

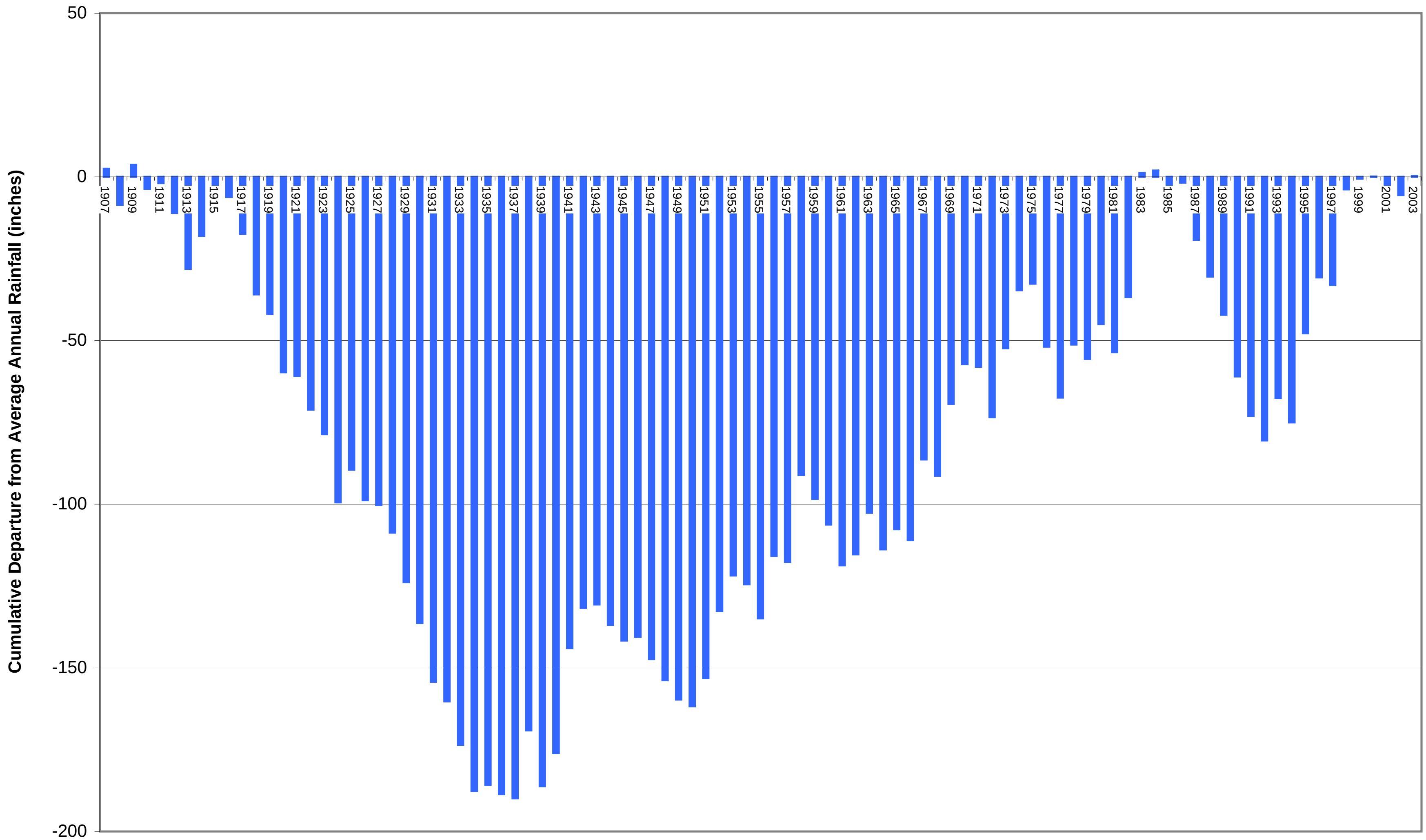


Kamman Hydrology & Engineering, Inc.

Gallinas Creek Restoration Hydrologic Feasiblity and Conceptual Design Report

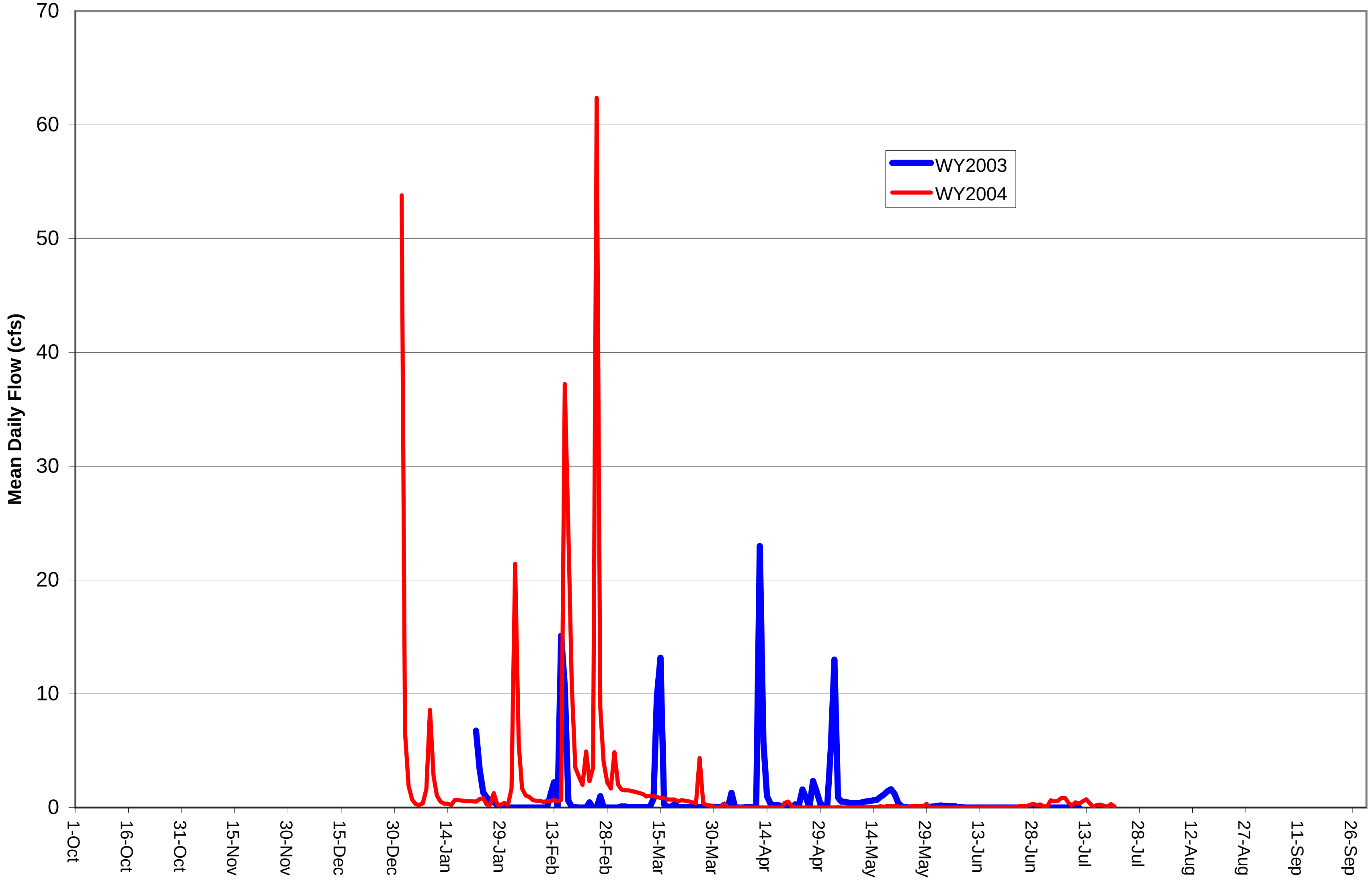
Total Annual Precipitation at Marin County Civic Center: WY1907-2003

FIGURE 4



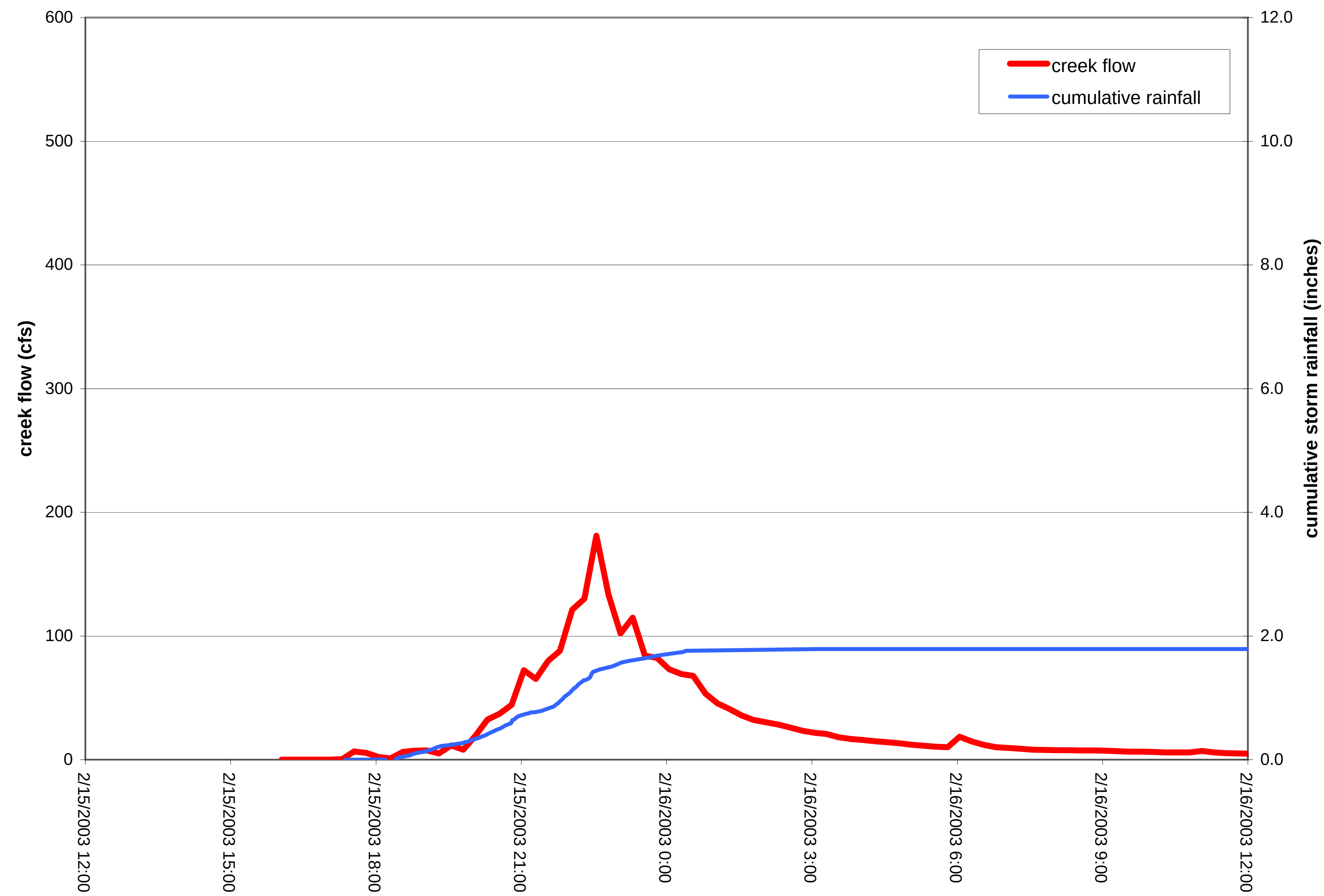
Note: Annual departures from the average are calculated by subtracting the long-term average rainfall from each annual rainfall total. Positive results indicate that the year experienced above average rainfall while a negative value indicates the year was drier than average. The chronological sum of annual departures identify prolonged wet and dry periods. A positive trend in the data indicates a wet period, while a negative trend indicates an extended dry period.

Kamman Hydrology & Engineering, Inc.	Gallinas Creek Restoration Hydrologic Feasiblity and Conceptual Design Report Cumulative Departure from Average Annual Rainfall: WY1907-2003	FIGURE 5



Note: Stream Flow Gauge located at intersection of Freitas Parkway and Las Pavadas Ave.

Kamman Hydrology & Engineering, Inc.	Gallinas Creek Restoration Hydrologic Feasiblity and Conceptual Design Report Partial Flow Hydrographs for Gallinas Creek: WY2003 and WY2004	FIGURE 6



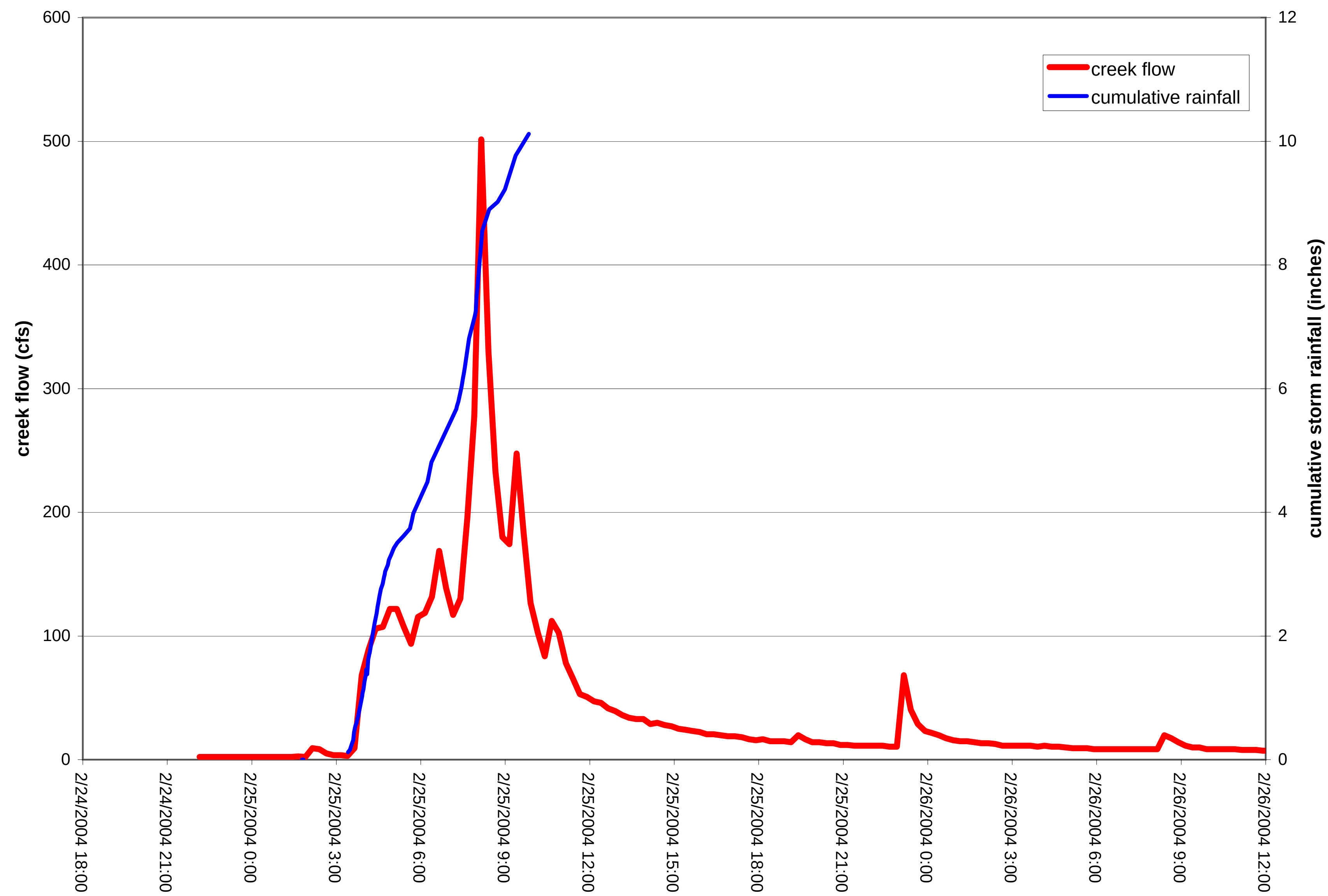
Kamman Hydrology & Engineering, Inc.

Gallinas Creek Restoration Hydrologic Feasiblity and Conceptual Design Report

Storm Flow vs. Cumulative Rainfall on Gallinas Creek: February 15-16, 2003

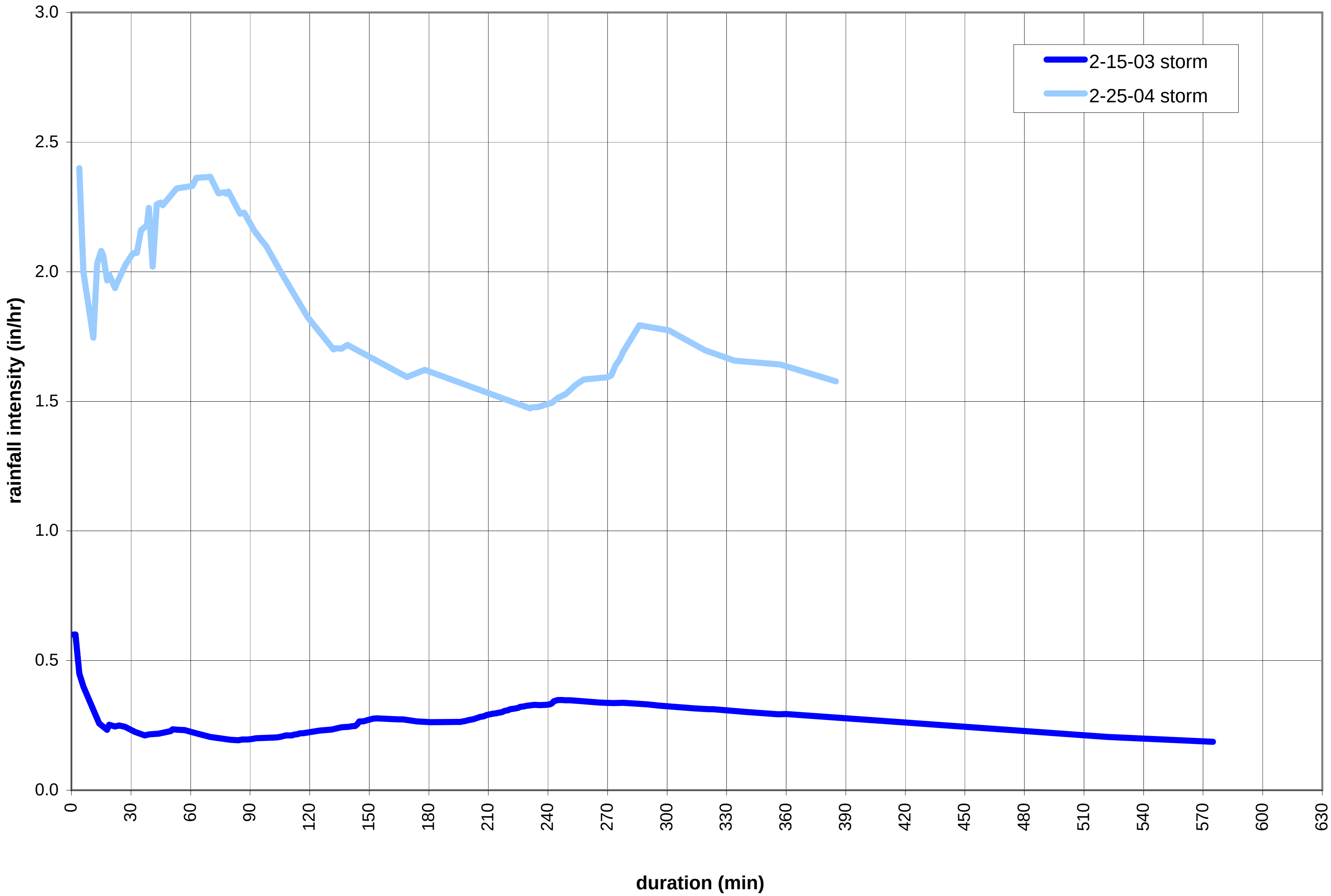
FIGURE 7

rainfall.xls,Figure 7



Kamman Hydrology & Engineering, Inc.	Gallinas Creek Restoration Hydrologic Feasiblity and Conceptual Design Report Storm Flow vs. Cumulative Rainfall on Gallinas Creek: February 25, 2004	FIGURE 8

rainfall.xls,Figure 8



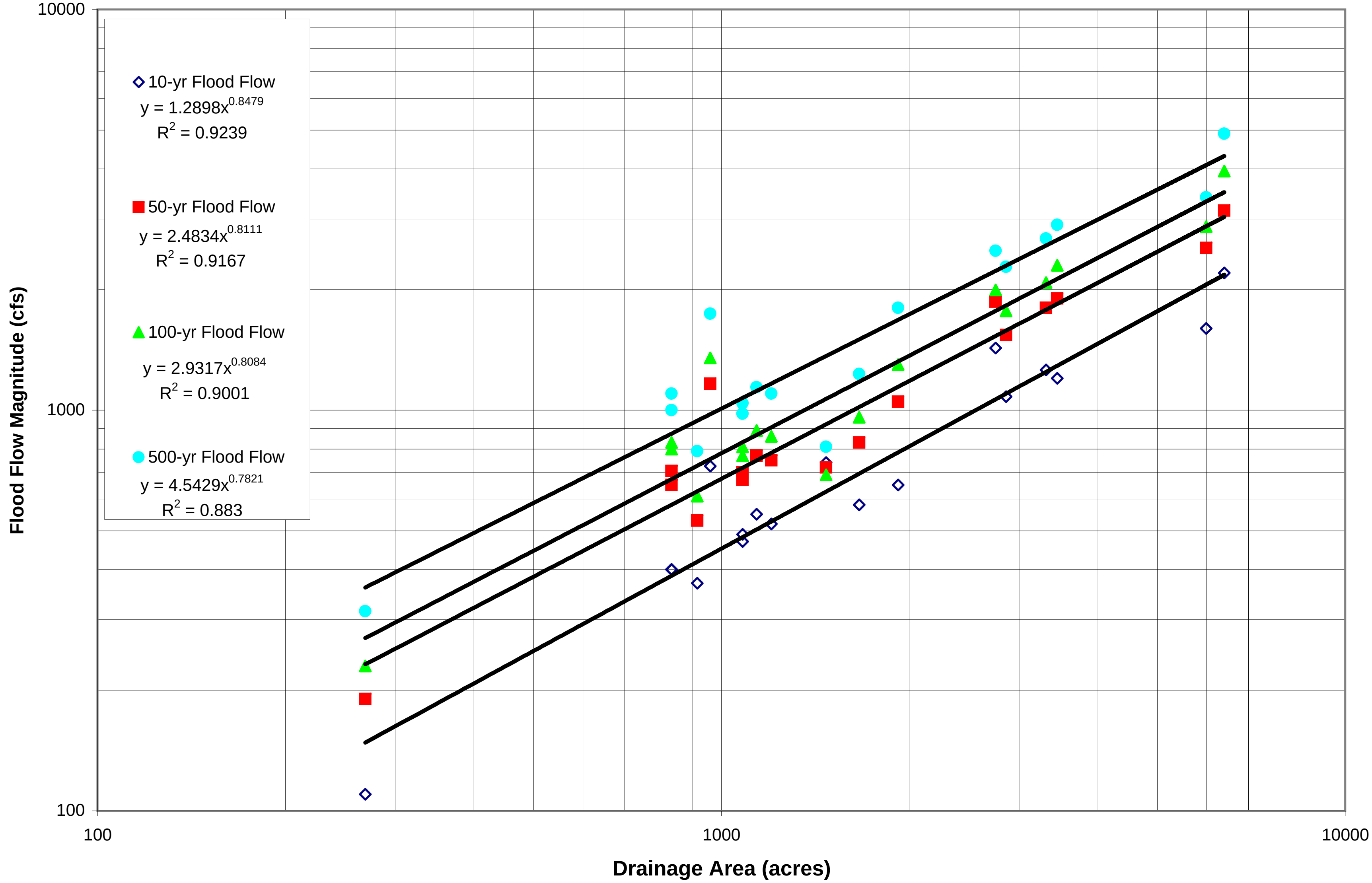
Kamman Hydrology & Engineering, Inc.

Gallinas Creek Restoration Hydrologic Feasiblity and Conceptual Design Report

Rainfall Intensity-Duration Curves: Feb. 15, 2003 and Feb. 25, 2004 Storms

FIGURE 9

rainfall.xls,Figure 9



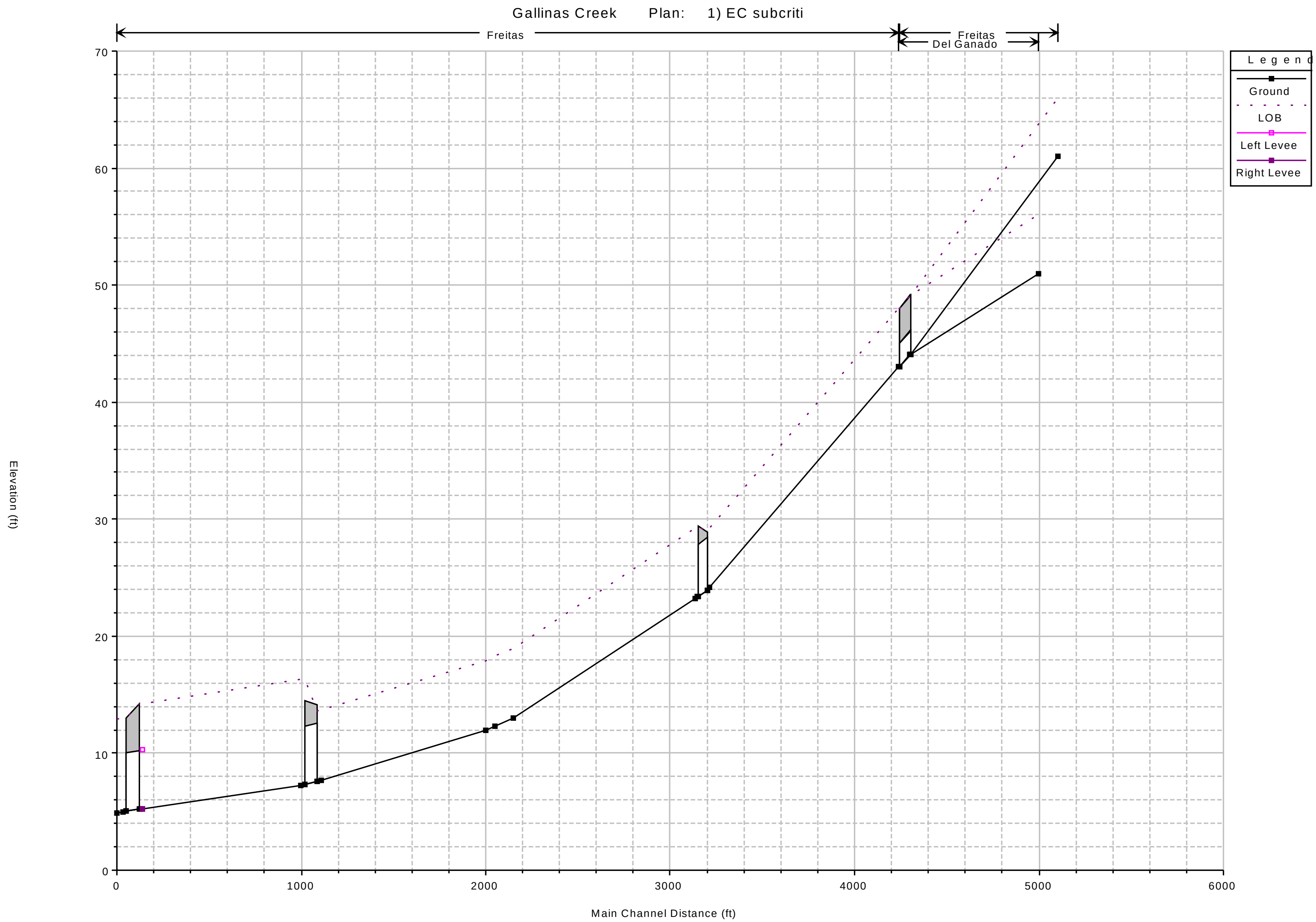
Kamman Hydrology & Engineering, Inc.

Gallinas Creek Restoration Hydrologic Feasiblity and Conceptual Design Report

Correlation of Drainage Area vs. Flow: FEMA Flood Flow Estimates for Area Creeks

FIGURE 10

Flood Frequency.xls,Figure 10

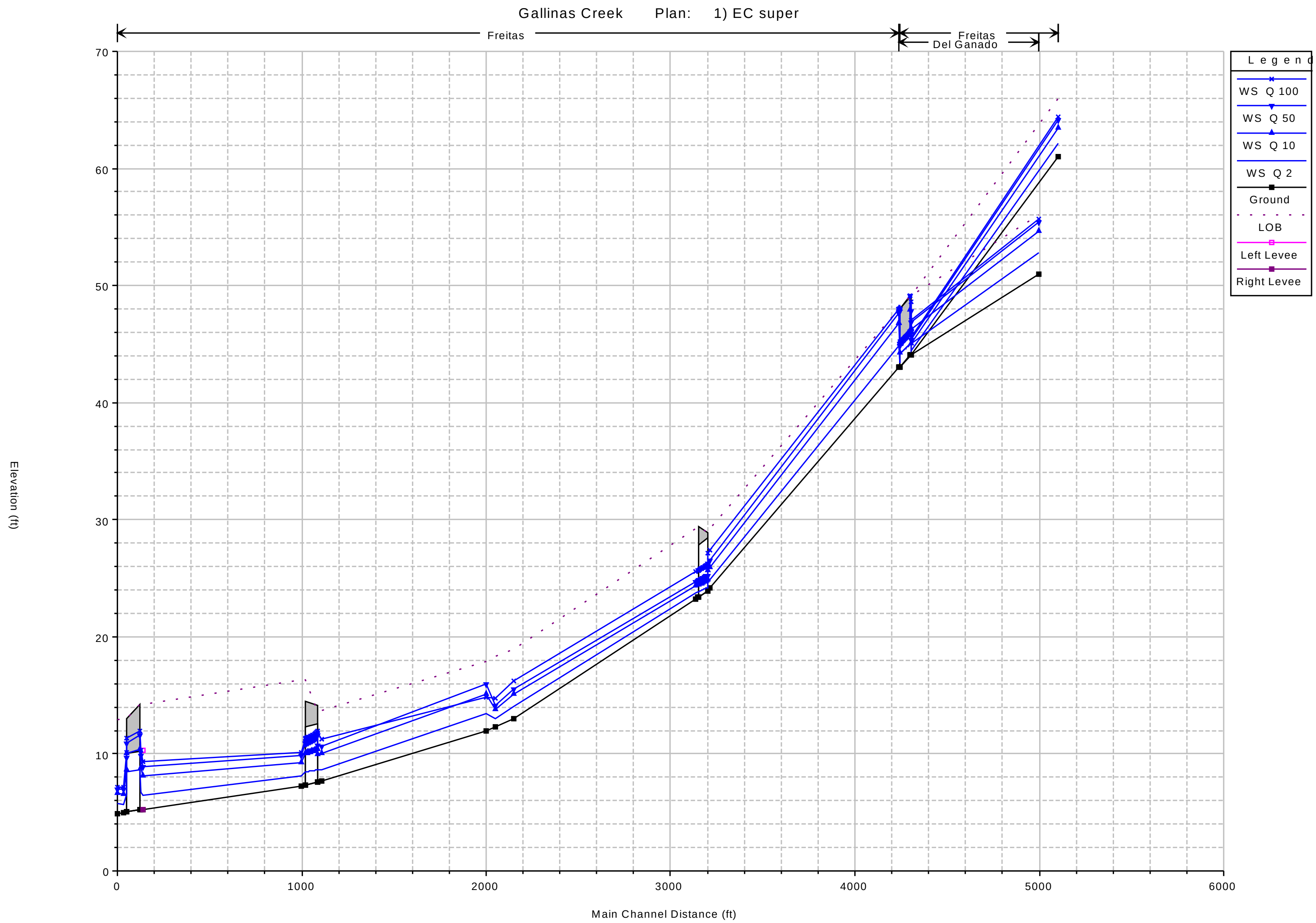


KAMMAN HYDROLOGY & ENGINEERING, INC.

Gallinas Cr. Restoration Hydrologic Feasibility and Conceptual Design Report

Longitudinal Profile of Hydraulic Analysis Study Reach: Existing Conditions

FIGURE 11



KAMMAN HYDROLOGY & ENGINEERING, INC.

Gallinas Cr. Restoration Hydrologic Feasibility and Conceptual Design Report

Simulated Water Surface Profiles: Existing Conditions

FIGURE 12