STETSON ENGINEERS INC.

TECHNICAL MEMORANDUM NO. 2: DETENTION BASIN ANALYSIS

Stetson Engineers Inc.
December 2, 2010

Executive Summary

Five sites in Ross Valley have been identified as suitable for large detentions basins; Loma Alta Tributary, Lefty Gomez Field, Memorial Park, Red Hill Community Park, and Phoenix Lake. Suitability is based on their proximity to Corte Madera Creek or a major tributary, ability to reduce flooding at key breakout points in Fairfax, San Anselmo, or Ross, size of the site and openness with few existing structures, current use that is compatible with flood detention, and public-ownership. To provide necessary capacity and contain the stored floodwaters, the fields at Lefty Gomez Field and Memorial Park will need to be lowered by 16 and 13 feet, respectively, with earthen embankments or floodwalls on two of the sides. Loma Alta Tributary and Red Hill Community Park will need an earthen embankment across the lower end. The Phoenix Dam spillway will need to be fitted with a six-foot high, inflatable/deflatable rubber dam to allow temporary storage of floodwaters, new bottom outlet arrangement for controlled emptying, and possibly some strengthening to the existing dam. A preliminary geotechnical and geologic feasibility study found no fatal flaws, and all sites were judged to be feasible with recommended mitigation measures. The basins will be designed and operated in accordance with the California Department of Water Resources, Division of Safety of Dams standards and will be subject to periodic inspection by Division engineers. The detention basins would remain dry and would not be flooded in most years except for Phoenix Lake which would retain its water supply function. Only during extremely heavy storms when floodwaters would otherwise breakout of the creek channel would operators shut the outlet and fill the basins. During these times, computer model simulations demonstrate that detention basins could reduce peak flow in the creek at key breakout points. It is conceivable that detention basins could provide enough peak flow reduction to contain the 100-year flow below Ross provided the Army Corps of Engineers completes the Unit 4 flood control project to the bay as planned. However, farther upstream in Fairfax and San Anselmo, peak flow reduction alone will not be enough to completely eliminate breakout of floodwaters. Measures that increase the conveyance capacity of the creek, such as flood-walls or small, earthen, landscaped berms, or creek channel enlargements will be needed in these areas in order to fully contain 100-year flows within the channel. Technical Memorandum No. 3, entitled ***"Critical Reach Analysis,"*** will present the analysis, assessment, and recommendation of measures that can achieve the needed increases in conveyance capacity in the creek at these points.

Introduction

The "Corte Madera Creek Watershed Flood Damage Reduction and Creek Management Strategy" study, currently underway, explores two primary methods of reducing the frequency and severity of flood damage in Ross Valley. One method involves increasing the conveyance capacity of the creek at key locations where capacity is limited. The other method involves storing large volumes of floodwater in several detention basins located high in the watershed, upstream of where major breakouts occur. Later, the study will explore secondary methods. These include floodplain management approaches, like raising buildings in the floodplain, and controlling floodwaters that overtop the creek by directing and containing these flows within designated floodways in the floodplain. The study will also explore non-traditional methods of attenuating storm water, like converting impervious surfaces to pervious, re-vegetating present-day non-native grasslands to better intercept rainfall, and installing residential-scale rainfall capture systems. While these methods could provide a limited degree of flood damage reduction, their primary benefit will be to create winter flows conditions that are more favorable for fish and enhance infiltration during more frequent, smaller storms. Enhanced infiltration helps replenish groundwater. Seepage from groundwater helps sustain the flow of cool water during the dry season when native fish and wildlife living in the creek need it most.

This technical memorandum focuses on the method of storing floodwaters in several large detention basins. Introductory concepts are covered first using the setting of the December 31, 2005 flood to provide necessary foundation and context. Issues covered in this memo include:

- Factors influencing the amount of runoff reaching the creek;
- Selection of possible sites for detention basins;
- Preliminary layouts for the possible detention basin sites;
- Effectiveness of the possible detention basins in reducing flooding.

Factors Influencing the Amount of Runoff Reaching the Creek

There are several factors influencing the amount of runoff reaching the creek during a flood. Interception[1] and infiltration characteristics of the watershed related to soils, slope, vegetation, impervious surfaces, and surface retention and conveyance play important roles. In Ross Valley soils in the steep-sloped hills are relatively shallow, underlain by rocks of the Franciscan Formation (a geologic designation), and have limited infiltration capacity. Soils are deeper in the valley bottomlands but infiltration during heavy storms can be limited due to saturation brought on by previous rainfall, seasonally high groundwater, and high water levels in adjacent creeks. Impervious surfaces associated with development are prevalent in the valley bottomlands but, overall, cover only about 5 per cent of the watershed lands above the key breakout points where floodwaters escape from the channel. (Figure 1)

Clearly, runoff reaching the creek during a flood is determined, first and foremost, by the amount and intensity of precipitation, both in the days preceding the flood and during the flood. A look at the hydrograph[2] for the December 31, 2005 flood shows how steady rain that fell earlier in December saturated the watershed leaving little capacity to attenuate the intense 24-hour deluge that started on the morning of December 30th. (Figure 2)

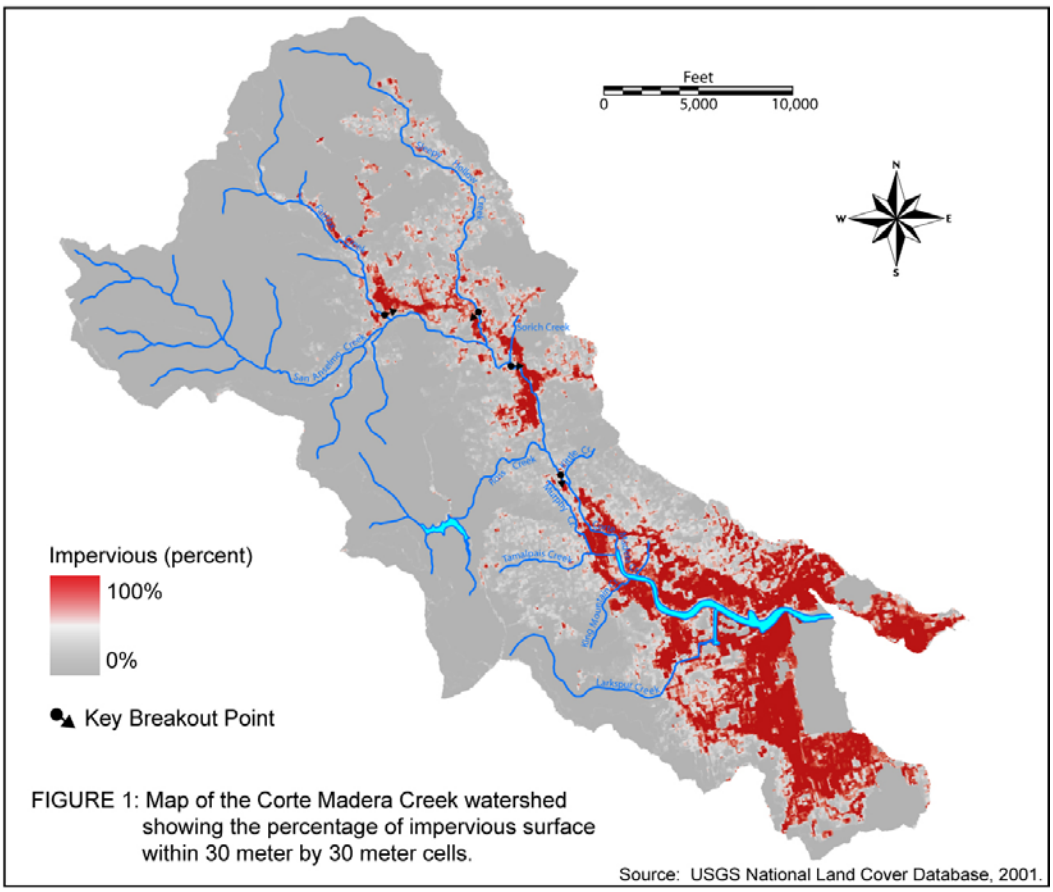


FIGURE 1: Map of the Corte Madera Creek watershed showing the percentage of impervious surface within 30 meter by 30 meter cells.

Source: USGS National Land Cover Database, 2001.

[1] Interception is the natural process of capture and storage of rainfall on leaves and branches.
[2] A graph of the height of a waterway due to rainfall runoff over time and the rainfall amount from a given storm event or events.

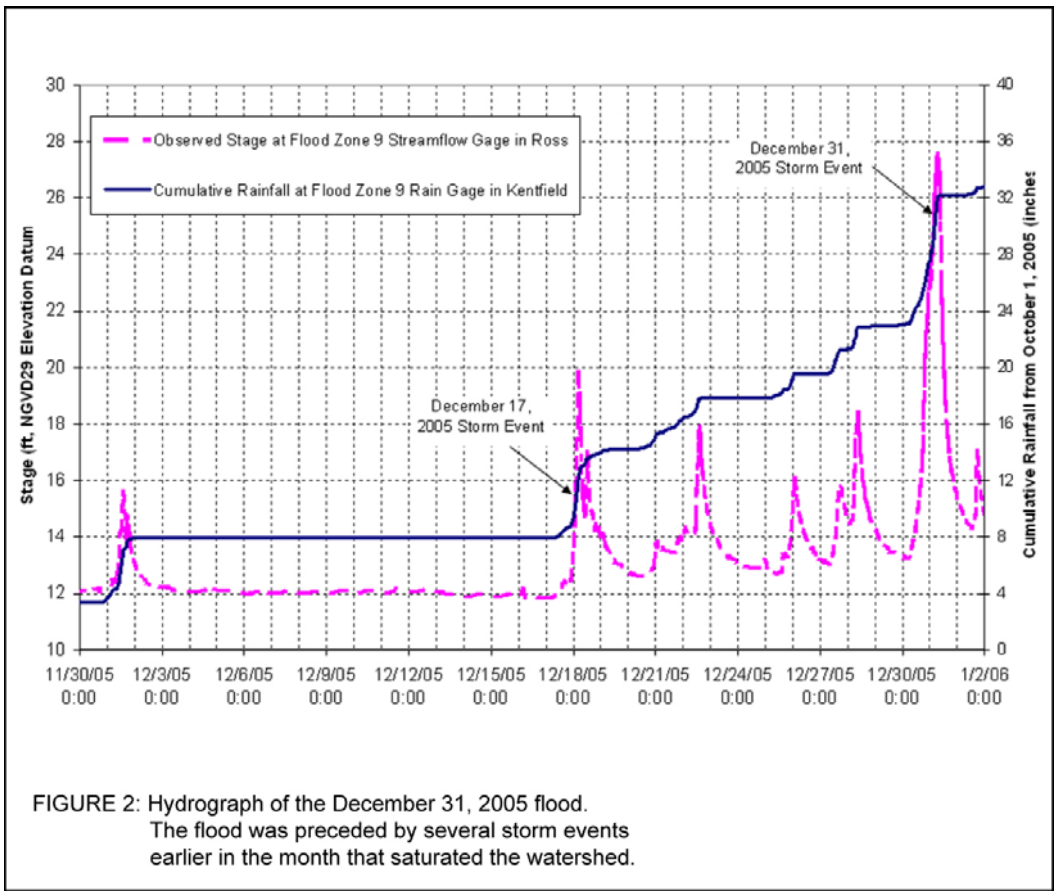


FIGURE 2: Hydrograph of the December 31, 2005 flood.
The flood was preceded by several storm events earlier in the month that saturated the watershed.

When properly designed and operated, flood detention basins can provide the supplemental holding capacity that is needed when the watershed has become saturated following a sustained series of Pacific storms, as occurred in December 2005. Operation of detention basins requires storm forecasting and monitoring of prevailing weather and watershed saturation conditions throughout the wet season. During heavy storms, operations require real-time tracking of rainfall and creek flows, particularly at key breakout points. Operators will use this information to determine whether flooding is imminent, which will then trigger filling the detention basins.

Selection of Possible Sites for Detention Basins

The watershed was canvassed for suitable sites for detention basins using the following evaluation criteria:

- Proximity to Corte Madera Creek or a major tributary;
- Ability to reduces flooding at key breakout points in Fairfax, San Anselmo, or Ross;
- Size and openness, with few existing structures;
- Existing site use that is compatible with flood detention; and,
- Public ownership.

Five sites meeting the evaluation criteria were identified and are listed in Table 1.

Table 1. Evaluation of Suitability of Possible Sites for Detention Basins

	Evaluation Criteria				
Site Name	**Creek Proximity**	**Flood Reduction**	**Size, Openness, Structures**	**Site Use and Compatibility with Flood Detention**	**Public Ownership**
Loma Alta Tributary	On an unnamed tributary to Fairfax Creek	Reduces flooding along Fairfax Creek, San Anselmo Creek, and Corte Madera Creek, including key breakout points in Fairfax, San Anselmo, Ross	4-acre creek bed and gulch with some riparian vegetation and oak woodland; no structures	Open space preserve for hiking, biking, and public enjoyment; compatible with detention	Marin County Open Space District
Lefty Gomez Field	On Fairfax Creek	Reduces flooding along Fairfax Creek, San Anselmo Creek, and Corte Madera Creek, including key breakout points in Fairfax, San Anselmo, and Ross	7-acre play field; restroom and concession structures, two wells and storage tank, water pipeline	Middle school and community recreation; compatible with detention	Ross Valley School District
Memorial Park	On Sorich Creek	Reduces flooding along Sorich Creek, San Anselmo Creek, and Corte Madera Creek, including key breakout points in San Anselmo, and Ross	7-acre park and play fields; restrooms, kids play equipment, tennis courts, storage structures, well and storage tank	Community play field and general recreation; compatible with detention	Town of San Anselmo
Red Hill Park	On an unnamed tributary to Sorich Creek	Reduces flooding along Sorich Creek, San Anselmo Creek, and Corte Madera Creek, including key breakout points in San Anselmo, and Ross	4.5-acre dog park and play field; restrooms, artificial turf athletic field	Community athletic field and dog recreation area; compatible with detention	Tamalpais Union High School District
Phoenix Lake	On Ross Creek	Reduces flooding along Ross Creek and Corte Madera Creek, including key breakout points in Ross	30-acre dam and reservoir	Water supply and public enjoyment; compatible with detention	Marin Municipal Water District

In addition to the five sites listed above, Upper Brookside School, Lower Brookside School, and Deer Park are considered potential sites. These sites are owned by the Ross Valley School District (RVSD). RVSD is currently evaluating possible modifications to these sites to meet increases in student enrollment, so the future compatibility of these sites with flood detention is unknown. These sites will remain under consideration while the District completes its evaluation.

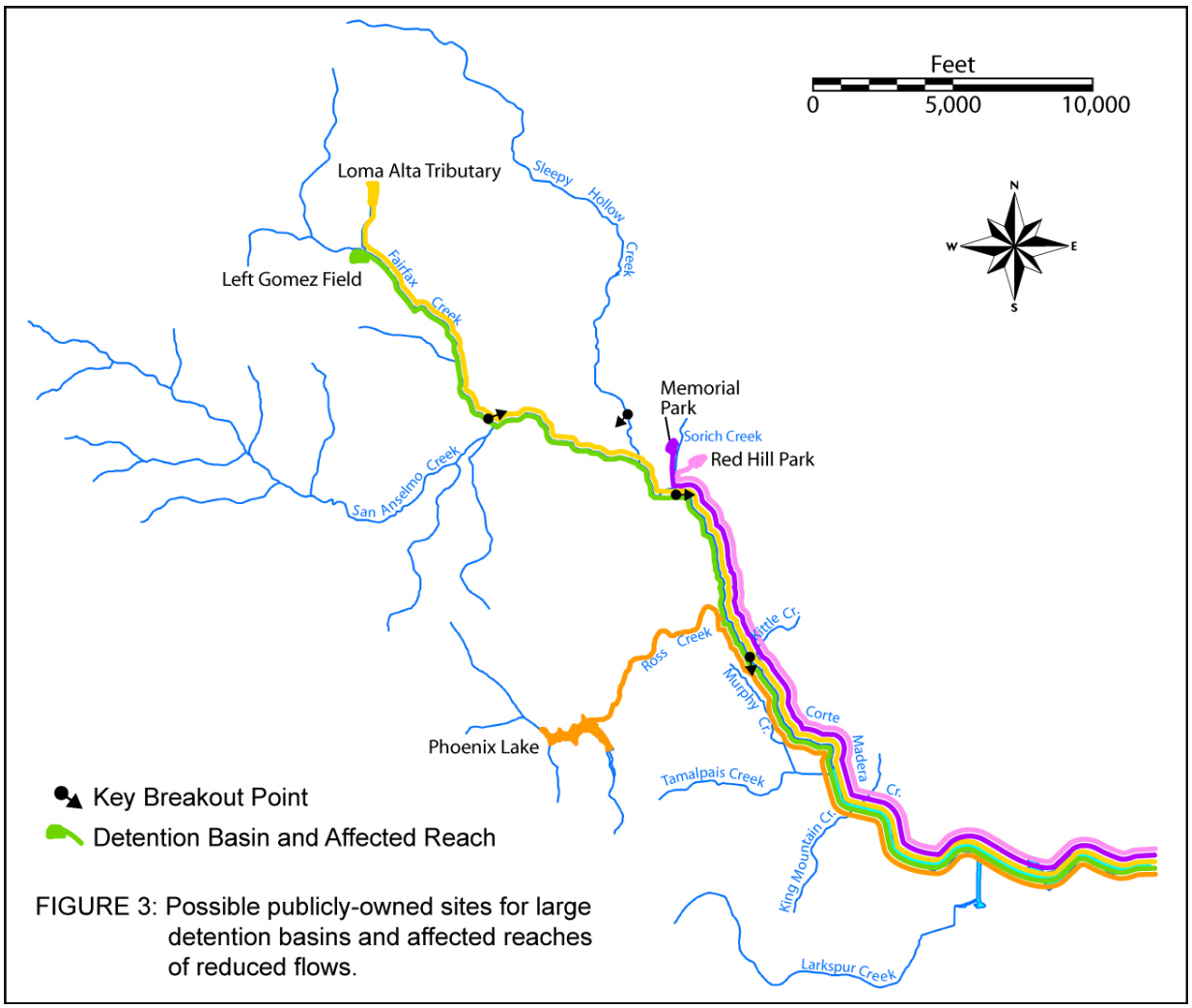


FIGURE 3: Possible publicly-owned sites for large detention basins and affected reaches of reduced flows.

Preliminary Layouts for the Possible Detention Basin Sites

Preliminary layouts were prepared for the five possible detention basin sites with the objective of maximizing the volume of floodwater that can be reasonably, practically, and safely detained at the each site. These preliminary layouts are a starting point in the design development process and are subject to modification later during the public and agency review process. Where necessary and practical, final designs will incorporate features that:

- Preserve and enhance the existing uses of the site;
- Harmonize with adjacent properties;
- Enhance infiltration to replenish groundwater; and,
- Enhance aquatic and riparian habitat along the adjacent creek corridor.

All sites were preliminarily evaluated based on field observation and available information for geotechnical and geologic feasibility, including geologic hazards, like landslides and settlement[3].

[3] The preliminary geotechnical and geologic evaluation, documented in reports entitled "Geotechnical and Geologic Feasibility Study, Detention Basins," by Miller Pacific Engineering Group, Novato, March 10, 2010 and March 18, 2010, can be viewed and downloaded at http://www.marinwatersheds.org/rossvalleywatershed-org/index.html.

The preliminary evaluation found no fatal flaws, and all sites were judged to be feasible. Confirmation will require further detailed geological investigation of the sites during the design process. The detention basins will fall under the jurisdiction of the California Department of Water Resources, Division of Safety of Dams[4]. As such, the basins will be designed and operated in accordance with Division standards and would be subject to periodic inspection by Division engineers. Following are descriptions of the preliminary layouts.

Loma Alta Tributary. Located in an unincorporated area of Fairfax near the end of Glen Drive, the Loma Alta Tributary site lies within the Loma Alta Open Space Preserve, which is owned and actively managed by the Marin County Open Space District for hiking, biking, and other forms of public recreation. The site is situated in a gulch along an unnamed tributary to Fairfax Creek which drains approximately 115-acres. The tributary joins Fairfax Creek just downstream of Lefty Gomez Field (Figure 4).

The detention basin will be formed by a 210-foot long by 25-foot high engineered earthen embankment across the gulch. A large, gated culvert will penetrate the embankment and will normally be kept open to allow unimpeded passage of a range of flows, as well as sediment, woody debris, and wildlife. When flooding is imminent, the gate will be closed to shut off flow for floodwater detention. A spillway bypass along the west side will allow safe passage of flood flows in rare cases when the basin becomes full.

When full, the basin will inundate about 3 acres and detain about 25 acre-feet of floodwater. Water depths will reach a maximum of 22 feet. Water will be detained for the duration of the storm and released as soon as downstream conditions permit, presumably within 48 hours. No structures will be affected by flood detention operations and, since operations occur only during very heavy storms, public use of the site will rarely be affected.

During a heavy storm, filling of the Loma Alta Tributary basin will be primarily triggered by monitoring information indicating imminent flooding at the key breakout points in Fairfax.

Lefty Gomez Field. This site, located along Sir Francis Drake Boulevard in Fairfax just below the Loma Alta Tributary site, is owned and maintained by the Ross Valley School District. It serves as the play field for White Hill Middle School and for community youth soccer and baseball leagues. The site lies on flat land and is bounded on the north by Fairfax Creek, on the south by Sir Francis Drake Boulevard, and on the east and west by residential development (Figure 5).

The detention basin will be formed by a 75-foot long by 17-foot high concrete dam and spillway structure across the creek. Two culverts will penetrate the structure; a large gated culvert, which will normally be kept open to allow unimpeded passage of a range of flows, sediment, woody debris, and wildlife, and a smaller, ungated culvert to allow limited, continuous discharge during detention operations. To provide necessary storage capacity, the field will be lowered by 16 feet and containment features will be built along the east and north sides. Material excavated from the field will be used to build the 8-foot high engineered earthen embankment along the east side. Concrete walls up to three feet high along a 150-foot stretch of Glen Drive and up to four feet high along the basketball courts will provide containment along the north side. The existing Sir Francis Drake Boulevard road embankment will provide containment along the south side.

[4] Phoenix Lake is already under the jurisdiction of DWR-DSOD.

No containment feature will be needed along the west side as the natural topography will be sufficient.

When full, the basin will inundate about 7 acres and detain 92 acre-feet of floodwater. Water depths will reach a maximum of 17 feet. Restroom structures will need to be relocated and playfields reconstructed. MMWD's pressurized water pipeline that passes through the site may need to be lowered or re-routed. The two existing wells and storage tank will be removed. Since operations will occur only during very heavy storms, recreational activities at the site will rarely be affected.

During a heavy storm, filling of the Left Gomez Field basin will be primarily triggered by monitoring information indicating imminent flooding at the key breakout points in Fairfax.

Memorial Park. Memorial Park, located in San Anselmo along Sorich Creek, is owned, managed, and maintained by the Town of San Anselmo. With its expansive play field, enclosed kids play area, and picnic tables, it is a key recreational facility for the citizens of San Anselmo and beyond. It serves as a play field for community youth and adult soccer, baseball, and softball leagues. Its lighted tennis courts offer daytime and nighttime tennis playing opportunities. The site lies on generally flat land and is drained by Sorich Creek, which is enclosed in a subsurface culvert for most of its way through the park. The site is bounded on the south by the Town of San Anselmo's Isabel Cook Residential Homes and Recreation Center and the Red Hill Shopping Center, on the east by a large residential apartment complex, on the north by the Memorial Park Log Cabin, and on the west by residential development (Figure 6).

The detention basin would be formed by an engineered earthen embankment up to 9-feet high along the south side across Sorich Creek and lower embankments along portions of the east and west sides. A large, gated culvert will penetrate the embankment and will normally be kept open to allow unimpeded passage of a range of flows, as well as sediment, woody debris, and wildlife. When flooding is imminent, the gate will allow shut-off for floodwater detention. In rare cases when the basin becomes full, an internal spillway will pass floodwaters on through the culverted reach of Sorich Creek below the basin. To provide necessary storage capacity, the field will be lowered by 13 feet and, in the process, Sorich Creek will be day lighted as it passes through the park. The excavated material will be used to build the embankments. No containment feature will be needed along the east and north sides.

When full, the basin will inundate 6 acres and detain 82 acre-feet of floodwater. Water depths will reach a maximum of 16 feet. The playfields will need to be reconstructed. Tennis courts will have to be relocated or removed. The existing well and storage tank will be removed. The enclosed kids play area and Log Cabin may be unaffected. Since operations will occur only during very heavy storms, recreational activities at the site will rarely be affected.

During a heavy storm, filling of the Memorial Park basin will be primarily triggered by monitoring information indicating imminent flooding at key breakout points in San Anselmo.

Red Hill Community Park. Located in San Anselmo between Shaw Drive and Sunny Hills Drive behind the Red Hill Shopping Center near the Hub, Red Hill Community Park covers about 5-acres and contains a dog park and all-weather artificial turf athletic field. The site is owned and maintained by the Tamalpais Union High School District and managed by the Tamalpais Union High School District and Ross Valley School District. The dog

park offers an opportunity for open field dog recreation while the all-weather artificial turf athletic field provides a venue for community youth and high school soccer, baseball, softball and lacrosse leagues. It is important to point out that the site is currently not compatible with flood detention because of the artificial turf athletic field. Recognizing that the park was completed within the last year costing nearly $ 2 million, conversion of this site to a multi-use flood detention facility should be deferred until the artificial turf has reached its useful life. At that time, the athletic field will need to be reconstructed in natural grass to be compatible with flood detention.

Nestled along an unnamed tributary to Sorich Creek in a flat low area between the elevated road embankments of Shaw Drive and Sunny Hills Drive, the site is well configured for a detention basin. The tributary drains a surrounding watershed area of 97 acres, mostly composed of undeveloped grass and tree covered hills. The lower portion of the watershed contains the park, RVSD facilities, and Sunny Hills School facilities. Just upstream of Sunny Hills School, runoff generated in the upper watershed is collected from a small natural drainage and conveyed through a 36-inch concrete culvert that runs underground through the RVSD facilities, park, and Red Hill Shopping Center. The culvert joins the Sorich Creek culvert underground near the Red Hill Shopping Center gas station. The Sorich Creek culvert continues on beneath Sir Francis Drake Boulevard and then flows as an open channel to its confluence with San Anselmo Creek just below Nokomis Avenue.

The detention basin will be formed by an approximately 500-foot long by 12-foot high engineered, earthen embankment across the lower end of the site connecting to the Shaw Drive and Sunny Hills Drive road embankments. A large, gated culvert will penetrate the embankment and join the existing culvert that runs underground through the Red Hill Shopping Center. The gate will normally be kept open but will be shut-off during floodwater detention operations. An internal spillway will pass floodwaters on through the culvert that runs through the shopping center (Figure 7).

When full, the basin will inundate 4 acres and detain 28 acre-feet of floodwater. Water depths will reach a maximum of 10 feet. Since operations will occur only during very heavy storms, public use of the site will rarely be affected.

During a heavy storm, filling of the Red Hill Community Park basin will be primarily triggered by monitoring information indicating imminent flooding at key breakout points in San Anselmo.

Phoenix Lake. Phoenix Lake is owned, operated, and maintained by Marin Municipal Water District (MMWD) primarily for the purpose of water supply reserve for use during shortages, but also serves as wildlife habitat and public recreation and enjoyment. The lake is formed by an earthen embankment dam across Ross Creek that was built in 1906, enlarged in 1909, and strengthened in 1969. The watershed above Phoenix Lake encompasses about 1,400 acres. When full, the lake covers 25 acres and holds approximately 300 acre-feet of water.

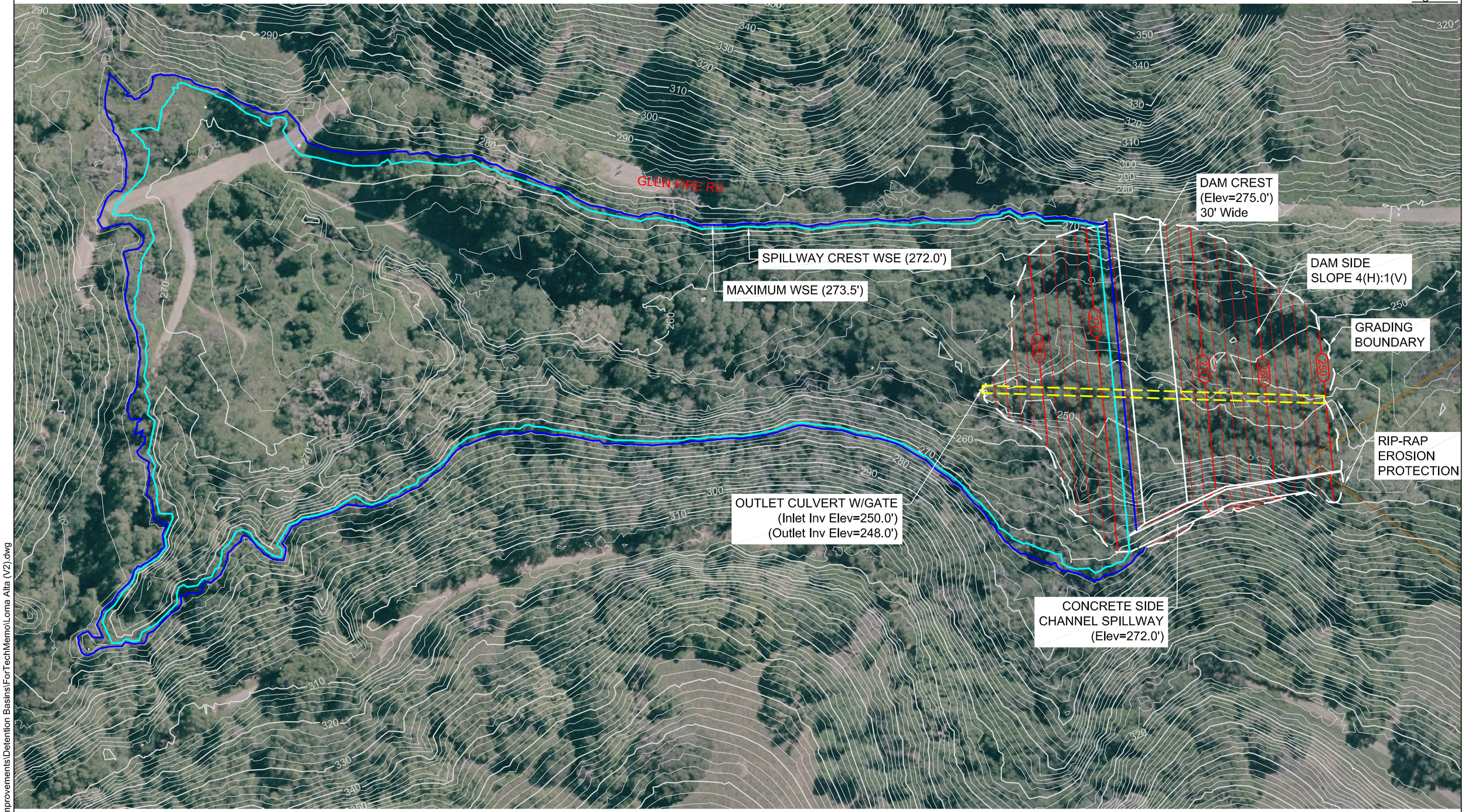
The dam is penetrated by a gated, 30-inch diameter, low-level, outlet pipe that has a discharge capacity of 115 cubic feet per second (51,600 gallons per minute) when the lake is full. The spillway is situated on the right side of the dam. In 1985 the spillway was modified by lowering the crest by six feet, from elevation 180 feet down to elevation 174 feet. This modification effectively lowered the normal lake water level and reduced the lake storage capacity by about 120 acre-feet, from 420 acre-feet to its present day capacity of 300 acre-feet.

Phoenix Lake currently functions as a de facto detention basin. During heavy storms, the lake water level rises above the spillway crest. This resulting "surcharge" storage attenuates stormflow and reduces the peak flow in the creek downstream. The attenuation effect could be enhanced through changes in lake operations and the addition of a new low level outlet pipe structure. Close monitoring of watershed saturation conditions coupled with storm forecasting could provide early warning of possible flooding. Under these conditions, drawing the lake level down ahead of a forecasted storm will provide storage space in the lake to detain floodwaters. By installing a 6-foot high inflatable/deflatable rubber dam across the spillway, the lake level will be temporarily raised to its pre-1985 elevation of 180 feet during floods when additional storage capacity and attenuation are needed. Figure 8 shows conceptual improvements to Phoenix Lake. These improvements mainly include 1) modifying the existing low-level outlet structure (a 30" pipe with an intake elevation at 130 ft NGVD29) to have two water level-control gates, one at elevation 140 ft and the other at elevation 160 ft; 2) installing a 6-foot high inflatable/deflatable rubber dam across the spillway; 3) creating about 10-14 acre-ft of additional (dead) storage below elevation 140 ft by excavating the lake bottom near the existing low-level intake; 4) stabilizing the dam embankment; and 5) installing emergency generators.

Further investigation is needed of the possible effects that operation of Phoenix Lake for flood detention will have on water supply and the existing earthen dam. Use of the lake for flood control detention is dependent on the consent by MMWD and the ability of the design to continue to serve MMWD's water supply operation without interruption. Manipulation of lake levels for flood detention will be limited to the wet season which allows enough time for lake levels to return to normal by late spring. Flood detention operations will affect fishing opportunities and lake aesthetics during the wet season.

During a heavy storm, filling of the Phoenix Lake basin will be primarily triggered by monitoring information indicating imminent flooding at key breakout points in Ross.

Figure 4



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Detention Basin Estimated Quantities

Elevations	
Bottom Elev	250.0 Feet
Top of Dam Elev	275.0 Feet
Spillway Crest WSE	272.0 Feet
Maximum WSE	273.5 Feet

Freeboards to Top of Dam	
@ Spillway Crest WSE	3.0 Feet
@ Maximum WSE	1.5 Feet
Areas	
@ Spillway Crest WSE	3.00 Acres
@ Maximum WSE	3.24 Acres

Capacities	
@ Spillway Crest WSE	24.93 Acrefeet
@ Maximum WSE	29.63 Acrefeet

Earthwork Estimated Quantities

Cut	0	CY
Fill	16,740	CY
Net	16,740	CY (Fill)

LEGEND:

- EXISTING 2 FT CONTOURS
- PROPOSED 2 FT CONTOURS
- SPILLWAY CREST WSE (272')
- MAXIMUM WSE (273.5')

Notes:

1. Source of topography is LIDAR survey by Delta Geomatics, September 2009.
2. Source of aerial photo is Marin County, 2004.
3. Vertical datum is NAVD88.

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LOMA ALTA TRIBUTARY DETENTION BASIN

PLAN VIEW

Figure 5

Earthwork Estimated Quantities

Cut	124,550	CY
Fill	2,090	CY
Net	122,460	CY (Excavation)

Detention Basin Estimated Quantities

Elevations

Bottom Elev	199.5 to 198.5 Feet
Top of Dam Elev	220.0 Feet
Spillway Crest WSE	217.0 Feet
Maximum WSE	218.5 Feet

Freeboards to Top of Dam

@ Spillway Crest WSE	3.0 Feet
@ Maximum WSE	1.5 Feet

Areas

Bottom Area	4.00 Acres
@ Spillway Crest WSE	7.02 Acres
@ Maximum WSE	7.31 Acres

Capacities

@ Spillway Crest WSE	92.35 Acrefeet
@ Maximum WSE	103.10 Acrefeet

Others

1' Wide Conc. Wall	500 Feet
Access Road	225 Feet
Access Ramp	105 Feet
Drain Channel	1,830 Feet

LEGEND:

- EXISTING 2 FT CONTOURS
- PROPOSED 2 FT CONTOURS
- SPILLWAY CREST WSE (217')
- MAXIMUM WSE (218.5')

Notes:

1. Source of topography is LIDAR survey by Delta Geomatics, September 2009.
2. Source of aerial photo is Marin County, 2004.
3. Vertical datum is NAVD88.

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LEFTY GOMEZ DETENTION BASIN
PLAN VIEW

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Figure 6

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Earthwork Estimated Quantities

Cut	117,080	CY
Fill	4,720	CY
Net	112,360	CY (Excavation)

Detention Basin Estimated Quantities

Elevations	
Bottom Elev	60.0 Feet
Top of Dam Elev	79.0 Feet
Spillway Crest WSE	76.0 Feet
Maximum WSE	77.0 Feet
Freeboards to Top of Dam	
@ Spillway Crest WSE	3.0 Feet
@ Maximum WSE	2.0 Feet
Areas	
Bottom Area	4.37 Acres
@ Spillway Crest WSE	5.89 Acres
@ Maximum WSE	6.00 Acres
Capacities	
@ Spillway Crest WSE	81.92 Acrefeet
@ Maximum WSE	87.87 Acrefeet
Others	
Low Flow Channel	550 Feet
Access Ramp	130 Feet

LEGEND:
- EXISTING 2 FT CONTOURS
- PROPOSED 2 FT CONTOURS
- SPILLWAY CREST WSE (76')
- MAXIMUM WSE (77')

Notes:
1. Source of topography is LIDAR survey by Delta Geomatics, September 2009.
2. Source of aerial photo is Marin County, 2004.
3. Vertical datum is NAVD88.

Date: 01/27/2011

MEMORIAL PARK DETENTION BASIN
PLAN VIEW

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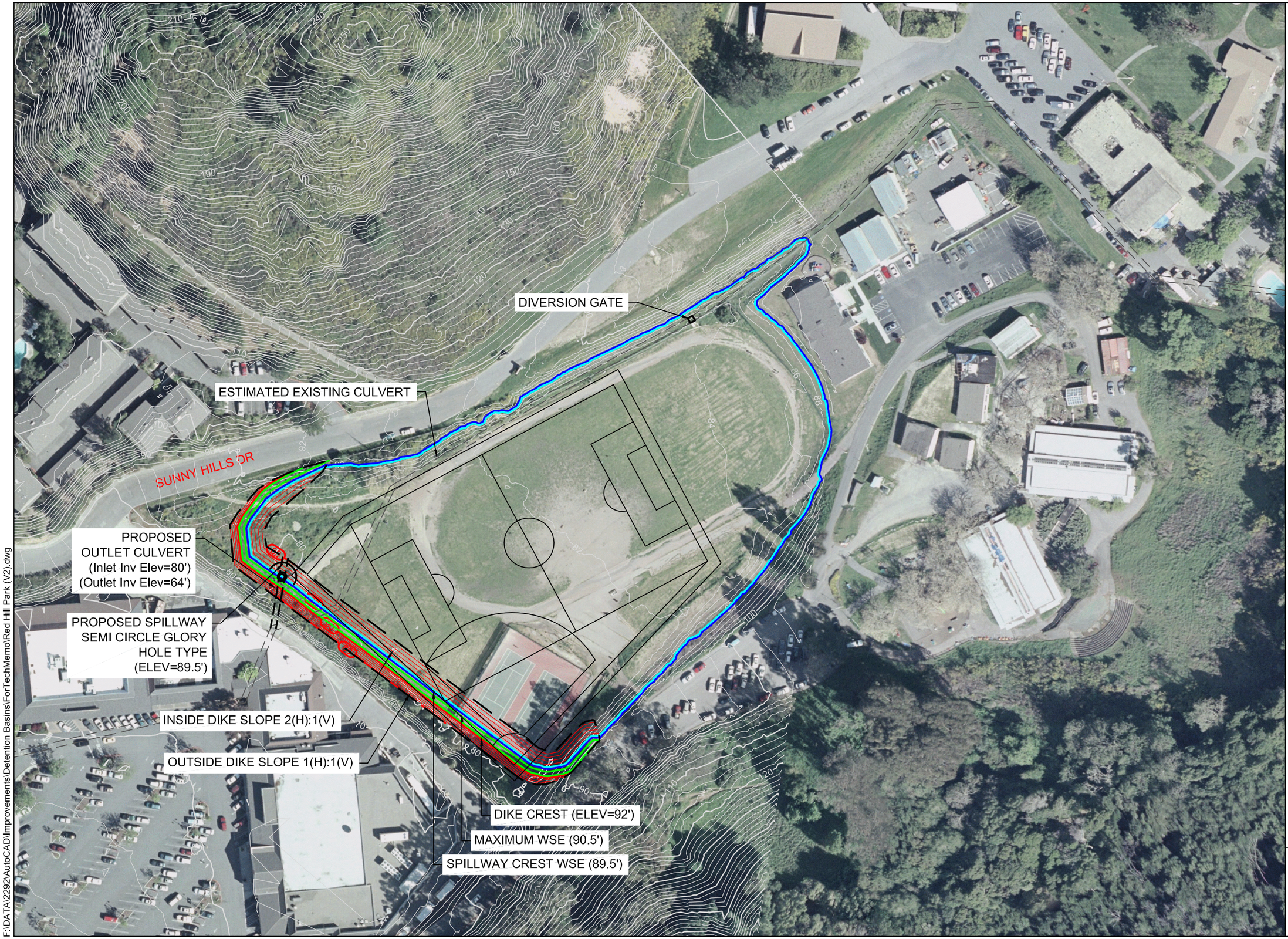
Figure 7



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Earthwork Estimated Quantities

Cut	0	CY
Fill	5,300	CY
Net	5,300	CY (Fill)

Detention Basin Estimated Quantities

Elevations	
Bottom Elev	from 80.0 to 86.0 Feet
Top of Dam Elev	92.0 Feet
Spillway Crest WSE	89.5 Feet
Maximum WSE	90.5 Feet
Freeboards to Top of Dam	
@ Spillway Crest WSE	2.5 Feet
@ Maximum WSE	1.5 Feet
Areas	
Bottom Area	3.80 Acres
@ Spillway Crest WSE	4.36 Acres
@ Maximum WSE	4.45 Acres
Capacities	
@ Spillway Crest WSE	28.31 Acrefeet
@ Maximum WSE	32.71 Acrefeet

LEGEND:
- EXISTING 2 FT CONTOURS
- PROPOSED 2 FT CONTOURS
- SPILLWAY CREST WSE (89.5')
- MAXIMUM WSE (90.5')

Notes:
1. Source of topography is LIDAR survey by Delta Geomatics, September 2009.
2. Source of aerial photo is Marin County, 2004.
3. Vertical datum is NAVD88.

Date: 01/27/2011

RED HILL PARK DETENTION BASIN
PLAN VIEW

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FIGURE 8

INSTALL INFLATABLE RUBBER DAM

INSTALL EMERGENCY GENERATORS

EXISTING FLOATING BRIDGE
PUMP STATION (WATER SUPPLY)

STABILIZE DAM
EMBAKMENT

EXISTING 30" OUTLET PIPE

EXISTING DAM CREST

NEW INTAKE STRUCTURES

EXISTING INTAKE STRUCTURE

EXCAVATE
LAKE BOTTOM

LEGEND

CONTOUR LINES (2 FOOT INTERVAL)

BATHYMETRIC CONTOUR LINES (2 FOOT INTERVAL)

179.16 SPOT ELEVATION

Notes:

1. This drawing is in California State Plane NAD 83, zone 3 and vertical datum NGVD 29.
2. Bathymetry data points source is XYZ file data received from Environmental Data Solutions in November 2009.
3. 2' Interval Contourlines and Spot Elevations are based on the 2004 aerial survey contour data received from Marin County.

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Conceptual view of the Phoenix Lake spillway with an inflatable/deflatable rubber dam raised by 6 feet, adding about 120 acre-feet of floodwater detention capacity.

STETSON
ENGINEERS INC.

DATE: JANUARY 27, 2011 | JN: 2292-4

PHOENIX LAKE DETENTION BASIN IMPROVEMENTS

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Effectiveness of the Possible Detention Basins in Reducing Flooding

The December 31, 2005 flood, an approximate 100-year flood event, was used as a case-study to analyze and assess the effectiveness the five possible detention basin sites. Hydrologic model simulations of the flood, using the calibrated HEC-HMS[5] hydrologic model developed by Stetson Engineers, were run with the hypothetical detention basins in place. Model results of this hypothetical scenario were compared to results of the "without" detention basins scenario (i.e., the model-simulated, actual flood conditions). Since all other model parameters in the two scenarios remained unchanged, it was reasoned that the flood reductions revealed by comparing the results were attributable to the detention basins.

Reducing peak flow in the creek at key breakout points where floodwaters escape from the channel is crucial to reducing the frequency and severity of flood damage in Ross Valley. 100-year flood flows and creek channel capacities at these key breakout points are shown in Figure 9. Model results at these key breakout points are shown in Figures 10 - 23.

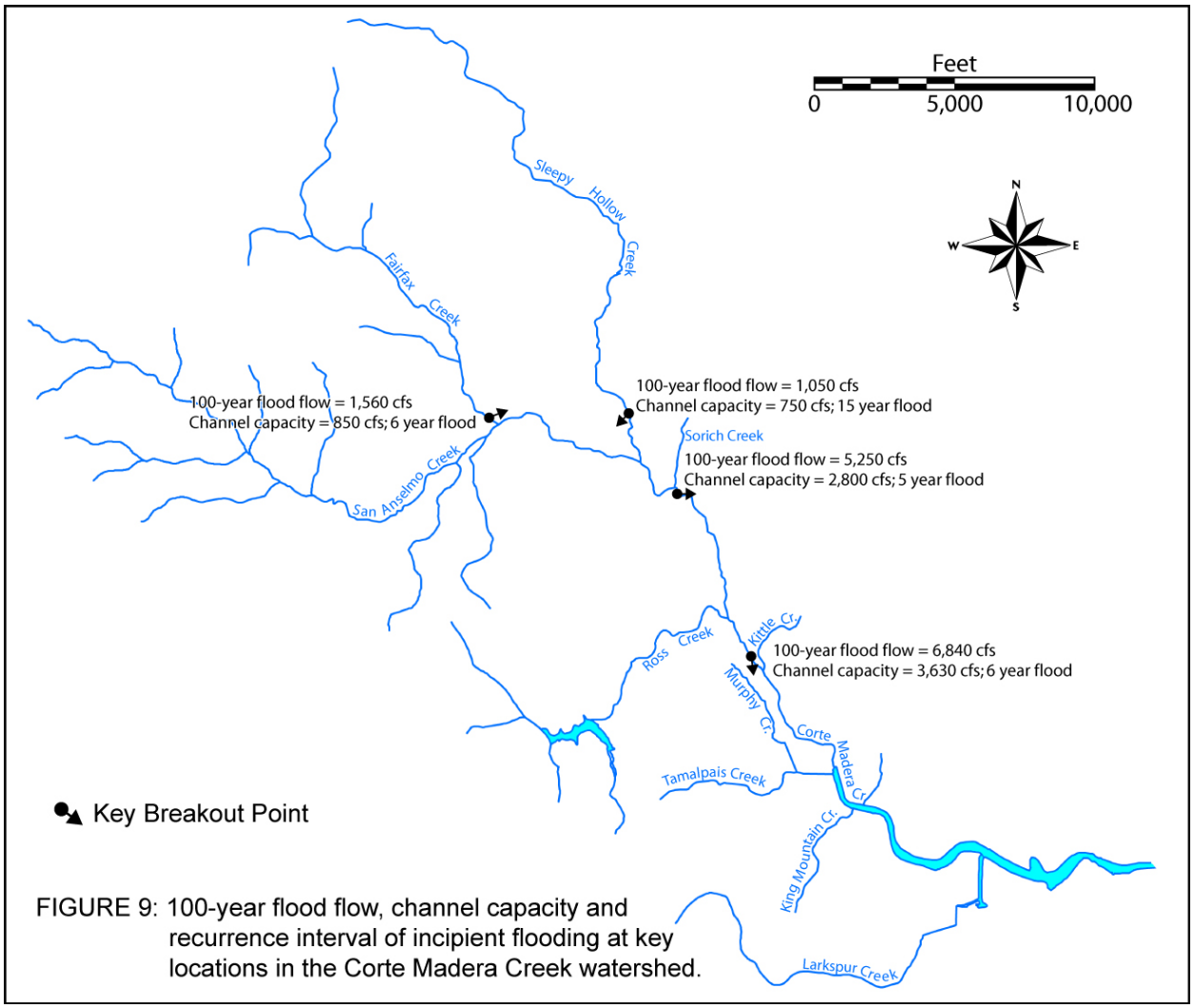

FIGURE 9: 100-year flood flow, channel capacity and recurrence interval of incipient flooding at key locations in the Corte Madera Creek watershed.

[5] U.S. Army Corps of Engineers Hydrologic Engineering Center's (HEC) Hydrologic Modeling System (HMS)

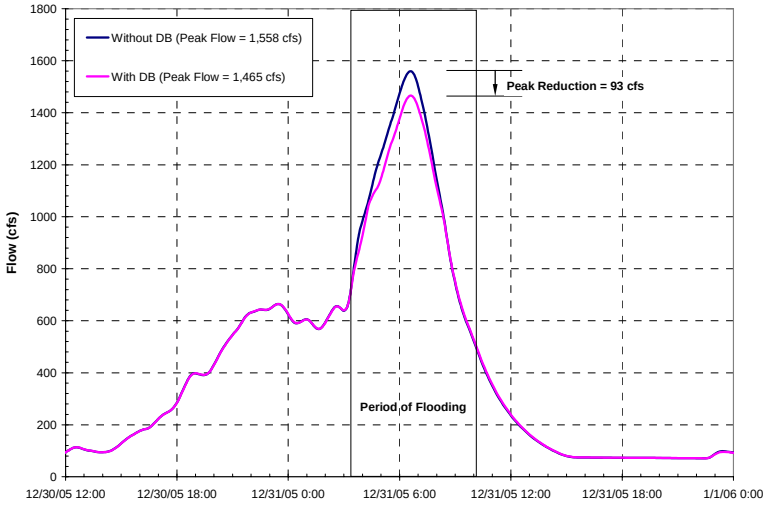

Figure 10: Reduction in peak flow at key breakout point in Fairfax attributable to Loma Alta detention basin

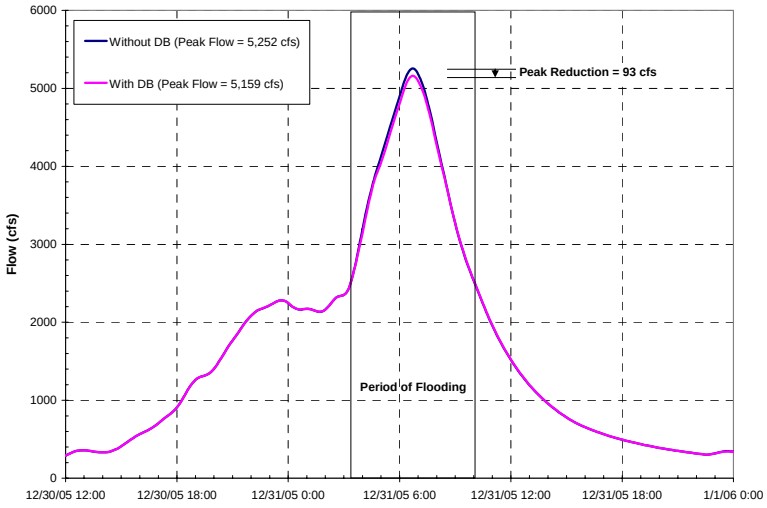

Figure 11: Reduction in peak flow at key breakout point in San Anselmo attributable to Loma Alta detention basin

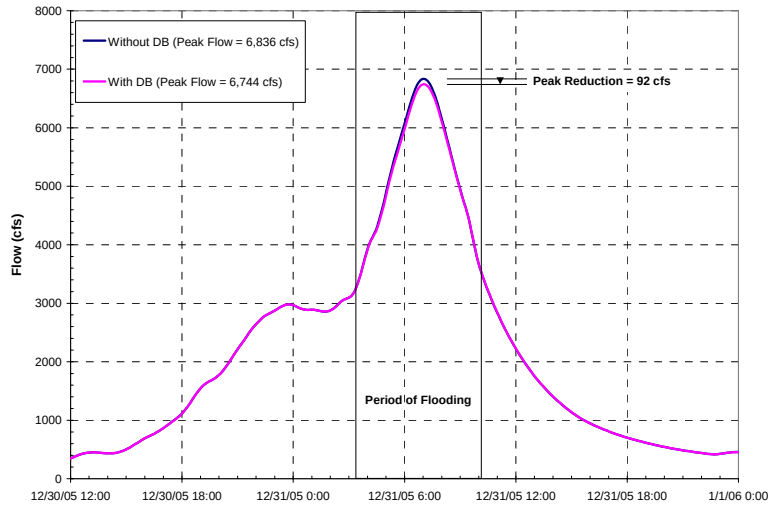

Figure 12: Reduction in peak flow at key breakout point in Ross attributable to Loma Alta detention basin

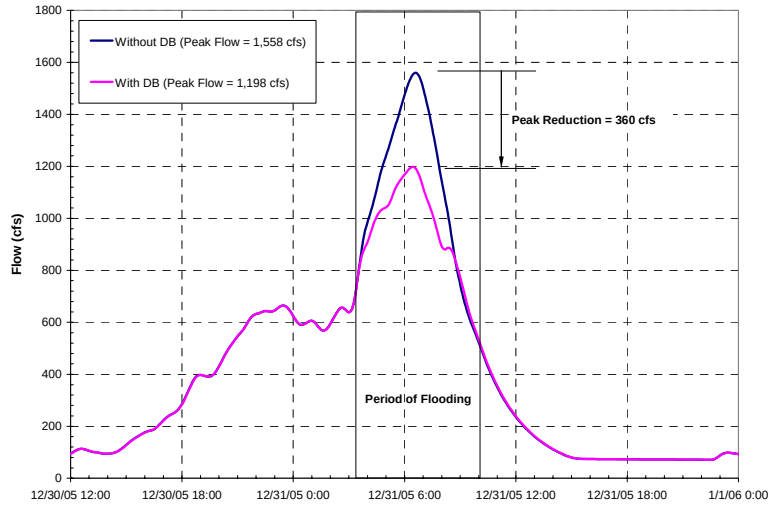

Figure 13: Reduction in peak flow at key breakout point in Fairfax attributable to Lefty Gomez detention basin

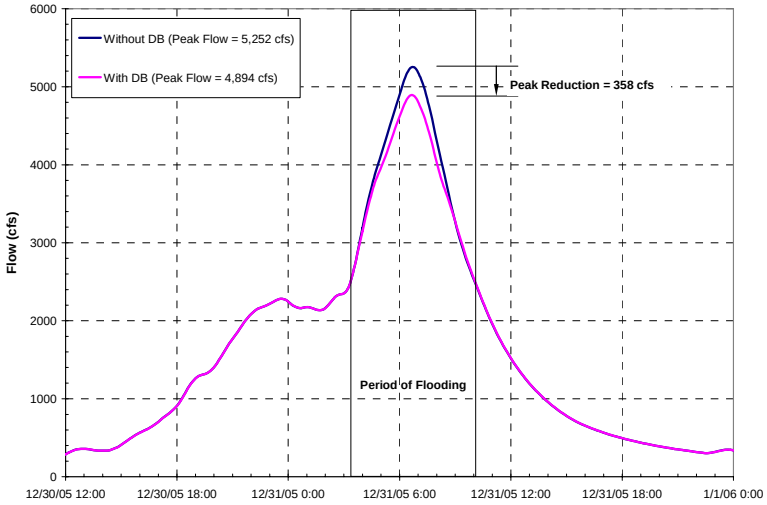

Figure 14: Reduction in peak flow at key breakout point in San Anselmo attributable to Lefty Gomez detention basin

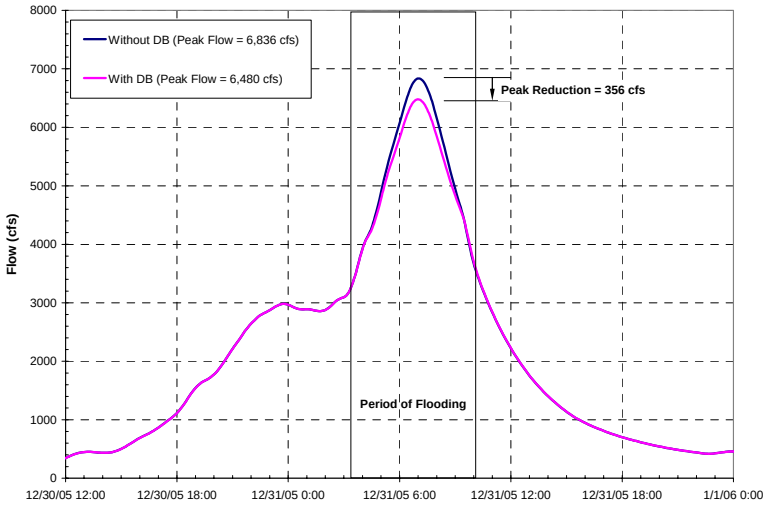

Figure 15: Reduction in peak flow at key breakout point in Ross attributable to Lefty Gomez detention basin

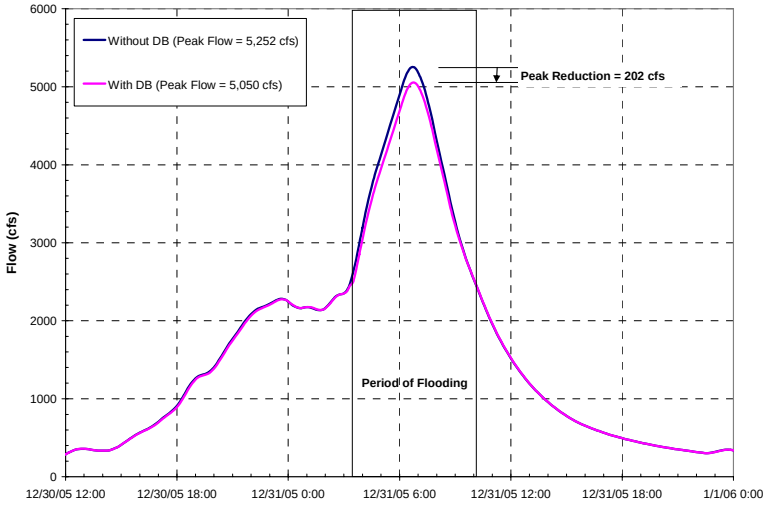

Figure 16: Reduction in peak flow at key breakout point in San Anselmo attributable to Memorial Park detention basin

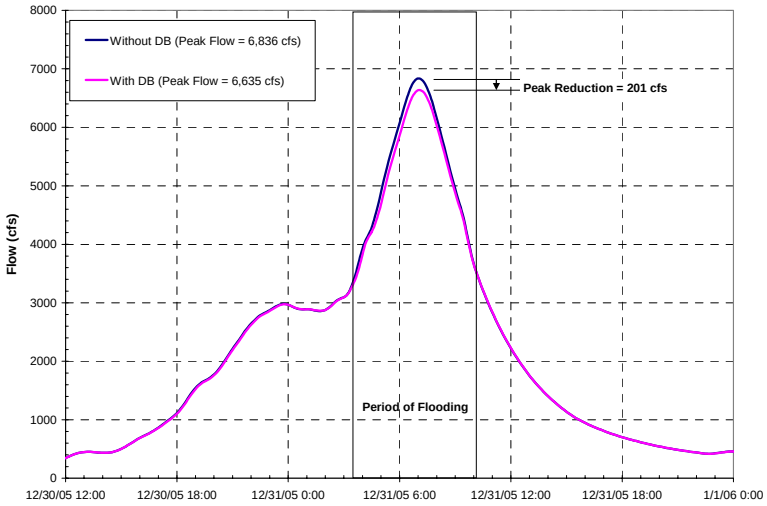

Figure 17: Reduction in peak flow at key breakout point in Ross attributable to Memorial Park detention basin

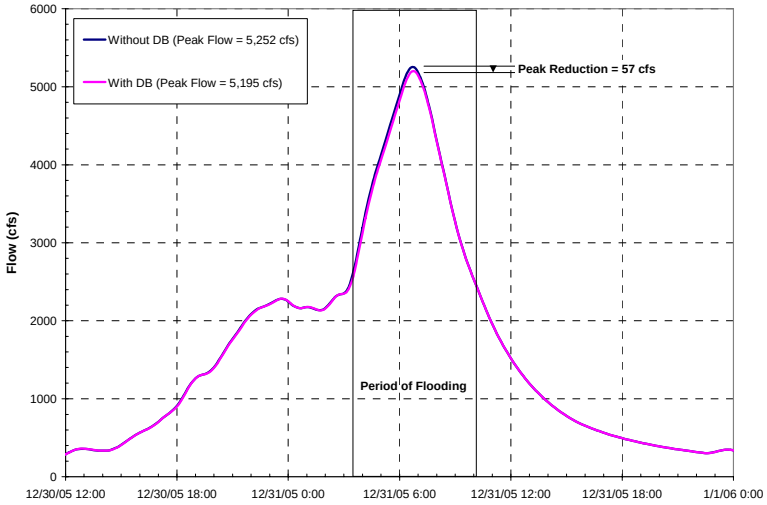

Figure 18: Reduction in peak flow at key breakout point in San Anselmo attributable to Red Hill Park detention basin

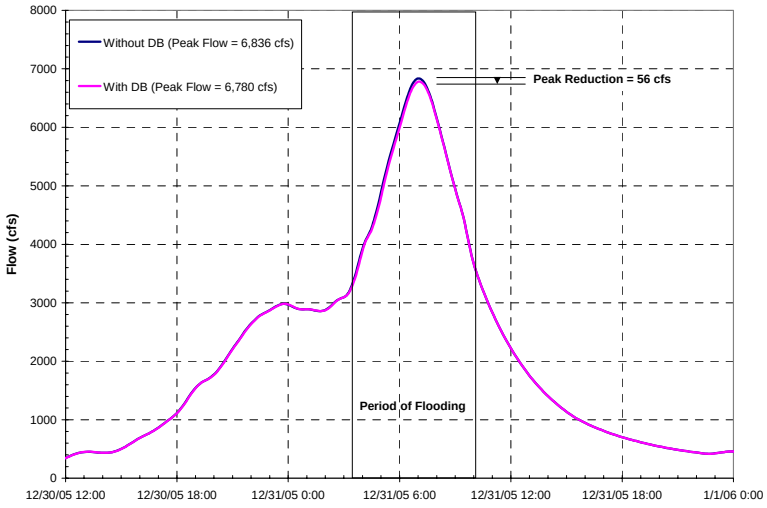

Figure 19: Reduction in peak flow at key breakout point in Ross attributable to Red Hill Park detention basin

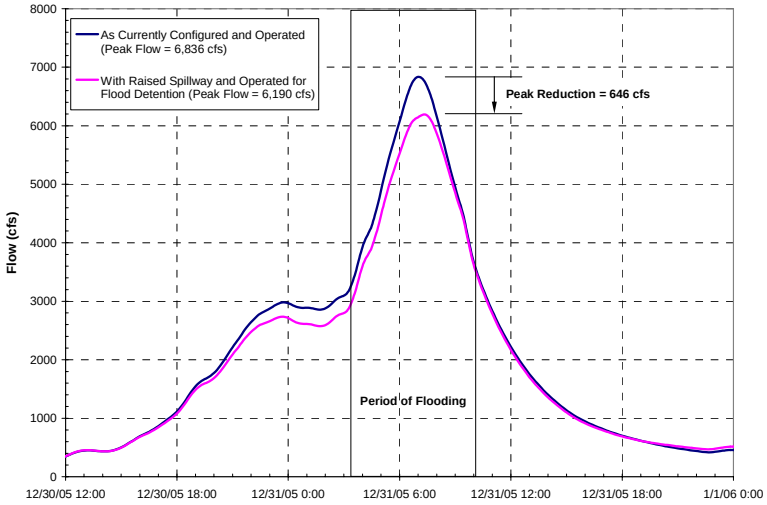

Figure 20: Reduction in peak flow at key breakout point in Ross attributable to Phoenix Lake detention basin

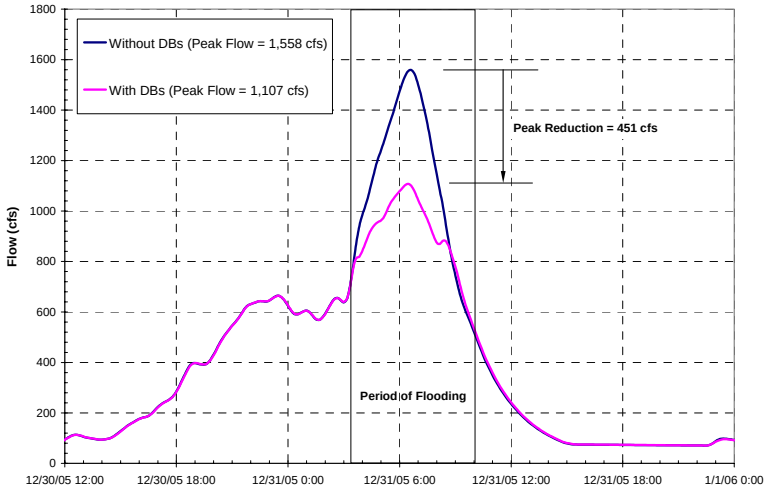

Figure 21: Reduction in peak flow at key breakout point in Fairfax attributable to all detention basins combined

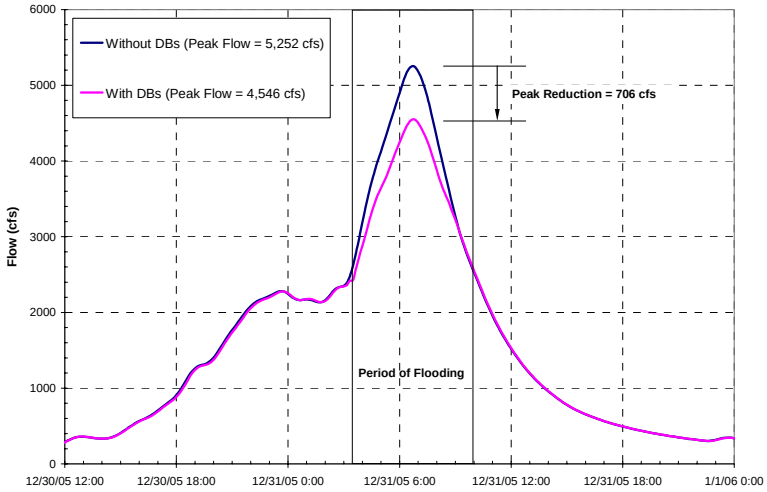

Figure 22: Reduction in peak flow at key breakout point in San Anselmo attributable to all detention basins combined

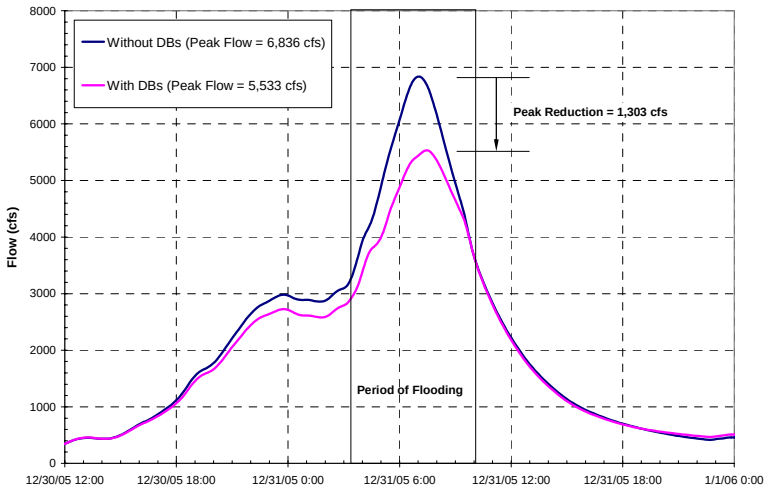

Figure 23: Reduction in peak flow at key breakout point in Ross attributable to all detention basins combined

Model results demonstrate that the five possible detention basins could reduce peak flow in the creek at key breakout points. Considering that the Lagunitas Road Bridge replacement in the Town of Ross, which was completed in December, 2010, has been designed to pass 5,500 cfs, and the Army Corps of Engineers stated design flow for completion of Unit 4[6] to the bay is 5,400 cfs; it is conceivable that detention basins could provide enough peak flow reduction to contain the 100-year flow below Ross. However, farther upstream in Fairfax and San Anselmo, peak flow reduction will not be enough to completely eliminate breakout of floodwaters. Measures that increase the conveyance capacity of the creek, such as flood-walls, earthen, landscaped

[6] "Unit 4" is the Army Corps of Engineer's name for the remainder of the long-standing federal flood control project behind the Post Office in the Town of Ross. It is currently scheduled for construction in 2013.

berms, or creek channel enlargements, will be needed in these areas in order to fully contain 100-year flows within the channel.

Technical Memorandum No. 3, entitled "***Critical Reach Analysis,***" will present the analysis and assessment of measures that can achieve the needed increases in conveyance capacity in the creek at these points.