American River Basin

Attachment 9: Economic Analysis – Flood Damage Reduction Costs and Benefits

Supporting Documentation

Att9_IG1_ARB_DReduc_2of3 includes the following:

- Antelope Creek Water Efficiency and Flood Control Damage Reduction Analysis
- Mitigation Monitoring Plan
- Update to the Dry Creek Watershed Flood Control Plan (Part 1 of 2)

Antelope Creek Water Efficiency and Flood Control Damage Reduction Analysis

December 28, 2010 JN 60-100771

E. Brian Keating, P.E. CFM
District Manager
Placer County Flood Control and Water Conservation District
3091 County Center Drive, Suite 220
Auburn, CA 95603

Subject: Antelope Creek Water Efficiency and Flood Control Project Flood Damage Reduction Analysis

Dear Brian:

The purpose of this letter is to document the Flood Damage Reduction Analysis that was completed for the proposed Antelope Creek Water Efficiency and Flood Control Project (Project) and present the Expected Annual Damage (EAD) benefits that would result from the completion of the Project.

Background

The Draft November 2010 *Update to the Dry Creek Flood Control Plan* (Plan Update) produced by Civil Engineering Solutions, Inc. with RBF Consulting for the Placer County Flood Control and Water Conservation District (District) describes and recommends potential flood control improvement projects and mitigation measures to reduce peak flows at key locations through the Dry Creek watershed. One of the projects recommended by the Plan Update is a flood control project on Antelope Creek in the City of Roseville that the District included as part of a proposed Antelope Creek Water Efficiency and Flood Control Project (Project). A vicinity map showing the Dry Creek watershed and the location of the Project is included as Exhibit 1.

The multi-objective Project includes lining the Antelope and Caperton Canals with a concrete gunite lining. The canal lining portion of the Project is not expected to have any impact on flood damages and is not part of this analysis.

The District is submitting a Proposition 84 Integrated Regional Water Management (IRWM) grant application to the Department of Water Resources (DWR) to assist with funding of the Project. The IRWM application requires an economic analysis related to the flood reduction benefits of the Project.

This letter report describes the flood damage reduction analysis (FDRA) of the Project performed to identify flood damage reduction benefits in support of the grant application.

Project Description

The Project site is located adjacent to Interstate-80, north of Atlantic Street on Antelope Creek in the City of Roseville. The proposed project concept is to construct two in-channel embankments and/or weirs spanning the main channel with culverts that have capacity for low to moderate flows. The embankments and/or weirs will detain higher flows to reduce peak flow rates downstream from the

Project site. The locations of the structures are just upstream of the railroad bridge and Atlantic Street and at an existing bike path culvert, just downstream from Roseville Parkway. The project is currently at a planning level stage and design details will be developed at a later date. This evaluation assumes that arch structures would be used for the culverts to provide a natural stream bottom and that the embankment/weir at the bike path location would replace an existing culvert with one with more capacity. The structures would be designed to be overtopped.

The purpose of the Project is to reduce peak flows downstream from the Project site. The Project is separated into 2 phases: Phase 1 involves construction of a new structure near Atlantic Street and Phase 2 involves replacement of the existing bike path crossing with a flow control structure that would improve low flow conveyance and increase the volume impounded before being overtopped. Exhibits 2 and 3 attached to this letter illustrate the locations and a conceptual layout of the proposed weir/embankments.

The structure near Atlantic Street was modeled as a 10- to 12-foot high embankment on the floodplain with a Conspan Arch culvert with a span of 32 feet and a rise of 7.5 feet. The second weir will replace the existing bike bridge, raising the bridge deck about 4 to 6 feet. An embankment or wall will tie in the crest of the new structure to existing ground to limit overtopping to the desired area. The model assumed that the two existing 6.5-foot diameter culverts will be replaced with a Conspan Arch with a span of 20 feet and a rise of 7 feet.

Hydrology and Hydraulic Analysis

Detailed hydrology and hydraulic models were developed for the Plan Update. Hydrology models were developed for various levels of build-out in the Dry Creek watershed. This analysis used the 2007 existing conditions hydrology. As stipulated in the IRWM grant application (IRWM Grant Application, Exhibit E, page 56, note 1), both without project and with project conditions are assessed based on existing conditions hydrology.

The Plan Update hydrology uses cloudburst centering per the District's hydrology procedures. The centerings are based on various locations and angle combinations. The Plan Update identified 7 critical storm centerings that produced nearly all peak flows at key locations throughout the watershed. Three of the critical storm centerings, centered at locations in the Antelope Creek and Secret Ravine watersheds, produce the maximum peak flows at locations downstream from the Project site. The three critical storm centerings are AC5I at 0°, SE40M at 30°, and SE40N at 0°. Details related to the hydrology are available in the Plan Update.

An extensive unsteady-state HEC-RAS model was created for the Plan Update using existing models. The existing conditions HEC-RAS geometry that includes the District's Miners Ravine Off-Channel Detention Basin was used as the basis for the baseline (Without Project) conditions for this analysis. The model datum is NGVD 29. Maximum peak stages and maximum peak flows for each of the three centerings for the 10-year, 25-year, 50-year, and 100-year flow conditions were generated for the Without Project flow conditions, Project Phase 1 flow conditions, and Project Phase 2 flow conditions. Project Phase 2 flow conditions reflect both Phase 1 and Phase 2 being complete. For each recurrence interval and Project condition scenario, the maximum peak stage produced by the maximum of the three critical centerings was tabulated for use in the FDRA.

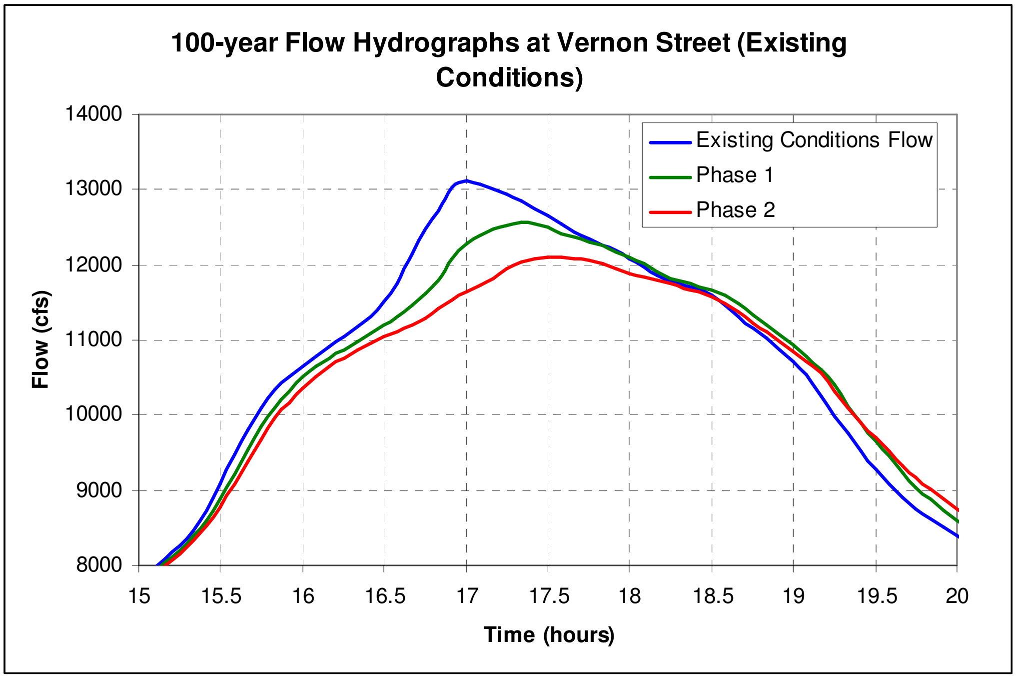
The Table 1 lists peak stages at 5 example locations on Dry Creek, downstream of the Project site for each of the 5 recurrence intervals for the Without Project, Phase 1, and Phase 2 flow conditions.

Table 1: Maximum peak flood stage at sample locations for various scenarios

Without Project					
	Recurrence Interval	**10**	**25**	**50**	**100**
Location	**HEC-RAS River Station**	**Peak Stage (ft)**	**Peak Stage (ft)**	**Peak Stage (ft)**	**Peak Stage (ft)**
Near Bernice Avenue	81041.20	145.2	147.1	148.4	150.0
Royer Park	77943	136.9	139.9	140.9	142.0
Near Earl Avenue	74433.10	131.1	133.2	134.4	135.3
Near Riverside Avenue	73756.6	129.7	131.7	132.8	133.4
Vernon Street	70071.60	124.0	126.1	127.2	129.2
Near Billy Mitchell Blvd	52140	93.9	95.7	96.5	97.3
Phase 1					
	Recurrence Interval	**10**	**25**	**50**	**100**
Location	**HEC-RAS River Station**	**Peak Stage (ft)**	**Peak Stage (ft)**	**Peak Stage (ft)**	**Peak Stage (ft)**
Near Bernice Avenue	81041.20	145.1	147.0	148.2	149.8
Royer Park	77943	136.8	139.5	140.7	141.8
Near Earl Avenue	74433.10	131.0	133.1	134.3	135.1
Near Riverside Avenue	73756.6	129.6	131.6	132.7	133.3
Vernon Street	70071.60	124.0	126.0	127.1	129.1
Near Billy Mitchell Blvd	52140	93.9	95.6	96.5	97.2
Phase 2					
	Recurrence Interval	**10**	**25**	**50**	**100**
Location	**HEC-RAS River Station**	**Peak Stage (ft)**	**Peak Stage (ft)**	**Peak Stage (ft)**	**Peak Stage (ft)**
Near Bernice Avenue	81041.20	145.0	146.8	148.0	149.6
Royer Park	77943	136.7	139.2	140.6	141.4
Near Earl Avenue	74433.10	130.9	133.0	134.2	135.0
Near Riverside Avenue	73756.6	129.6	131.5	132.6	133.2
Vernon Street	70071.60	123.9	125.9	126.9	129.1
Near Billy Mitchell Blvd	52140	93.9	95.6	96.4	97.1

Due to it being proximate to locations of flood prone properties, Dry Creek at Vernon Street became, and continues to be used, as a reference location for flood impacts in the Dry Creek watershed. Exhibits 4 and 5 illustrate the location of flood prone properties that could benefit from the proposed project, and Vernon Street at Dry Creek. Figure 1 presents the 100-year flow hydrographs for the existing conditions, Phase 1, and Phase 2 scenarios for the SE40N° 0 centering that generates maximum peak flow rates at Vernon Street. The maximum peak flow rate is reduced by about 530 cfs for Phase 1 and about 1000 cfs for Phase 2.

Figure 1: Flow hydrographs for Vernon Street.



Flood Prone Properties

Information about parcels that have experienced flood damage was provided by the District and included separate databases for parcels within the City of Roseville and parcels in unincorporated Placer County. The Placer County database contains high water marks for the 1995 flood event and flood depths for the 1983, 1986, and 1995 flood events.

The District also provided 2008 LiDAR data (from DWR) in NAVD 88. By using the databases provided by the District and the LiDAR data, a total of 128 flood prone parcels were identified downstream of the Project

Finished floor or lowest living area elevations were available for most parcels from the City of Roseville and Placer County flood prone parcel databases. Finished floor elevations were estimated from 2008 LiDAR and converted to the model datum the elevations were not available in the databases. Google Earth street view was also used to determine if finished floor elevations appeared to be close to ground elevations, or if the structure was raised. Finished floor elevations for 13 parcels were estimated in this manner.

The building size was also available from the databases for most buildings. For 21 buildings without a building size available, an estimate was obtained from Zillow.com, which acquires building size from publicly available records. For properties where the building size could not be acquired, the size was estimated using aerial imagery.

The database from the City of Roseville listed an estimated 1997 property value of $83.90 per square foot for living space and $22.10 per square foot for garage space. For the 2010 estimate, the property values were estimated to be $130 per square foot of living space and $30 per square foot of garage space.

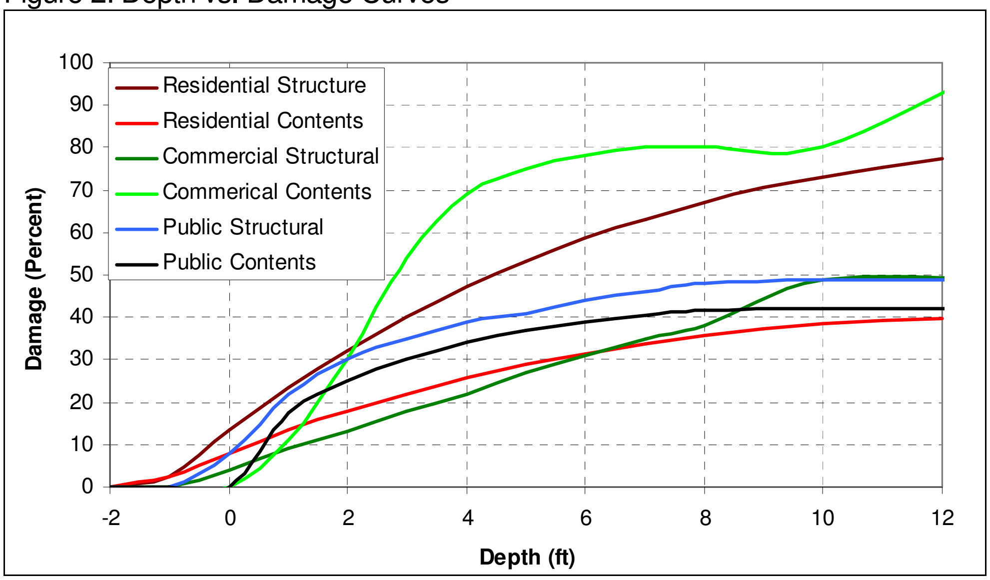
Flood Damage Analysis

The flood damage analysis (FDA) was completed using HEC-FDA, a computer program developed by the US Army Corps of Engineers (USACE). HEC-FDA uses the stage and discharge data produced in HEC-RAS and structure information to develop damage-stage relationships and combines the damage-stage functions with discharge-exceedance probability and stage-discharge relationships, and then applies a Monte Carlo simulation process to compute expected annual damage while accounting for uncertainty (See HEC-FDA User's Manual).

Depth damage curves published by both USACE and FEMA were used in the FDA (See USACE Economic Guidance Memorandum—EGM 04-01, *Generic Depth-Damage Relationships*, October 2003).

The depth damage curves for residential, commercial, and public buildings are presented in Figure 2. All residential buildings are assumed to be 1-story without a basement.

Figure 2: Depth vs. Damage Curves



The structure value to content value ratio was assumed to be 0.50 for residential, commercial, and public buildings. Contents of structures may include equipment, furnishings, raw materials, and commercial inventory.

A factor of plus or minus 0.25 feet was applied to the 100-year stage data to account for uncertainty.

HEC-FDA produced an expected annual damage results based on the structural damage curves and flood model described in this memo. The EAD based on structural damage only is presented in Table 2.

Table 2: Expected Annual Damage based on structural damage curves

Scenario	Expected Annual Damage	Expected Annual Damage Reduced
Without Project	$ 101,000	--
Phase 1	$ 97,000	$ 4,000
Phase 2	$ 89,000	$ 12,000

The event damage for structural damage only for the 2, 10, 25, 50, and 100-year recurrence intervals is presented in Table 3.

Table 3: Event Damage for Structural Damage Only

Hydrologic Event	Event Probability	Event Damage Without Project	Event Damage With Project Phase 1	Phase 1 Event Benefit	Event Damage With Project Phase 2	Phase 2 Event Benefit
10-year	0.10	$179,000	$176,000	$3,000	$172,000	$7,000
25-year	0.04	$745,000	$718,000	$27,000	$656,000	$89,000
50-year	0.02	$1,689,000	$1,679,000	$10,000	$1,527,000	$162,000
100-year	0.01	$2,505,000	$2,415,000	$90,000	$2,202,000	$303,000

The Figure 3 presents the loss-probability curves. The expected annual damage reduction is the area between the curves.

Figure 3: Loss vs. Probability Curves

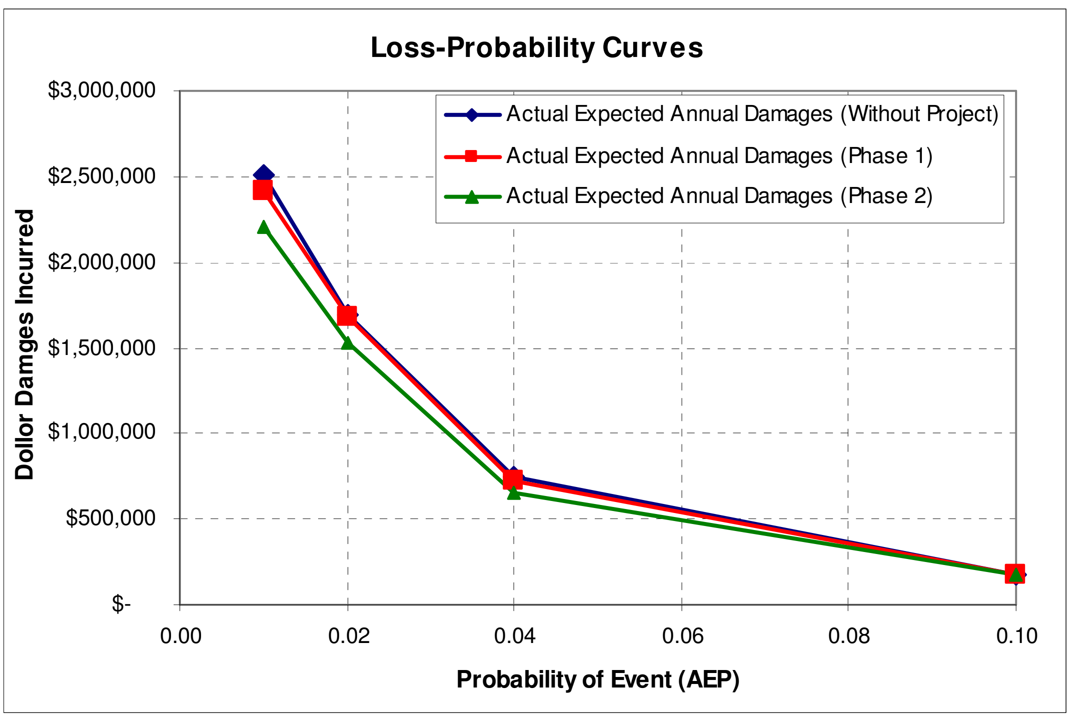


Table 4 presents the present value of future benefits of the Project, assuming an analysis period of 50 year with a 6% discount rate, consistent with DWR standard practice. The results are presented in the following tables:

Table 4: Present Value of Expected Annual Damage Benefits (structural damage only)

Expected Annual Damage Without Project	$101,000
Expected Annual Damage with Phase 1	$97,000
Expected Damage Benefit	$4,000
Expected Annual Damage with Phase 1+2	$89,000
Expected Damage Benefit	$12,000
Present Value Coefficient	15.76
Present Value of Future Benefits (Phase 1)	***$64,000***
Present Value of Future Benefits (Phase 2)	***$190,000***

Adjustments to Flood Damage Analysis Results

Several adjustments were made to the EAD values to account for various non-building damages, such as clean-up and other non-structural costs that can be considered to be proportional to structural damage. Some of the additional adjustment factors were taken from DWR *Flood Rapid Assessment Model Development*, November 2008 (F-RAM). These adjustments include:

- *Vehicle damage*: Street flooding can cause vehicle damage as flood waters rise above the vehicle floorboards. There is a used car lot on Riverside Avenue that has the potential for flood damage and other vehicles would likely be damaged in the event of a flood. A small reduction in peak flood stage in a given event could cause a major reduction in automobile damage if flows remain below automobile floorboards. Assuming 100 vehicles would be damaged during a 100-year flood event with the vehicles experiencing 30% damage, and assuming an average vehicle value of $10,000, an estimate of $300,000 in vehicle damage may be expected for the 100-year flow event. This represents 12% of the estimated 100-year event structural damage.

- *Roadway inundation damage:* A value of $30,000 per mile of inundated minor road is assumed in F-RAM. Using a conservative assumption of 2 miles of inundated minor roads (in the areas that would receive benefit from the Project) for the 100-year flood event, about $60,000 of damage to minor roads is expected. This is about 2% of the estimated 100-year event structural damage and damage reduction benefit can be assumed to be proportional to structural damage reduction benefit.

- *Bridge overtopping:* Seven bridges are overtopped in the existing condition 100-year flood event downstream from the Project. While the Project does not prevent any of these bridges to be overtopped in the existing conditions 100-year flood event, the height of overtopping may be reduced. Also, the new Cook Riolo Road bridge is not indicated as being overtopped in the existing condition 100-year flood event, but the Plan Update does indicate that it would be overtopped in the 100-year flood event based on unmitigated build-out in the Dry Creek watershed. The Project may prevent the bridge from being overtopped for the 100-year build-out conditions, however, this study is based on existing hydrology and no bridge related damage reduction was included for Cook Riolo Road. Furthermore, the benefit due to reduced overtopping of the other bridges is assumed to be negligible.

- *Other Factors*: Costs related to other factors include: emergency response services, loss of business income, temporary relocation, transportation system disruptions, loss of public services, damage to landscaping, and damage to other infrastructure such as sewer and power are not included in the structural damage estimates. Based on F-RAM documentation, indirect damages can be estimated as 25% of the direct damages to residential and commercial structures.

Factors for non-structural damage indicate that total damage can be expected to be at least 37% higher than structural damage based on property damage alone, not including loss of business to commercial and industrial enterprises, costs of flooding disruption to utilities (gas, electricity, water, sewerage, telecommunications and postal services), and costs imposed on public services, such as education and health services. To provide a reasonable comprehensive estimate for the flood reduction benefit of the project, the EAD for each scenario was increased by 50%. Table 5 presents the EAD adjusted by 50% to account for non-structural and indirect damages.

Table 5: Expected Annual Damage Adjusted for Non-Structural Factors

Scenario	**Expected Annual Damage**	**Expected Annual Damage Reduced**
Without Project	$ 151,000	--
Phase 1	$ 145,000	$ 6,000
Phase 2	$ 134,000	$ 17,000

Table 6 presents the present value of future benefits of the Project, assuming an analysis period of 50 years with a 6% discount rate, consistent with DWR standard practice.

Table 6: Expected Annual Damage Adjusted for Non-Structural Factors

Expected Annual Damage Without Project	$151,000
Expected Annual Damage with Phase 1	$145,000
Expected Damage Benefit	$6,000
Expected Annual Damage with Phase 2	$134,000
Expected Damage Benefit	$17,000
Present Value Coefficient	15.76
Present Value of Future Benefits (Phase 1)	***$95,000***
Present Value of Future Benefits (Phase 2)	***$268,000***

Conclusion

Even though Phases 1 and 2 of the Project would provide a significant flow reduction in a 100-year storm event, this reduction corresponds to only a relatively small (less than one-half foot) reduction in peak flood stage at key locations. Based on the HEC-FDA results multiplied by 1.5 to account for non-structural and indirect damages, the present value of the expected benefit of Phase 1 is $95,000 and the expected benefit of the complete Project with Phase 2 is $268,000.

Though these results alone do not provide justification for the cost of the proposed project, other factors, such as increased benefit of other potential future regional projects and reducing measures necessary to provide 100-year protection to properties may help justify the cost. Additionally, there are few potentially feasible regional flood reduction projects in the Dry Creek watershed and the Antelope Creek Project was identified as being the most cost effective of the options available.

Sincerely,

Harvey Oslick, P.E.
Senior Associate

Cc: Rob Swartz, RWA
Leslie Dumas, RMC

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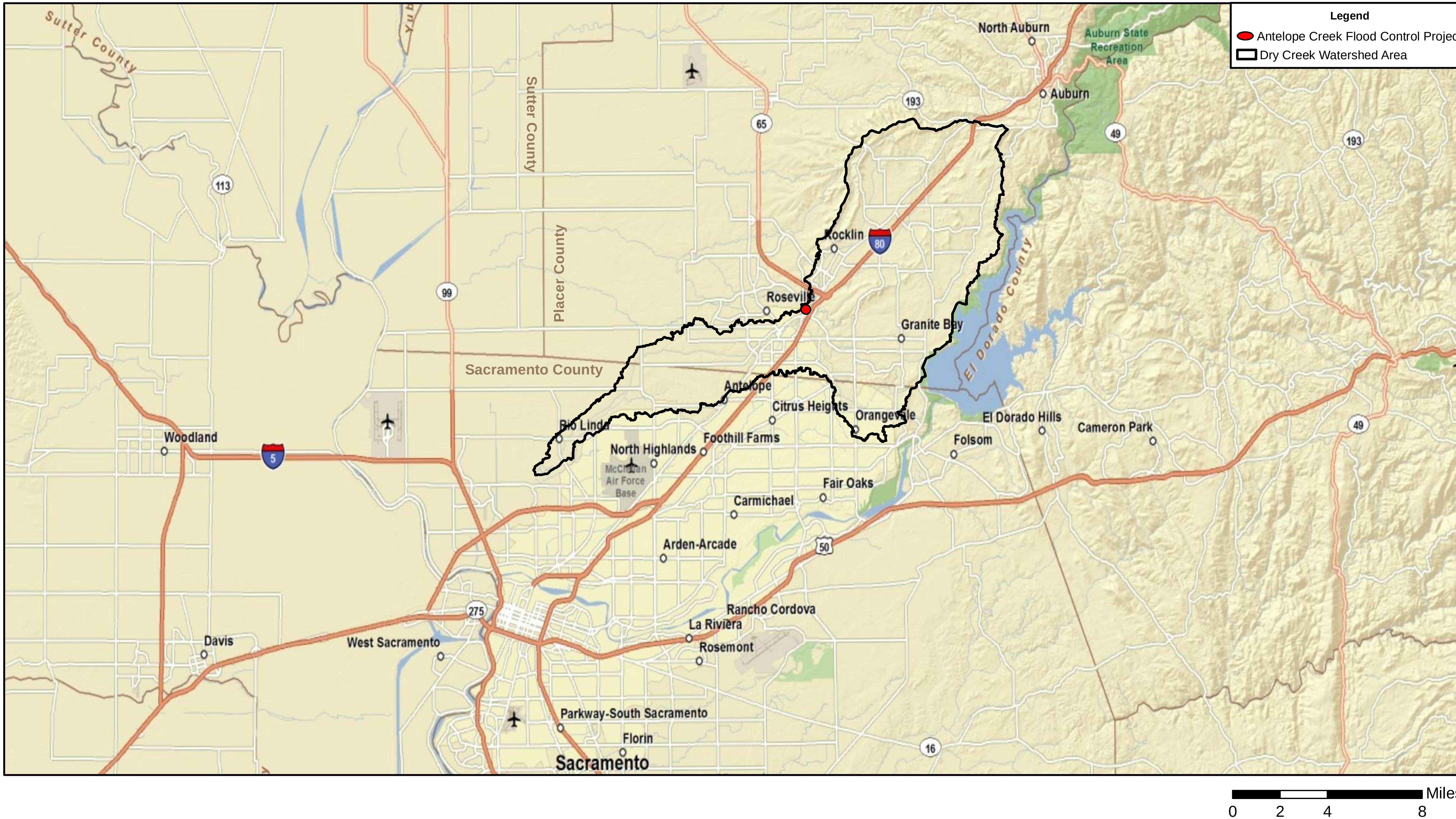
DRY CREEK WATERSHED VICINITY MAP AND ANTELOPE CREEK FLOOD CONTROL PROJECT



PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

December 2010

ANTELOPE CREEK FLOOD CONTROL PROJECT
FLOOD DAMAGE REDUCTION ANALYSIS

Exhibit 1

ANTELOPE CREEK FLOOD CONTROL PROJECT - PHASE 1

PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

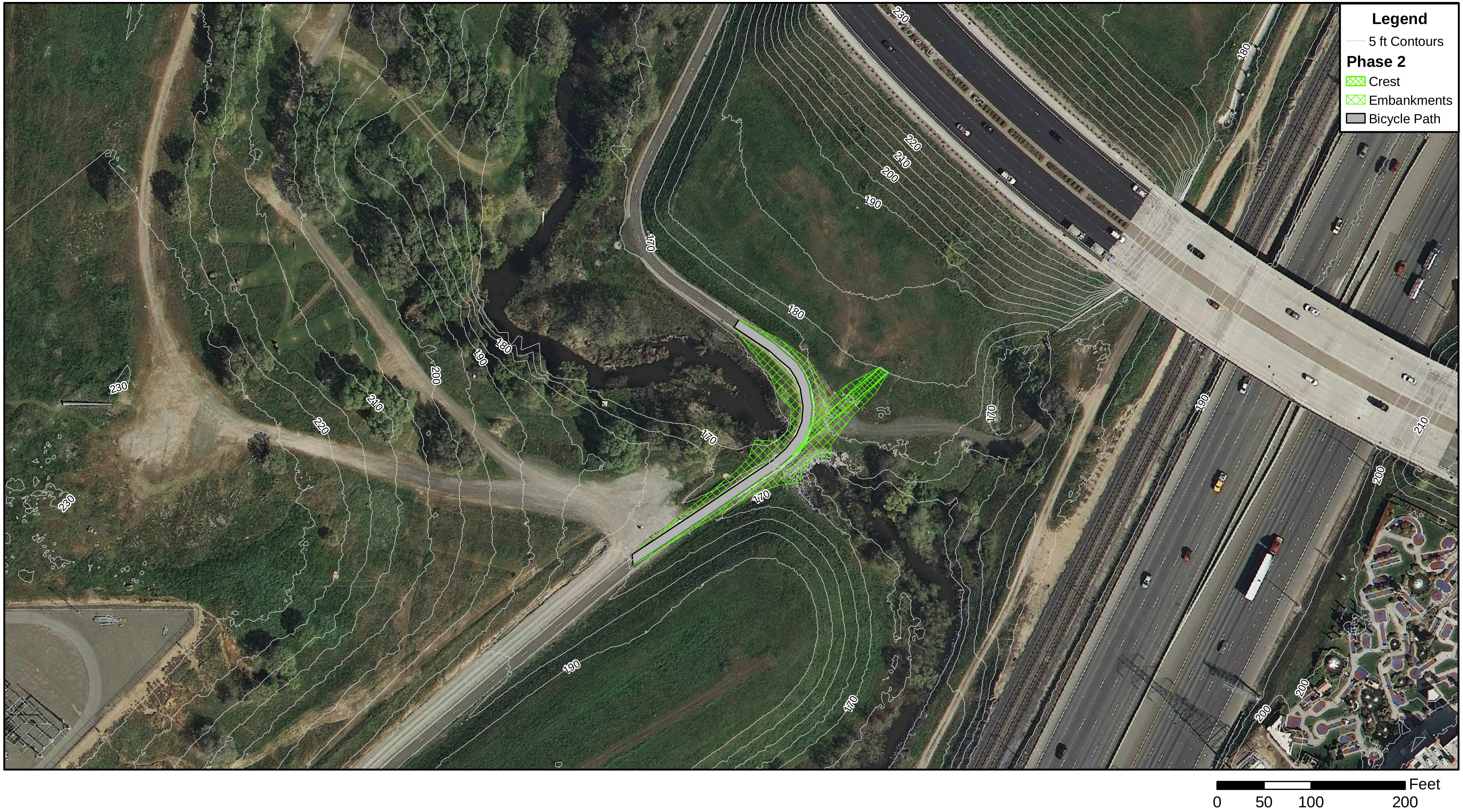
RBF CONSULTING

ANTELOPE CREEK FLOOD CONTROL PROJECT
FLOOD DAMAGE REDUCTION ANALYSIS

December 2010

Exhibit 2

ANTELOPE CREEK FLOOD CONTROL PROJECT - PHASE 2



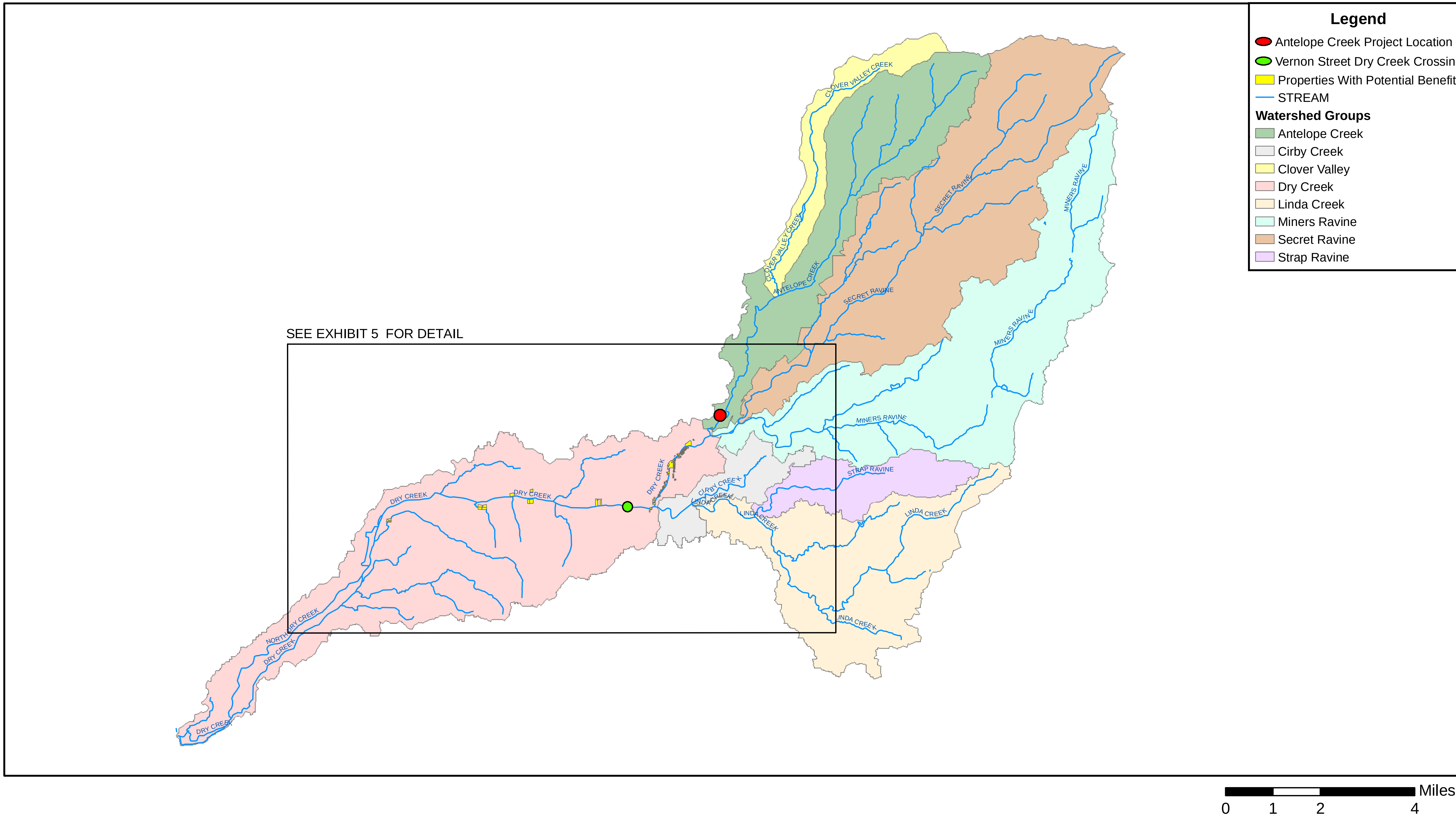
PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

December 2010

ANTELOPE CREEK FLOOD CONTROL PROJECT
FLOOD DAMAGE REDUCTION ANALYSIS

Exhibit 3

DRY CREEK WATERSHED GROUPS AND FLOOD PRONE PROPERTIES WITH POTENTIAL BENEFITS



PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

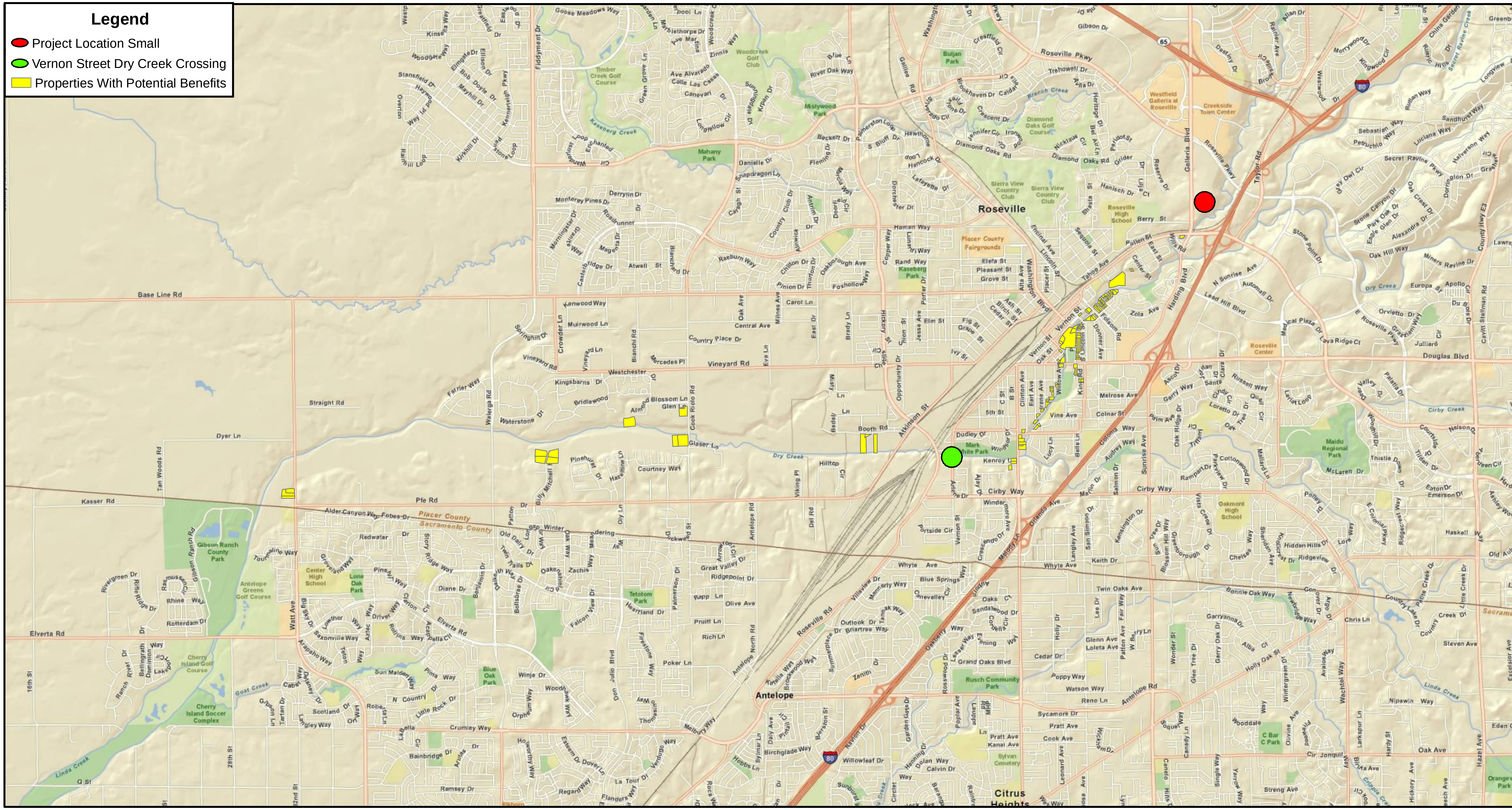
RBF CONSULTING

ANTELOPE CREEK FLOOD CONTROL PROJECT
FLOOD DAMAGE REDUCTION ANALYSIS

December 2010

Exhibit 4

DETAIL OF PROJECT AREA AND FLOOD PRONE PROPERTIES WITH POTENTIAL BENEFITS



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PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

RBF CONSULTING

December 2010

ANTELOPE CREEK FLOOD CONTROL PROJECT
FLOOD DAMAGE REDUCTION ANALYSIS

Exhibit 5

Mitigation Monitoring Plan

Mitigation Monitoring Program

Project Title:	Miners Ravine Off-Channel Detention Basin Facility
Lead Agency Name and Address:	Placer County Flood Control and Water Conservation District 11444 B Avenue Auburn, CA 95603
Contact Person and Phone Number:	E. Brian Keating, District Engineer 530-889-7592
Project Location:	The project site is located along Miners Ravine on the west and east sides of Sierra College Boulevard in the City of Roseville and Placer County. The western portion of the site is within the Roseville City limits; the eastern portion is on unincorporated Placer County lands. The project site is located in Section 32, Township 11 north, Range 7 east on the Rocklin 7.5-minute quadrangle.
Project Sponsor's Name and Address:	Placer County Flood Control and Water Conservation District 11444 B Avenue Auburn, CA 95603

Description of Project: The District is proposing to construct a multi-objective flood control and creek restoration project that will provide regional flood control benefits through off-channel detention, as well as habitat restoration and enhancement and a recreational trail system. The purpose of the project is to provide flood damage reduction in the 101-square-mile Dry Creek watershed by increasing the off-channel storage capacity available at the project site while providing environmental and recreational enhancements in the corridor. The project is intended to achieve the following objectives.

- Reduce flood flows through off-channel detention and increase floodplain capacity immediately adjacent to the creek.
- Reduce the likelihood of Sierra College Boulevard (a major thoroughfare) being overtopped during flooding events.
- Maintain the existing 100-year floodplain footprint.
- Minimize the potential for fish stranding in the floodplain and detention pond.
- Enhance rearing habitat for anadromous fish in Miners Ravine.
- Restore and enhance wetland habitat at the project site (in the eastern basin).
- Restore riparian habitat and oak woodland at the project site (on the floodplain adjacent to Miners Ravine)
- Provide a multi-use recreation trail and trailhead parking.
- Provide improved public access to recreational and educational opportunities along Miners Ravine.

Introduction: The District prepared an Initial Study/Proposed Mitigated Negative Declaration (IS/ Proposed MND) (December 2005) for the proposed project that identifies potential impacts and mitigation measures to reduce significant impacts to a less-than-significant level. Seven mitigation measures were identified as a result of the impact analysis conducted for the project. The IS/Proposed MND concluded that implementation of these mitigation measures would reduce all potentially significant impacts to a less-than-significant level.

This mitigation monitoring and reporting program has been prepared to comply with Section 21081.6(a)(1) of the Public Resources Code which requires the following:

> The public agency shall adopt a reporting or monitoring program for the changes made to the project or conditions of project approval, adopted in order to mitigate or avoid significant effects on the environment. The reporting or monitoring program shall be designed to ensure compliance during project implementation.

Mitigation Monitoring Program: This Mitigation Monitoring Program (summarized in Table 1) lists all the mitigation measures identified in the District's IS/Proposed MND. In general, monitoring becomes effective at the time the action is taken on the project. Timing of monitoring is organized as follows:

1. *Prior to Construction:* The monitoring activity consists of insuring that a particular mitigation action has taken place prior to the beginning of any construction or grading activities.

2. *During Construction:* The monitoring activity consists of active monitoring while grading or construction is occurring on the project site.

3. *Ongoing:* The monitoring activity consists of monitoring after the grading and construction phase of the project has been completed and relates to ongoing operation of the project.

Table 1. Mitigation Monitoring Program

Mitigation Measure	Funding Source	Monitoring Agency	Timing	Monitoring Program	Standards for Success
Mitigation Measure B-1: Install Construction Barrier Fencing to Protect Sensitive Biological Resources Adjacent to the Construction Zone:	District	District	Prior to construction	Construction contractor, project engineer, and resource specialist will identify locations for fencing and stake around sensitive resource sites	Avoidance of designated sensitive biological resources adjacent to the construction zone
Mitigation Measure B-2: Retain a Biologist to Monitor Construction Activities	District	District	Weekly during construction	Biological monitor will assist construction crew in compliance with project implementation restrictions and guidelines and be responsible for ensuring that contractor maintains marked perimeter of the construction and staging areas adjacent to sensitive biological resources	Adherence by construction contractor to construction restrictions and guidelines and avoidance of specified sensitive biological resources
Mitigation Measure B-3: Conduct a Preconstruction Survey for Northwestern Pond Turtles Preconstruction surveys	District	District	Within 48 hours prior to the initiation of ground disturbance	Qualified wildlife biologist to be retained by the District	Avoidance of active pond turtle nest
Mitigation Measure B-4: Conduct Preconstruction Surveys for Swainson's Hawk Nests and Implement Appropriate Restrictions and Compensation	District	District	Prior to construction	Qualified wildlife biologist will conduct surveys of suitable habitat within 0.25 mile of the project area during the breeding season before project activities begin	Avoidance of impacts on nesting Swainson's Hawk and minimization of disturbance on their foraging habitat

Mitigation Measure	Funding Source	Monitoring Agency	Timing	Monitoring Program	Standards for Success
Mitigation Measure B-5: Conduct Preconstruction Nesting Bird and Raptor Surveys and Implement Appropriate Restrictions	District	District	Prior to construction	Tree removal will occur prior to February 28 to avoid the breeding season and discourage birds from nesting near construction area All trees within 350 feet of potential construction activity will be surveyed No construction vehicles will be permitted within restricted areas unless directly related to management or protection of legally protected species	Avoidance of nesting migratory birds and raptors
Mitigation Measure CR-1: Implement a Plan to Address the Discovery of Unanticipated Cultural and Paleontological Resources	District	District	During construction	If the contractor unearths buried cultural or paleontological resources during construction, work will stop in that area and within 100 ft. of the find until a qualified archaeologist or paleontologist can assess significance of the find, and if necessary, develop appropriate treatment measures in consultation with the District and any other appropriate agencies	Avoidance of buried cultural or paleontologic al resources

Mitigation Measure	Funding Source	Monitoring Agency	Timing	Monitoring Program	Standards for Success
Mitigation Measure CR-2: Implement a Plan to Address the Discovery of Human Remains	District	District	During construction	If any human remains are discovered or recognized in any location other than a dedicated cemetery, no further excavation or disturbance of the site or nearby area will occur until: 1. the Placer County coroner is informed and has determined that investigation of the cause of death is not required; and 2. if the remains are of Native American origin, the descendants of the deceased Native Americans have made a recommendation to the landowner or the person responsible for the excavation work, for means of treating or disposing of, with appropriate dignity, the human remains and any associated grave goods as provided in PRC 5097.98; or the NAHC has been unable to identify a descendant or the descendant failed to make a recommendation within 24 hours after being notified by the commission	Avoidance of human remains

Update to the Dry Creek Watershed Flood Control Plan (Part 1 of 2)

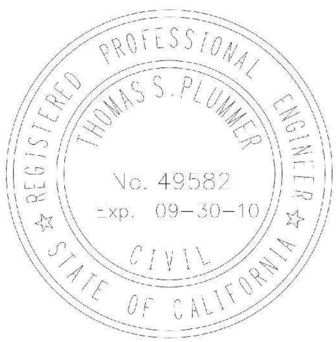
Update to the Dry Creek Watershed Flood Control Plan

Draft, November 2010

Placer County Flood Control and Water Conservation District

Prepared by: CIVIL ENGINEERING SOLUTIONS, INC. RBF CONSULTING

The Dry Creek Watershed Plan Update was prepared under the direction of:



Thomas S. Plummer, P.E.
Civil Engineering Solutions, President

Harvey R. Oslick, P.E.
RBF Consulting, Senior Associate

UPDATE TO THE DRY CREEK WATERSHED FLOOD CONTROL PLAN

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Executive Summary

EXECUTIVE SUMMARY

ES-1 PURPOSE

The primary purposes of this Update to the Dry Creek Watershed Flood Control Plan (Plan Update), prepared for the Placer County Flood Control and Water Conservation District (District), are to update the hydrologic analysis of the watershed, provide recommendations for feasible means to reduce future flood damages, identify possible means to mitigate development impacts on flooding, and recommend an updated funding plan. The 1992 Dry Creek Watershed Flood Control Plan (1992 Plan) recommended structural and non-structural measures to correct existing deficiencies and mitigate for impacts of future development. Some of the recommendations have been implemented while many have not due to environmental and/or economic constraints. This Plan Update evaluates the hydrology of the watershed and provides recommendations to correct existing deficiencies and mitigate impacts of future development using an overall watershed approach with the objective of identifying measures that will be both feasible and effective.

ES-2 BACKGROUND

The Dry Creek watershed covers an area of 101 square miles in Placer and Sacramento Counties. The majority of the watershed (82 percent) is contained within the limits of Placer County. The Cities of Rocklin and Roseville and the Town of Loomis are wholly or partially contained within the watershed. Other unincorporated communities in the watershed include Granite Bay, Penryn, Newcastle, Orangevale, and Rio Linda. A vicinity map of the watershed is provided on Plate 1 and a watershed overview is provided on Plate 2.

The purpose of the 1992 Plan was to provide the District and other governmental agencies (in both Placer and Sacramento Counties) with the information and policies necessary to manage the storm waters within the Dry Creek watershed. The 1992 Plan was intended to provide an approach for meeting existing and future flood control needs in the watershed. In addition, the 1992 Plan recommended structural and non-structural measures to correct existing deficiencies and mitigate for impacts of future development within the watershed. The 1992 Plan was formally adopted by the District Board in June 1995.

The 1992 Plan focused on the ability of on-channel regional detention basins to mitigate both existing flooding problems and the increase in flood flows due to upstream development. Based on costs and corresponding flood flow reduction efficiency at Vernon Street in Roseville, seven detention basin sites were selected for inclusion in the 1992 Plan. If implemented, these sites could have provided peak 100-year flood flow reduction of nearly 4,000 cubic feet per second (cfs) at Vernon Street. However, none of the on-channel regional detention basins included in the 1992 Plan have been, nor are currently expected to be, implemented.

ES-3 CURRENT CONDITIONS

From a hydrologic standpoint, imperviousness of a watershed, which is directly linked to land use, is the single most important factor used in determining stormwater runoff rates and volumes. Establishing current runoff quantities is a required step in the preparation of this Plan Update. Imperviousness is linked to land use. The 1992 Plan evaluated existing conditions based on 1989 land use and future conditions based on General Plan build-out data available at the time. This Plan Update uses available aerial imagery and information about development to estimate how much of the watershed was covered with impervious surfaces. This estimate forms the basis for a hydrologic evaluation of impacts that have occurred since the 1992 Plan was implemented and what impacts may be associated with development from the current conditions moving forward to build-out based on current General Plans. It is estimated that 43 percent of the impervious area expected to be added to the watershed from 1992 to build-out had already occurred through 2007.

Though there has been significant progress towards reducing flood risks in the Dry Creek watershed through the implementation of local improvement projects including bridge replacements, flow bypasses, building elevation projects and residential buy-outs, there are still numerous flood hazard areas and roadway stream crossings that do not have adequate capacity. One regional flood control project, Miners Ravine Off-Channel Detention Basin, was completed in 2007. The Miners Ravine project does provide some peak discharge reductions, but these reductions generally just provide partial mitigation for development that has already occurred. Since the 1992 Plan, flood damages occurred in January 1995, January 1997, February 1998 and December 2005. Other than some local bridge improvements, no flood hazard reduction projects are currently planned, although the City of Rocklin is in the process of investigating the feasibility of a flood damage reduction project along Sucker Ravine.

ES-4 HYDROLOGY

A major component of this Plan Update is a new hydrologic modeling system that provides the tools necessary to evaluate the dynamics of stream flow routing throughout the watershed. With this new modeling system, it is possible to quantify project impacts and benefits that could not be evaluated with the technologies available at the time that the 1992 Plan was prepared. The new modeling system has been calibrated to reproduce measured stream flows based on rainfall gage records, thereby establishing the validity of the models. The District's Stormwater Management Manual provides procedures for applying design storm rainfall. These procedures were followed in the Plan Update, but do not match the rainfall and rainfall to runoff transformation process used in the 1992 Plan. Therefore, the new modeling system does not produce exactly the same results as the one used to create the 1992 Plan and conclusions drawn from comparing results between the 1992 Plan and the Plan Update values must be limited to understanding the difference. Absolute inference related to changes in flow due to development and projects must only consider a common baseline modeling system.

ES-5 RECOMMENDATIONS

Since on-channel dams as recommended in the 1992 Plan are no longer feasible as flood damage reduction projects within the Dry Creek watershed, alternative means for flood damage reduction must be used. This Plan Update identifies potential structural improvements to reduce peak flow rates at some locations. However, the potential projects presented in the Plan Update do not have sufficient benefit to fully mitigate for anticipated development impacts and would not correct existing deficiencies. Therefore, non-structural flood hazard reduction and flood risk management measures, such as building elevation projects, are proposed as the most feasible means to reduce future flood damages within the watershed. The Plan Update recommends pursuing building elevation and/or relocation projects, and residential buy-outs for the highest risk, repetitive loss properties.

The District and City of Roseville have a flood warning ALERT System that monitors numerous precipitation and stream gages and provides a good source of flood warning information. Enhancing the flood warning system's predictive capabilities, possibly based on rainfall predictions and the modeling system developed for this Plan Update, may be worthwhile in the future as the costs for such features lower over time.

Five development impact flood flow mitigation projects are recommended as part of the Plan Update. These projects include weirs that span the stream channels to limit the impacts of the proposed projects on the streams while enhancing floodplain storage and modifying flood flow timing to reduce peak downstream discharges at key locations. Table ES-1 summarizes the planning level cost estimates for the five recommended projects and each project's reduction in peak discharge at Vernon Street in Roseville based on the single design storm that generates the 100-year discharge at Vernon Street. The expected flow reduction benefit of each project taken individually and the expected net flow reduction benefit of all five projects together are listed. The combination of all of the projects would result in a greater benefit than the sum of the individual projects due to flow timing. Evaluations based on other design storms (other storm centerings) could indicate greater or lesser benefits. (Information about potential project benefits based on other design storms is presented in the report and its appendices.)

Table ES-1: Recommended Regional Projects for New Development Impact Mitigation

Description	**Cost**	**Flow Reduction**
Antelope Creek at Atlantic Street	$ 3,014,000	418
Linda Creek near Auburn-Folsom Road	$ 933,000	14
Linda Creek at Wedgewood Drive	$ 1,019,000	22
Linda Creek at Old Auburn Road	$ 785,000	36
Secret Ravine at Sierra College Boulevard	$ 3,506,000	150
Total Cost and Net Flow Reduction @ Vernon	**$ 9,257,000**	**650**

The Plan Update identifies that local on-site detention basins typically do not provide regional mitigation for increases in runoff. In fact, some typical applications of local detention can actually exacerbate regional flood flows by delaying the timing of the increased runoff volume from the development to coincide with the surrounding natural flows, thereby making the superimposition of the detained and natural flows higher than had the increased development flows been released earlier. However, removal of local detention requirements can only be permitted if it is confirmed that there would not be any localized unacceptable increase in discharge rate. This Plan Update recommends application of Low Impact Design (LID) principles that promote infiltration as a primary means of on-site mitigation, and the system modeling tools developed for this Plan Update provide a means to assess the impacts of major developments on the regional system to determine if credits are justified based on impacts differing significantly from that assumed in the mitigation element of this Plan Update.

ES-6 FUNDING

The funding plan identifies a potential set of funding sources to adequately fund the capital improvements envisioned in the Plan Update and to fund ongoing costs of operations and maintenance. Potential sources include government grants, development impact fees, general funds, and fees collected through County Service Areas (CSAs), Mello Roos Community Facility Districts (CFDs) and utility districts. The drainage facilities recommended in this Plan Update are designed to both correct existing deficiencies in the drainage system and to accommodate future development based on build-out conditions of the current General Plans of the various governmental jurisdictions included in the Dry Creek watershed. Development impact fees are proposed to cover the costs of mitigating for future project impacts, not for correcting existing deficiencies. The Plan Update has determined that the balance of funds collected to date is not sufficient to construct facilities to mitigate for the remaining impacts of projects constructed between the 1992 Plan implementation and current conditions. The Plan Update recommends assigning the current Dry Creek Trust Fund impact fee balance to mitigate what it can of existing impacts and new fees be collected and applied to projects to mitigate for moving from the current condition to General Plan build-out.

1.0 Project Background

1.0 PROJECT BACKGROUND

1.1 PURPOSE

The primary purposes of this Update to the Dry Creek Watershed Flood Control Plan (Plan Update) are to update the hydrologic analysis of the watershed, to identify possible means to mitigate development impacts on flooding and reduce flood damages, to provide new analytical tools to evaluate projects, and to recommend an updated funding plan. The 1992 Dry Creek Watershed Flood Control Plan (1992 Plan) recommended structural and non-structural measures to correct existing deficiencies and mitigate for impacts of future development. Some of the recommendations have been implemented while many have not due to environmental and/or economic constraints. This Plan Update evaluates the hydrology of the watershed and provides recommendations based on an overall watershed approach with the objective of identifying improvements that will be both feasible and effective.

1.2 WATERSHED DESCRIPTION

The Dry Creek watershed covers an area of 101 square miles in Placer and Sacramento Counties. The majority of the watershed (82 percent) is contained within the limits of Placer County. The Cities of Rocklin and Roseville, and the Town of Loomis are wholly or partially contained within the watershed. Other unincorporated communities in the watershed include Granite Bay, Penryn, Newcastle, Orangevale, and Rio Linda. A vicinity map of the watershed is provided on Plate 1 and a watershed overview is provided on Plate 2.

The headwaters of Dry Creek are located in the upper portions of the Loomis Basin, the vicinity of Penryn and Newcastle, in unincorporated Placer County, in the Granite Bay area near Folsom Lake, and in Orangevale in Sacramento County. Antelope Creek and Clover Valley Creek form the northwest boundary of the watershed, and Secret Ravine and Miners Ravine comprise the northeast portion of the watershed. Antelope Creek and Miners Ravine, after combining with Clover Valley Creek and Secret Ravine, respectively, combine near Interstate 80 and Atlantic Street in Roseville to form Dry Creek. Cirby Creek, made up of the combination of Cirby and Linda Creeks and Strap Ravine, joins Dry Creek just upstream of Riverside Avenue in Roseville. Downstream of Roseville, just downstream of Elverta Road, Dry Creek branches into North Dry Creek and Dry Creek and forms Cherry Island in the Rio Linda area.[1] (See Plate 2.)

Watershed topography, soil types and ground cover, and land use (imperviousness) are the basic elements that determine the portion of rainfall that becomes runoff and the timing of the runoff flowing through the watershed. These elements are introduced in

[1] James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.

this section and are elaborated upon in a subsequent section of the Plan Update. Additional descriptive information about the watershed is available in the various sources referenced in the Plan Update.

1.2.1 Topography

The lower end of the Dry Creek watershed is on the Sacramento Valley floor and the headwaters are located in the Sierra Nevada foothills. The mouth of Dry Creek, at its confluence with the Natomas East Main Drainage Canal, is at an elevation of about 30 feet above mean sea level (msl). Antelope Creek, Secret Ravine, and Miners Ravine have headwaters in the vicinity of Newcastle and Penryn at elevations of 900 to 1,200 feet msl, in hilly topography typical of the foothills. Linda Creek, Cirby Creek, and Strap Ravine have headwaters in Orangevale in Sacramento County, and in the Granite Bay area at elevations of 300 to 500 feet msl, with less relief than is found in the other Dry Creek tributaries.[2]

The upper portions of the Dry Creek watershed are characterized by relatively steep slopes and moderate relief. The lower reaches of the Dry Creek watershed, especially downstream of Roseville, are characterized by very gentle slopes. The stream channels throughout the watershed are generally well defined, but are not especially wide or deep.[3]

1.2.2 Soils

Soils within the Dry Creek watershed are variable, depending upon landscape position and underlying geology. Most soils are formed from either granitic or volcanic parent material, and often include a clay pan, or other consolidated layer that impedes water permeability. Shallow soils and rock outcrops are fairly common at higher elevations.[4] The United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS) has given each soil type a hydrologic classification based on infiltration rates. Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four hydrologic soil groups (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. The hydrologic soil groups are defined as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of

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[2] James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.
[3] James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.
[4] ECORP Consulting, Inc., Dry Creek Watershed Coordinated Resource Management Plan, 2003.

water transmission (0.15-0.36 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have low rate of water transmission (0.05-0.20 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have very low rate of water transmission (0-0.09 in/hr).[5]

Table 1 lists the hydrologic soil groups found within the Dry Creek watershed for Placer and Sacramento Counties.

Table 1. Dry Creek Watershed Hydrologic Soil Types

Watershed Name	Hydrologic Soil Type (acres)			
	A	**B**	**C**	**D**
Antelope Creek	0	3,278	529	3,501
Cirby Creek	42	8	172	1,506
Clover Valley	0	602	179	1,543
Dry Creek	796	1,057	1,799	12,221
Linda Creek	64	2,318	351	5,234
Miners Ravine	0	9,155	694	3,249
Secret Ravine	18	8,106	1,371	4,667
Strap Ravine	31	750	53	1,611
Total	951	25,273	5,148	33,532
Percentage	1.5%	38.9%	7.9%	51.7%

A map depicting the hydrologic soil group for the soils in the Dry Creek watershed is shown in Plate 3. For additional information, an extensive listing of the soil names and classifications for the soils located in the Dry Creek watershed can be found in the 2003 Dry Creek Watershed Coordinated Resource Management Plan (DCWCRMP).

1.2.3 Land Use and Development Projections

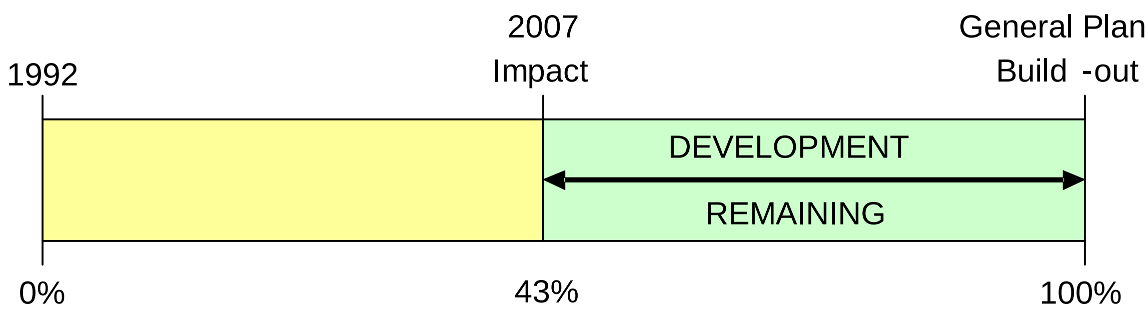
The types of land use that occur in a watershed are significant in determining the amount of runoff that results from a given amount of rainfall. Much of the difference in runoff from different land uses can be attributed to the difference in the percentage of the land that is impervious (paved or covered by buildings). Another important factor that is determined by the type of land use is the condition, or hydraulic efficiency, of the smaller tributaries and streams in the area. The land uses in the Dry Creek watershed vary widely, from mixed urban, suburban, rural, and open space land.

[5] USDA NRCS, Urban Hydrology for Small Watersheds, TR-55, 1986.

From the completion of the 1992 Plan through 1997, land development within the Dry Creek watershed was relatively slow due to an economic recession. Development activities began to accelerate in 1998, and by 2002, development was occurring at record levels. Another recession slowed land development down in late 2002 and early in 2003. From 2004 and continuing into 2007, land development activity was high again, but by late 2007 the pace of land development dropped dramatically due to a severe recession. Due to the slow pace of development since 2007, it was determined that the estimate of 2007 land use could be considered as new baseline from which to move forward for the purposes of this Plan Update. This Plan Update anticipates that development to the build-out conditions described in the various municipal General Plans will eventually occur.

It is estimated that approximately 43 percent of the projected total impacts (based on impervious area estimates, prior to considering mitigation measures) of development on runoff expected to occur between 1992 and the General Plan build-out condition, occurred prior to 2007 (refer to Figure 1). These development status values are presented relative to the initiation of the mitigation impact fee program.

Figure 1: Development Scenario



Estimates of imperviousness were used to indicate the amount of development that has occurred. Plate 4 identifies the imperviousness for the watershed in the 1992 (baseline) conditions. Plate 5 identifies the imperviousness for the watershed in the 2007 conditions, and Plate 6 identifies the imperviousness for the watershed for the General Plan (build-out) conditions. Plate 7, Plate 8 and Plate 9 illustrate land use for the baseline, 2007 and build-out conditions, respectively. Table 2 lists the estimated impervious area within the Dry Creek watershed and its major sub-basins for the baseline 1992, 2007 and build-out conditions. Percent build-out of the entire watershed is indicated in absolute terms and in terms relative to the baseline conditions from which impact fees from the 1992 Plan were established. {(80.96-66.49)/(100.00-66.49)=43.2}

Table 2: Watershed Imperviousness

Watershed	Area (sq. mi)	Impervious Area (sq. mi)		
		1992	2007	Build-out
Antelope Creek	11.42	2.37	2.52	3.02
Cirby Creek	2.70	1.18	1.45	1.49
Clover Valley	3.63	0.24	0.33	0.88
Dry Cerek	24.80	6.12	6.84	8.38
Linda Creek	12.45	1.29	2.29	2.56
Miners Ravine	20.47	1.92	2.56	3.09
Secret Ravine	22.13	3.45	3.93	5.29
Strap Ravine	3.82	0.68	1.09	1.24
Grand Total	**101.41**	**17.25**	**21.01**	**25.95**
Percent build-out from 1992 baseline		0.00	43.19	100.00
Percent build-out in absolute terms		66.49	80.96	100.00
Percent impervious		17.0%	20.1%	25.6%

1.3 1992 DRY CREEK WATERSHED FLOOD CONTROL PLAN

The purpose of 1992 Plan was to provide the District and other governmental agencies (in both Placer and Sacramento Counties) with the information and policies necessary to manage the storm waters within the Dry Creek watershed. The 1992 Plan was intended to provide an approach for meeting existing and future flood control needs in the watershed. In addition, the 1992 Plan recommended structural and non-structural measures to correct existing deficiencies and mitigate for impacts of future development within the watershed. The 1992 Plan was formally adopted by District Board in June 1995.

The 1992 Plan focused on the ability of on-channel regional detention basins to mitigate both existing flooding problems and the increase in flood flows due to upstream development. The 1992 Plan studied 25 potential detention basin sites throughout the Dry Creek watershed and identified 16 sites that might be feasible. The 16 sites were evaluated to determine both local flood reduction and regional flood reduction capacity. Regional flood reduction capacity was measured based on flow rates at Vernon Street in Roseville. Based on costs and corresponding flood flow reduction efficiency at Vernon Street, seven sites were selected for inclusion in the 1992 Plan. If implemented, these sites could have provided peak 100 year flood flow reduction of nearly 4,000 cubic feet per second (cfs) at Vernon Street. However, none of the on-channel regional detention basins included in the 1992 Plan have been, nor are currently expected to be, implemented.

The 1992 Plan also included an extensive evaluation of bridge and culvert replacement needs, and an evaluation of three channel improvement projects. Furthermore, the 1992 Plan addressed non-structural alternatives and included sections on local stormwater detention, floodplain management and a flood warning system to describe these measures.

1.4 INFORMATION SOURCES

Numerous information sources were referenced in the preparation of this Plan Update, including the following hydrologic and environmental reports. Additional references can be found in 5.4Appendix A. Data sources used in the direct development of the computer models prepared as part of the Plan Update are described in Sections 1.5 and 1.7.

1.4.1 Hydrologic Reports

1.4.1.1 1988 Hydrology Office Report, Dry Creek Basin, Placer and Sacramento Counties (United States Army Corps of Engineers [USACE])

The 1988 Hydrology Office Report was an update of a 1984 study prepared by the Sacramento District of the USACE for use in the feasibility study for flood control projects with the Dry Creek watershed. The study provides flood history data, performed both general storm and cloudburst storm hydrology, and evaluated existing land use conditions and projected 2040 flood flows. Standard Project Flood (SPF), 100-year, 50-year, 25-year, and 10-year discharges were tabulated.

1.4.1.2 1992 Dry Creek Watershed Flood Control Plan (JMM)

The 1992 Dry Creek Watershed Flood Control Plan has been the basis of flood control planning in the Dry Creek watershed used by the District, Placer County, the City of Roseville, the City of Rocklin and other local communities. This Plan Update will supersede the 1992 Plan.

1.4.1.3 2000 Dry Creek Watershed Flood Detention and Stream Restoration Feasibility Study (Swanson & EDAW)

The Dry Creek Watershed Flood Detention and Stream Restoration Feasibility Study investigated 19 potential sites for regional flood detention projects based on project feasibility, relative cost, and environmental issues. Two sites, Miners Ravine below Sierra College Boulevard and Secret Ravine above Sierra College Boulevard, were examined conceptually as example projects to produce preliminary cost estimates for multi-use regional flood detention projects.

1.4.1.4 2001 Flood Insurance Study (Federal Emergency Management Agency [FEMA])

The Placer County Flood Insurance Study (FIS) provided an update to the FEMA 100-year floodplain maps, and baseline FEMA hydrology. The FIS was largely based on the hydrology of the 1992 Plan; however, some updates were made for various areas of the watershed, where new studies with better calibrations had been made.

1.4.1.5 2001 Town of Loomis Drainage Master Plan (West Yost)

The Town of Loomis Drainage Master Plan describes the existing storm drain system for the Town of Loomis and provides recommendations for upgrades to the system to decrease localized flooding problems. The localized flooding issues are due primarily to inadequate storm drain infrastructure, and not necessarily flood flows from streams in the Dry Creek Watershed. It also lists several crossings of Antelope Creek, Sucker Ravine, and Secret Ravine that are inundated by flood flows. The crossings are presented in the Existing Flood Hazard section of this report.

1.4.1.6 2004 Alternative Regional Detention Sites (URS)

The Alternative Regional Detention Sites report documents analysis of four potential sites for regional detention basins: Strap Ravine immediately upstream of McLaren Drive next to Maidu Park in Roseville; Miners Ravine upstream of East Roseville Parkway; Linda Creek west of Rocky Ridge Drive and south of Meadowlark Way in Roseville; and Miners Ravine immediately downstream of Sierra College Boulevard. The report uses the hydrology information developed for the 1992 Plan and created an unsteady-state HEC-RAS hydraulic model from various existing hydraulic models. The report recommended the construction of the Miners Ravine detention basin immediately downstream of Sierra College Boulevard and reported that “although the other three sites did reduce peak discharges immediately downstream of their locations, their hydraulic benefits were localized and only minor positive impacts downstream near Riverside Ave. and Vernon St. Bridges (E-1).” The only regional detention basin that was recommended in this report, Miners Ravine Off-Channel Detention Basin, was completed in 2007.

1.4.1.7 2006 Central Rocklin Drainage Master Plan (West Yost)

The Central Rocklin Drainage Master Plan documents analysis of the urban drainage through storm drain systems and also includes sections on stream flooding. The District’s HEC-2 models used for the 1992 report and the 1998 FEMA Flood Insurance Studies (FIS) were converted to HEC-RAS and used to analyze flooding in the Dry Creek tributary streams in the City of Rocklin. Five locations along Antelope Creek and four locations along Sucker Ravine were identified where City of Rocklin roadways would be expected to be overtopped during a 100-year storm event.

1.4.1.8 2007 Miners Ravine Off-Channel Detention Basin Hydrology and Hydraulic Design Report (RBF Consulting)

The Miners Ravine Off-Channel Detention Basin Hydrology and Hydraulic Design Report contains the methodology and calculations used to design the Miners Ravine Off-Channel Detention Basin for the District. The report outlines the baseline hydrology for key points in the Dry Creek Watershed. Hydraulic design methods and calculations are also documented, including spillway design, sediment transport, and failure scenarios.

1.4.2 Environmental Documents

1.4.2.1 1994 Dry Creek Watershed Flood Control Program Programmatic Environmental Impact Report (Jones & Stokes)

The Dry Creek Watershed Flood Control Program Programmatic Environmental Impact Report (PEIR) describes the potential environmental impacts of the proposals of the 1992 Plan and presents mitigation measures to be used while implementing the recommendations of the 1992 Plan.

1.4.2.2 2002 Miners Ravine Restoration Project (EDAW)

The Miners Ravine Restoration Project report describes the plan for improvements of the Miners Ravine Nature Reserve near the intersection of Oak Glen Lane and Auburn-Folsom Road to enhance floodplain function and habitat value. The plan includes channel excavation to restore natural floodplain function, removal of debris, bank re-vegetation, and removal of barriers to fish passage.

1.4.2.3 2002 Miners Ravine Habitat Assessment (State of California, The Resources Agency, Department of Water Resources)

The Miners Ravine Habitat Assessment report describes the biological habitat survey of Miners Ravine with special attention given to salmon habitat.

1.4.2.4 2003 Dry Creek Watershed Coordinated Resources Management Plan (Dry Creek Conservancy, Harding Lawson Associates, Swanson Hydrology & Geomorphology, ECORP Consulting, Inc.)

The broad scope of the Dry Creek Watershed Coordinated Resources Management Plan offered a comprehensive review of the Dry Creek watershed covering hydrology, biology and wildlife, population growth and development projections, and policy implementation plans.

1.5 COMPUTER MODELING

The Plan Update provides a new hydrologic modeling system that is a significant technological advance over the 1992 Plan. Though the 1992 Plan was state-of-the-art at the time it was prepared, the new modeling system is better able to evaluate flood flow timing and backwater impacts on flow routing that are significant to development impact and project analysis than the 1992 Plan model. Computer programs, including the USACE's "Flood Hydrograph Package" (HEC-1), "Hydrologic Modeling System" (HEC-HMS) and "River Analysis System" (HEC-RAS) software developed by the U.S. Army Corps of Engineers (USACE); GIS software; and other software, referred to as the Dry Creek Hydrology Toolbox (DCTOOLBOX) developed specifically for this Plan Update, were employed to develop a new basis for watershed runoff and flood flow evaluations. The new modeling system includes substantially more detail than the 1992 modeling system thereby allowing it to be used on smaller tributaries which will facilitate its application on smaller projects. Furthermore, the new modeling system has been calibrated using precipitation and stream flow gage data from December 1995, January 2007 and December 2005 storm events to ensure the validity of the results.

The Plan Update uses more than seven times the number of sub-watersheds than included in the 1992 Plan HEC-1 model to facilitate evaluation of smaller features and the effects of routing along tributaries. Also, whereas the 1992 Plan developed some HEC-1 flow (Modified Puls) routing parameters using steady-state flood profiles calculated in HEC-2, the Plan Update HEC-1 and HEC-HMS models include far more detailed flow routing parameters developed using steady-state HEC-RAS models. Additionally, an unsteady-state hydraulic routing model that covers the streams in the lower (downstream) two-thirds of the watershed was prepared and used to perform critical routing analysis. The unsteady-state hydraulic model was used to calibrate the system model and to perform realistic evaluations of project impacts that would otherwise not be feasible. The watershed details, improved hydrologic routing, implementation of hydraulic (unsteady-state HEC-RAS) routing, and event calibrations form the basis of the Plan Update. The Plan Update uses HEC-HMS that is replacing HEC-1, to take advantage of its capabilities and to modernize the analysis procedure.

1.5.1 Application of HEC-1 and HEC-HMS

The District's procedures for using HEC-1 to perform hydrology studies are provided in the District's Stormwater Management Manual (SWMM) dated September 1, 1990 which were formally adopted in 1994. Historically, the District's methodology for using HEC-1 requires the use of the Placer County Design Precipitation Program (PDP) dated August 15, 1994. A key element of the District's hydrology procedures requires the use of multiple storm centerings to identify the appropriate design rainfall distribution for each unique condition.

The 1992 Plan was based on modeling of multiple storm center locations generally consistent with, but not equivalent to, the subsequently adopted procedures. Various storm centering model runs established the peak flow rates at key locations throughout the watershed. Hydrology for local benefit analysis was performed for each of the projects included in the 1992 Plan based on storm centers within each project's tributary watershed. Hydrology was also performed for each project based on the storm centering that generated the peak discharge along Dry Creek at Vernon Street to measure regional benefit. In the 1992 Plan, the storm used to measure regional benefit of projects was centered in the Miners Ravine watershed. Numerous subsequent studies relied on using this single storm centering.

In the process of applying the PDP for the Plan Update, it was determined that there was an error in the programming code that became significant under some circumstances. As a result, the District's PDP software was updated to Version 2.0 (PDP2) with this Plan Update, to correct a precipitation generation error and to provide a smoother precipitation intensity distribution based on interpolation of rainfall depths.

The DCTOOLBOX provides an improved means to prepare HEC-1 input files based on District approved methodologies, to perform multiple storm centering analyses, to convert HEC-1 files to HEC-HMS and to perform some other functions such as creating summary output tables. HEC-HMS offers more GIS mapping capabilities, input data error detection and other advantages over HEC-1. The DCTOOLBOX provides a much more efficient means to apply the PDP in HEC-HMS than is possible using HEC-1 input file conversion tools built into HEC-HMS.

1.5.2 Application of HEC-RAS

The Plan Update used HEC-RAS to calculate Modified Puls routing parameters used in the hydrology models and to perform hydraulic routing to account for varying backwater conditions that cannot be simulated using HEC-1 or HEC-HMS. Varying backwater infers that there is not a one-to-one correlation between stage and discharge, a condition that is typical at structures and in the vicinity of stream confluences. HEC-RAS has replaced the USACE's HEC-2 "Water Surface Profiles" and UNET "One-Dimensional Unsteady Flow Through a Full Network of Open Channels" computer programs. The Modified Puls routing parameters were calculated using steady-state HEC-RAS and were included in the HEC-1 and HEC-HMS models which only allow a one-to-one stage vs. discharge relationship. Unsteady-state HEC-RAS was used for evaluations that are sensitive to backwater conditions.

Initially, the baseline project model was compiled in HEC-RAS version 4.0 for the lower two-thirds of the watershed. The model was built based on the assembly of existing hydraulic models for the various main tributaries of Dry Creek including: Miners Ravine, Secret Ravine, Sucker Ravine, Strap Ravine, Linda Creek, Cirby Creek, Antelope Creek, and Clover Valley. Modifications to the model were made as determined to be appropriate for the new system model to run in the unsteady-state mode. The model was also run in the steady-state mode to calculate Modified Puls routing parameters. However, HEC-RAS version 4.0 did not provide correct storage parameters for Modified Puls, so version 4.0.1 beta was obtained from USACE and was used for the Modified Puls calculations and preliminary unsteady-state analyses. Additionally, simple (no structures) steady-state HEC-RAS models were created for some of the upstream reaches using the topographic data obtained for the Plan Update for the sole purpose of calculating Modified Puls routing parameters for Plan Update hydrology. Hydrographs from the HEC-HMS model output were input into the unsteady-state models using USACE's "Data Storage System" (HEC-DSS). Software tools within the DCTOOLBOX were also developed specifically for this Plan Update to assist in the organization and retrieval of the results of the HEC-RAS and HEC-HMS hydrology analyses. Ultimately, multiple combinations of hydrology and hydraulics were evaluated to consider appropriate land use and project scenarios necessary for Plan Update development. Final unsteady-state HEC-RAS model runs were all made using HEC-RAS version 4.1.0.

1.5.3 Topographic Data

The primary source of topographic data used for watershed delineations in this Plan Update was interferometric synthetic aperture radar (IFSAR) data acquired from Intermap Technologies Inc. The Intermap data is proprietary and was licensed to the District.

The Intermap data represents a higher point density of data than typically found in the USGS Digital Elevation Model (DEM), with a slightly better vertical resolution. The data set used in this Plan Update also included some artifact terrain areas near bridges and overpasses which did not correctly represent the ground surface. However, this data exceeds the accuracy requirements for determining watershed boundaries (with other supplemental data sources and limited field investigation) and watershed overland response factors, but is limited in its usefulness for detailed hydraulic studies or other purposes requiring higher resolution data. The topographic mapping based on the Intermap data is provided in Appendix B.

Supplemental data sources used to define watershed boundaries included a digital terrain model (DTM) provided by the City of Roseville, previous detailed drainage studies and some field investigations. Though the City of Roseville's DTM was not well documented and may have absolute accuracy issues, it was developed as part of the City's 2007 aerial imagery ortho-rectification process and it included breaklines that were useful in defining grade breaks and flow directions in some locations where it was unclear from other sources. Also, sub-watersheds within the Cirby Creek watershed were based on a previous detailed delineation provided by the City of Roseville. Other supplemental data included Placer County Water Agency (PCWA) water distribution canal maps, municipal drainage master plans, and other storm drainage system layout information. Field investigations were performed to refine boundaries at a few locations.

The Plan Update used HEC-RAS unsteady-state hydraulic models to perform flow routing and project benefit analysis. These unsteady-state models where assembled for the Plan Update from various sources (see Section 3.5.2), though these are primarily from FEMA models. Therefore, this Plan Update used other sources of topographic data, including topography developed for FEMA and some private development projects, indirectly.

1.5.4 Land Use

For the purpose of this Plan Update, land use data mapping (GIS) was assembled for three conditions: 1992, 2007, and the General Plan build-out. The 1992 Plan included land use maps (AutoCAD) for the estimated 1989/1992 land use conditions. These maps were converted to GIS files to establish the 1992 baseline land use areas. The 1992 Baseline Land Use is shown in detail in Plate 7.

A high resolution aerial map taken in 2005 was used to compare each parcel to the General Plan build-out land use map. If the aerial showed a lower density land use than called for in the build-out condition, the land use type visible in the aerial image was applied. A color orthorectified radar image (CORI) obtained from Intermap, also from 2005, was also used to establish current conditions impervious area. Other information was used to have the impervious area estimate reflect what was built through 2007. Specifically, data from the City of Rocklin Master Plan dated February 2006 was used to update areas in Rocklin and information from the City of Roseville website provided "current uses" data. Field inspection of some properties was performed, and observed conditions were incorporated into the impervious area estimates. In many cases the known site land uses, and field inspected land uses conflicted with the land use identified in the applicable Master Plan. In these cases the known land use was as a basis for "current condition" studies. The 2007 (current) Land Use is shown in Plate 8.

Updated General Plan build-out land use files were requested from various agencies in the Dry Creek watershed. Information was obtained and converted into a GIS file type (shape file). In many cases, the various agencies had overlapping information which conflicted with each other. To resolve these issues, information from the agency responsible for mapping that area or the current land use observed in the field was used, as determined to be appropriate. The General Plan Build-Out Land Use is shown in Plate 9.

1.6 HISTORIC FLOODING

Floods in the Dry Creek watershed generally occur from October through April. The floods are usually caused by a combination of prolonged rainfall leading to saturated soils, and a short period of one to six hours of intense precipitation associated with frontal convection or severe thunderstorms.

Dry Creek and its tributaries have an extensive record of flood conditions, especially in the Roseville area. Streamflow records are available for a gage in Roseville beginning in 1950. Damaging floods occurred in December 1955, April 1958, October 1962, December 1964, March 1983 and February 1986. The floods of 1983 and 1986 were the largest and most damaging on record before 1992. Hydrologic studies have shown that the recurrence interval of the March 1983 flood was approximately 10 years and the recurrence interval of the February 1986 flood was from 50 to 100 years, depending on the specific location in the Dry Creek watershed.[6] Flood events also occurred in 1995 and 2005, with the 1995 flood event causing extensive damage.

[6] James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.

Figure 2 is a photograph of Dry Creek flows inundating portions of downtown Roseville, including Royer Park, Douglas Boulevard, and Saugstad Park, during the 1995 flood event.

Figure 2: Portions of downtown Roseville are inundated during the 1995 flood event

1.6.1 March 1983

The March 1983 event was estimated to have an average exceedance recurrence interval of about 10 years and "damaged approximately 25 residences along Linda and Cirby Creeks in Roseville. Portions of Royer Park were under water was well as areas in the Sierra Lakes Mobile Home Park. Dry Creek overflowed the Darling Way and Riverside Avenue bridges, disrupting traffic and flooding six businesses along Riverside Avenue.[7]

1.6.2 February 1986

The February 1986 event was classified as an approximately 70 year event, and Placer County was designated as a Federal Disaster Area. Nearly all bridges and culverts were overtopped with 30 crossings sustaining embankment damage including Rocky Ridge Drive washing out. Two bridges over Dry Creek were damaged and street cave-ins occurred at a number of locations. Flooding caused the closure of many major streets in the watershed, including Riverside Avenue, Darling Way, Douglas Boulevard, Vernon Street, Sierra College Boulevard, and others. Around 100 homes in Roseville along Dry Creek, Linda Creek, and Cirby Creek were flooded with water levels up to five feet above floor levels.

Ten homes along Antelope Creek and Secret Ravine tributaries in Rocklin and about sixteen homes along Miners Ravine in Placer County, in the area of Joe Rodgers Road,

[7] James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.

were flooded. Roseville City Hall and libraries were temporarily closed when their basements flooded. Downstream of Roseville, several residences along Dry Creek in Placer County were flooded. Flooding occurred along most of Elkhorn Boulevard near Dry Creek in Sacramento County, including many residences, schools, and businesses. Available gaged flow rates and stream stages from the February 1986 storm event were used to calibrate the 1992 model. Total damages within Placer County were estimated at $7.5 million. Based upon application for disaster assistance, 62 homes were damaged or destroyed within the watershed, although the actual number of damaged homes is thought to have been higher. Dozens of businesses in downtown Roseville were damaged or destroyed, and one fatality was associated with this flood event.

1.6.3 March 25, 1989

The March 1989 event was estimated to have an average exceedance recurrence interval of between 1 and 2 years. Available gaged flow rates and stream stages from the March 1989 storm event were used to calibrate the 1992 model.

1.6.4 January 1995

The January 1995 event had been classified as being approximately a 100 year event prior to this Plan Update. Further analysis of available data indicated that the January 1995 event was statistically closer to a 200-year storm event than a 100 year event at some key locations. (Identification of the 1995 storm event as potentially being significantly more severe than a 100-year storm event in no way limits municipality's ability to regulate to this maximum storm of record instead of a 100-year event.) The January 1995 storm resulted in the most severe recorded flooding to date occurring in the Dry Creek watershed, with Placer County being designated as a Federal Disaster Area.

The storm included two high precipitation storm events spaced about 12 hours apart. The first event delivered approximately a 10-year storm event. The second storm event delivered even higher intensities of precipitation. As with the 1986 flood, numerous bridges were overtopped. Total damages within Placer County were estimated at $8.3 million, with 750 damaged or destroyed structures ($4.2 million estimated damages for the Roseville area alone). Of the $4.2 million in damages, one million was for road and bridge repairs, and two million was for utility repairs. Within the Roseville area, 385 homes, businesses, apartments, and mobile homes were damaged or destroyed. In addition, two sewage treatment plants were overtopped, and one landfill was damaged. No injuries or fatalities were associated with this flood event. Figure 3 shows a photograph of flows from Miners Ravine overtopping Sierra College Boulevard during the January 1995 event.

Figure 3: Miners Ravine overtopping Sierra College Boulevard during the January 1995 storm event

1.6.5 January 1997

The flood events of 1997 were some of the most severe on record for the region. An isolated storm event typical for the Roseville area occurred on top of soils saturated from repetitive storm events causing a flash flood. This flooding resulted in 21 structures being inundated with floodwaters. The impact of this event was significantly reduced by a partially completed Cirby-Linda-Dry Creek Flood Control project. No injuries or fatalities were associated with this flood event.[8]

1.6.6 February 1998

A small flood event occurred on February 3, 1998, resulting in eight structures being inundated by floodwaters in the Dry Creek Basin. Once again, this event was caused by an isolated storm event centered over the watershed. No injuries or fatalities were associated with this flood event.[9]

1.6.7 December 2005

The December 2005 event was estimated to have an average exceedance recurrence interval of between 10 and 25 years. This event, often referred to as the "New Years Eve" event, occurred in the early morning hours of December 31, 2005. Most gages reported peak 6 hour precipitation between the 10-year and 25-year precipitation depths listed in the SWMM. Flooding was most noticeable in the lower watershed where the

[8] City of Roseville, *Draft Flood Risk Assessment*, 2004.
[9] City of Roseville, *Draft Flood Risk Assessment*, 2004.

overtopping of Walerga Road made news as vehicles and drivers attempting to cross the bridge during overtopping flows required emergency assistance to have their stalled vehicles pulled to safety. One vehicle was pushed by the velocities in the overtopping flows onto the guardrail, and against a tree, requiring a helicopter rescue.

Roadways that were overtopped included Champion Oaks Drive on Linda Creek as shown on Figure 4 and Barton Road on Miners Ravine as shown on Figure 5.

Figure 4: Flows from Linda Creek overtop Champion Oaks Drive during the 2005 flood event

Figure 5: Miners Ravine overtopping Barton Road during the 2005 flood event

In addition to the events listed above, flooding has occurred in numerous other events for storms in 1950, 1952, 1963, 1969, 1970, and 1973. However insufficient historic data are available to precisely define the geographic extent of flooding and the impact of these events.[10]

1.7 GAGE DATA

The District, the City of Roseville, and Sacramento County own and maintain 23 precipitation gages and 20 stream gages distributed throughout the Dry Creek watershed. These gages, the location of which are shown on Plate 10, contain ALERT type transmitters and are used to record, forecast and predict flooding in critical flood hazard areas of Placer and Sacramento County. The real-time gage data is transmitted to base station servers in Auburn, Roseville and Sacramento where the data is recorded and stored for either real-time or historical use. Additionally, the base stations located in Auburn and Roseville act as redundant data storage servers since both systems receive a majority of the Western Placer County gage data. All data received by the Auburn and Roseville base stations is also uploaded to a server in Colorado maintained by OneRain, Inc. This data is available via the internet through the Contrail Web system. Plate 10 indicates whether the stream gage provides only stage values or if a rating curve based on flow measurements is available to provide a direct estimate of discharge.

Historical record event data was supplied for this Plan Update from data stored by the City of Roseville. Some of the gage records for the calibration events used in this plan were missing either because the data was corrupted or the gages were not installed or functioning properly. The application of the valid record gage data is explained in Appendix C for each record event of the calibration analysis.

1.8 RELATED FLOOD MANAGEMENT PROGRAMS

Floodplain management is the operation of a community program providing corrective and preventative measures for reducing flood damage. These measures take a variety of forms and generally include requirements for zoning, subdivision or building, and special-purpose floodplain ordinances. A community's agreement to adopt and enforce floodplain management ordinances, particularly with respect to new construction, is an important element to provide flood loss reduction building standards for new and existing development.

1.8.1 FEMA

FEMA plays a particularly prominent role in floodplain management. FEMA is charged with overseeing disaster assistance and mapping floodplains. One of FEMA's programs

[10] City of Roseville, *Draft Flood Risk Assessment*, 2004.

is the National Flood Insurance Program (NFIP). Nearly 20,000 communities across the United States and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary; however, Placer and Sacramento Counties, including the Cities of Lincoln, Rocklin and Roseville and the Town of Loomis, are participants in the Flood Insurance Program. In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the Nation's floodplains.

Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance.[11] These Flood Insurance Rate Maps (FIRMs) identify floodplains in the watershed that are used to assign risk and insurance rates for homeowners and businesses. FIRMs denote the location of the federal 100-year flood area, 500-year flood area, and the Base Flood Elevation. In a 100-year floodplain, there is a 1 percent chance of flooding in a given year, and in a 500-year floodplain, there is a 0.2 percent chance of flooding in a given year. If an area is within a 100-year floodplain, flood insurance is required by most mortgage companies. FEMA is also responsible for the accreditation of levee systems.

1.8.2 Roseville[12]

Flood protection is a major concern in Roseville as well as the remainder of the Sacramento/South Placer region. Flooding in Roseville is associated with storm runoff exceeding creek and storm drainage capacities. As a result, flooding in the City is generally confined to limited areas of low elevation adjacent to the creek systems.

The City of Roseville is involved in several flood control projects and mitigation programs designed to protect residents and lessen the potential for flooding both within the City and within neighboring communities:

The City has initiated the Cirby-Linda-Dry Creek Flood Control Project to reduce storm water back up at constrictions and increase the overall capacity of the floodplain. Of the seven work packages described in the project study, five have been completed. As a result of those improvements, the number of structures in the floodplain has been reduced to about 90. Most of the structures remaining in the floodplain are near Cirby Creek in the Zien Court and Trimble Way area and along Dry Creek upstream of Folsom Road.

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[11] FEMA Website. Available at: http://www.fema.gov/hazard/flood/index.shtm. Accessed: July 10, 2010.
[12] City of Roseville General Plan, 2025, adopted by the City Council on May 5, 2010. Available at: http://www.roseville.ca.us/planning/general_plan_n_development_guidelines.asp. Accessed: July 14, 2010.

The City is currently collecting drainage mitigation fees within the Pleasant Grove and Dry Creek watersheds to be used to alleviate potential downstream drainage problems in these basins. Roseville is also involved, through the Placer County Flood Control District, in the Auburn Ravine, Coon Creek, and Pleasant Grove Creeks Flood Mitigation Plan dated June 1993, as well as the Dry Creek Watershed Flood Control Plan.

The City presently has a flood alert system in place. In the event of potential flooding, warnings will be broadcast on Roseville's Government Access Channel (cable channel 11) and on local radio stations. The system is designed to provide residents up to three hours advance warning of potential flooding within the 100-year floodplain. Details of this program are described in the City of Roseville's Emergency Response Plan.

1.8.3 Rocklin[13]

The City of Rocklin has a Floodplain Management Program established as part of a community effort of corrective and preventive measures for reducing flood damage. These measures include zoning, subdivision or building requirements, and special-purpose floodplain ordinances. Specifically, the City has a Recreation-Conservation (R-C) designation for all established floodplain areas, and restricts development which would have an adverse impact on flood control. The City also requires new development to detain drainage to maintain peak flow runoff at pre-development levels.

In addition, the City of Rocklin participates in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. City of Rocklin Municipal Code *Section 15.16 Flood Hazard Areas* addresses floodplain management. In exchange for this voluntary participation, the NFIP make federally-backed flood insurance available to homeowners, renters, and business owners in the City.

1.8.4 Loomis[14]

Flood maintenance is an ongoing problem in Loomis, due to the fact that many of the major drainages are located on private property, and the Town generally does not have access to conduct maintenance operations to keep channels clear of debris. There is no clear responsibility regarding maintenance of drainages on private property (Town or property owners), though newer developments are required to include easements to facilitate maintenance. Nevertheless, this does not address existing deficiencies, which are experienced throughout the community. The Town of Loomis joined the NFIP on December 29, 1986.

[13] City of Rocklin Flood Zone Information, 2010. Available at: http://www.rocklin.ca.us/government/development/engineering/tools_n_resources/flood_zone_information.asp. Accessed: July 14, 2010.
[14] Town of Loomis General Plan, Adopted July 31, 2001. Available at: http://www.loomisca.gov/uploads/final%20general%20plan.pdf. Accessed: July 14, 2010.

2.0 Existing Conditions

2.0 EXISTING CONDITIONS

2.1 MAIN CHANNEL AND TRIBUTARIES

The main channels and tributaries associated with the Dry Creek watershed are described below.

2.1.1 Dry Creek

Dry Creek is a second-order perennial stream that is approximately 17.6 miles long. The immediate sub-watershed area is 24.4 square miles. From the confluence of Miners Ravine and Secret Ravine, Dry Creek has relatively few meanders until Watt Avenue, after which it returns to more natural channel configurations. Dry Creek has four main tributaries consisting of nine streams, namely Miners Ravine and False Ravine; Sucker and Secret Ravines; Antelope Creek and Clover Valley; and Linda Creek, Cirby Creek, and Strap Ravine.

2.1.2 Miners Ravine and False Ravine

Miners Ravine is a perennial tributary whose main channel is approximately 15.2 miles long. It is entrenched within an alluvial valley floor, and serves to drain approximately 20.1 square miles of mixed-use land. The upper reaches of Miners Ravine are composed of intermittent drainages (8.0 miles) and the lower reach are primarily intermittent (12.1 miles) with some perennial first-order reaches (2.9 miles) and some second-order reaches (0.6 miles).

False Ravine, an approximately 1.5 mile long tributary, empties into Miners Ravine just west of East Roseville Parkway, upstream of North Sunset Avenue.

2.1.3 Secret Ravine and Sucker Ravine

Secret Ravine is a 7.8-mile long perennial stream. The contributing sub-watershed area is approximately 22.3 square miles. The upper reaches of Secret Ravine are all intermittent drainage ways (12.7 miles) and the lower reaches are intermittent (8.1 miles) and perennial (6.3 miles).

Sucker Ravine is a perennial stream and a tributary of Secret Ravine. Sucker Ravine flows from northeast to southwest within the City of Rocklin and is part of the Dry Creek watershed. The approximately five mile stream joins Secret Ravine after crossing under Interstate-80 and China Garden Road, near Greenbrae Road.

2.1.4 Antelope Creek and Clover Valley Creek

Antelope Creek is a perennial creek draining the northeast portion of the Dry Creek watershed. The mainstem is approximately 9.5 miles long and the watershed area is 21.4 square miles. The Antelope Creek system is composed of approximately 12.4 miles of intermittent tributaries in addition to a major tributary, Clover Valley Creek (7.1 miles long; watershed area of 10.2 square miles). The Aitken Reservoir is located within the Antelope Creek sub-watershed.[17]

Clover Valley Creek drains the northwest portion of the Dry Creek watershed. Recent development in Clover Valley, including on-channel ponds and urbanization has altered the timing and quantity of streamflows. The 6.5 mile stream is bounded by hills in a narrow valley. The Clover Valley Creek joins with Antelope Creek downstream of Argonaut Avenue near Midas Avenue.

2.1.5 Cirby Creek, Linda Creek and Strap Ravine

Cirby Creek is a perennial stream approximately 2.7 miles long with a watershed area of approximately 3.4 square miles. Linda Creek comprises the upstream sub-watershed and Cirby Creek outflows directly into Dry Creek. The Cirby Creek watershed is almost entirely within the urbanized area of the City of Roseville.

Linda Creek is a perennial stream, approximately 10.8 miles long. The sub-watershed drainage area is 12.2 square miles and there are 7.3 miles of intermittent drainageways and 11.2 miles of perennial, first-order streams. Other waterbodies within this sub-watershed are Swan Lake, an unnamed reservoir, and approximately 10 unnamed ponds.

Strap Ravine is a perennial waterway that is approximately 3.6 miles long and drains an area of approximately 4.8 square miles. There are four unnamed ponds located on the USGS topographic map for this sub-watershed. Strap Ravine is a tributary to Linda Creek, and joins Linda Creek near North Cirby Way, just downstream of McLaren Drive.

2.2 LOCAL AND REGIONAL STRUCTURAL FLOOD CONTROL PROJECTS COMPLETED SINCE 1992

The Miners Ravine Off-Channel Detention Basin is the only regional flood control project that has been implemented within the Dry Creek watershed. Numerous local structural flood control projects, including stream crossings and conveyance improvements have been implemented since 1992. Selected earlier projects are listed for historical reference. On-site detention associated with specific development projects are categorized as non-structural floodplain management measures and are not listed in this section.

[17] ECORP Consulting, Inc., Dry Creek Watershed Coordinated Resource Management Plan, 2003.

2.2.1 Miners Ravine Off-Channel Detention Basin

The District completed the Miners Ravine Off-Channel Detention Basin in 2007. This project includes a basin that covers approximately 12 acres on a 26-acre parcel just west of Sierra College Boulevard near the intersection of Olympus Drive. The project includes an embankment that is approximately 18 feet high that is designed to impound up to 122 acre-feet of flood flows below the basin's spillway crest. The project provides mitigation for some of the increased flows within the Dry Creek watershed caused by development since the 1992 Plan. The project uses an off-channel detention basin to temporarily detain a portion of peak flood flows for a few hours in order to slow the release of the waters back into Miners Ravine. The gravity-draining design did not raise floodplain elevations outside of the basin, and limits the potential for trapping fish. Stormwater runoff in the main channel of Miners Ravine flows through the area unimpeded by the project when high water flows are not present.

2.2.2 Local Structural Flood Control Projects

Sixteen flood control projects within the Dry Creek watershed have been completed since 1986. These flood control projects consisted of various culvert improvements, replacements, and/or removals; channel modifications; bridge replacements; and floodwall installations. Table D.1, included in Appendix D, provides a chronological listing of local flood control projects.

2.3 NON-STRUCTURAL IMPROVEMENTS SINCE 1992

Non-structural improvements that have been implemented and/or maintained since 1992 include building elevation projects, residential buy-outs, an ALERT flood warning system, streambed maintenance and local detention. Local detention projects are discussed in Section 3.9.3.

2.3.1 Building Elevation Projects

In 2001, FEMA funded 75 percent of this $1 million program to elevate flood-prone homes. These are structures that would not be brought completely out of the floodplain by construction of our flood control project. Homeowner participation was voluntary. 27 of 44 homeowners on the list elevated their homes via this program. Most of those 27 are located in the Folsom/Maciel neighborhood along Dry Creek.

2.3.2 Residential Buy-outs

In 2001, flood control improvements were completed in two areas on Linda Creek: the Champion Oaks/West Colonial Parkway area, and the Sunrise/Oakridge area. This project reduced the size of the floodplain resulting in 233 homes no longer being located in the floodplain, and reducing the risk of flooding for 44 additional homes. Cost = $16.1 million ($8.7 million FEMA funds, $7.4 million City funds).[18]

2.3.3 ALERT Flood Warning System

The District, the City of Roseville, and Sacramento County each own and maintain ALERT flood warning response systems within the Dry Creek watershed. The ALERT system is a radio telemetry system licensed by the Federal Communication Commission. Remote stations transmit real-time precipitation and stream level data to base stations located in Auburn, Roseville and Sacramento. Detailed information about the existing ALERT system can be found in Section 1.7 and on Plate 10.

2.3.4 Annual Streambed Maintenance Program

Placer County has a stream channel maintenance program that is managed by the District. The County's program includes up to 2 miles per year of stream channel work at critical locations to maintain channel capacity, reduce debris and reduce invasive species.

After the 1986 flood, the City of Roseville entered into a Memorandum of Understanding with the State Department of Fish & Game, to allow fallen trees and debris to be cleared from creeks, which could otherwise float downstream and block culverts and bridges. Annual cost = $100,000.[19] The City operates a stream cleaning program in the flood prone areas of Roseville each year. Details of this program can be found in the City's Creek Maintenance Guidelines dated February 2001 and the Stream Clearing Inspection Report dated July 2001.

The City of Rocklin does not have a maintenance program for our stream channels, but rather a series of "Check Lists" used by City maintenance staff. The maintenance work focuses more on the engineered drainage systems that drain, retain, or detain storm runoff. Detention and retention basins are inspected each year and necessary maintenance is scheduled. Storm drain and culvert outlets are inspected during dry months and vegetation is cleared in the area 15 to 20 feet from the pipe outlets and 10 to 15 feet from culvert inlets. Inspection of critical infrastructure occurs before, during and after rain events. The primary objective is to remove any loose or floatable debris that will obstruct flow through box culverts, culverts, drain ditches. The type of material usually removed can vary from large tree limbs, tires, pieces of plywood and discarded pallets. The inspections begin in the fall and end in the spring.[20]

[18] City of Roseville Website, 2010. Available at: http://www.roseville.ca.us/
[19] City of Roseville Website, 2010. Available at: http://www.roseville.ca.us/
[20] E-mail from Kent Foster, Director of General Service, City of Rocklin

2.4 EXISTING FLOOD HAZARDS

Plate 11 illustrates the locations of identified significant flood hazards within the Dry Creek watershed. This section provides a description of key locations, but does not indicate each roadway known to have been, or expected to be, overtopped during a major flooding event. Section 0 and Appendix E provide information about, and listing of, the structures with known or expected overtopping issues. The numbers listed in each section correspond to locations on Plate 11.

2.4.1 Rocklin[21]

Sucker Ravine at Dominguez Road (1): Smaller crossings downstream of Dominguez Road cause backwater problems upstream, including the Dominguez road crossing which may impact future developments.

Pacific Street near Brace Road (2): Sheet flooding in the roadway due to backwater in the western part of Sucker Ravine and inadequately sized culverts forces road closures.

Brace Road on the eastern tributary of Sucker Ravine (3): Overtopped due to an inadequately sized 24-foot corrugated metal pipe (CMP) culvert.

Sucker Ravine at Racetrack Road (4): A house adjacent to Sucker Ravine on Racetrack Road lies in the floodplain. Future development may increase flood depths and frequencies at the house.

Sucker Ravine at Sierra Meadows (5): The water surface elevations are close to overtopping the road, although it has historically not been overtopped.

Antelope Creek Tributary / Sierra Meadows / Circuit Court (6): A small creek starts west of Sierra Meadows Drive, crosses Circuit Drive, passes under Pacific Street and continues west where it enters Antelope Creek near Yankee Hill Road. Culverts under Circuit Drive are undersized for the current runoff from an industrial area on Sierra Meadows Drive. If a larger culvert is constructed under Circuit Court, channel restoration and enlarged culverts between Circuit Drive and Antelope Creek need to be constructed.

Sucker Ravine at Rocklin Road (including I-80, Lakeside Drive, and Sierra Lakes Mobile Home Park) (7): Sierra Lakes Mobile Home Park flooded in the February 1986 storm, resulting in the need to evacuate residents under emergency conditions.[22] Extensive flooding may occur in the Sierra Lakes Mobile Home Park due to backwater from the I-80 culvert. The *City of Rocklin Drainage Master Plan* indicates that Rocklin Road may be overtopped by one to two feet causing disruption to a major artery.

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[21] West Yost & Associates, *City of Rocklin Drainage Master Plan*, February 2006.

[22] City of Rocklin, Request for Proposal Engineering Deisgn Services for Central Rocklin Drainage Improvements (Sucker Ravine), August 2010.

Midas Avenue upstream to Del Mar Avenue (8): All the bridges including, and between, these two bridges are overtopped by 2.25-6.47 feet of water in 100-year event.

2.4.2 Roseville

Royer Park on Dry Creek (9): Multiple houses are adjacent to the FEMA floodplain and are subject to flooding.

Folsom Road on Dry Creek (10): The houses upstream from Folsom Road have been subject to historical flooding. Several have been elevated.

Riverside Avenue on Dry Creek (11): Several parcels are within the FEMA floodplain and are subject to flooding.

Oakridge Drive between Cirby Creek and Linda Creek (12): Over 100 homes flooded in the February 1986 storm event. Several of the flooded homes have been elevated. Channel modifications, including an added floodwall, bypass pipes, and a bypass channel were completed on Cirby and Linda Creeks in the 1990's.

2.4.3 Loomis[23]

Sucker Ravine (13): Sucker Ravine's major crossings are at King Road, Saunders Avenue, Sierra College Boulevard, and Bankhead Road. The culvert at Kings Road backs floodwater. At Saunders Avenue, the road is overtopped flood flow; and Sierra College Boulevard backs water up during flood runoff.

Secret Ravine (14): Secret Ravine crosses Horseshoe Bar Road, Brace Road, and Gade Lane. Each of these bridges is overtopped during at 100-year event. Brace Road would be overtopped by about three feet.

Antelope Creek (15): Antelope Creek has major crossings at King Road, Sierra College Boulevard, and Delmar Avenue. Two or three homes are located in the flood plain upstream of King Road. The 100-year runoff will overtop the road. The floodplain widens upstream of Sierra College Boulevard during a 100-year runoff event; however, the road is not overtopped. At Delmar Road, the 100-year runoff will overtop the road; however, no homes are within the floodplain.

2.4.4 Placer County

Miners Ravine (16): Problem areas for flooding are upstream of Sierra College Boulevard, near Joe Rodgers Road, and at the bridges of Leibinger Lane, Carolinda

[23] West Yost & Associates, *Town of Loomis Drainage Master Plan*, November 2001.

Drive, and Itchy Acres Road.[24]

Secret Ravine (17): Three properties on Rustic Hills Drive have reported flood damages.

Linda Creek below Auburn-Folsom Road (18): Numerous properties in the Troy/Purdy Lane area are adjacent to the 100-year floodplain and are subject to flooding.

Lower Dry Creek between Roseville and Sacramento County (19): Several homes were flooded during the February 1986 storm event.

2.4.5 Sacramento County

Dry Creek (20): Flooding has occurred along most of Elkhorn Boulevard, including many residences, schools and businesses. Over 200 homes and business were flooded along Elkhorn Boulevard during the February 1986 storm event.[25]

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[24] ECORP Consulting, Inc., Dry Creek Watershed Coordinated Resource Management Plan, 2003.
[25] James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992,

3.0 Updated Hydrology

3.0 UPDATED HYDROLOGY

3.1 MODELING SYSTEM DEVELOPMENT

The Plan Update provides a new hydrologic modeling system that has significant technological advances over that used in the 1992 Plan. Though the 1992 Plan was state-of-the-art at the time it was prepared, the new modeling system is better able to evaluate flood flow timing that is significant to development impact and project analyses. Computer programs, including HEC-HMS and HEC-RAS, GIS software, and the DCTOOLBOX were employed to develop a new basis for watershed runoff and flood flow evaluation. The new modeling system includes substantially more detail than the 1992 modeling system allowing it to be used on smaller tributaries which will facilitate its application on smaller projects. Furthermore, the new modeling system has been calibrated using precipitation and stream flow gage data from the December 1995, December 2005, and January 2007 storm events to ensure the validity of the results. The new modeling system provides capabilities to evaluate Dry Creek hydrology in ways that were not possible with the models from the 1992 Plan, but are now necessary to adequately evaluate the potential impacts of projects on flooding conditions.

The process that led to the development of the new modeling system started with applying the District's procedures in the SWMM to the hydrology model developed for the 1992 Plan. Updating the model from the 1992 Plan demonstrated that the application of PDP2 to the 1992 Plan model would result in peak flow rates in excess of those expected based on rainfall and measured stream flows. In other words, updating the model from the 1992 Plan model using SWMM would void calibration performed as part of the 1992 Plan and would not provide a model that could be calibrated using storm data that has been collected since 1992. This conclusion led to the decision to create a new hydrology model and to calibrate it using a substantial set of rainfall and runoff data that was not available at the time that the 1992 Plan was being developed. The new hydrology model is based on more accurate topographic data than was available in 1992. In addition to the new hydrology model using the USACE programs HEC-1 and HEC-HMS, the new modeling system includes an unsteady-state hydraulic model (HEC-RAS) for the lower two-thirds of the watershed that is a key tool necessary to accurately determine potential project benefits. The new hydrology model and unsteady-state hydraulic model together are the new modeling system that forms the basis for this Plan Update.

The following sections describe the general process used to create the updated modeling system with additional detail provided in referenced appendices.

3.1.1 Key Locations for Summary Comparisons

To simplify data review, only a sampling of the data produced by the models is presented in the main body of this Plan Update. Peak flow rates for the 100-year event at key locations of interest are presented in tables in sections 3 and 4, while additional data is included in appendices. All of the final work product models and results have been provided to the District on an external hard drive. Recommendations for key locations of interest were requested from local agencies and District staff. The key locations were selected because of known flooding issues or because local agencies use the point as a basis for flood impact evaluation purposes. These locations are the 26 locations listed on the summary tables included in the main body of this report. The 1992 point numbering scheme has been carried forward into this project, and new points added during this study have been given point numbers greater than 1000. Point Numbers are identified on the watershed maps included in Appendix B.

3.2 UPDATE OF THE 1992 PLAN MODEL TO CURRENT DISTRICT METHODOLOGY

The first step of the hydrologic analyses performed for this Plan Update was to adapt the 1992 Plan HEC-1 model to methodologies consistent with current SWMM procedures. This adaptation included:

Replacing the rainfall distribution that was applied in the 1992 Plan model with a distribution based on the SWMM, and
Replacing the sub-watershed rainfall to runoff transformation method from Snyder unit hydrograph with kinematic wave.

The adapted model was run with a storm centering similar to that used in the 1992 Plan which generated the peak flow rates at Vernon Street. The adapted model results were compared at key locations to the results from the 1992 Plan model. This comparison (both models were based on Future Unmitigated conditions) is provided in Table 3.

The results of the comparison indicate that the adapted model produces slightly higher flows at Vernon Street. Wider variations at other locations are due to differences in storm centering. The storm centering for the 1992 Plan was based on calibration to actual events (February 1986 and March 1989) while the adapted model used SWMM based centering. Plate 1 illustrates the differences in precipitation between the 100-year event used in the 1992 Plan to model peak flows at Vernon Street and the 100-year SWMM based centering used to calculate peak flows at Vernon Street with the adapted model. Detailed review of adapted model performance indicated that a simple conversion and adaptation of the 1992 Plan model to SWMM requirements would not result in properly calibrated results. Therefore, it was concluded that additional modifications to the analysis would be necessary to achieve calibrated results with a HEC-1 model modified to meet the requirements of the SWMM.

Additional details related to the model adaptation process are provided in Appendix F.

Table 3: Original 1992 Plan Model Compared to 1992 Plan Model Adapted to SWMM

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year Vernon Peak JMM	100-year Adapted to SWMM CESI/RBF
Miners Ravine					
UR15K2	MR15	207	Dick Cook Road	915	2005
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	1423	1746
YMR29I	MR29R	202	Cottonwood Lake	2910	4029
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	3084	4210
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	8864	9359
Secret Ravine					
YE50F2	SE50R	235	Brace Road	3038	3404
YSE51K	SE51R	232	Sierra College Blvd.	3272	3641
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	3345	3725
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	4422	4527
Clover Valley					
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	724	961
Antelope Creek					
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	1986	2207
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	2093	2303
UC41E4	AC41R	126	Antelope Creek Road - Downstream of SR-65 (Gage 1583)	2963	3449
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	2970	3446
Cirby Creek					
YCC40C	CC40R	51	Coloma Way (Gage 1635)	912	900
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	948	935
Strap Ravine					
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek at McClaren (Gage 1611)	972	1214
Linda Creek					
ULC5B	LCC1	92	Troy Purdee Lane	775	940
UC45J2	LC45R	82	At Sacramento/Placer County Line	1827	2042
ULC80I	LC80R	76	Champion Oaks/Sanoma Way (Gage 1626/1628)	2788	2920
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	3629	3757
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3895	3965
Dry Creek					
UDC5B	DC5R	26	Royer Park	11489	12323
YDCCC	RYCOMB	23	Confluence with Linda Creek/Cirby Creek	15447	16141
YDC10D	VERNON	21	Vernon Street Crossing	15051	15484
YDC71B	DCC11	9	Sacramento County/Placer County Line	15622	15568

3.3 WATERSHED DELINEATION AND SUBDIVISION

The first step in developing a new hydrology model for this Plan Update was to delineate new watershed boundaries. The boundaries from the 1992 Plan were reviewed with IFSAR (Intermap) data and it was determined that some boundaries required significant revision. The new watershed delineations were primarily developed using Intermap data obtained for this purpose supplemented by other sources of information as described in Section 1.5.3. Watersheds were subdivided based on hydrologically significant boundaries, such as where portions of the watershed have different lengths of flow indicating different timing of runoff. Smaller sub-watersheds allow the Plan Update model to support evaluations on smaller tributaries, to quantify the impact of numerous surface lake storage features throughout the watershed, and to correctly reflect the runoff timing of different sub-stream areas within the 172 larger watersheds used in the 1992 Plan. The average watershed size in the Plan Update is approximately 100 acres. Ultimately, 1,288 sub-watersheds were delineated for the Plan Update. The new sub-watersheds use a naming convention that correlates to the 1992 Plan designations. Plate 13 illustrates the refinements made to the major watershed boundaries as a part of this Plan Update.

Concurrent with this Plan Update, an update of the hydrology for the adjacent Pleasant Grove Creek watershed was performed by the City of Roseville. The boundary between the Dry Creek and Pleasant Grove Creek watersheds was reconciled and used for the final analyses in both projects.

It was also observed that many canals passing through the Dry Creek watershed have a hydrologic impact on the location and routing of the tributaries with natural flow paths that cross the canals. Data was obtained from Placer County Water Agency regarding their canal system and its overflow discharge points which aided in establishing watershed boundaries.

Appendix B illustrates the watershed boundaries delineated for this Plan Update and the locations where boundaries were revised from the 1992 Plan.

3.4 LAND USE HYDROLOGIC FACTORS FOR 1992, 2007, AND GENERAL PLAN BUILD-OUT

3.4.1 Land Use

Land use provides key information about the amount and rate of runoff from each watershed. Impervious area is used to define that portion of the watershed from which the models assume all incident rainfall becomes runoff. Impervious area was also used to determine appropriate parameters for overland flow length and slope that impact watershed runoff response time. Land use was used to determine loss rates from the pervious portion of each watershed.

Plate 7, Plate 8 and Plate 9 show estimated land use types based on estimated 1992 (baseline), 2007 (current), and General Plan (build-out) conditions respectively. The baseline conditions were largely obtained from the 1992 Plan; however, some corrections were made to the drawing file sets provided from the 1992 Plan for areas of overlap and areas without data during the conversion to GIS file type. The build-out land use comes from the combined layers from the General Plans of the various City and County agencies within the watershed. Corrections were also made to this dataset as the data was combined from the various entities. The 2007 (current) conditions land use was derived from General Plan build-out land use, 2005 aerial imagery and other data as described in Section 1.5.4.

Table 4 summarizes the basic land use types (summarized from 480 classifications assigned to the source data) that were assigned for each of the scenarios. 5.4Appendix F provides detailed land use summary information for the baseline, current and build-out scenarios, respectively.

Table 4: Land Use By Scenario

Land Use Code	Description	1992 Areas (acres)	2007 Areas (acres)	General Plan (acres)
OS	OPEN SPACE	27,748	19,002	3,703
AG	AGRICULTURAL	1,297	1,516	2,463
RR	RURAL RESIDENTIAL	9,944	12,321	17,202
RE	RURAL ESTATES	8,229	8,397	10,986
LDR	LOW DENSITY RESIDENTIAL	8,868	13,117	16,191
MDR	MEDIUM DENSITY RESIDENTIAL	2,665	3,030	3,464
HDR	HIGH DENSITY RESIDENTIAL	441	529	604
RES	RESERVE	4	4	8
REC	RECREATIONAL/PARKS	452	600	2,013
PQP	PUBLIC/QUASI PUBLIC	408	598	886
COMM	COMMERCIAL	1,547	1,740	2,392
IND	INDUSTRIAL	1,575	1,725	2,301
BP	BUSINESS PROFESSIONAL	552	887	1,047
ROAD	ROADWAYS	1,136	1,416	1,598
CITY	CITY UNKNOWN	38	44	67
	TOTAL	64,903	64,924	64,924

Appendix F also provides a complete summary of the land use hydrologic factors used in preparing this Plan Update. The same factors were used for the baseline (1992), current (2007) and build-out scenarios.

3.4.2 Impervious Area

One key hydrologic factor derived directly from the land use is the percentage of impervious cover. Rainfall landing on impervious surfaces is generally assumed to runoff directly into the gutters and storm drain systems, thereby discharging into the streams without an opportunity for infiltration, evapotranspiration or local storage to occur. Generally, certain types of land use will have similar amounts of impervious cover no matter where they are built. However, in some cases, the impervious cover for similar land uses can vary due to local agency requirements.

To determine appropriate percentages of impervious cover by land use for the Plan Update, several documented and published rates were researched and tested in the calibration events. Most notably, the imperviousness rates documented in the SWMM and the DCWCRMP were used. Some adjustments were made based on the final calibrations of the model. The final rates used in the analysis are indicated in Appendix F for all 480 land use types applied in the Plan Update. Plate 4, Plate 5 and Plate 6 illustrate the imperviousness within the Dry Creek watershed for the 1992 baseline, current (2007) and build-out conditions, respectively.

3.4.3 Loss Rates

A second key hydrologic factor derived from the land use and the hydrologic soils types is the constant infiltration rate. The hydrologic soils types are shown on Plate 3. Generally, similar types of land use will have similar types of landscaping. While each project may have different landscaping, the assumed factors are for typical conditions and will balance out over the watershed. The constant infiltration rate applies to the non-impervious areas only and indicates the estimated combined effect of all constant losses, such as infiltration and evapotranspiration. Infiltration is the main component, which is why this factor is dependant on the hydrologic soil group. Development does not usually degrade this factor to a lesser value. In fact, in a number of cases, development may change this factor to a larger value, such as in the conversion of grasslands to park, where the density of grass and tree vegetation is substantially increased, slowing down runoff rates and providing an increased opportunity for infiltration to occur.

The SWMM procedures account for rainfall losses in two forms: an initial loss and a constant loss rate. The initial loss (amount reported in inches and applied to all areas of the watershed) indicates an amount of rainfall which goes into the wetting and filling of shallow storage in the watershed. Generally, this amount of rainfall must occur before any runoff will begin. The constant loss rate (or constant infiltration rate) simulates the combined effects of infiltration and evapotranspiration in the watershed.

The SWMM specifies the use of an initial loss of 0.1 inches for flood studies. Historically, because of the widespread use of HEC-1, the methodology of “initial and constant” losses has been applied. However, for this Plan Update, it was found that the application of “deficit and constant” loss rates calibrated better (especially for smaller events) than the previously applied methodology. This methodology can be applied with the use of HEC-HMS, but is not available in HEC-1.

For “deficit and constant” losses, the constant loss rate is applied exactly the same as in the application of initial and constant loss rate methodology. The initial loss is replaced by factors for a total loss amount, an initial amount of the total loss which is occupied at the start of the event and a recovery rate. It was found that a total loss amount of 0.2 inches for urbanized areas, and 0.4 inches for non-urbanized areas worked best in the calibration events. To initiate each event with the 0.1 inches consistent with the SWMM requirements, 0.1 inches was specified for the initial deficit, meaning 0.3 inches was assumed to be full for non-urban areas, and 0.1 inches was assumed to be full for the urban areas. Because the calibration events went for long periods of time, this methodology allowed for significant drying to occur between rainfall events, and more loss to occur in the initial rainfall of subsequent events, providing a better calibration.

A detailed discussion of the hydrologic calibration procedures used in this Plan Update is included in Appendix C.

3.4.4 Response Time Factors

For this Plan Update, a significant amount of effort was expended calibrating hydrologic parameters according to SWMM procedures. Initially, overland response factors (slope and length) were determined for every watershed in the updated models, based on the Intermap topography. Based on several early calibration tests, it was concluded that application of measured response factors significantly under-estimates the response time for the non-urban areas and results in peak hydrograph timing several hours in advance of stream gage data.

It was ultimately discovered that setting values for the slope and length overland response factors based solely on watershed imperviousness, and not actual slope and length, provided better overall model calibration, with timing of the peaks of recorded flooding closely matching model predictions. The relationships between imperviousness and the slope and length used to determine overland flow response time in the calibrated models are provided in Appendix F.

3.5 CHANNEL ROUTING

Routing of runoff through the channels in the hydrology model can be performed using various methods, including Muskingham-Cunge, kinematic wave routing, and Modified Puls routing. Muskingham-Cunge and kinematic wave routing are limited to a simplified cross section per reach. The Modified Puls routing method uses a storage-discharge relationship for each reach. Storage-discharge relationships can be developed using steady-state hydraulic modeling in HEC-RAS for a range of discharges. Routing of runoff in HEC-1 and HEC-HMS does not account for situations where varying tailwater conditions can result in multiple water surface elevations at the same discharge.

A more accurate method to perform channel routing is to use an unsteady-state hydraulic model that can account for situations where a single storage-discharge relationship does not adequately represent actual conditions. These situations commonly occur at structures such as bridges and confluences, and are even more pronounced in off-channel storage configurations such as the Miners Ravine Off-Channel Detention Basin. It was therefore determined that an unsteady-state hydraulic routing model would be required to evaluate current conditions and potential future projects.

3.5.1 Channel Routing in the Hydrology Models

It was found that Modified Puls routing factors more closely represented the measured runoff response characteristics than the Muskingham-Cunge and kinematic wave routing options developed in the base models. A steady-state hydraulic model was developed using the Intermap topography for the significant upper reaches of the watersheds not covered by the main hydraulic routing model. Modified Puls routing parameters were developed from both the Intermap-based upper watershed model (developed specifically to provide channel routing parameters for the hydrology model) and a steady-state version the composite hydraulic model developed for the lower watershed. These parameters were used in the hydrology model for the most significant routing features. Including Modified Puls routing parameters for the reaches in the lower watershed covered by the unsteady-state hydraulic model allows the HEC-HMS simulation to provide reasonable results in many locations, but the results are significantly different from the unsteady HEC-RAS model in some key locations.

3.5.2 Unsteady-State Hydraulic Routing Model

Unsteady-state hydraulic models of the streams in the lower two-thirds of the Dry Creek watershed were used as the primary means of performing flow routing in the area it covers. Models were created to simulate 1992 and 2007 conditions and to model potential regional flood control projects. One HEC-RAS model was prepared with 2006 conditions to assess the effectiveness of the Miners Ravine Off-Channel Detention Basin project using the Plan Update models. Also, a 2010 model was prepared that included recent modifications to the Sierra College Boulevard culvert at Secret Ravine to provide an appropriate baseline for evaluating potential future projects. The 1992 condition composite unsteady-state HEC-RAS model of the Dry Creek watershed was developed using the sources of cross section and reach information listed in Table 5.

Table 5: Composite Unsteady-State HEC-RAS Model Data Sources

River	Reach	Data Sources
Antelope Creek	AntelopeBlwClove	PWA FIS above 10725.49 (old 320), Allnew Composite[26]
Antelope Creek	Reach 1	PWA FIS
Cirby Creek	Above Linda	PWA FIS previously converted with adjustments made for City of Roseville study by RBF
Cirby Creek	Below Linda	Allnew Composite
Clover Valley	Clover Valley 1	PWA FIS
Dry Creek	Above Cirby	Allnew Composite modified by RBF for City of Roseville redevelopment studies
Dry Creek	Below Cirby	Allnew Composite and Placer Vineyards models
False Ravine	Reach 1	Allnew Composite
Linda Creek	Above S Branch	Nolte Restudy 2004
Linda Creek	South Branch	Nolte Restudy 2004

[26] Spink (Stantec), Model Combination for City of Roseville, 2005.

River	Reach	Data Sources
Linda Creek	Below S Branch	Nolte Restudy 2004 revised by RBF based on Champion Oaks study for City of Roseville
Linda Creek	Below Strap	PWA FIS
Miners Ravine	Below Secret	Allnew Composite
Miners Ravine	Above False	PWA FIS above 13180.5 (old 308), 14146.17 to 18310.19 new model from RBF Miners Ravine and Sierra College Blvd evaluations
Miners Ravine	Bet Secret-False	Allnew Composite
Secret Ravine	Below Sucker	PWA FIS above 6488.499 (old 260), Allnew Composite below
Secret Ravine	Reach 1	PWA FIS
Strap Ravine	Reach 1	Allnew Composite
Sucker Ravine	Reach 1	PWA FIS

Each of the reaches was imported into HEC-RAS. Bridge definitions, where applicable, were adjusted to match existing conditions as observed during field investigation. The cross sections and structures were adjusted as appropriate to achieve stable unsteady-state performance without significantly altering effective conveyance. Other changes in the model to achieve unsteady-state function included establishing HTab parameters at each structure, appropriate application of permanent ineffective flow areas, select use of pilot channels and interpolated cross sections at various intervals.

The baseline composite model was constructed to match the approximate 1992 conditions by removing flood control improvements that had been implemented to reflect conditions without the improvements realized since that time. Significant projects implemented since 1992 were added based on record drawings to create the 2007 conditions model. These projects are discussed in Section 3.9.2.

Appropriately configured unsteady-state hydraulic models were used in the calibration process, determinations of 100-year discharges at key locations for impact analyses and project alternative evaluations. A steady-state version of the composite model was used to determine storage versus discharge relationships for reach routing (Modified Puls parameters) in the hydrology models.

3.6 HYDROLOGIC COMPUTER MODEL CALIBRATIONS

The refined watershed and new sub-watershed delineations, plus new the channel routing tools, provide the basis for the Plan Update models. To ensure that the models will produce appropriate response to incident rainfall, the parameters that affect the amount and timing of runoff need to be adjusted to demonstrate that the model reproduces known conditions. Calibration of a model is the process used to ensure that the model predicts actual system behavior as closely as possible. In model calibration, known input data for a historical event is entered into the model, and the output from the model is compared with the known flood conditions. Parameters in the model are then adjusted until the model output matches historic data for the event.[27] Once a model is calibrated, application of rainfall of a know recurrence interval can be used to estimate the flood levels corresponding to the same interval, though one needs to verify that the rainfall duration and distribution is the critical set for that recurrence interval to generate the peak discharge at the location of concern.

Four historic floods were selected to be used in the calibration process based on the significance of the events and the availability of rainfall and stream gage records. The events used for calibration of the models were the January 1995 event, the December 1995 event, the January 1997 event, and the December 2005 event.

The details of the processes used to perform the calibration analysis are provided in Appendix C.

The results of the calibration process are a hydrologic modeling system that includes hydrology calculations performed using HEC-HMS and hydraulic routing calculations performed using unsteady-state HEC-RAS that has been thoroughly validated to be able to accurately transform rainfall to runoff within the Dry Creek watershed.

3.7 COMPARATIVE ANALYSIS SCHEME

The Plan Update compares scenarios of various hydrology models combined with various hydraulic models. These Scenarios were used to evaluate what has occurred since 1992 and the potential of future changes as determined to be appropriate, to identify appropriate flood impact mitigation measures and support associated funding plans. Land use conditions that were evaluated include: 1992 conditions; 2007 conditions; and build-out conditions, with and without incorporation of Low Impact Development (LID) features. (LID features are simulated in the hydrology model by reducing the effective impervious area that would otherwise be associated with the land use.) Hydraulic models were used to simulate 1992 conditions, 2006 conditions, 2007 conditions including the Miners Ravine Off-Channel Detention Basin Project, and conditions with the potential projects identified in this Plan Update.

Table 6 identifies the scenarios used to perform the primary analyses used to prepare the Plan Update. Additional scenarios were used to evaluate the potential projects individually. The scenarios are identified with numbers one through seven for reference.

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[27] James M. Montgomery, Dry Creek Watershed Flood Control Plan, 1992.

Table 6: Model Scenario Matrix

	Land Use			
Hydraulic Model	1992	2007	Build-out no LID	Build-out with LID
1992	(1) 1992 Corrected Original Baseline	(2) 2007 Unmitigated	X	X
2006 (without Miners Ravine Project)	X	(3) 2006 – No Miners (Local Detention Only)	X	X
2007 (with Miners Ravine Project)	X	(4) 2007 Current (Plan Update Baseline)	(5) Future Unmitigated (Updated from new baseline)	(6) Build-out w/ LID & no Projects
With potential projects	X	X	X	(7) Build-out w/ LID & Projects

1. The *1992 Corrected Original Baseline* scenario uses Plan Update model methodology to provide a consistent basis for evaluating what has occurred since the preparation of the 1992 Plan. It uses 1992 hydrology and 1992 hydraulic conditions.
2. The *2007 Unmitigated* scenario uses 2007 hydrology and 1992 hydraulic conditions to simulate conditions that would have existed in 2007 without the implementation of any mitigation measures.
3. The *2006 – No Miners (Local Detention Only)* scenario uses 2007 hydrology and 2006 hydraulic conditions to provide a basis for separately evaluating the effectiveness of local detention and the regional detention basin project.
4. The *2007 Current (Plan Update Baseline)* scenario uses 2007 hydrology and 2007 hydraulics to provide a baseline for evaluating projects implemented after initiation of this Plan Update.
5. The *Future Unmitigated* (Update from new baseline) scenario uses build-out hydrology without LID features and 2007 hydraulic conditions to provide a basis for potential impacts if build-out were to occur without any new mitigation measures.
6. The *Build-out with LID and no Projects* scenario uses build-out hydrology with LID and 2007 hydraulic conditions to provide a basis for determining how much additional regional attenuation would be required in addition to inclusion of LID features.
7. The *Build-out with LID and Projects* scenario uses build-out hydrology with LID and hydraulic conditions that reflect current conditions plus the five potential projects recommended in this Plan Update.

Eight different comparative evaluations where made to quantify current and potential impacts and mitigation using these seven scenarios. (Note that minor anomalies in the HEC-RAS unsteady-state modeling cause small changes to be indicated in the comparisons where none would be expected.)

Table 7: Scenario Comparison Summary

Comparison No.	Scenario Comparison	Description	Purpose
1	4-1	Current baseline minus 1992 conditions	Quantify the net impacts to date towards which the current impact fee balance can be used for mitigation
2	2-3	Current unmitigated minus Current local detention only	Quantify the benefit of local detention incorporated to date
3	3-4	Current local detention only minus Current baseline	Quantify the benefit of the Miners Ravine project
4	5-4	Future unmitigated minus Current baseline	Quantify the impacts for which the plan proposes mitigation
5	5-6	Future unmitigated minus LID only	Quantify the mitigation expected to be realized by incorporating LID features into future projects
6	5-7	Future unmitigated minus Projects & LID	Quantify the benefit of LID along with the proposed projects
7	6-7	LID only minus Project & LID	Quantify the benefit of the proposed projects over LID only
8	7-4	Project & LID minus Current baseline	Quantify the net impact of build-out with plan implementation

3.8 BASELINE CONDITIONS MODELING IN HEC-HMS

With the new hydrologic modeling system that has been validated through a comprehensive calibration process, flow rates throughout the watershed can be calculated based on specific recurrence interval design rainfall events. The new models based on the calibrated model prepared for the Plan Update provide a system to make valid comparisons to current and future conditions.

Design rainfall events are based on procedures in the SWMM. The Plan Update evaluates 2-, 10-, 25-, 50-, 100-, 200- and 500-year recurrence interval storm events. The SWMM calls for a storm centering approach to determine peak flow conditions at any location as described in the following section.

3.8.1 Storm Centering Analysis for Key Locations of Interest (HEC-1)

Application of SWMM requires determination of what cloudburst centering location and angle combination would result in peak discharge conditions for each location of concern. By using automated capabilities of the DCTOOLBOX, storm centering analyses was performed using HEC-1 for the 100-year event with 0, 30, 60, and 90 degree storm angles at all sub-watershed locations within the Plan Update models. The full set of cloudburst center and angle analyses were run based on the 1992 baseline model.

The results of the centering analysis were compared for all of the approximately 3,800 nodes in the analysis, but special attention was paid to the key locations. It was found that the following seven storm centering locations and storm angles (refer to Table 8) produce the peak flows or nearly (within a few percent) the peak flows for every key location in the watershed. Plate 14 illustrates where the seven centerings control the key peak flow rates.

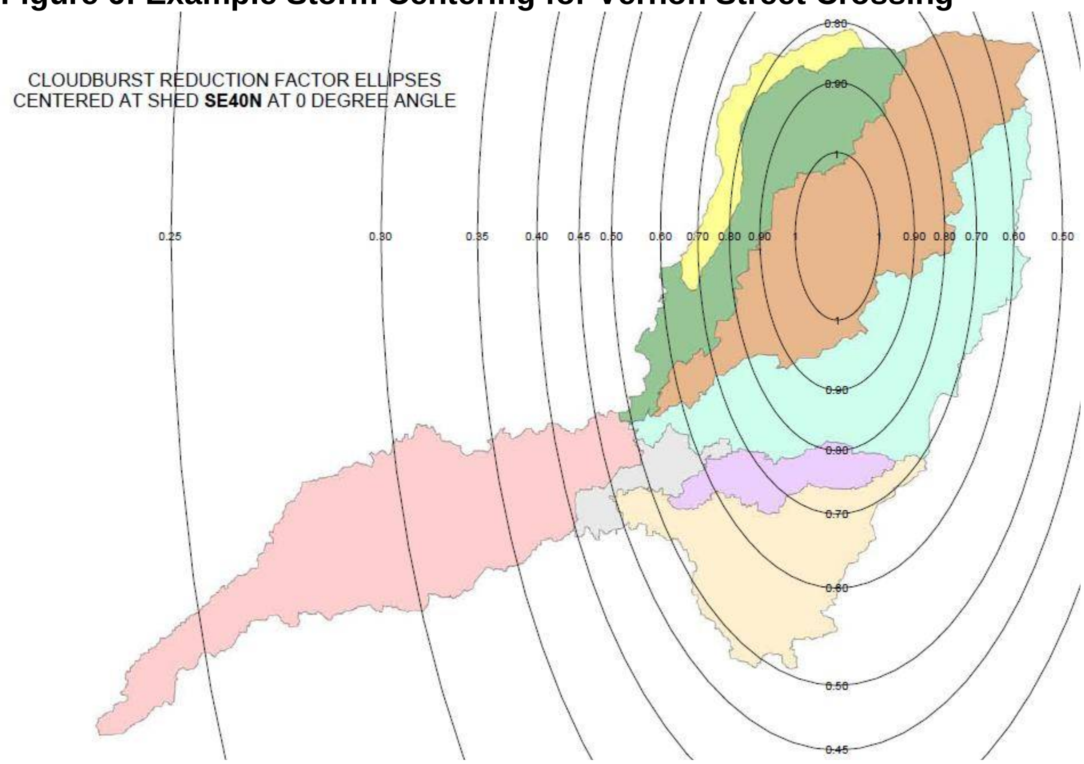
Table 8: Summary of Storm Centering Locations and Angles

Watershed Center Location	In Watershed	Storm Angle
LC5A	Linda Creek	0
SE40N	Secret Ravine	0
LC40L	Linda Creek	30
MR15J	Miners Ravine	30
SE40M	Secret Ravine	30
AC5I	Antelope Creek	60
CC5G	Cirby Creek	90

These seven centering location and angle combinations are used in this Plan Update to evaluate project alternatives and impacts at key locations throughout the watershed.

Figure 6 illustrates the storm centering adjustment ellipses with adjustment factors for the peak 1-hour precipitation of the event.

Figure 6: Example Storm Centering for Vernon Street Crossing



Storm centering and cloudburst reduction factor adjustments for all seven events are shown on Plates 15 through 21.

Watershed outflow hydrographs from HEC-HMS were linked to the hydraulic routing model and run to generate the Plan Update's final predicted baseline discharges.

A comparison of the baseline peak flow rates between the 1992 Plan and this Plan Update at key locations for the 100-year event is shown in Table 9 to illustrate the differences between the 1992 Plan and Plan Update model results.

Table 9: Summary of Peak Flows for the Baseline 100-Year Event

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	1989 JMM	1992 Corrected Orig. Base.
Miners Ravine					
UR15K2	MR15	207	Dick Cook Road	1684	1682
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	2468	1947
YMR29I	MR29R	202	Cottonwood Lake	2680	2380
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2881	2314
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7844	7498
Secret Ravine					
YE50F2	SE50R	235	Brace Road	3090	4754
YSE51K	SE51R	232	Sierra College Blvd.	3375	5226
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	3374	4795
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	4197	5508
Clover Valley					
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	857	1348
Antelope Creek					
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2180	2813
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	2330	2974
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	3086	3728
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3075	3692
Cirby Creek					
YCC40C	CC40R	51	Coloma Way (Gage 1635)	842	762
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	4113	3107
Strap Ravine					
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek @ McClaren (Gage 1611)	920	921
Linda Creek					
ULC5B	LCC1	92	Troy Purdee Lane	473	545
UC45J2	LC45R	82	At Sacramento/Placer County Line	2489	2042
ULC80I	LC80R	76	Champion Oaks/Sanoma Way (Gage 1626/1628)	3297	2165

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	1989 JMM	1992 Corrected Orig. Base.
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	3972	2684
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	4126	3041
Dry Creek					
UDC5B	DC5R	26	Royer Park	10476	10782
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	13825	9433
YDC10D	VERNON	21	Vernon Street Crossing	13706	12792
YDC71B	DCC11	9	Sacramento/Placer County Line	14048	12622

3.9 CURRENT CONDITIONS (2007) MODELING

The current conditions hydraulic model reflects hydraulically significant changes to the watershed through 2007. The only hydraulically significant change that has occurred between the completion of the Miners Ravine Off-channel Detention Basin in 2007 and 2010 is modification of Sierra College Boulevard at Secret Ravine. The impact of this roadway modification is addressed in the project evaluation portion of the Plan Update in Section 4.4.2.

3.9.1 Current Condition HEC-HMS Modeling

To determine appropriate hydrologic parameters for the Plan Update current condition models, land use was estimated as described in Section 1.5.4 and shown on Plate 8. Land use summary tables for the 2007 baseline conditions are provided in Appendix F. Impervious area values were extracted from the data illustrated on Plate 5.

Watershed outflow hydrographs from HEC-HMS were linked to the hydraulic routing model and run to generate the Plan Update's discharges for current conditions.

A comparison of the 1992 baseline conditions peak flow rates (modeled to be consistent with the Plan Update discharges) and the Plan Update 2007 baseline condition at key locations for the 100-year event is shown in Table 10. This comparison indicates the net impact of development and mitigation from the 1992 baseline to the current condition. This comparison shows current (2007) condition Vernon Street 100-year peak discharge to be 247 cfs above the 1992 baseline condition. Impact fees that have been collected from projects to-date can be used on mitigation projects for this impact to-date.

3.9.2 Hydraulic Routing for Current (2007) Condition Evaluation

For the current (2007) conditions model, the 1992 hydraulic routing model was adjusted to include the following four projects of significance:

3.9.2.1 Southern Pacific Railroad Bridge

The 2007 condition hydraulics were adapted from the 1992 hydraulic conditions models by adding the four elliptical culverts that were added to the crossing, each with a span of 12.5 feet and a rise of 17.5 feet. The bridge deck was extended to the bottom of the channel with the top of the deck at 135.5 feet. The length of the culverts is 98 feet. For the existing conditions model, the culverts were removed and the low chord of the bridge deck was raised to 127.9 feet. A six-foot wide pier in the center of the channel was placed, because the other three piles are located outside the channel.

3.9.2.2 Miners Ravine Off-channel Detention Basin

For the existing conditions model to reflect the construction of the detention facility, the rating curves were replaced with post-construction rating curves. An additional storage area was included upstream, east of Sierra College Boulevard, including adding a weir and flap gates to connect the upstream storage area to the new detention basin. The culvert size was increased to match the replaced culverts under Sierra College Boulevard. The spillway of the detention facility was added as a storage area connection to the downstream storage area. The lateral weirs connecting the channel to the detention basin were also adjusted to reflect the post-construction elevations.

3.9.2.3 Linda Creek Bypass Channel

To model the channel built after 1992, the current conditions model was altered to include an additional 1208 foot reach, just downstream of River Station 8810 on Below Strap reach on Linda Creek. Because the new reach was added, the resulting new downstream reach of Linda Creek was renamed “Below Bypass”. The trapezoidal cross sections were taken from the construction plans for the project. A section was added at each end, with inverts at 146 feet upstream and 144 downstream per the construction plans. A lateral weir at an elevation of 146 feet was used to connect Linda Creek at River Station 9500, next to the left bank station, to the upstream segment of the reach. An initial flow was added in the channel to stabilize the data for unsteady-state flow modeling.

3.9.2.4 Linda Creek Bypass Piping

For the current conditions model, a lateral weir was added at River Station 3019.3 on the Below Strap reach on Linda Creek. The points on the channel bottom were lowered to flow into the lateral weir per the construction drawings for the project. Two parallel, nine-foot diameter circular culverts, 860 feet in length, were connected from the lateral weir to River Station 1235.899 downstream on Linda Creek, in the same reach.

Table 10: Comparison of 1992 Baseline to Plan Update (2007) Baseline Modeled 100-Year Peak Flows (Comparison No. 1)

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year 1992-Corrected	100-year 2007-Current	Net Impacts to 2007
Miners Ravine						
UR15K2	MR15	207	Dick Cook Road	1763	1764	-1
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	1955	1947	8
YMR29I	MR29R	202	Cottonwood Lake	2398	2380	18
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2320	2314	6
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7194	7498	-304
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4344	4754	-410
YSE51K	SE51R	232	Sierra College Blvd.	4838	5226	-388
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4577	4795	-218
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5415	5508	-93
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1010	1348	-338
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2842	2813	29
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	2914	2974	-60
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	3744	3728	16
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3708	3692	16
Cirby Creek						
YCC40C	CC40R	51	Coloma Way (Gage 1635)	935	762	173
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3294	3107	187
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek @ McClaren (Gage 1611)	1191	921	270
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	560	545	15
UC45J2	LC45R	82	At Sacramento County/ Placer County Line	2334	2042	292
ULC80I	LC80R	76	Champion Oaks/Sanoma Way (Gage 1626/1628)	2232	2165	67
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2738	2684	54

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year 1992-Corrected	100-year 2007-Current	Net Impacts to 2007
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3255	3041	214
Dry Creek						
UDC5B	DC5R	26	Royer Park	10454	10782	-328
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	8792	9433	-641
YDC10D	VERNON	21	Vernon Street Crossing	13039	12792	247
YDC71B	DCC11	9	Sacramento/Placer County Line	12667	12622	45

3.9.3 Effectiveness of Local Detention

Two alternative versions of the 2007 analysis were performed to evaluate the benefits of the local detention basins constructed from 1992 to 2007. The "With Local Detention" scenario is the baseline current condition which includes local detention facilities installed as part of various developments, but does not include the Miners Ravine Off-Channel Detention Basin project. The "Without Local Detention" scenario does not include these specific local detention facilities or the Miners Ravine project.

Details of the various detention basins that were identified in the Plan Update process are included in Appendix I.

Within HEC-HMS, Modified Puls routing tables were added downstream of each watershed affected by a detention basins to approximate the impacts of the detention facilities.

Table 11 compares the "With Local Detention" and "Without Local Detention" scenarios to assess the effectiveness of local detention.

Table 11: Comparison of "With Local Detention" and "Without Local Detention" Scenarios (Comparison No. 2)

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year 2007-Unmitigated	100-year 2006-No Miners	Deten. Benefit
Miners Ravine						
UR15K2	MR15	207	Dick Cook Road	1766	1767	-1
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	1959	1954	5
YMR29I	MR29R	202	Cottonwood Lake	2400	2401	-1
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2319	2324	-5
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7381	7277	104
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4775	4341	434
YSE51K	SE51R	232	Sierra College Blvd.	5222	4838	384

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year 2007-Unmitigated	100-year 2006-No Miners	Deten. Benefit
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4807	4576	231
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5507	5414	93
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1322	1012	310
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2867	2842	25
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3005	2915	90
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	3807	3733	74
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3762	3704	58
Cirby Creek						
YCC40C	CC40R	51	Coloma Wy (Gage 1635)	934	940	-6
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3264	3294	-30
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek @ McClaren (Gage 1611)	1191	1191	0
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	573	560	13
UC45J2	LC45R	82	At Sacramento County/ Placer County Line	2275	2334	-59
ULC80I	LC80R	76	Champion Oaks/Sanoma Way (Gage 1626/1628)	2206	2232	-26
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2726	2738	-12
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3221	3249	-28
Dry Creek						
UDC5B	DC5R	26	Royer Park	10711	10623	88
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	9217	8796	421
YDC10D	VERNON	21	Vernon Street Crossing	13141	13152	-11
YDC71B	DCC11	9	Sacramento/Placer County Line	13254	12744	510

3.9.4 Benefits of the Miners Ravine Detention Facility

The Miners Ravine Off-Channel Detention Basin project was designed to provide flood control benefit over a wide range of flow conditions along Miners Ravine, from the 2-year up to the 100-year event. The design report indicated that the project would provide a 263 cfs reduction in the 100-year storm event peak discharge at Vernon Street based on a modified 1992 Plan hydrology model with the storm centered to produce the maximum discharges at Vernon Street and the project hydraulic model simulations.[28] The model that was used as a basis for design of the Miners Ravine project indicated a peak 100-year discharge at Sierra College Boulevard of 3,788 cfs, which happens to correspond closely to the flow capacity of the Sierra College Boulevard culvert before roadway overtopping. This flow rate of 3,788 cfs is lower than the 1992 Plan 100-year future conditions flow rate of 4,465 cfs and the FEMA 100-year flow rate of 4,900 cfs. The basin is configured to provide maximum flood attenuation for a storm event with a maximum flood stage that would almost overtop Sierra College Boulevard.

Though Sierra College Boulevard overtopped in 1995 with at an estimated discharge in excess of 4,000 cfs, precipitation records indicate that this storm may have been more severe that a 200-year event on Miners Ravine. The Plan Update analysis indicates a 2007 baseline condition 100-year discharge of 2,399 cfs and a unmitigated build-out condition 100-year discharge of 2,594 cfs in Miners Ravine at Cavitt Stallman Road, just upstream from Sierra College Boulevard. The lower flow rates are primarily due to the routing parameters used in the new model that were based on an extensive calibration process. Because the Plan Update flow rates are lower than the design flow rate, the indicated benefit is lower than that identified in the project design process.

Table 12: Comparison of the 2007 Plan Update Baseline to conditions without the Miners Ravine Project (Comparison No. 3)

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year 2006-No Miners	100-year 2007-Current	Miners Ravine Benefit
Miners Ravine						
UR15K2	MR15	207	Dick Cook Road	1767	1763	4
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	1954	1955	-1
YMR29I	MR29R	202	Cottonwood Lake	2401	2398	3
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2324	2320	4
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7277	7194	83
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4341	4344	-3
YSE51K	SE51R	232	Sierra College Blvd.	4838	4838	0

[28] RBF Consulting, Miners Ravine Off-Channel Detention Basin Hydrology and Hydraulic Design Report, September 2007, p. 31-32.

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year 2006-No Miners	100-year 2007-Current	Miners Ravine Benefit
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4576	4577	-1
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5414	5415	-1
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1012	1010	2
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2842	2842	0
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	2915	2914	1
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	3733	3744	-11
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3704	3708	-4
Cirby Creek						
YCC40C	CC40R	51	Coloma Wy (Gage 1635)	940	935	5
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3294	3294	0
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek @ McClaren (Gage 1611)	1191	1191	0
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	560	560	0
UC45J2	LC45R	82	At Sacramento County/ Placer County Line	2334	2334	0
ULC80I	LC80R	76	Champion Oaks/Sanoma Way (Gage 1626/1628)	2232	2232	0
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2738	2738	0
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3249	3255	-6
Dry Creek						
UDC5B	DC5R	26	Royer Park	10623	10454	169
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	8796	8792	4
YDC10D	VERNON	21	Vernon Street Crossing	13152	13039	113
YDC71B	DCC11	9	Sacramento/Placer County Line	12744	12667	77

3.10 GENERAL PLAN BUILD-OUT MODELING (HEC-HMS)

The projected General Plan land use data sets from various planning agencies within the watershed were assembled as shown in Plate 9. Build-out imperviousness is illustrated on Plate 6. Land use summary tables for the general plan build-out condition are provided in Appendix F.

Hydrology models were prepared and run for two different future condition evaluations, one with and one without LID features expected to be required in new development. The model without LID was used to evaluate Future Unmitigated conditions and the model with LID ws used to evaluate the benefit of LID and was used to perform project evaluations.

3.10.1 General Plan with Current Mitigation

In the first build-out evaluation, the adopted future land-use was inserted into the Plan Update baseline (2007) models and run. This model represents the expected build-out flows that would results if no additional mitigation were placed in the watershed. Table 13 compares build-out flows with current mitigation to current condition flows, indicating the amount of future mitigation necessary to mitigate for anticipated development.

Table 13: Future Mitigation Needs (Comparison No. 4)

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year Future Unmitigated	100-year 2007-Current	Mitigation Needs
Miners Ravine						
UR15K2	MR15	207	Dick Cook Road	1853	1763	90
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	2031	1955	76
YMR29I	MR29R	202	Cottonwood Lake	2487	2398	89
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2447	2320	127
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7364	7194	170
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4807	4344	463
YSE51K	SE51R	232	Sierra College Blvd.	5095	4838	257
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4764	4577	187
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5443	5415	28
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1207	1010	197
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2912	2842	70

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year Future Unmitigated	100-year 2007-Current	Mitigation Needs
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3025	2914	111
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	4163	3744	419
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3932	3708	224
Cirby Creek						
YCC40C	CC40R	51	Coloma Wy (Gage 1635)	953	935	18
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3402	3294	108
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek at McClaren (Gage 1611)	1253	1191	62
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	594	560	34
UC45J2	LC45R	82	At Sacramento County/ Placer County Line	2573	2334	239
ULC80I	LC80R	76	Champion Oaks/Sonoma Way (Gage 1626/1628)	2221	2232	-11
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2769	2738	31
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3360	3255	105
Dry Creek						
UDC5B	DC5R	26	Royer Park	10989	10454	535
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	8930	8792	138
YDC10D	VERNON	21	Vernon Street Crossing	13865	13039	826
YDC71B	DCC11	9	Sacramento/Placer County Line	13263	12667	596

3.10.2 Future Fully Developed Unmitigated Other Regulatory Flows

It is expected that the District will require that the Future Unmitigated results be used for floodplain evaluations, though additional requirements may also apply. For comparison, Table 14 lists the values from the 1992 Plan which have been used for District evaluations and the effective Flood Insurance Study (FIS) used for FEMA regulatory issues. The District should be consulted to verify that appropriate discharge rates and floodplain elevations are selected for any project evaluation.

Table 14: Potential and Other Regulatory Flows

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year Future Unmitigated	100-year Future JMM	100-year FIS FEMA
Miners Ravine						
UR15K2	MR15	207	Dick Cook Road	1853	2277	3150
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	2031	2967	
YMR29I	MR29R	202	Cottonwood Lake	2487	3202	
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2447	3421	4900
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7364	8428	7840
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4807	3649	3080
YSE51K	SE51R	232	Sierra College Blvd.	5095	3814	3710
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4764	3820	4150
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5443	4332	4200
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1207	934	860
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2912	2541	865
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3025	2703	2330
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	4163	3500	
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3932	3486	3080
Cirby Creek						
YCC40C	CC40R	51	Coloma Wy (Gage 1635)	953	1113	720
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3388	4614	4340
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek at McClaren (Gage 1611)	1253	1054	920
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	594	640	
UC45J2	LC45R	82	At Sacramento County/ Placer County Line	2541	2774	
ULC80I	LC80R	76	Champion Oaks/Sonoma Way (Gage 1626/1628)	2217	3612	3300
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2766	4464	4160
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3348	4613	4130

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year Future Unmitigated	100-year Future JMM	100-year FIS FEMA
Dry Creek						
UDC5B	DC5R	26	Royer Park	10989	11358	
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	8930	15181	14000
YDC10D	VERNON	21	Vernon Street Crossing	13865	14830	14000
YDC71B	DCC11	9	Sacramento/Placer County Line	13263	15414	14000

3.11 PEAK FLOW TABLES FOR VARIOUS RECURRENCE INTERVALS

Tables of peak flows for the 500-year, 200-year, 100-year, 50-year, 25-year, 10-year and 2-year events, for the various modeled scenarios are included in Appendix G.

4.0 Potential Improvement Projects and Mitigation Measures

4.0 POTENTIAL IMPROVEMENT PROJECTS AND MITIGATION MEASURES

4.1 PLANNED BRIDGE AND CULVERT IMPROVEMENTS

The 1992 Plan identified 208 crossings (bridges and culverts). The 1992 Plan concluded that 130 of the bridges and culverts would be overtopped during the 100-year flood event based on 1989 land use conditions. Each jurisdiction reviewed the list of inadequately sized bridges and culverts and prepared a list of the crossings with the highest priority for replacement. Several factors were included in this decision, including:

Potential for injury or loss of life
Potential for property damage or damage to the bridge or culvert
Emergency access to isolated areas
Inconvenience caused by road closure
Exclusion of privately owned structures

Since the 1992 Plan, several bridge and culvert crossings have been modified or replaced, or have been scheduled for replacement, and are listed in Table 15:

Table 15: Scheduled and Completed Bridge and Culvert Projects

Bridge Location	Replacement Status	Recommended for Replacement in 1992 Plan
Dry Creek at Walerga Road	Not Completed	Yes
Dry Creek at Cook Riolo Road	Not Completed	Yes
Dry Creek at Watt Avenue	Not Completed	No
Miners Ravine at Barton Road	Completed	Yes
Miners Ravine at Dick Cook Road	Completed; No As-Builts Received	Yes
Dry Creek at PFE/Atkinson Street	Completed	Yes
Dry Creek Railroad Crossing near PFE/Atkinson Street	Completed	No
Miners Ravine at Sierra College Boulevard	Completed	Yes
Secret Ravine at Sierra College Boulevard	Completed	No

4.2 BRIDGE AND CULVERT PROJECT RECOMMENDATIONS

Bridge and culvert improvement recommendations need to consider the risks associated with the existing condition, what risk reduction would likely be feasible, and the potential negative impacts of the recommended improvements. In some circumstances, removing a restriction at a bridge could reduce effective floodplain storage and increase downstream peak discharges. Detailed analyses of bridge and culvert modification projects using the modeling system developed for this Plan Update can quantify the potential impacts of proposed projects on regional flooding and can, if necessary, be used to evaluate mitigation measures to offset potential increases in discharge due to stream crossing modifications. This Plan Update recommends pursuing roadway improvement projects to reduce roadway overtopping, with the caveat that special features be constructed so that bridge enlargements do not reduce the effectiveness of existing floodplain areas at reducing downstream discharges. This can involve the construction of weirs upstream from the replacement to maintain use of existing floodplain storage.

Lists of structures that may be overtopped during a 100-year storm event are included in Appendix E.

The 1992 Plan recommended replacement of 42 structures, six of which have been replaced as listed previously in Table 15. Of the 36 structures that have not been replaced or scheduled to be replaced, 17 are not included in the Plan Update HEC-RAS model because the model does not include all of the smaller tributaries and corresponding structures that were addressed in the 1992 Plan. Table E.2 lists the 17 structures recommended for replacement in the 1992 Plan that are not included in the Plan Update HEC-RAS model, and this Plan Update does not revise the recommendations for these structures The other 19 structures that were recommended for replacement in the 1992 Plan that have not been replaced or scheduled for replacement are included in the Plan Update HEC-RAS model and recommendations are made based on the model results and potential project feasibility.

The Plan Update HEC-RAS model includes 67 public roadways that are overtopped by at least one of the seven critical 100-year storm centerings, including 14 of 19 structures recommended for replacement in the 1992 Plan. The other five structures that were recommended for replacement in the 1992 plan that are not shown to be overtopped by any of the seven critical storm centerings in the Plan Update HEC-RAS model are: Linda Creek at Sunrise Avenue, Strap Ravine at Sierra College Boulevard, Dry Creek at Darling Way, Miners Ravine at Auburn Folsom Road, and Miners Ravine at King Road.

It is important to note that the seven critical centerings do not necessarily represent the 100-year storm event at each structure, which could be somewhat greater if the critical storm centering for each structure were to be evaluated. However, the differences are not expected to be significant.

This Plan Update recommends replacing a total of 23 of the 67 structures that are overtopped, including 12 structures that were previously recommended for replacement in the 1992 Plan. A complete listing of the overtopped structures and structures recommended for replacement can be found in Table E.1.

4.3 REGIONAL DETENTION BASIN PROJECT RECOMMENDATIONS

Regional detention basin projects have the potential to reduce peak flows at significant locations in the watershed. Vernon Street was selected as the key location to compare the impact of the potential projects. The storm centering that produces the peak 100-year flow at Vernon Street, SE40N at 0, was used as the design storm to analyze the potential benefits of the projects. Information from previous studies and suggestions made by the District, review of topographic data and aerial imagery, and limited field observations were used to help determine potential project locations. The selection process considered the volume in the peak of the hydrograph and the potential to build a facility to detain a significant enough part of that peak to provide worthwhile benefit. Ten potential project sites were analyzed to determine peak flow reduction benefits. All ten flood control projects, including those deemed infeasible, are described in detail in Appendix H. Of the ten potential projects, five have the potential to reduce peak flow rates at Vernon Street for the design storm centering. Table H.1 shows the locations the ten potential project sites within the Dry Creek watershed. Table 16 lists the five feasible potential regional detention basin projects and the potential peak flow reduction at Vernon Street for the design storm. The net combined benefit does not equal the sum of the benefits of the individual projects due to the effect of the projects on the timing of flows.

It is possible that additional locations could be identified for local or regional flood control projects that were not evaluated as part of this Plan Update. For example, the City of Rocklin is currently investigating the feasibility of a flood damage reduction project along Sucker Ravine to reduce localized flooding. Such a project may have some regional benefit that could be considered by the District in the context of meeting Plan Update objectives.

Table 16. Potential Regional Detention Basin Projects

Project Location	Project Type	Peak Flow Reduction at Vernon Street (cfs)
Antelope Creek at Atlantic Street	Weir	418
Secret Ravine at Sierra College Boulevard	Weir	150
Linda Creek at Old Auburn Road	Off-channel	36
Linda Creek at Wedgewood Drive	Weir	22
Linda Creek at Auburn-Folsom Road	Off-channel	14
Net Combined Benefit of Five Listed Projects		650

4.3.1 Antelope Creek at Atlantic Street

One potential project site is located adjacent to westbound Interstate 80, north of Atlantic Street on Antelope Creek. The majority of the project site is owned by the City of Roseville. A capped landfill exists adjacent to the stream at the location of this potential project site. A flood easement may be negotiated with the City of Roseville for areas impacted by the potential project.

The potential flood detention project that was evaluated consists of constructing two weirs spanning the main channel to allow passage of low flows while detaining higher flows. This concept was evaluated with one weir just upstream from the railroad bridge that runs adjacent to Atlantic Street and a second weir just upstream from the bicycle path bridge. The calculations show that the project has the potential to reduce peak flows at Vernon by 418 cfs for the design storm. For the purposes of this planning level analysis and cost estimate the evaluated project consisted of two walls spanning the main channel that act as weirs. A potential project at this location could be a different configuration, for example an earthen embankment with a culvert. The details of the potential project would be addressed in a future design level evaluation.

4.3.2 Secret Ravine at Sierra College Boulevard

Another potential project site is located upstream (east) from Sierra College Boulevard on Secret Ravine. This potential project involves construction of an in-channel weir just upstream from Sierra College Boulevard that would allow the low flows to pass, but detain the high flows. The potential project site is approximately 20 acres, of which approximately 15 acres are located within the existing floodplain. This project was evaluated for construction in 2007 but could not be constructed at that time due to funding constraints. The potential project could reduce peak flow rates by 150 cfs at Vernon Street for the design storm. Although this planning level analysis and cost estimate considered a wall that spans the main channel, a different project configuration may be evaluated as part of a future design level evaluation.

4.3.3 Linda Creek at Old Auburn Road

Just upstream (south) of Old Auburn Road on Linda Creek is a potential project site that was previously studied by the City of Roseville for possible future development. A portion of the site was found to be infeasible for development purposes due to the current extent of the floodplain. However, this portion of the site may be used for detention purposes by excavating approximately 5,000 cubic yards, and depositing it on the right bank, above the existing floodplain. This potential project would include a berm constructed along the left (west) bank to increase effective detention volume in the off-channel detention basin. This project has the potential of reducing peak flow at Vernon Street by 36 cfs.

4.3.4 Linda Creek at Wedgewood Drive

Just upstream (north) from Wedgewood Drive on Linda Creek is a steep, narrow ravine between residential developments that could potentially be used as a flood detention project site. The surface area of the potential project site is approximately 2.5 acres that is covered by riparian vegetation and trees. The project concept would be to construct an in-channel weir, allowing low flow passage, but detaining the peak flows by increasing the water surface elevation. Based on the evaluated configuration, the potential project could decrease peak flows by 22 cfs at Vernon Street.

4.3.5 Linda Creek near Auburn-Folsom Road

Another potential project site is located on the upper portion of Linda Creek, upstream (east) from Auburn-Folsom Road, adjacent to Cavitt Junior High School. The project site is approximately 6.5 acres and is currently undeveloped open space with some tree coverage. The potential project site is within the preliminary FEMA floodplain.[29] The project concept would be to add a berm on the right bank of Linda Creek, creating an off-channel detention basin to divert and attenuate peak flows. The project has the potential of reducing peak flows at Vernon Street by 14 cfs.

4.4 CHANNEL IMPROVEMENT AND RESTORATION OPPORTUNITIES, AND POTENTIAL PROJECT CONSTRAINTS

Restoration Resources performed field investigations at each of the five potential regional detention basin sites described in this Plan Update to provide a preliminary review of environmental considerations without the benefit of formal environmental surveys. In each case, US Army Corp of Engineers (USACE) Clean Water Act (CWA), Section 404, California Department of Fish and Game (CDFG) Section 1600 Streambed Alteration Agreement and State Water Resources Control Board (SWRCB) Section 401 permit requirements would need to be met. Additionally, any project that involves placement of fill within the FEMA regulatory floodway must satisfy FEMA requirements. A brief summary of potential constraints and opportunities at each of the five sites is included below. The full report is included as Appendix K.

4.4.1 Antelope Creek at Atlantic Street

Locating a weir near the railroad overcrossing would need to address an underground gas and sewer line. A project along Antelope Creek upstream from Atlantic Street would need to avoid or mitigate for impacts to Oregon Ash and Valley Oak trees, some other woody and riparian habitat, and a few elderberry shrubs. Detailed analysis and coordination with the landfill managers will be required to ensure that the project would not negatively impact the landfill. This potential site provides opportunities for stream habitat enhancements by constructing an oxbow channel. Potential locations for oak tree and oak woodland habitat mitigation also are present upstream from Atlantic Street.

The upstream weir location near the service road and the bicycle path overcrossing could impact well-developed stream zone waters of the U.S. and wetlands, along with riparian habitat which developed as a result of beaver damming activities. A sewer line is also present in the vicinity of the upstream weir location. Removal of the beaver dam and beaver control may enhance stream function. Increased flood storage may be achieved through modification of the bicycle path configuration to minimize potential impacts to upstream habitat. Though increased flood depths would be infrequent and for short duration, the impact of these changes would need to be evaluated and addressed as part of the project.

4.4.2 Secret Ravine at Sierra College Boulevard

The potential project site upstream from Sierra College Boulevard contains some

[29] Nolte and Associates, Preliminary Sacramento County Flood Insurance Study, 2006.

wetlands, elderberry shrubs and Northwestern Pond turtle habitat. Although there are some potential habitat impacts, there are significant opportunities for oak woodland, riparian, and grassland enhancements.

This site is privately owned and the project would cause the existing regulatory base flood elevation to increase by approximately three feet. Land acquisition is a significant constraint on this project. Though FEMA requirements for causing a rise in floodplain elevations would need to be addressed, obtaining rights to flood the areas of potential impacted should satisfy the most significant aspect of FEMA requirements.

Recent modifications to Sierra College Boulevard at Secret Ravine raised the elevation at which the roadway would be overtopped. The 2007 conditions evaluations considered the roadway to be in its 2007 configuration while the project evaluations are based on the modified configuration.

4.4.3 Linda Creek at Old Auburn Road

The site along Linda Creek upstream from Old Auburn Road has become completely occupied by oak tree mitigation and is maintained by the City of Roseville. Use of this site would be challenging because it would require offsetting the current mitigation uses.

4.4.4 Linda Creek at Wedgewood Drive

The site along Linda Creek upstream from Wedgewood Drive supports extensive mature riparian woodland and riparian wetland communities. The creek corridor is relatively narrow and confined by the steep local topography. The potential rise in water level could impact adjacent upland oak woodlands and would need to be addressed. Construction of the modifications would also need to address any impacts on surrounding private properties.

4.4.5 Linda Creek near Auburn-Folsom Road

Potential constraints on the identified potential project site on Linda Creek upstream from Auburn-Folsom Road include existing oak trees, wetland habitat, riparian habitat, mitigation plantings, elderberry shrubs, and salmonid habitat in stream and juvenile entrapment issues. Existing water and sewer lines would need to be accommodated in site planning. Potential opportunities at this site include oak, wetland and riparian wetland, woodland, and elderberry mitigation.

4.5 NON-STRUCTURAL FLOOD HAZARD REDUCTION MEASURES

4.5.1 Local Storage/Detention Facilities

Although not typically a part of a stormwater program, it is necessary to mitigate a local projects' potential development impact on a stream. While various local detention basins have been constructed in order to mitigate the increase of runoff flows due to development, impacts on local and regional flooding should be evaluated on a case-by-case basis.

4.5.2 Elevation and Buy-Out Projects

Elevation and buy-out projects would be a feasible means to relieve some of the remaining flood problems in the watershed.

Retrofitting existing structures through elevation projects can reduce the risk of flood damage. Communities may apply to FEMA's Hazard Mitigation Assistance (HMA) grant programs for funding for elevation projects. The HMA grant applications are submitted by State emergency management agencies of behalf of local subapplicants for projects for individual properties.

Elevation above flood hazard levels may reduce the risk to the elevated property. Project costs for elevation, as estimated by FEMA, are shown in Table 17.

Table 17. Approximate Square Foot Costs of Elevating a Home (2009 Dollars)[30]

Construction Type	Existing Foundation	Retrofit	Cost (per square foot of house footprint)
Frame (for frame house with brick veneer on wall, add 10 percent)	Basement or Crawlspace	Elevate **2** Feet on Continuous Foundation Walls or Open Foundation	$29
		Elevate **4** Feet on Continuous Foundation Walls or Open Foundation	$32
		Elevate **8** Feet on Continuous Foundation Walls or Open Foundation	$37
	Slab-on-Grade	Elevate **2** Feet on Continuous Foundation Walls or Open	$80

[30] FEMA 347 Above the Flood: Elevating Your Flood Prone House and FEMA 312 Homeowner's Guide to Retrofitting: Six ways to Protect Your House from Flooding.

		Foundation	
		Elevate **4** Feet on Continuous Foundation Walls or Open Foundation	$83
		Elevate **8** Feet on Continuous Foundation Walls or Open Foundation	$88
Masonry	Basement or Crawlspace	Elevate **2** Feet on Continuous Foundation Walls or Open Foundation	$60
		Elevate **4** Feet on Continuous Foundation Walls or Open Foundation	$63
		Elevate **8** Feet on Continuous Foundation Walls or Open Foundation	$68
	Slab-on-Grade	Elevate **2** Feet on Continuous Foundation Walls or Open Foundation	$88
		Elevate **4** Feet on Continuous Foundation Walls or Open Foundation	$91
		Elevate **8** Feet on Continuous Foundation Walls or Open Foundation	$96

Buyouts represent a final mitigation solution to remove existing structures from flood hazard areas and may be an effective mitigation strategy when flood reduction methods are more costly than the value of the property that is at risk.

FEMA provides funding to the State and local community buyout projects in flood hazard areas when money is available. The buyout process is entirely voluntary by the homeowner.[31]

4.5.3 ALERT Flood Warning Response System

Implementation of an ALERT flood warning response system has been successful in providing flood warnings within the Dry Creek watershed. This Plan Update recommends that the current ALERT flood warning response system be maintained. As technology continues to advance, it is expected that a system that links real time (or possibly even predicted rainfall data) to a hydrologic model, in order to predict flood conditions will become feasible. Such a system could provide more warning than is currently available. Benefits of additional flood warning include increased opportunities

[31] FEMA 317: Property Acquisition Handbook for Local Communities.

for sandbagging, evacuation, quicker emergency response and road closures. Improving the ALERT system can provide mitigation for accelerating flows into the creeks which can reduce the time to peak flood stage.

4.5.4 Low Impact Development

An analysis was performed to evaluate the potential flood impacts to the watershed from the proposed planned use of LID measures as a result of the State Water Resources Control Board's new Construction General Permit standards, and expected future updates to the Municipal Separate Storm Sewer Systems (MS4) Phase II permit standards.

The analysis evaluated the alternative LID measures identified in the Construction General Permit. It was found that some measures such as "Rain Barrels" are effective for the small, frequent events they are designed for, but simply do not add any benefits during flood events when they are full. Other similar functioning LID devices such as typical detention storage and some bio-retention configurations do not offer significant flood benefits for large events. However, it was determined that LID measures which promote infiltration and biological uptake would have some potential to impact flood flows by effectively reducing the imperviousness of proposed developments.

For this evaluation, it was assumed that 50 percent of the LID mitigation measures would be effective at reducing the imperviousness of developments. It was also assumed that the LID measures would not slow down runoff from the timing of current developments because it is expected that the capacity of the systems below connections to the storm drain system fill during the major storm events.

The results of the analysis found that for a 2-year flood, that implementing LID on new developments could reduce the impacts of the Future Unmitigated condition by approximately 50 percent. For the 100-year event, the analysis demonstrated that impacts could be reduced through the use of LID by between 4 percent and 20 percent. A benefit of 7 percent was noted at the Vernon Street crossing.

The following tables provide comparisons that indicate the expected benefit of incorporation of LID features into future projects (Table 18), the expected benefit of both LID and the proposed projects (Plan Update implementation benefit) (Table 19), the expected benefit of the proposed projects over LID only (Table 20), and the net impact of build-out with Plan Update recommendations (Table 21).

Table 18: Expected Benefit of LID (Comparison No. 5)

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year Future Unmitigated	Build-out w/LID & no proj.	LID Benefit
Miners Ravine						
UR15K2	MR15	207	Dick Cook Road	1853	1845	8
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	2031	2039	-8
YMR29I	MR29R	202	Cottonwood Lake	2487	2544	-57
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2447	2535	-88
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7364	7254	110
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4807	4733	74
YSE51K	SE51R	232	Sierra College Blvd.	5095	5029	66
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4764	4726	38
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5443	5431	12
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1207	1210	-3
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2912	2912	0
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3025	3024	1
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	4163	4286	-123
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3932	3983	-51
Cirby Creek						
YCC40C	CC40R	51	Coloma Wy (Gage 1635)	953	952	1
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3402	3419	-17
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek at McClaren (Gage 1611)	1253	1274	-21
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	594	594	0
UC45J2	LC45R	82	At Sacramento County/ Placer County Line	2573	2545	28
ULC80I	LC80R	76	Champion Oaks/Sonoma Way (Gage 1626/1628)	2221	2235	-14
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2769	2765	4
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3360	3342	18

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year Future Unmitigated	Build-out w/LID & no proj.	LID Benefit
Dry Creek						
UDC5B	DC5R	26	Royer Park	10989	10914	75
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	8930	8915	15
YDC10D	VERNON	21	Vernon Street Crossing	13865	13816	49
YDC71B	DCC11	9	Sacramento/Placer County Line	13263	13200	63

Table 19: Expected Benefit of LID and Proposed Projects (Comparison No. 6)

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year Future Unmitigated	Build-out w/LID & Projects	Plan Benefit
Miners Ravine						
UR15K2	MR15	207	Dick Cook Road	1853	1852	1
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	2031	2047	-16
YMR29I	MR29R	202	Cottonwood Lake	2487	2544	-57
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2447	2534	-87
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7364	7184	180
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4807	4733	74
YSE51K	SE51R	232	Sierra College Blvd.	5095	4975	120
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4764	4582	182
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5443	5373	70
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1207	1210	-3
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2912	2912	0
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3025	3024	1
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	4163	4275	-112
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3932	3840	92
Cirby Creek						
YCC40C	CC40R	51	Coloma Wy (Gage 1635)	953	956	-3

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year Future Unmitigated	Build-out w/LID & Projects	Plan Benefit
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3402	3353	49
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek at McClaren (Gage 1611)	1253	1273	-20
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	594	412	182
UC45J2	LC45R	82	At Sacramento County/ Placer County Line	2573	2441	132
ULC80I	LC80R	76	Champion Oaks/Sonoma Way (Gage 1626/1628)	2221	2205	16
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2769	2750	19
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3360	3338	22
Dry Creek						
UDC5B	DC5R	26	Royer Park	10989	10658	331
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	8930	8734	196
YDC10D	VERNON	21	Vernon Street Crossing	13865	13166	699
YDC71B	DCC11	9	Sacramento/Placer County Line	13263	12653	610

Table 20: Expected Benefit of Proposed Projects over LID only (Comparison No. 7)

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	Build-out w/LID & no Projects	Build-out w/LID & Projects	Project Benefit
Miners Ravine						
UR15K2	MR15	207	Dick Cook Road	1845	1852	-7
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	2039	2047	-8
YMR29I	MR29R	202	Cottonwood Lake	2544	2544	0
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2535	2534	1
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7254	7184	70
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4733	4733	0
YSE51K	SE51R	232	Sierra College Blvd.	5029	4975	54
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4726	4582	144

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	Build-out w/LID & no Projects	Build-out w/LID & Projects	Project Benefit
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5431	5373	58
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1210	1210	0
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2912	2912	0
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	3024	3024	0
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	4286	4275	11
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3983	3840	143
Cirby Creek						
YCC40C	CC40R	51	Coloma Wy (Gage 1635)	952	956	-4
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3419	3353	66
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek at McClaren (Gage 1611)	1274	1273	1
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	594	412	182
UC45J2	LC45R	82	At Sacramento County/ Placer County Line	2545	2441	104
ULC80I	LC80R	76	Champion Oaks/Sonoma Way (Gage 1626/1628)	2235	2205	30
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2765	2750	15
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3342	3338	4
Dry Creek						
UDC5B	DC5R	26	Royer Park	10914	10658	256
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	8915	8734	181
YDC10D	VERNON	21	Vernon Street Crossing	13816	13166	650
YDC71B	DCC11	9	Sacramento/Placer County Line	13200	12653	547

Table 21: Net Impact of Build-out with Plan Update Recommendations (Comparison No.8)

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year 2007 Current	Build-out w/LID & Projects	Net Impacts
Miners Ravine						
UR15K2	MR15	207	Dick Cook Road	1763	1852	89
UR20P2	MR20R	205	Moss Lane (Gages 1609/1610)	1955	2047	92
YMR29I	MR29R	202	Cottonwood Lake	2398	2544	146
UR30H3	MR30R	197	Joe Rodgers Area - Leibenger Lane	2320	2534	214
UMR40E	MR40R	178	Upstream of Confluence with Antelope Creek	7194	7184	-10
Secret Ravine						
YE50F2	SE50R	235	Brace Road	4344	4733	389
YSE51K	SE51R	232	Sierra College Blvd.	4838	4975	137
USE52D	SE52R	231	China Gardens Near Rustic Hills/Rocklin Road (Gage 1618)	4577	4582	5
YSE85Q	SE85R	227	Upstream of Confluence with Miners Ravine	5415	5373	-42
Clover Valley						
UCV10B	CV10R	155	Upstream of Confluence with Antelope Creek	1010	1210	200
Antelope Creek						
YAC30B	AC30R	140	Sierra College Blvd. (Gage 1573)	2842	2912	70
UC35G3	AC35R	134	Upstream of Confluence with Clover Valley - Midas Avenue	2914	3024	110
UC41E4	AC41R	126	Antelope Creek Rd – D/S of SR-65 (Gage 1583)	3744	4275	531
UDC4D	AC45R	122	Upstream of Confluence with Miners Ravine	3708	3840	132
Cirby Creek						
YCC40C	CC40R	51	Coloma Wy (Gage 1635)	935	956	21
YCC45E	CCC5	49	Upstream of Confluence with Linda Creek	3294	3353	59
Strap Ravine						
UR20A4	SR20R	96	Upstream of Confluence with Linda Creek at McClaren (Gage 1611)	1191	1273	82
Linda Creek						
ULC5B	LCC1	92	Troy Purdee Lane	560	412	-148
UC45J2	LC45R	82	At Sacramento County/ Placer County Line	2334	2441	107
ULC80I	LC80R	76	Champion Oaks/Sonoma Way (Gage 1626/1628)	2232	2205	-27
ULC95C	LC95R	67	Upstream of Confluence with Cirby Creek	2738	2750	12

2007 NODE	1992 HEC-1 NODE	1992 Study Point #	Description	100-year 2007 Current	Build-out w/LID & Projects	Net Impacts
YCC45G	CC45R	45	Upstream of Confluence with Dry Creek	3255	3338	83
Dry Creek						
UDC5B	DC5R	26	Royer Park	10454	10658	204
YDCCC	RYCOMB	23	Linda Creek/Cirby Creek Confluence	8792	8734	-58
YDC10D	VERNON	21	Vernon Street Crossing	13039	13166	127
YDC71B	DCC11	9	Sacramento/Placer County Line	12667	12653	-14

4.6 COST ESTIMATES

Planning level costs estimates (in 2010 dollars, Engineering New Record 20-City Construction Cost Index is 8865) for the five flood control project sites within the Dry Creek watershed (discussed in Section 4.3) that have the potential to reduce peak flow rates at Vernon Street for the design storm centering are listed below in Table 22.

Table 22. Project cost estimates and peak flow reduction summary for regional mitigation projects.

Project	Total Cost with Land Acquisition	Peak Flow Reduction at Vernon (SE40N@0 Centering)	Cost ($) per cfs reduction
Antelope Creek at Atlantic Street	$ 3,014,000.00	418	$ 7,000
Linda Creek near Auburn-Folsom Road	$ 933,000.00	14	$ 67,000
Linda Creek at Wedgewood Drive	$ 1,019,000.00	22	$ 46,000
Linda Creek at Old Auburn Road	$ 785,000.00	36	$ 22,000
Secret Ravine at Sierra College Boulevard	$ 3,506,000.00	150	$ 23,000
Total/Combined/Average	**$ 9,257,000.00**	**650**	**$14,000**

It is estimated that upgrading the ALERT system will cost approximately $150,000, bringing the total recommended project cost to $9,407,000. In addition to funding the capital costs associated with the five recommended mitigation projects and ALERT system improvements, funding for on-going maintenance and life cycle replacement costs (present value of cost to replace those portions of the projects that should be considered to have a 50-year service life) should also be considered. Table 23 lists estimates for on-going maintenance and replacement costs.

Table 23: Estimated Maintenance and Replacement Costs

Project	Annual Maintenance Cost	Present Value of Replacement Cost	Annualized value of replacement for i=6%, 50-year
Miners Ravine Off-Channel Detention Basin	$15,000	$1,000,000	$63,444
Antelope Creek at Atlantic Street	$8,000	$1,000,000	$63,444
Linda Creek near Auburn-Folsom Road	$1,500	$200,000	$12,689
Linda Creek at Wedgewood Drive	$2,500	$300,000	$19,033
Linda Creek at Old Auburn Road	$1,500	$175,000	$11,103
Secret Ravine at Sierra College Boulevard	$10,000	$800,000	$50,755

4.7 PROJECT RECOMMENDATIONS

To reduce manage the risks and reduce potential hazards associated with existing local and regional flooding deficiencies, the following recommendations are provided:

1. Implement bridge and culvert improvements in a manner that does not exacerbate flooding at other locations in the watershed. Stream crossing modifications may provide opportunities for additional projects that could improve the flood control benefit of the existing floodplain.
2. Support governmental structure elevation and buy-outs as these programs are expected to be the most effective means available to reduce future flood damage to existing structures.
3. Incorporate LID measures into project design that promotes infiltration.
4. Implement the identified feasible regional flood control improvements to mitigate for development impacts as funding becomes available. Pursue opportunities for stream corridor enhancements and multiple objective components to increase local project support.

Five development impact flood flow mitigation projects are recommended as part of the Plan Update. These projects include weirs that span the stream channels to limit the impacts of the proposed projects on the streams while enhancing floodplain storage and modifying flood flow timing to reduce peak downstream discharges at key locations.

4.8 POLICY RECOMMENDATIONS

The Plan Update identified that local on-site detention basins typically do not provide regional mitigation for increases in runoff. In fact, some typical applications of local detention can actually exacerbate regional flood flows by delaying the timing of the increased runoff volume from the development to coincide with the surrounding natural flows, thereby making the superimposition of the detained and natural flows higher than had the increased development flows been released earlier. However, removal of local detention requirements can only be permitted if it is confirmed that there would not be any localized unacceptable increase in discharge rate. This Plan Update recommends application of Low Impact Design (LID) principles that promote infiltration as a primary means of on-site mitigation, and the system modeling tools developed for this Plan

Update provide a means to assess the impacts of major developments on the regional system to determine if credits are justified based on impacts differing significantly from that assumed in the mitigation element of this Plan Update.

5.0 Funding Plan

5.0 FUNDING PLAN

This section presents the recommended funding plan of the Plan Update. The purpose of the funding plan is to identify a potential set of funding sources to adequately fund the capital improvements envisioned in the Plan Update and to fund ongoing costs of operations and maintenance. The drainage facilities recommended in this Plan Update are designed to mitigate for future new development based on General Plan build-out conditions of the various governmental jurisdictions comprising the Dry Creek watershed. As detailed in other sections of this Plan Update, the set of potentially feasible projects identified in this Plan Update are not expected to provide sufficient flow reduction to fully mitigate for future development and they are not expected to correct existing deficiencies in the flood control system. In addition to the regional drainage impacts addressed in this update, in many cases there will be a need for additional on-site drainage improvements for individual properties. The costs to both correct existing deficiencies and to address on-site drainage improvements on individual properties are not included in this funding plan because these costs have not been quantified.

The five regional mitigation projects recommended in this update are estimated to cost approximately $9.257 million plus $150,000 to upgrade the ALERT system, for a total of $9.407 million (Table 22). These include the direct construction costs of the five regional mitigation projects as well as associated costs for design, engineering, permitting, and land acquisition.

Due to the fact that the Dry Creek watershed overlaps several jurisdictions it is important that each jurisdiction contributes its fair share of funding for the necessary drainage improvements. Each jurisdiction's fair share includes collection of the regional development impact fees described in this section.

5.1 FUNDING MECHANISMS UTILIZED TO DATE

Since the original flood control plan was prepared in 1992, drainage improvements in Dry Creek have been funded with a combination of government grants, development impact fees, and fees collected in unincorporated Placer County through County Service Area (CSA) 28. As they are collected, development fees are held in the Dry Creek Trust Fund and CSA 28 fees are held in a separate CSA 28 Zone 22 account. Development fees and CSA 28 fees continue to be a part of the current funding plan. Due to the uncertainty of both the availability and amount of government grants, this funding plan does not assume any grant funding. However, should grants become available, appropriate adjustments to this funding plan can be made at that time.

5.2 FUNDING TO MITIGATE IMPACTS FROM NEW DEVELOPMENT

This funding plan update is based upon the principle that new development is responsible for mitigating, as much as possible, the drainage impacts it creates. As such, this funding plan assumes that new development pays development fees in a sufficient amount to fund 100 percent of the costs of the five regional mitigation projects identified in this Plan Update. This funding plan sets forth an updated schedule of development fees that is intended to replace the fee schedule that is currently in place in each of the jurisdictions of the Dry Creek watershed.

Currently, each of the jurisdictions in the watershed has its own set of development fees and those fees vary depending on the sub-basin in which the development is located. This updated funding plan recommends a uniform schedule of fees across all sub-basins in the watershed. The reason for this change is that the updated hydrology models indicate that it would be more appropriate for the costs of drainage facilities to be shared more or less equally for properties throughout the watershed. The potential projects were conceived using a watershed-wide approach and the potential benefits of the projects were also considered based on regional benefits, not only benefits local to the projects. In other words, it would be difficult to equitably allocate the costs of the recommended drainage facilities among the various sub-basins in the Dry Creek watershed. Furthermore, a uniform fee schedule will provide for easier administration by the multiple jurisdictions.

Each jurisdiction except Sacramento County currently collects a separate development fee for single family residential (defined as four dwelling units per acre and less), high density residential (greater than four dwelling units per acre), and commercial/industrial uses. The development fees vary for each of these land uses due to the relative drainage impacts, measured by impervious surface area, and adjusted for typical densities of development. Sacramento County has a fee schedule that is structured differently than the other jurisdictions.

The updated development fees have been calculated based on the estimated $9.4 million in costs to build the five regional mitigation projects. On a preliminary basis, the development fees have been updated as listed in Table 24 .

Table 24. 2010 Development Fees* and Updated Development Fees

	Current Development Fee (2010)	Estimated Updated Development Fee
Single Family Residential	$224 to $826/unit	$753/unit
High Density Residential	$113 to $231/unit	$274/unit
Commercial/Industrial	$1,350 to $2,763/acre	$2,204/acre

* 2010 fee schedule for all jurisdictions except Sacramento County. Sacramento County collects fees differently than the other jurisdictions.

These preliminary development fee estimates have been prepared consistent with AB 1600 (Government Code §66000 et. seq.) requirements based on the estimated impervious area applicable to each land use. A final set of development fees will be fully documented by an AB 1600 nexus study, which will be completed before a new fee schedule is formally adopted.

One challenge of development fees as a source of funding is that they fluctuate over time – fee revenues are high when real estate conditions are strong and low when real estate conditions are weak, as is the case today. However, because the basis for collecting development fees is to mitigate impacts from new development, the variability of development fee revenues is not necessarily problematic for the funding of those drainage facilities mitigating new development impacts. In some cases, private development can provide up-front funding for regional drainage facilities if those facilities are required in order for a specific development project to proceed, such as a large subdivision. In these cases, the private developer might be eligible for future fee credits and/or reimbursements from other developments that benefit from these improvements. Fees can be adjusted over time based on the Engineering News Record Construction Cost Index to address future project cost increases.

5.3 FUNDING TO CORRECT EXISTING DEFICIENCIES AND O&M COSTS

The Plan Update determined that the mitigation to-date has not fully mitigated for impacts to-date and that existing deficiencies remain in the flood control system from pre-1992 Plan conditional. The Plan Update concludes that non-structural flood control measures, such as the elevation and buy-out program, will be the most cost effective method to correct existing deficiencies. However, the number of properties that may ultimately participate in the elevation and buy-out program is not known and therefore the costs of such a program have not been quantified.

The District's costs for ongoing operations and maintenance (O&M) will increase as additional drainage facilities are built. When all five regional mitigation projects are completed, it is estimated that O&M costs will be in the range of $38,500 per year and that the annualized cost to replace the facilities, assuming a 50-year lifespan, is approximately $220,500 per year, both in current 2010 dollar terms (Table 23). Therefore, the total O&M and replacement cost when all five regional mitigation projects are completed is estimated at $259,000 per year in current 2010 dollars.

The funding mechanisms that are potentially available to the jurisdictions to fund the costs to correct existing deficiencies and ongoing O&M costs include the following:

- County Service Areas (CSA)
- Mello Roos Community Facilities Districts (CFD)
- Utility Fees
- General Funds
- Government Grants

Since each jurisdiction in the Dry Creek watershed faces a unique set of local circumstances, the funding solutions that are utilized by one jurisdiction may not necessarily be ideal for another. For example, Mello Roos CFD financing is often utilized in large land development projects because in those projects land is typically controlled by a small number of property owners and therefore the voting requirements needed to adopt the district are more easily satisfied. Thus, jurisdictions that have the potential for large land development projects are more likely to be able to utilize CFD financing than those that do not.

The costs to correct existing deficiencies and to fund ongoing O&M costs should be shared equitably among the jurisdictions comprising the Dry Creek watershed. One approach to such an allocation is to spread the costs based on a proportionate share of impervious area. Table 25 lists the allocation of O&M costs and facilities replacement costs based on this approach. Costs to correct existing deficiencies have not yet been estimated as part of this Plan Update because no feasible regional projects have been identified to correct existing conditions.

Table 25: Cost Allocation Table

Jurisdiction	% Allocation based on Impervious Area [1]	Cost Allocation
		O&M Costs at Build-out and Facilities Replacement Cost [2] (annual cost)
Placer County	37%	$95,830/year
City of Roseville	26%	$67,340/year
Sacramento County	20%	$51,800/year
City of Rocklin	11%	$28,490/year
Town of Loomis	6%	$15,540/year
City of Sacramento	de minimis	NA
Total: Dry Creek watershed	100%	$259,000/year

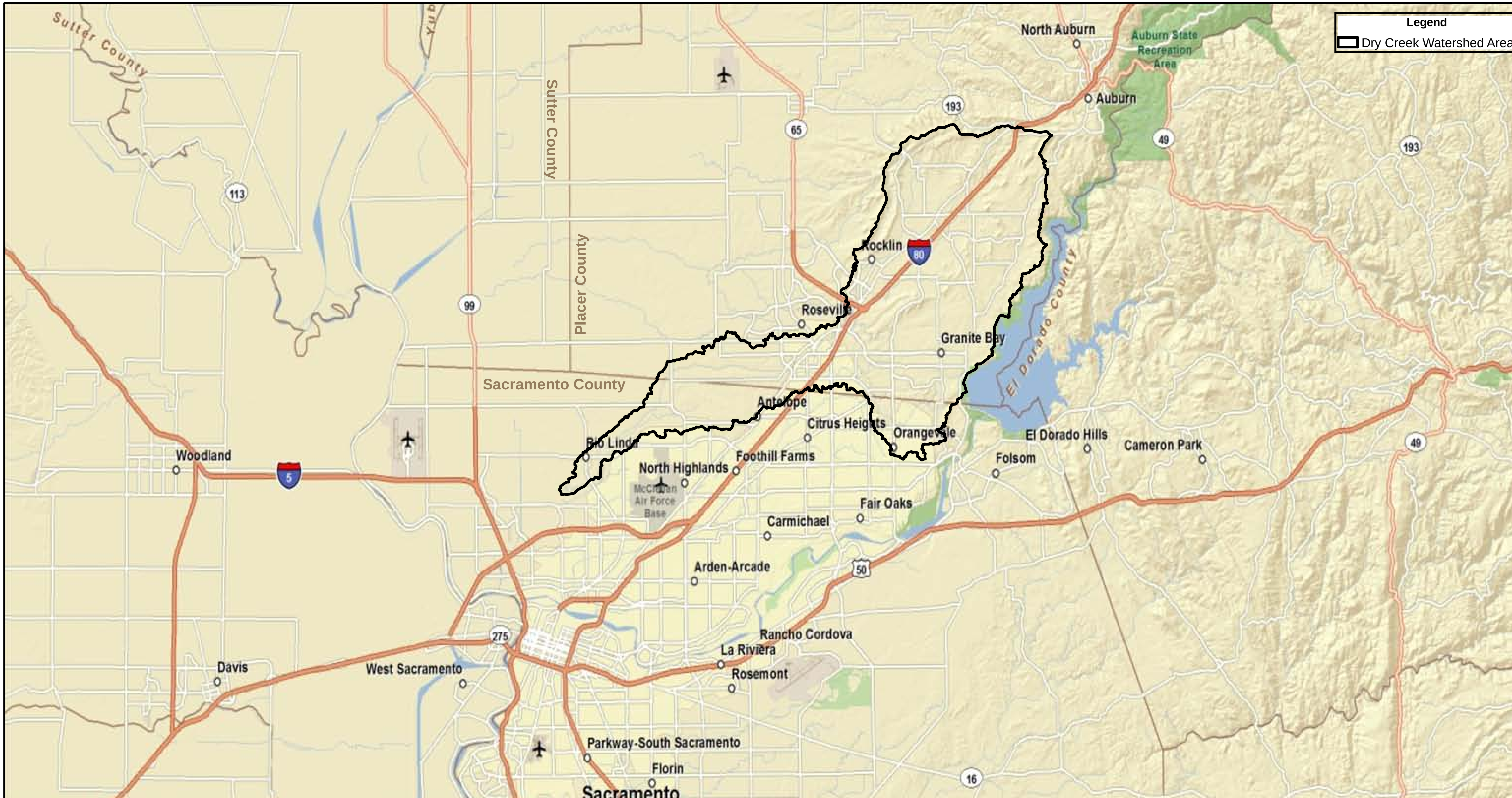
[1] Preliminary estimate based on applying an average impervious factor to residential and commercial/industrial uses in each jurisdiction.
[2] Costs expressed in 2010 dollars

5.4 IMPLEMENTATION ROLES

The District will continue to have responsibility for administering the flood control plan including planning, design, and construction of regional drainage facilities, and maintaining the hydrologic computer models. Each of the independent jurisdictions comprising the Dry Creek watershed will also play an important role in implementing the plan; each will be responsible for updating and collecting development fees consistent with this plan update so that the fee revenue will be adequate to construct drainage facilities as new development occurs. In addition, local solutions will be needed to fund the costs to correct existing deficiencies and ongoing operations and maintenance. As discussed, there are various funding mechanisms that could be utilized to fund these costs and the appropriate solution will depend on the particular circumstances facing each jurisdiction. As is always the case with regional drainage plans involving multiple jurisdictions, coordination and cooperation among the jurisdictions is essential to successful implementation of the plan.

Plates

DRY CREEK WATERSHED VICINITY MAP



PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

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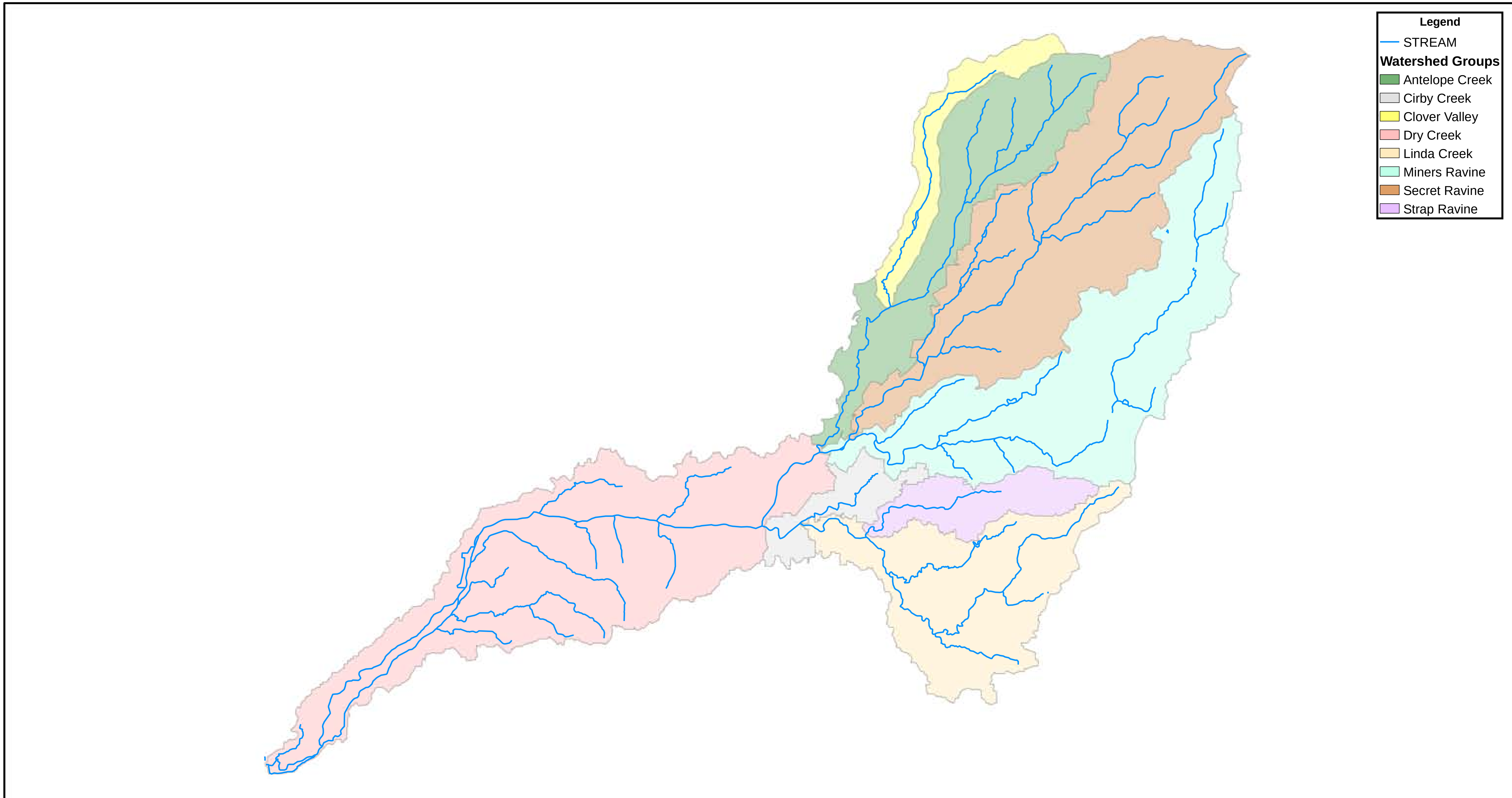
0 2 4 Miles

1 inch = 4 miles

PLATE 1

DRY CREEK WATERSHED GROUPS



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0 1 2 4 Miles

1 inch = 2 miles

PLATE 2

DRY CREEK WATERSHED HYDROLOGIC SOIL GROUPS

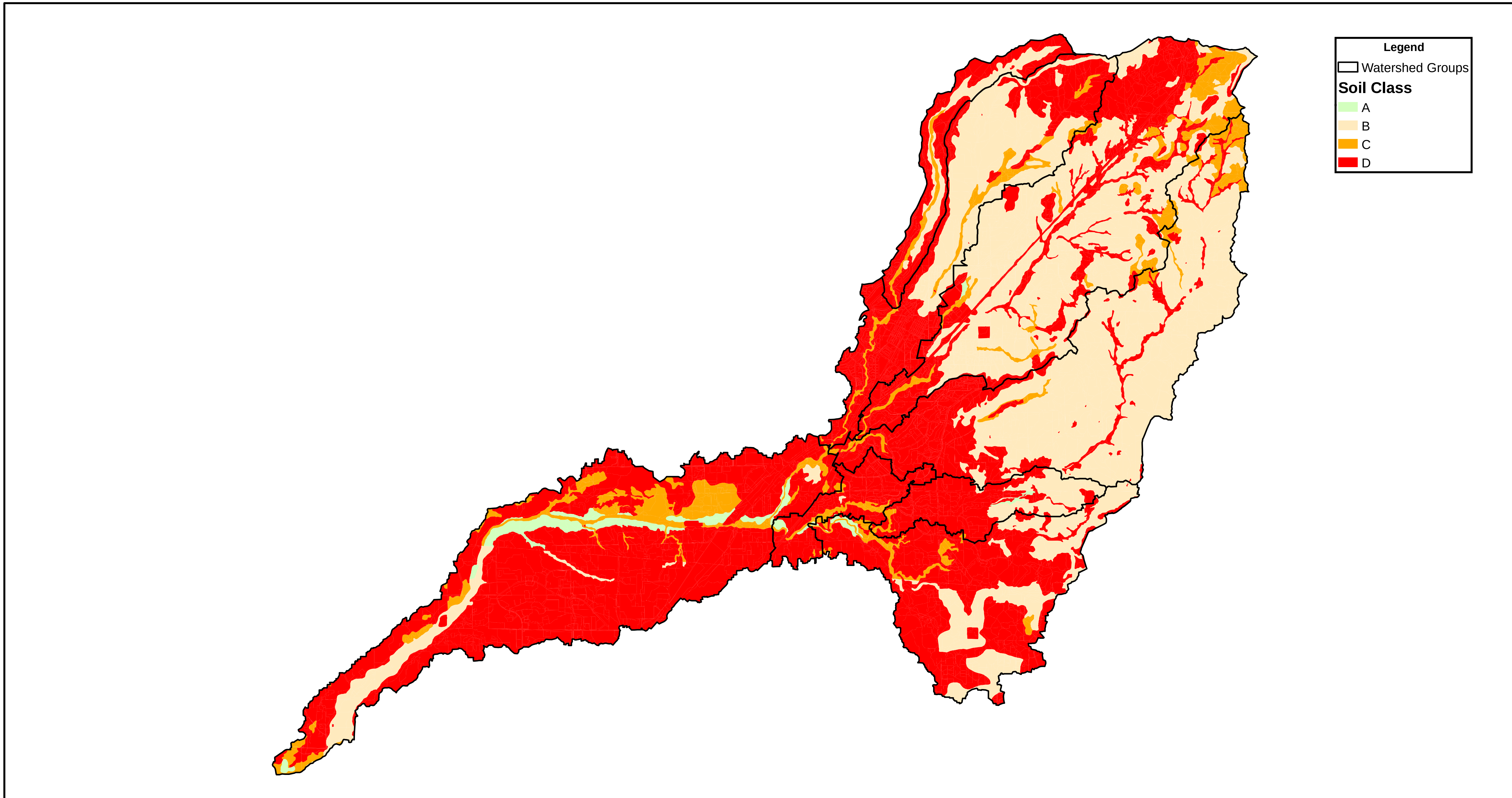

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PLATE 3

DRY CREEK WATERSHED 1992 LAND USE IMPERVIOUSNESS

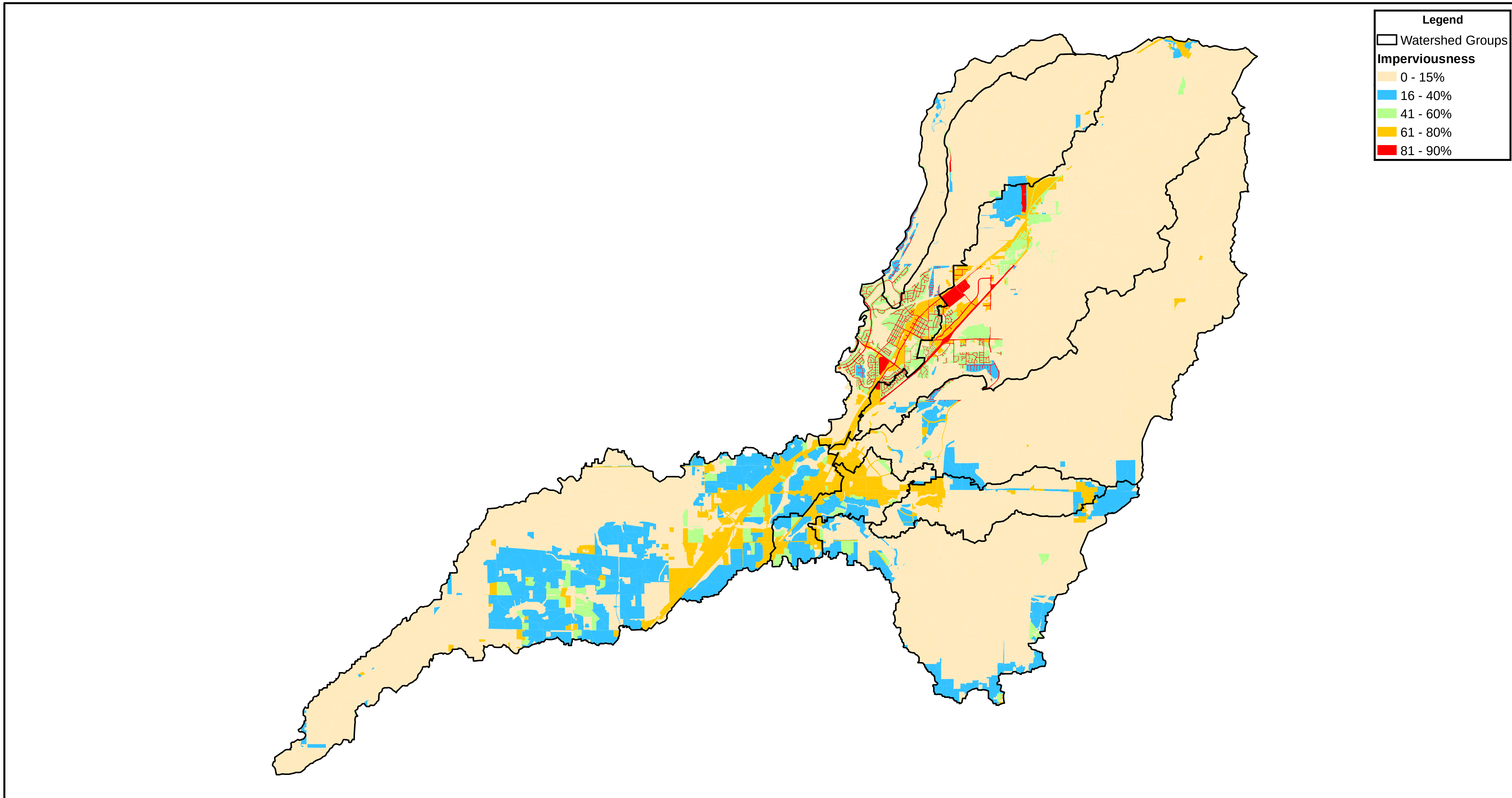

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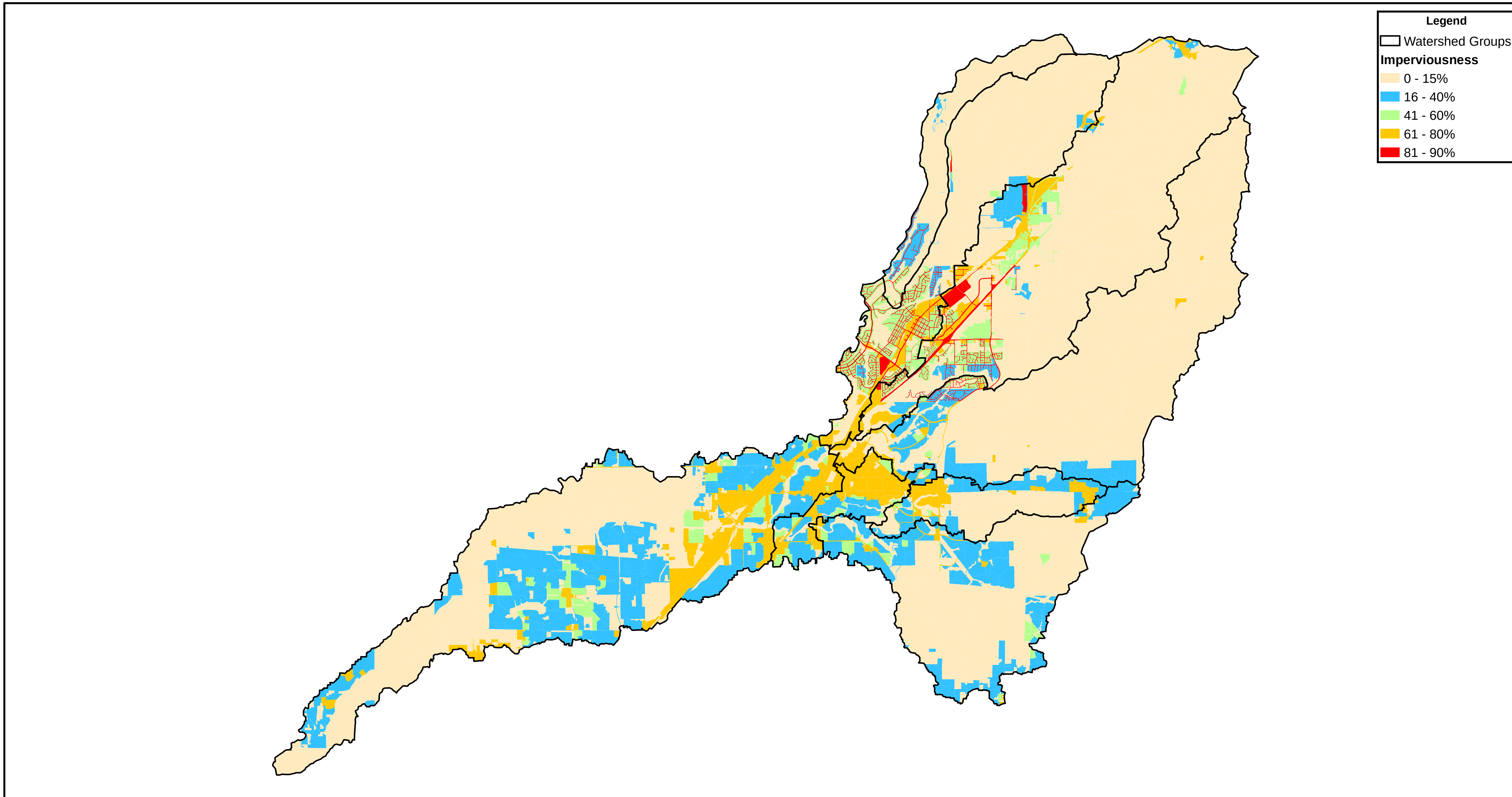
PLATE 4

DRY CREEK WATERSHED 2007 LAND USE IMPERVIOUSNESS



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0 1 2 4 Miles

1 inch = 2 miles

PLATE 5

DRY CREEK WATERSHED GENERAL PLAN BUILD-OUT IMPERVIOUSNESS

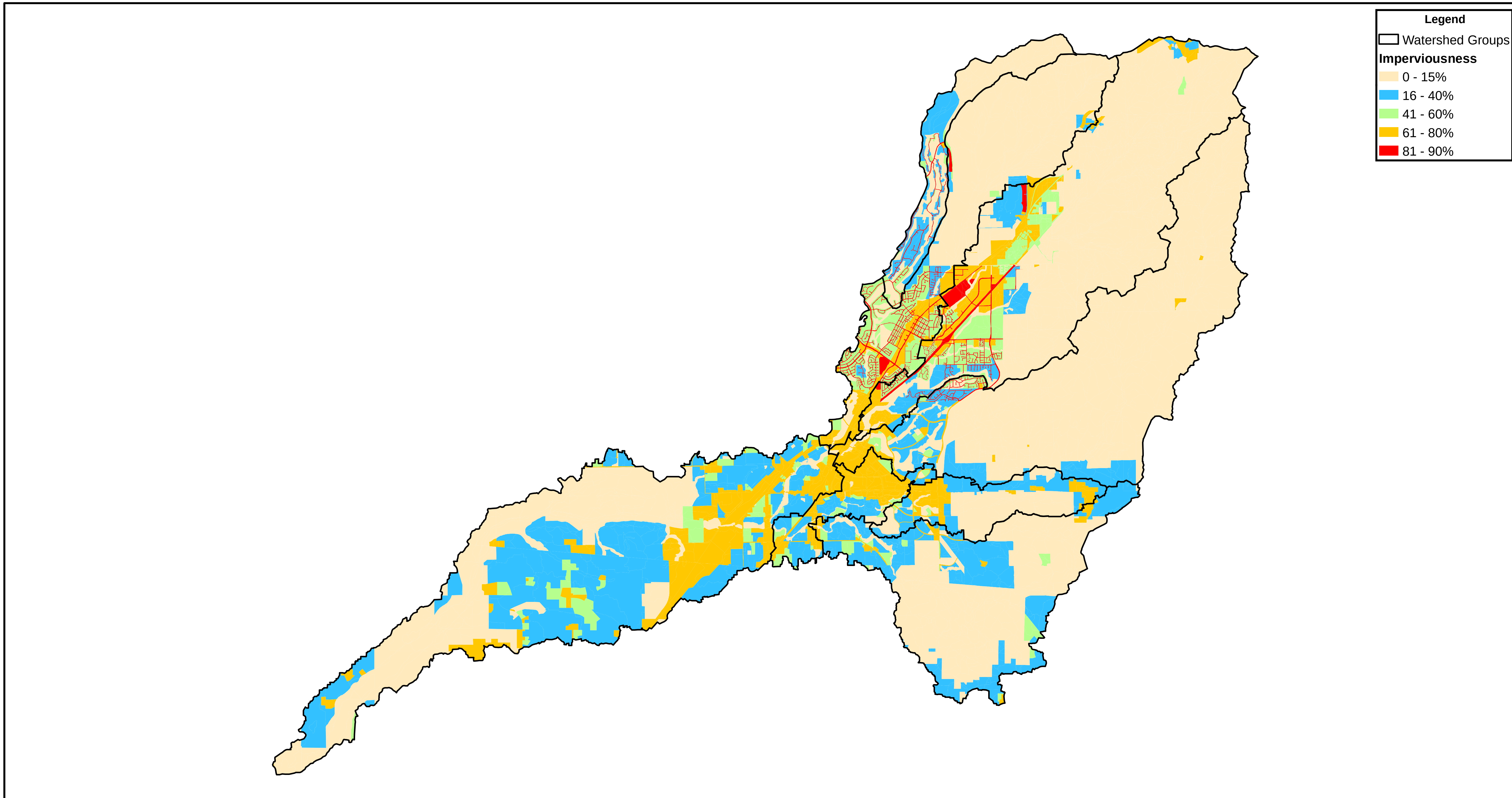

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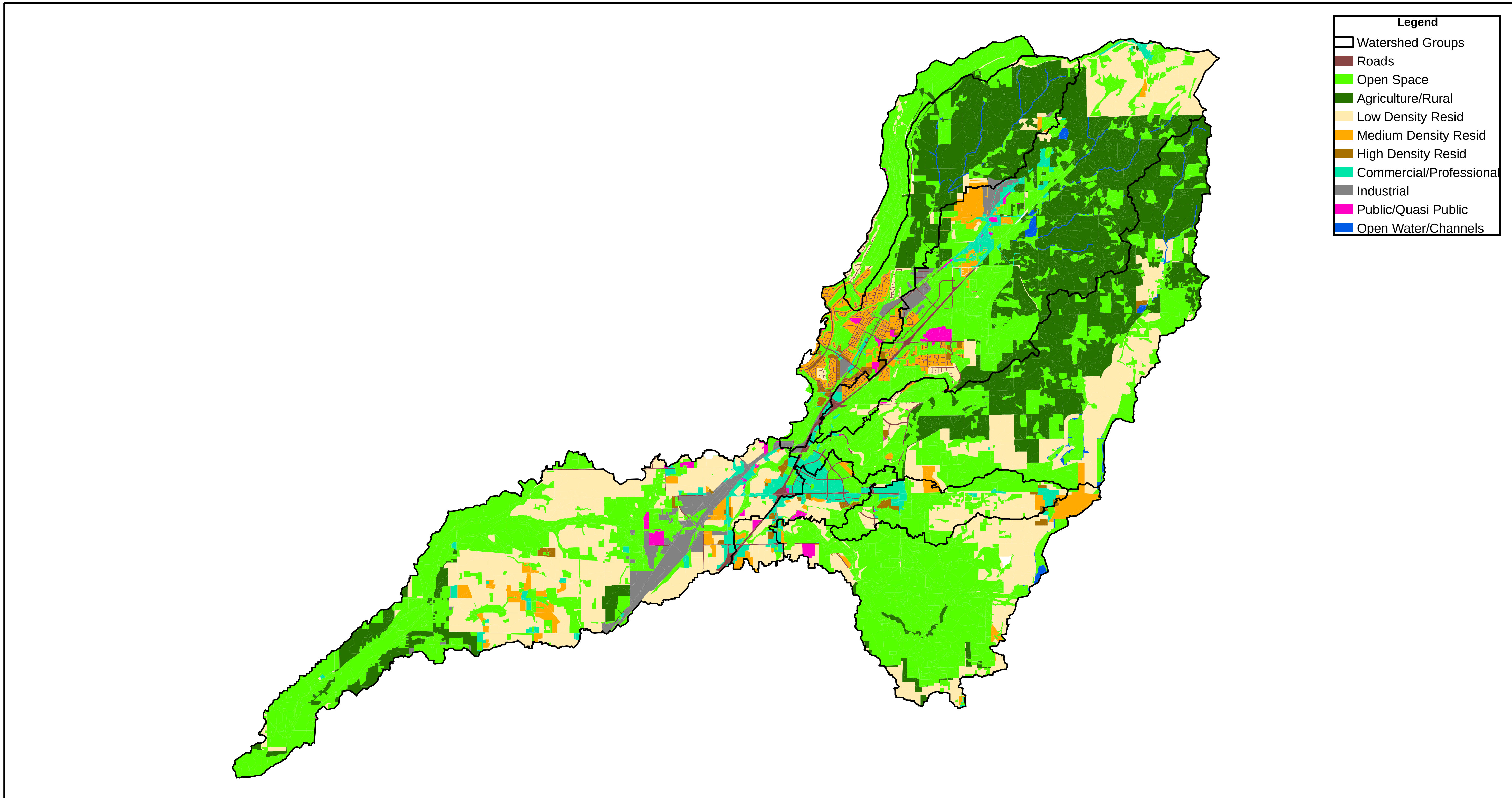
PLATE 6

DRY CREEK WATERSHED 1992 BASELINE LAND USE



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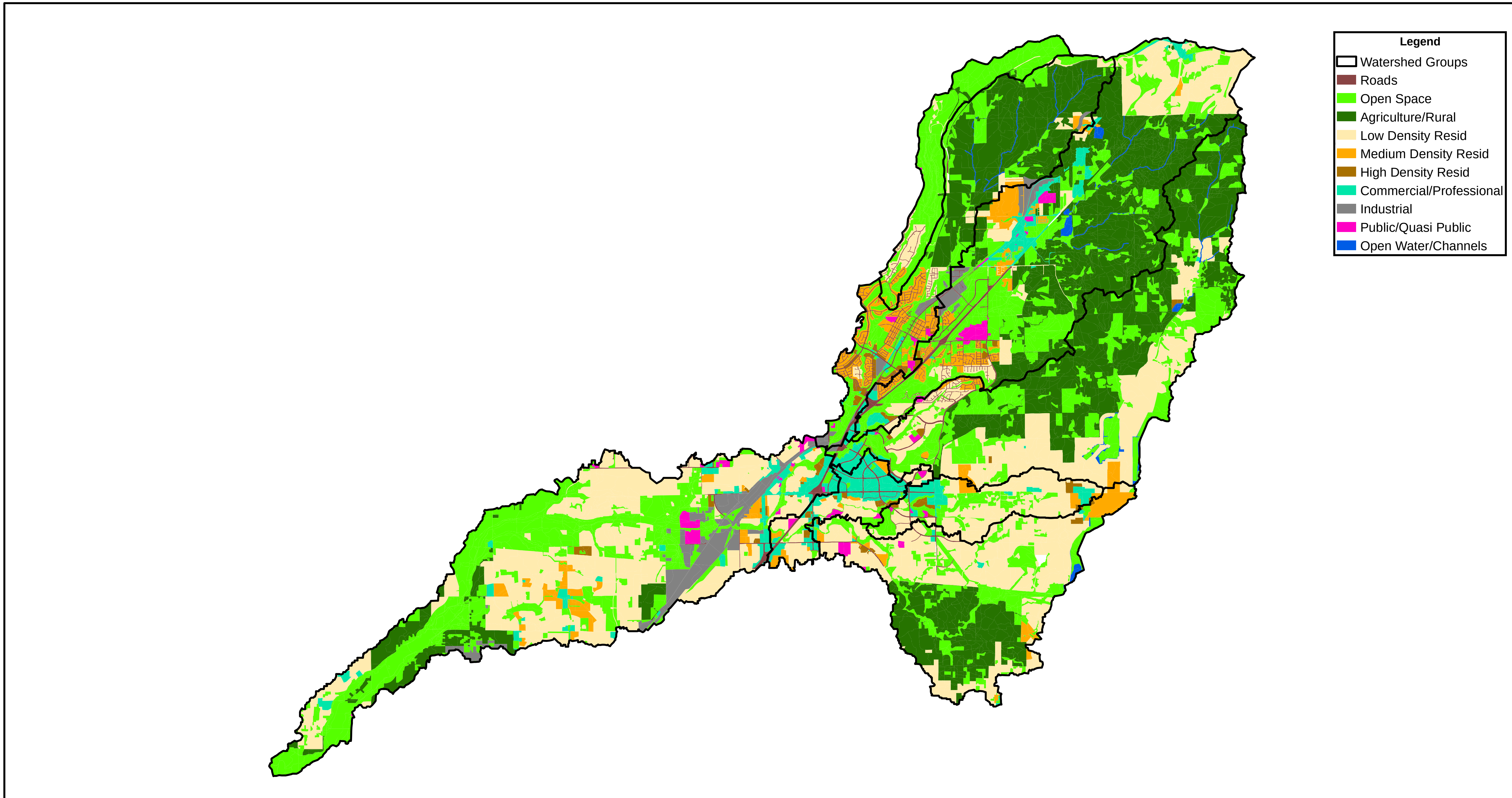
0 1 2 4 Miles

1 inch = 2 miles

PLATE 7

DRY CREEK WATERSHED 2007 CURRENT LAND USE



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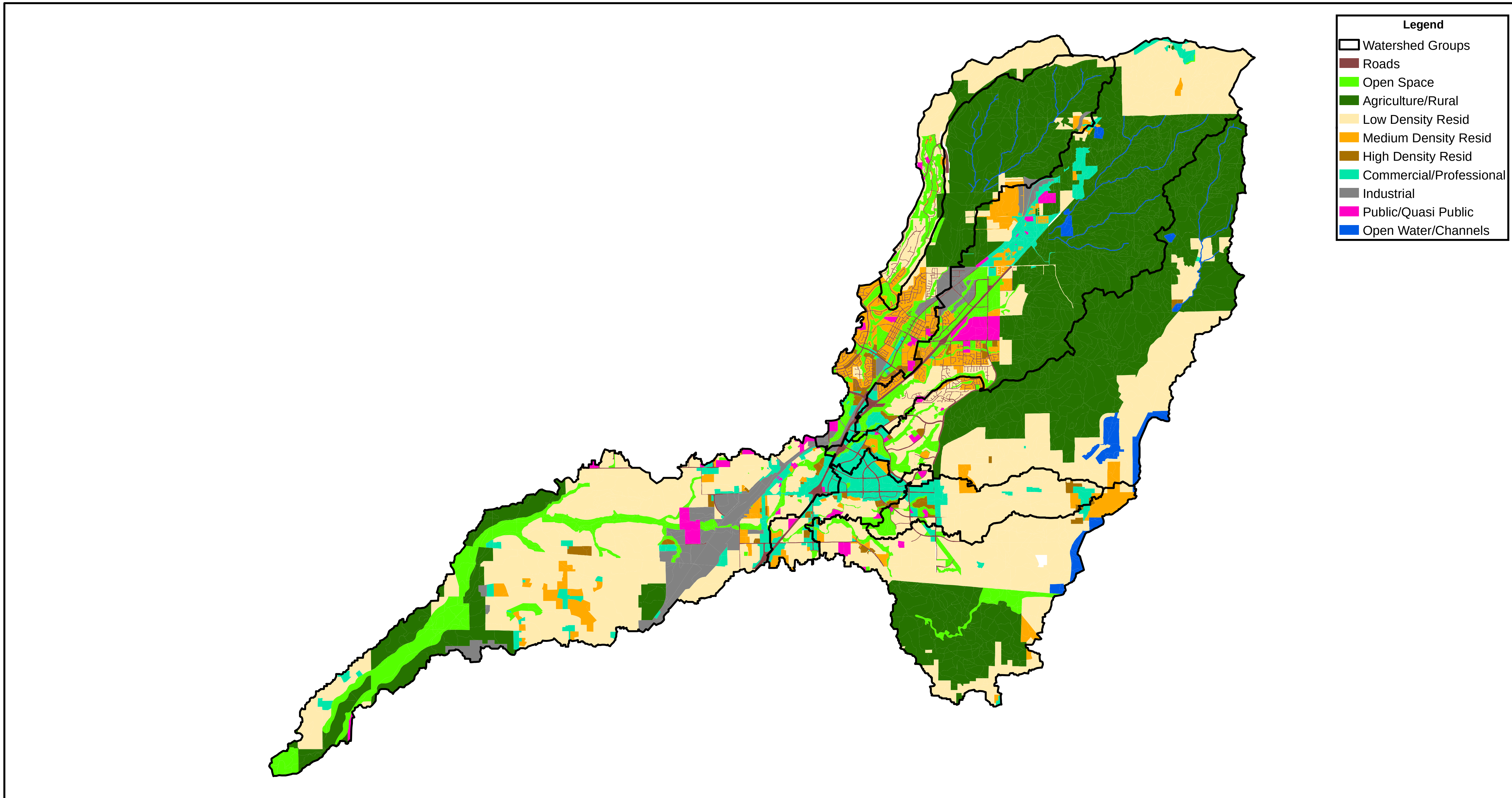
0 1 2 4 Miles

1 inch = 2 miles

PLATE 8

DRY CREEK WATERSHED GENERAL PLAN BUILD-OUT LAND USE



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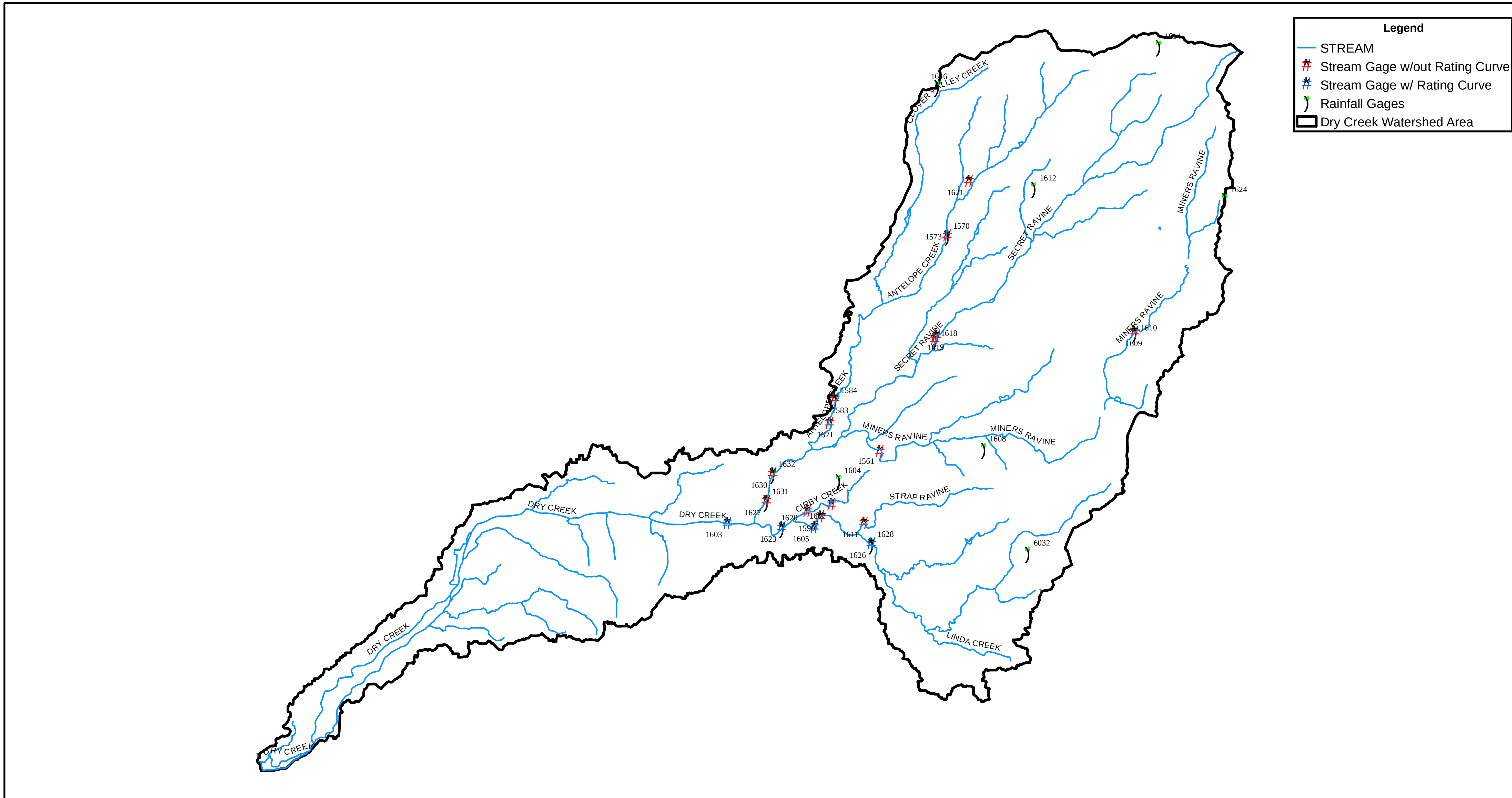
0 1 2 4 Miles

1 inch = 2 miles

PLATE 9

DRY CREEK WATERSHED STREAM AND RAINFALL GAGES



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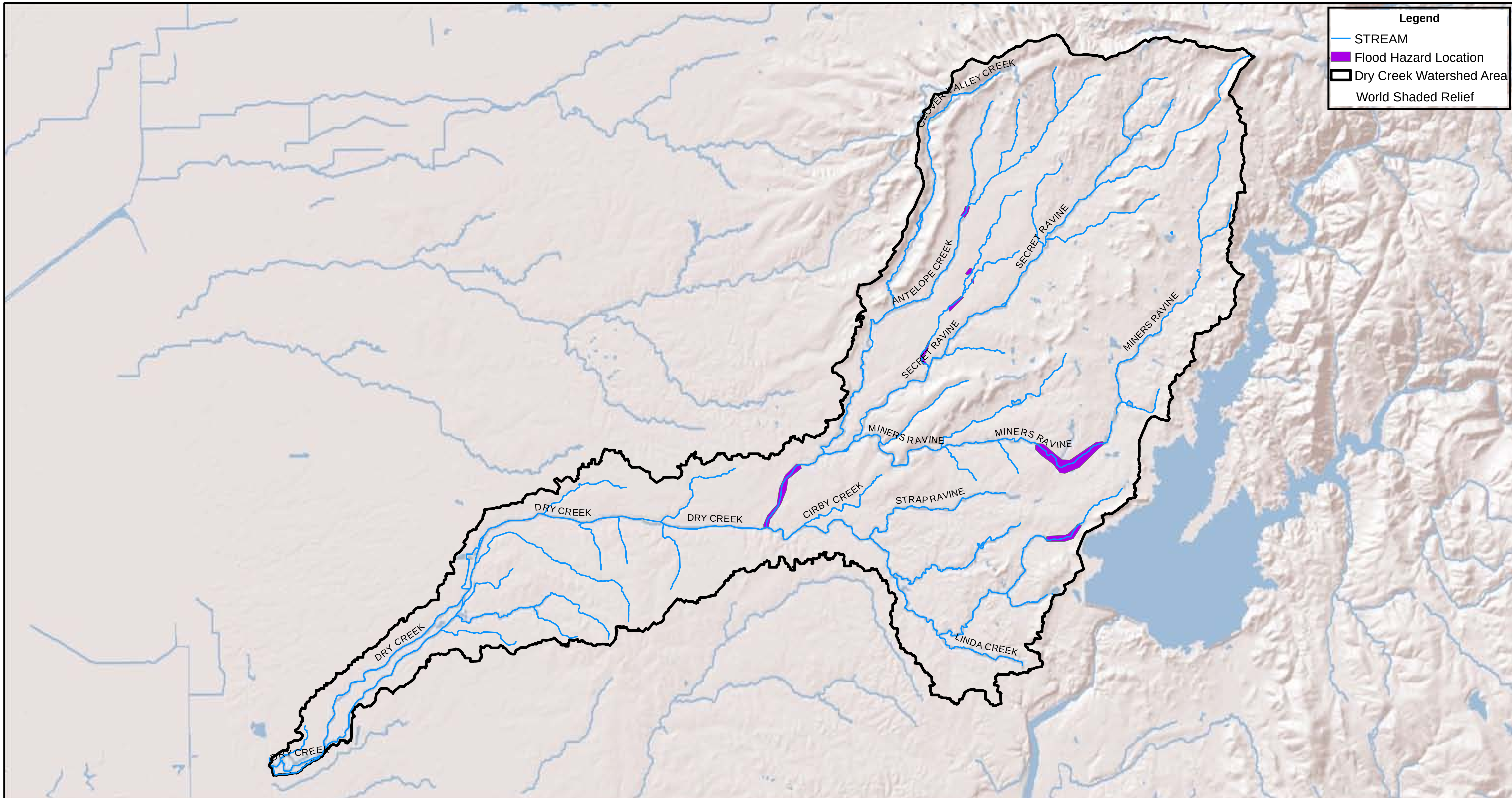
CIVIL ENGINEERING SOLUTIONS, INC.

0 1 2 4 Miles

1 inch = 2 miles

PLATE 10

DRY CREEK WATERSHED FLOOD HAZARD LOCATIONS



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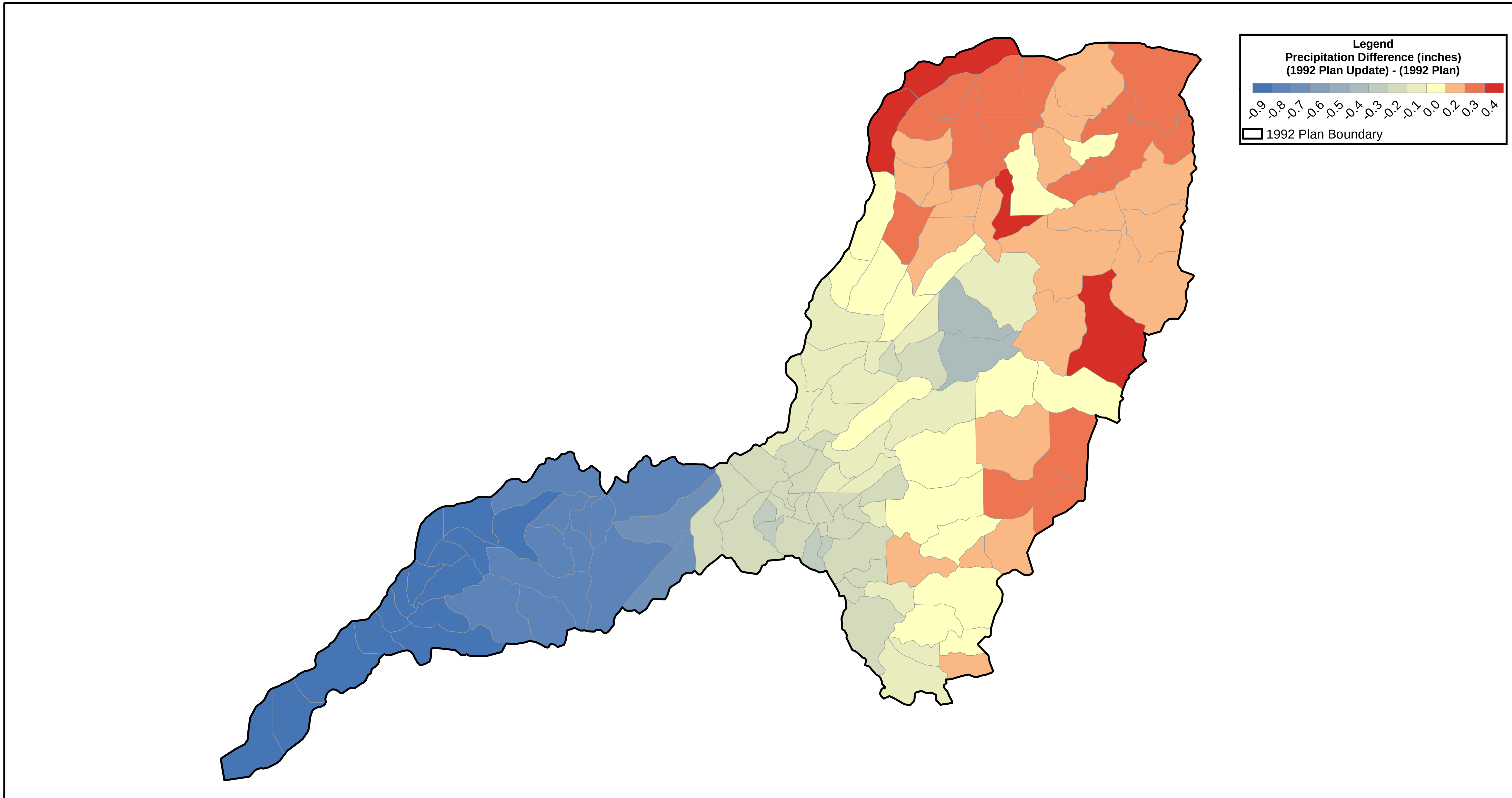
0 1 2 4 Miles

1 inch = 2 miles

PLATE 11

DRY CREEK WATERSHED PRECIPITATION COMPARISON BETWEEN PLAN UPDATE AND 1992 PLAN



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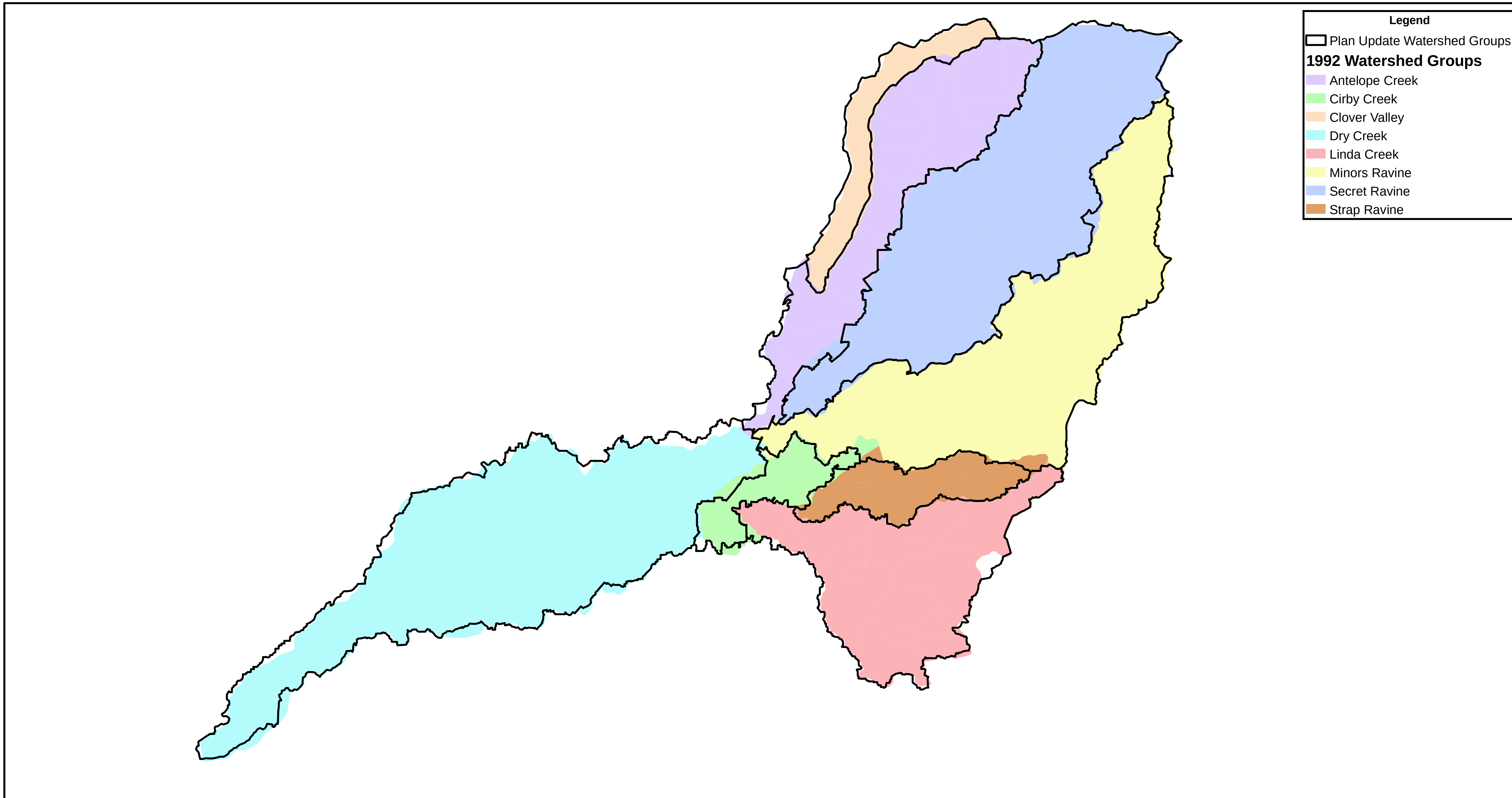
0 1 2 4 Miles

1 inch = 2 miles

PLATE 12

DRY CREEK WATERSHED DELINEATION COMPARISON BETWEEN 1992 PLAN AND PLAN UPDATE



PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

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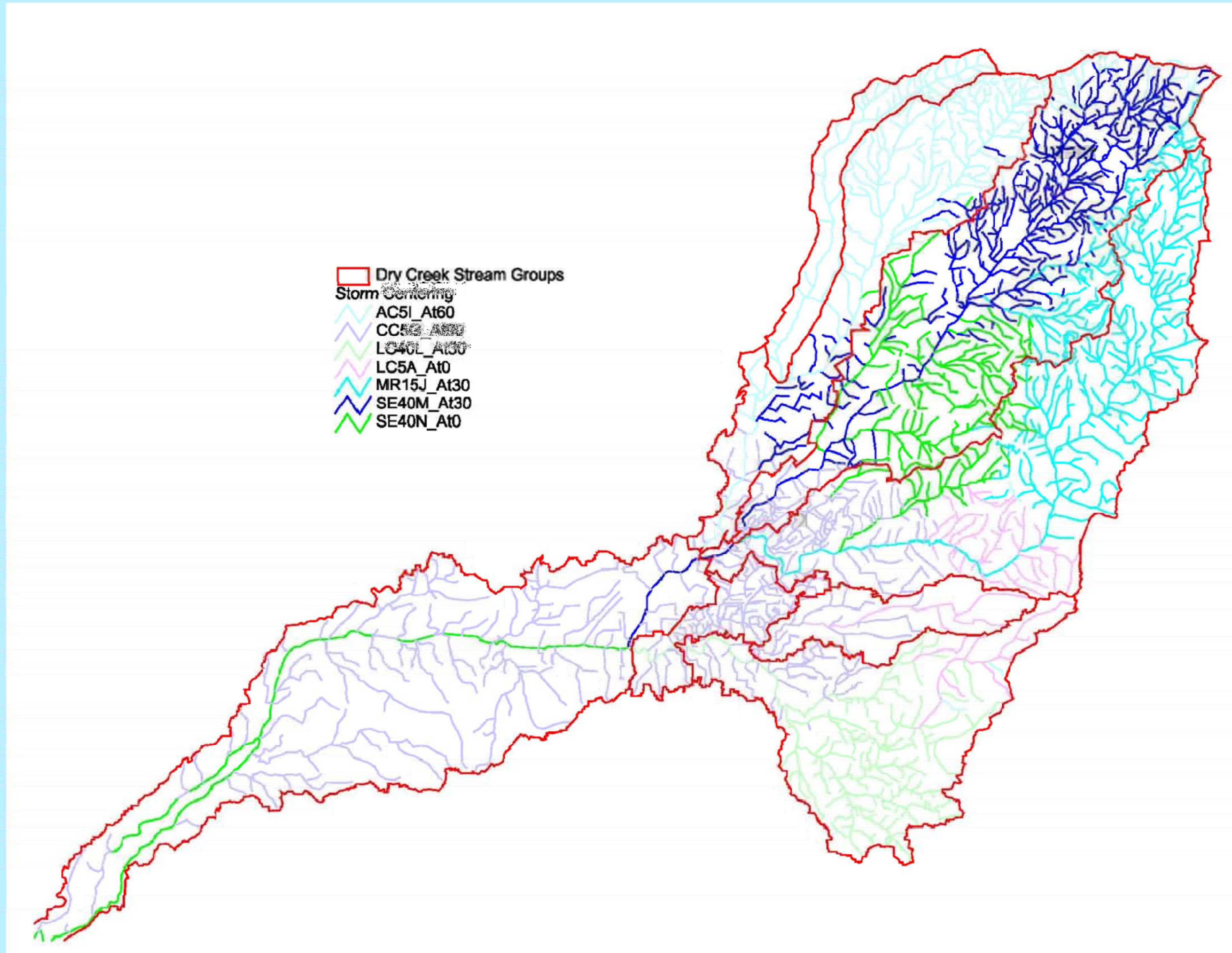
0 1 2 4 Miles

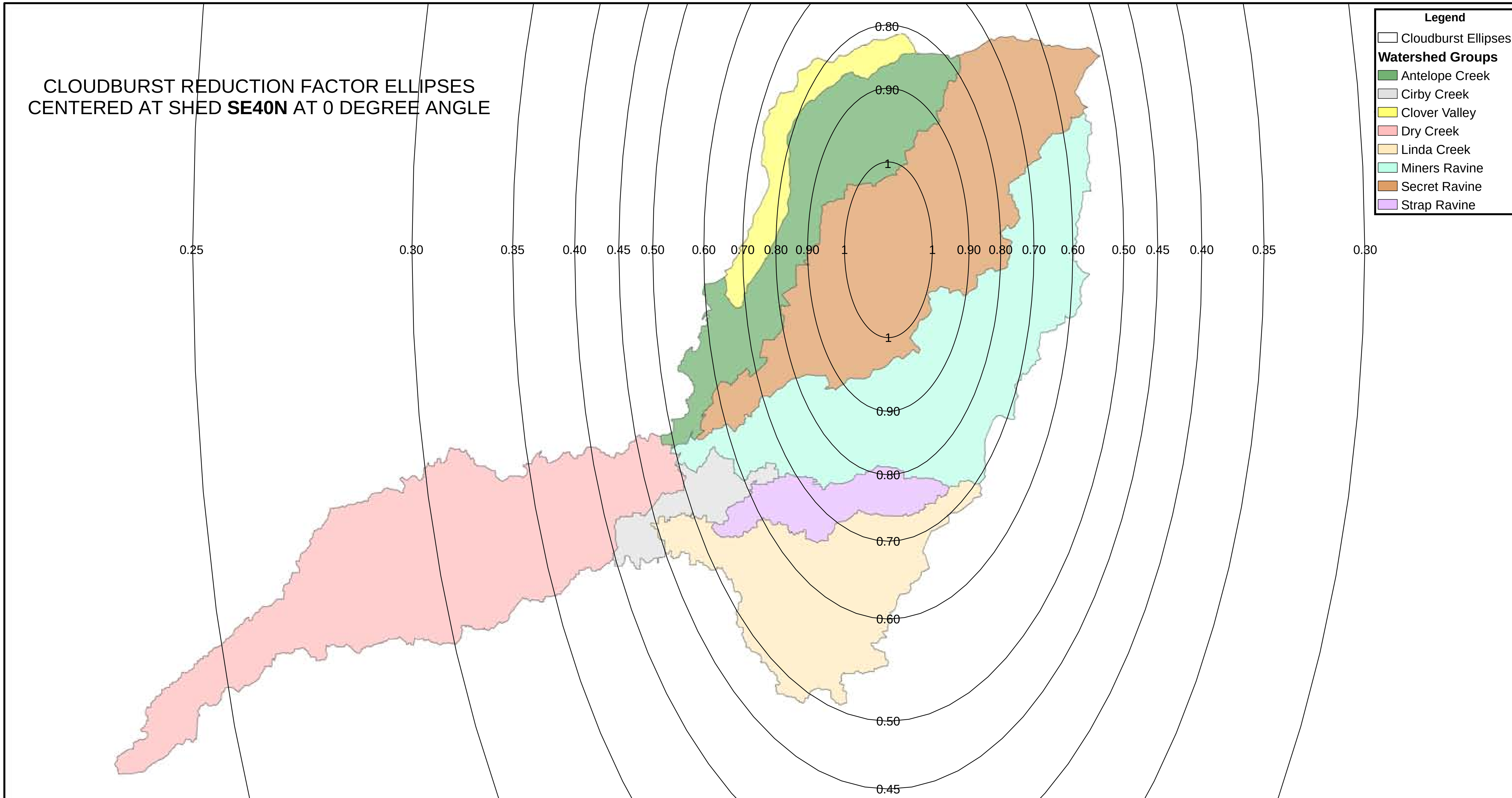
1 inch = 2 miles

PLATE 13

LOCATIONS WHERE STORM CENTERINGS CONTROL PEAK FLOOD RATES



DRY CREEK WATERSHED STORM CENTERING - SE40N AT 0ę



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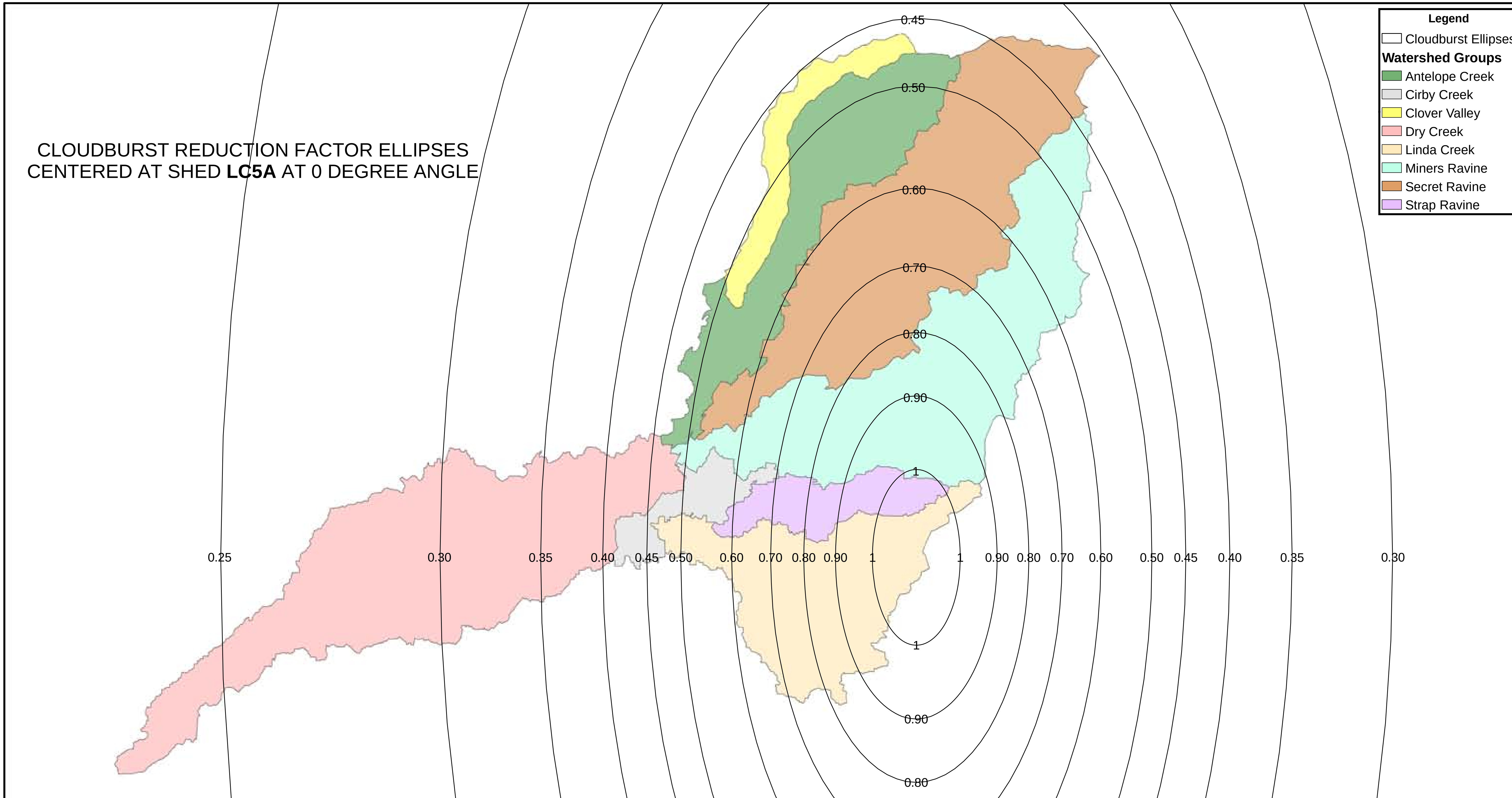
0 1 2 4 Miles

1 inch = 2 miles

PLATE 15

DRY CREEK WATERSHED STORM CENTERING -LC5A AT 0ę



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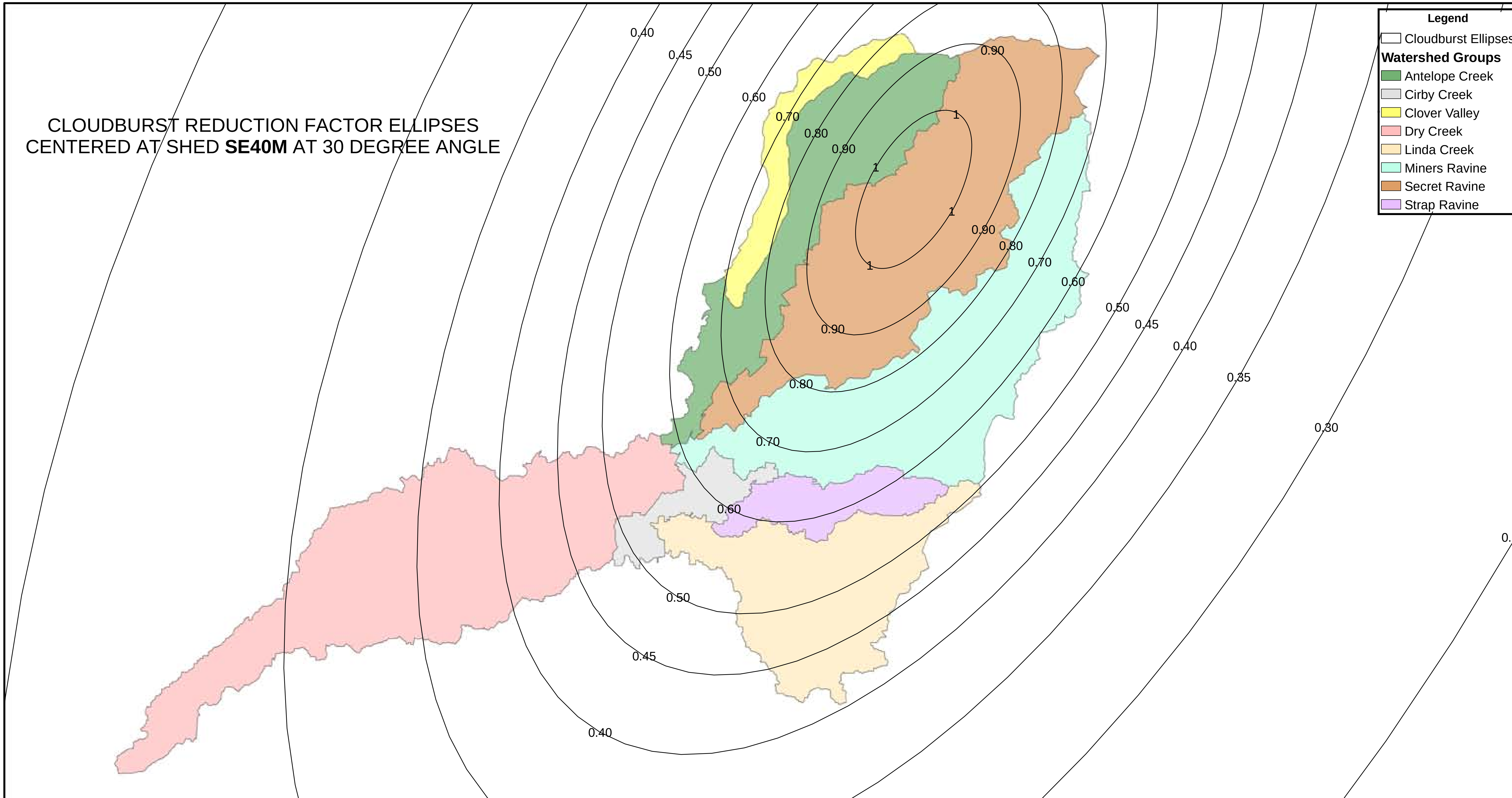
0 1 2 4 Miles

1 inch = 2 miles

PLATE 16

DRY CREEK WATERSHED STORM CENTERING -SE40M AT 30ę



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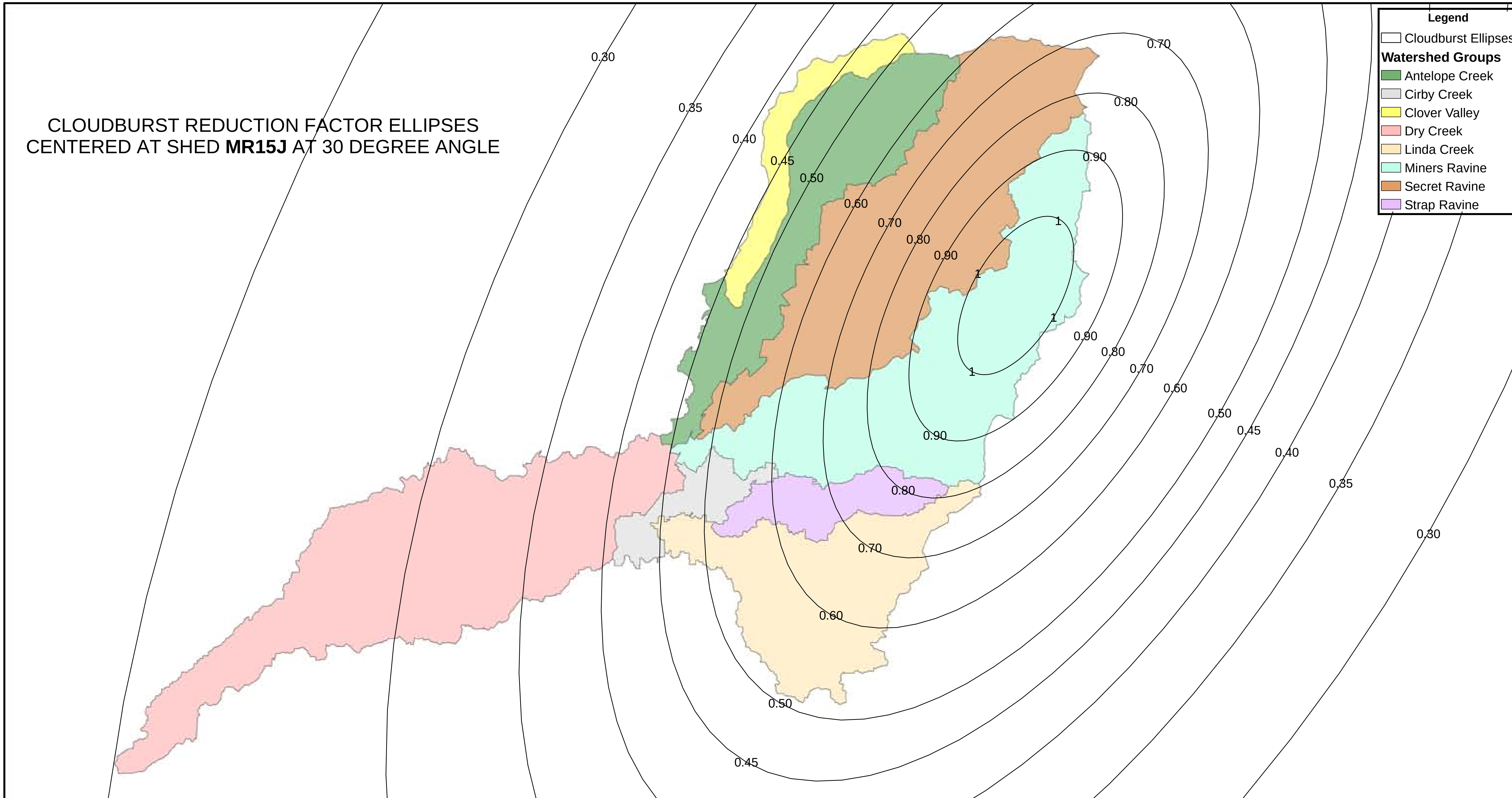
0 1 2 4 Miles

1 inch = 2 miles

PLATE 17

DRY CREEK WATERSHED STORM CENTERING - MR15J AT 30ę



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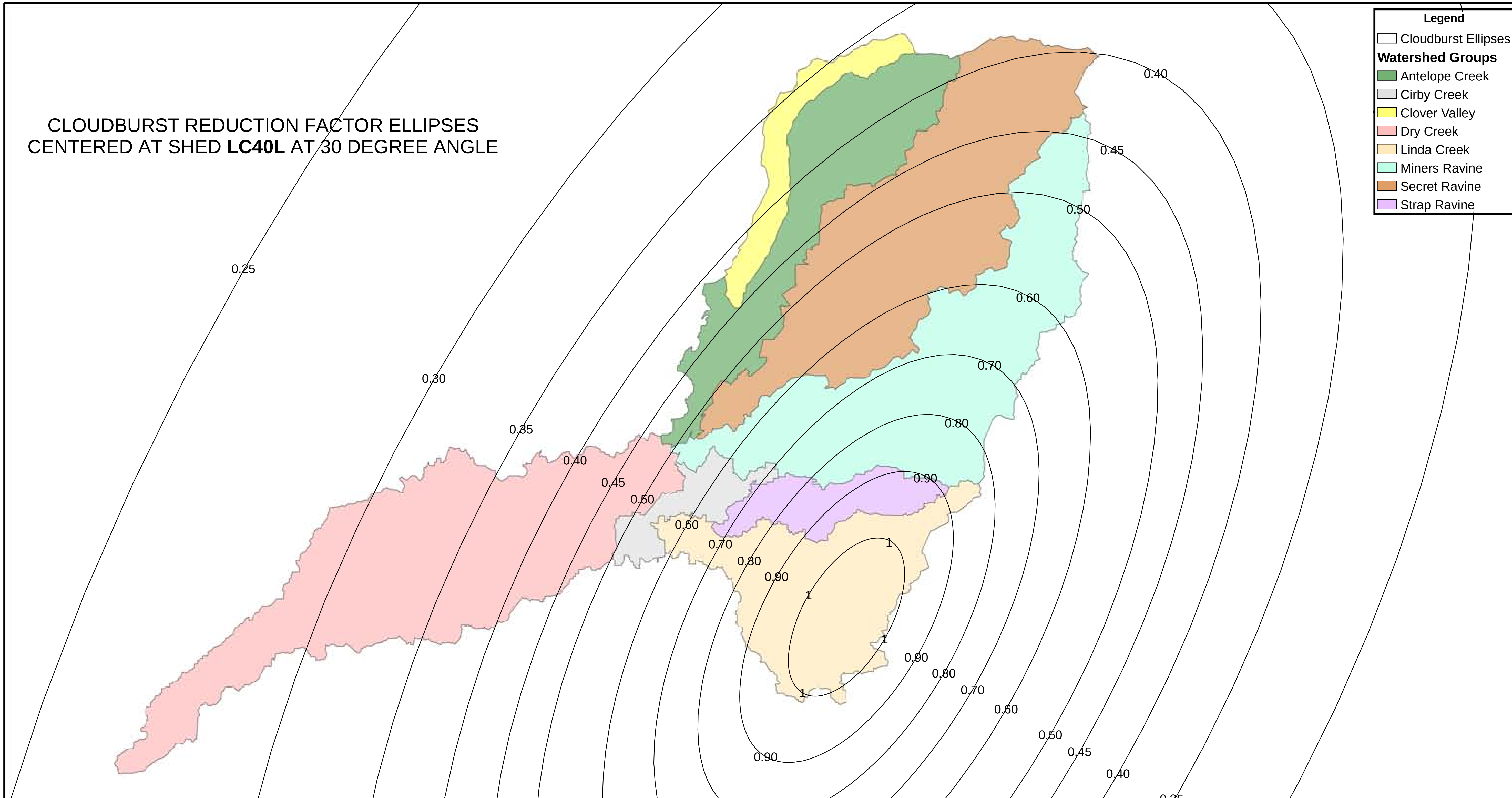
0 1 2 4 Miles

1 inch = 2 miles

PLATE 18

DRY CREEK WATERSHED STORM CENTERING - LC40L AT 30ę



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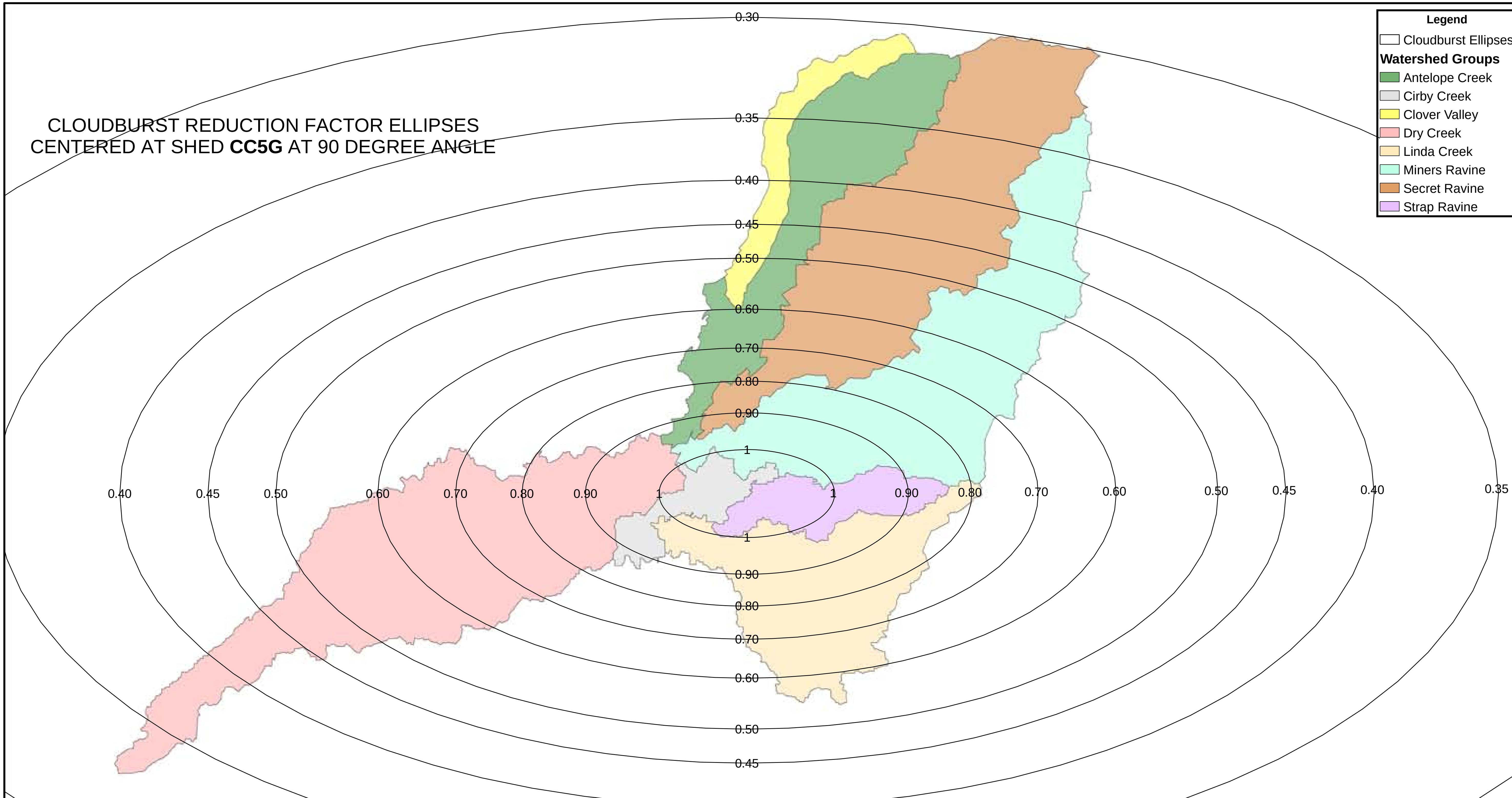
0 1 2 4 Miles

1 inch = 2 miles

PLATE 19

DRY CREEK WATERSHED STORM CENTERING - CC5G AT 90ę



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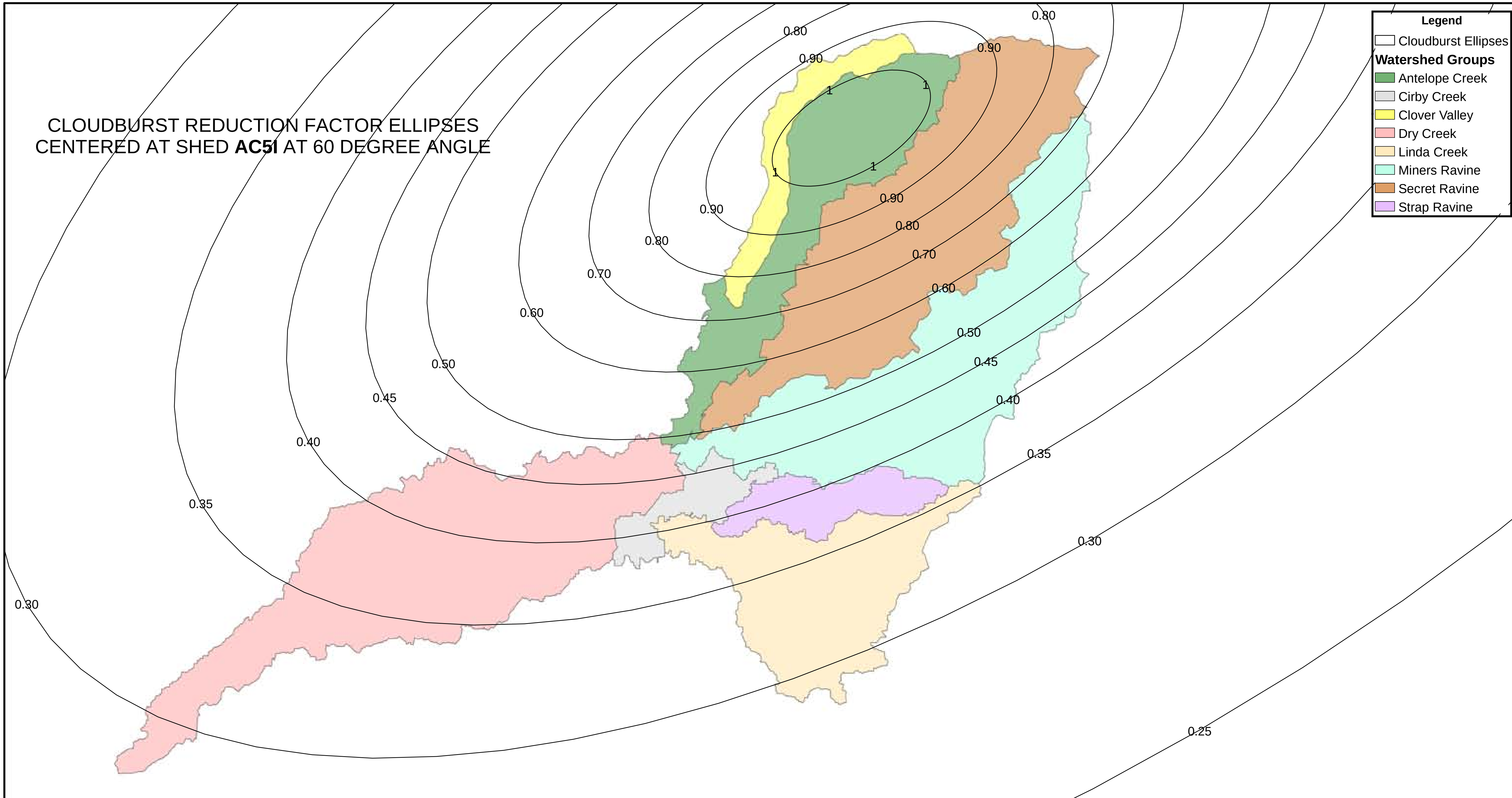
0 1 2 4 Miles

1 inch = 2 miles

PLATE 20

DRY CREEK WATERSHED STORM CENTERING - AC5I AT 60ę



PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

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0 1 2 4 Miles

1 inch = 2 miles

PLATE 21