RECLAMATION

Managing Water in the West

Draft Environmental Assessment/Initial Study and Finding of No Significant Impact/Mitigated Negative Declaration

Anderson-Cottonwood Irrigation District Integrated Regional Water Management Program – Groundwater Production Element Project

U.S. Department of the Interior
Bureau of Reclamation
Mid Pacific Region
Sacramento, California

Anderson-Cottonwood Irrigation District
2810 Silver St.
Anderson, CA 96007

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Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The mission of Anderson-Cottonwood Irrigation District is to utilize and protect its historic right to water, and to operate and improve the works essential for dependable conveyance of such water to its users.

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Acronyms and Abbreviations

µg/m³	micrograms per cubic meter
AB 32	Global Warming Solutions Act of 2006
ac-ft	acre-feet
ACID	Anderson-Cottonwood Irrigation District
APE	area of potential effects
bgs	below ground surface
BMP	best management practice
CAA	Clean Air Act
CAAQS	California Ambient Air Quality Standards
CARB	California Air Resources Board
CDC	California Department of Conservation
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	*Code of Federal Regulations*
CNDDB	California Natural Diversity Database
CO	carbon monoxide
CO_2	carbon dioxide
District	Anderson-Cottonwood Irrigation District
DOF	California Department of Finance
DWR	California Department of Water Resources
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
GHG	greenhouse gas
gpm	gallons per minute
H_2S	hydrogen sulfide
HFC	hydrofluorocarbon

IRWMP	Integrated Regional Water Management Plan
IS	Initial Study
ITA	Indian Trust Asset
lbs/days	pounds per day
M&I	municipal and industrial
NAAQS	National Ambient Air Quality Standards
NCWA	Northern California Water Association
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NO_2	nitrogen dioxide
NO_x	nitrogen oxide
NRHP	National Register of Historic Places
O_3	ozone
PFC	perfluorocarbon
$PM_{2.5}$	particulate matter less than 2.5 micrometers in aerodynamic diameter
PM_{10}	particulate matter less than 10 micrometers in aerodynamic diameter
project	Anderson-Cottonwood Irrigation District Groundwater Production Element Project
ppm	parts per million
Reclamation	Bureau of Reclamation
RGB	Redding Groundwater Basin
ROG	reactive organic gas
SF_6	sulfur hexafluoride
Shasta AQMD	Shasta County Air Quality Management District
SHPO	State Historic Preservation Office
SO_2	sulfur dioxide
SWPPP	stormwater pollution prevention plan
Tribes	American Indian Tribes
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

SECTION 1

Introduction and Purpose and Need

This Environmental Assessment (EA)/Initial Study (IS) was jointly prepared by the Bureau of Reclamation (Reclamation) and Anderson-Cottonwood Irrigation District (ACID) to respectively satisfy the requirements of both the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA).

1.1 Background

The Anderson-Cottonwood Irrigation District Groundwater Production Element Project (project) includes the installation of two groundwater wells to supplement existing district surface water and groundwater supplies. The project is supported by both state and federal grant funding. State funding is made available through California Proposition 50 Integrated Regional Water Management funds administered by the California Department of Water Resources (DWR), whereby Northern California Water Association (NCWA) is the grantee. The grant provides $9.5 million of funding to support the implementation of 11 projects throughout the Sacramento Valley. Federal funding is also being provided to seven districts to support their implementation of the Sacramento Valley Integrated Regional Water Management Plan (IRWMP). Although the projects funded by this grant are generally similar in nature, each project has independent utility, and will be implemented by each grantee to supplement their current surface water supplies in both normal and dry years, as determined appropriate by each project proponent.

Anderson-Cottonwood Irrigation District (ACID or District) is a Sacramento River Settlement Contractor organized under Section 11 of the California Water Code. ACID diverts water from the Sacramento River in Redding, California, primarily from a gravity diversion in the river at the seasonal ACID Diversion Dam in Redding. The District also operates a pump station on the river, approximately 4 miles downstream, to supply the Churn Creek lateral. ACID's distribution system includes approximately 35 miles of main canal, about 98 percent of which is unlined. The main canal flows through six inverted siphons to cross streams, such as Clear Creek, and three flume sections across smaller streams and lowland areas. When flow exceeds the canal capacity, ACID water overflows into several wasteways along the canal route.

ACID holds a water right, under pre-1914 postings, to divert water from the natural flow of the Sacramento River. The ACID surface water supply entitlement provides for a maximum total of 125,000 acre-feet (ac-ft) per year during the period April 1 through October 31; 121,000 ac-ft is considered base supply[1] and 4,000 ac-ft is Central Valley Project water[2]. During dry years this supply may be significantly less. The District does not currently own

[1]Base supply is defined as the quantity of surface water established in Articles 3 and 5 of the contract between the Bureau of Reclamation and ACID, which may be diverted by the Contractor from the Sacramento River each month during the period April through October of each year without payment to the United States for such quantities diverted.

[2]Project water is defined as all surface water diverted or scheduled to be diverted each month during the period April through October of each year by the Contractor from the Sacramento River which is in excess of the base supply.

any groundwater production wells, but is looking at installing up to two through the project. ACID has worked with DWR to install 13 groundwater monitoring wells, which have provided data for over 5 years.

1.2 Scope and Project Location and Setting

The proposed ACID Well No. 1 is located in the City of Anderson in Shasta County, California (Township 30 North, Range 04 West, Section 23; Mount Diablo Base and Meridian; 122˚17’19.15”W, 40˚26’19.34”N [North American Datum of 1983]) on the U.S. Geological Survey (USGS) Cottonwood 7.5-minute quadrangle (see Figure 1-1).

The proposed ACID Well No. 2 is located approximately 0.5 mile northwest of the town of Cottonwood in Shasta County, California (Township 29 North, Range 04 West, Section 2; Mount Diablo Base and Meridian; 122°17’30.03”W, 40°23’39.08”N [North American Datum of 1983]) on the USGS Cottonwood 7.5-minute quadrangle (see Figure 1-1).

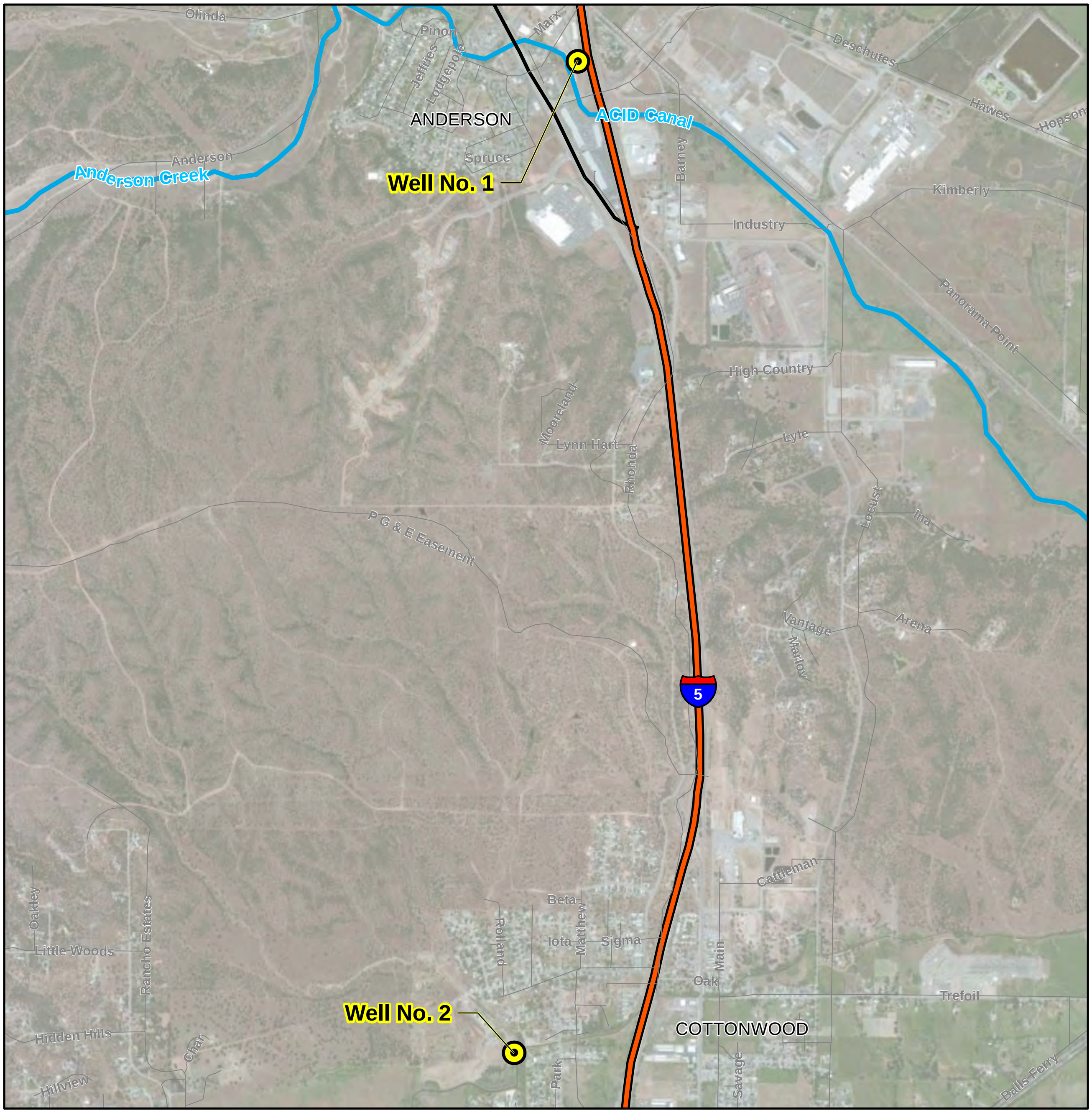
This EA/IS was prepared to analyze the possible impacts of the project and the construction activities associated with the installation of the proposed wells.

1.3 Purpose and Need and Project Goals and Objectives

1.3.1 Purpose and Need

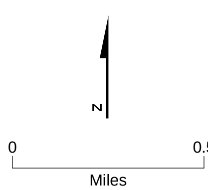
The purpose of the proposed action is to augment surface water supplies by installing and operating two groundwater production wells. This project is made possible by a 90/10 partnership between the State of California, DWR (Proposition 50 Sacramento Valley IRWMP Implementation funding), and the Reclamation Act of 1902 (32 Stat. 388), as amended and supplemented; Public Law 108-361, Section 103(d)(5), Section 9504(a). Under the Sacramento Valley IRWMP Grants Program, Reclamation provides financial assistance to support activities that promote the preparation and revision of written regional water management and conservation plans, implement activities identified in written water management plans, demonstrate new or previously unknown water management technologies and practices, and promote improved understanding of good water use practices and principles. Reclamation is providing financial assistance to ACID for Sacramento Valley IRWMP revision and implementation.

This project would improve the flexibility and reliability of the District’s water supply, particularly during dry and critically dry water years. In 2004, ACID’s surface water rights were reduced from 165,000 to 121,000 ac-ft per year as part of the renegotiation of the 40-year Settlement Contract. Furthermore, the west side of the District’s system has little to no downstream control. Control of the system is achieved at the head of the 35-mile main canal, causing some delivery difficulties at the downstream end of the service area. By pushing water from upstream to downstream without an ability to manage intermediate water surface elevations, downstream response time to water delivery needs can be greatly hindered. This project would help with the flexibility and reliability required to meet agricultural water needs.



LEGEND

- PROPOSED PRODUCTION WELL
- LOCAL ROAD
- STATE HIGHWAY 273
- WATER FLOW



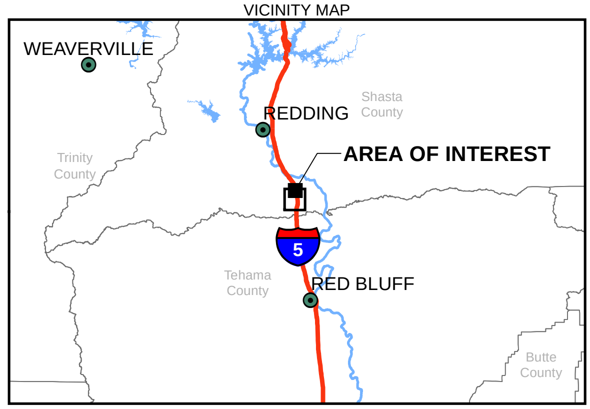


FIGURE 1-1
PROPOSED WELL LOCATIONS
EA/IS AND FONSI/MND FOR ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

1.3.2 Project Goals and Objectives

The primary project objective is to improve flexibility and reliability of water deliveries to the ACID service area through the installation of two groundwater production wells. The project goals are as follows:

- Increase system reliability and flexibility on a local and regional basis
- Offset reductions in Sacramento River diversions during drought years during July and August
- Periodically reduce Sacramento River diversions when feasible
- Increase instream Sacramento River flows resulting in ecological benefits
- Minimize any potential impacts on adjacent groundwater users and surface streams
- Continue to use the network of groundwater monitoring infrastructure within the basin through regional partnerships with the Redding Area Water Council and the DWR Northern District

1.4 Applicable Regulatory Requirements and Required Coordination

Federal laws, permits, licenses, and policy requirements have directed, limited, or guided the NEPA and CEQA analyses and decision-making process of this EA/IS and include the following (full discussions of these related authorizations are provided in Section 4, Consultation and Coordination):

- **U.S. Fish and Wildlife Service** – Federal Endangered Species Act
- **California Department of Fish and Game (CDFG)** – California Endangered Species Act
- **Regional Water Quality Control Board** – National Pollutant Discharge Elimination System permit
- **State Historic Preservation Office** – Section 106 Consultation
- **Shasta County Ordinance No. SCC 98-1** – Adopting the Coordinated AB 3030 Groundwater Management Plan for the Redding Basin
- **Shasta County –** Well Installation Permits

1.5 Potential Environmental Issues

This EA/IS analyzes potential impacts and cumulative effects associated with the proposed action to the following:

- Water resources
- Land use/agricultural resources
- Biological resources

- Cultural resources
- American Indian Trust Assets (ITA)
- Environmental justice
- Socioeconomic resources
- Air quality
- Global climate change

The CEQA analysis provides discussions for the environmental issues listed above and includes the following:

- Aesthetics
- Agriculture and forestry resources
- Geology and soils
- Hazards and hazardous materials
- Mineral resources
- Noise
- Population and housing
- Public services
- Recreation
- Transportation and traffic
- Utilities and service systems

SECTION 2

No Action Alternative and Proposed Action

This EA/IS considers two possible actions: the no action alternative and the proposed action. The no action alternative reflects both future conditions without the proposed action and serves as a basis of comparison for determining potential effects on the human environment.

2.1 No Action Alternative

The no action alternative assumes that ACID would continue to implement its current water management program. ACID would continue to operate under the provisions of its contract with Reclamation, and face cutbacks of up to 25 percent of its base and project water supply during critically dry water years[3]. As water shortages occur, ACID anticipates that groundwater pumping would increase both within the District's service area and in adjacent areas to meet future water demands. Under the no action alternative, it is assumed the District would not implement the proposed action or construct any wells in the future. Future land use is anticipated to become increasingly urban because of projected population increases, particularly within the Redding Basin subarea, and groundwater is an increasingly important source of supply for the area outside the District boundary (NCWA et al., 2006).

2.2 Proposed Action

ACID proposes to install two new groundwater production wells near its main canal. Figures 2-1 and 2-2 show the general location of the proposed wells.

2.2.1 Project Location

The proposed ACID Well No. 1 is located within a 0.5-acre area, in the City of Anderson in Shasta County, California (Township 30 North, Range 04 West, Section 23; Mount Diablo Base and Meridian; 122˚17'19.15"W longitude, 40˚26'19.34"N latitude [North American Datum of 1983] on the USGS Cottonwood 7.5-minute quadrangle). Figure 2-1 shows the proposed well location north of Deschutes Road.

The proposed ACID Well No. 2 is located within a 0.5-acre area, approximately 0.5 mile northwest of Cottonwood in Shasta County, California (Township 29 North, Range 04 West, Section 2; Mount Diablo Meridian; 122°17'30.03"W longitude, 40°23'39.08"N latitude [North American Datum of 1983] on the USGS Cottonwood 7.5-minute quadrangle). Figure 2-2 shows the proposed well location north of Gas Point Road and west of Rhonda Road.

[3]Critical dry year is defined as (1) the forecast full natural inflow to Shasta Lake for the current water year, as made by the United States on or before February 15 and reviewed as frequently thereafter as conditions and information warrant, is equal to or less than 3.2 million ac-ft; or (2) the total accumulated deficiencies below 4 million ac-ft, in the immediately prior water year or series of successive prior water years, each with inflows of less than 4 million ac-ft and together with the forecast deficiency for the current water year exceeding 800,000 acre-feet.

2.2.2 Construction Activities

Each well would require a 100-foot by 200-foot construction staging area. The final footprint of each well would not exceed 25 feet by 25 feet, with an estimated well depth of 500 feet. Conveyance piping would be required for each pump. A maximum of 100 feet of conveyance piping, 12 to 14 inches in diameter, would be installed approximately 12 to 24 inches underground at each well. The pipelines would discharge directly into the ACID main canal via open-ended discharge through the canal bank. The wells would be powered by electricity and could require a maximum 1,000 feet of overhead service line and one new power pole (approximately 12 inches in diameter) installed within 50 feet of each new well. Figures 2-1 and 2-2 identify existing power poles from which electricity would take off. The method of construction for the conveyance pipeline would be open trench. Existing roads would allow access to both wells, and would not require improvements. Final project design and construction are expected in fall 2011. Drill cuttings and fluids would be disposed of onsite at a location previously agreed upon by the property owner.

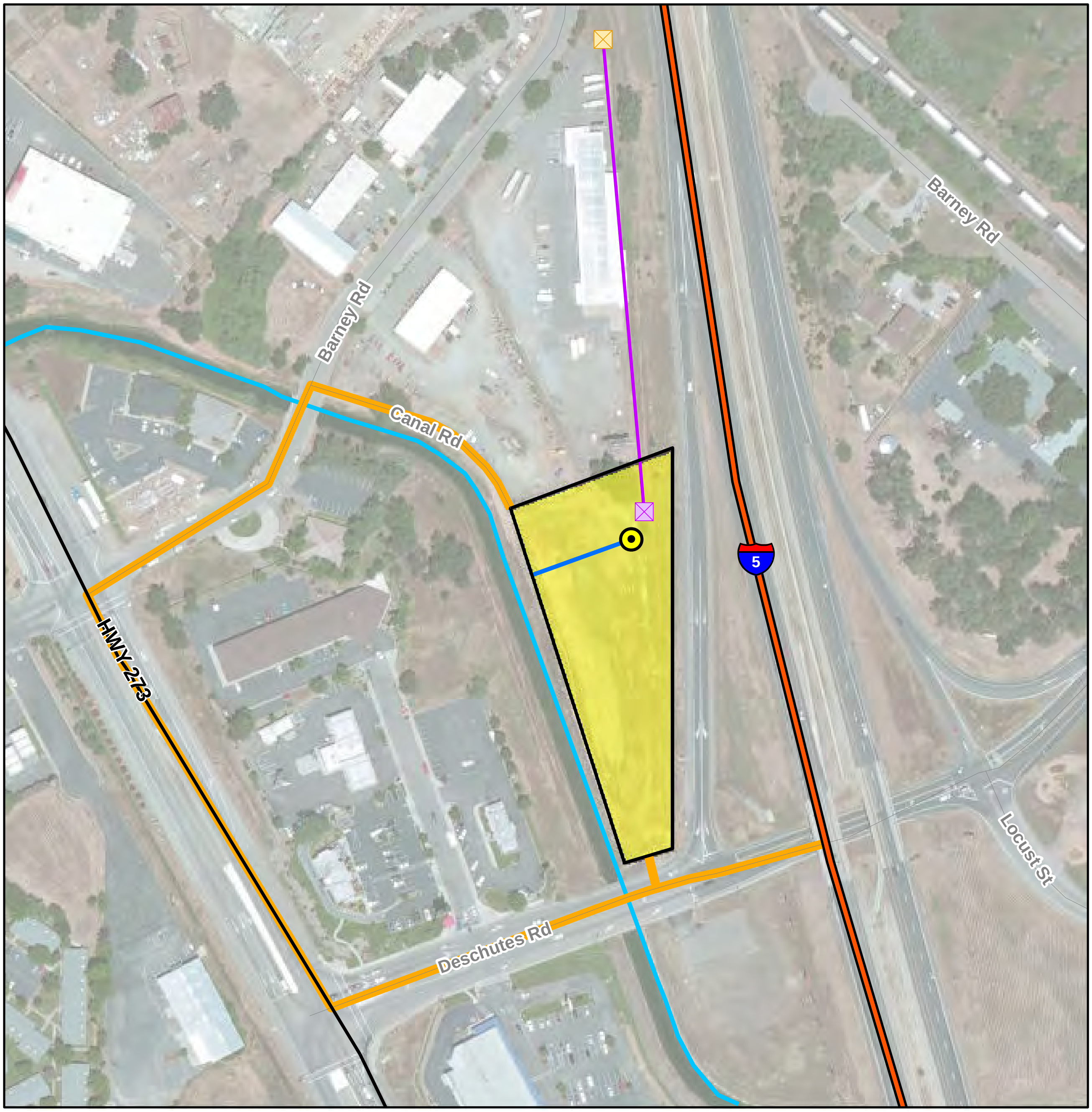
The following equipment is expected to be required for each proposed well installation:

- Self-propelled or trailer-mounted reverse circulation drilling rig (2 weeks)
- Pipe trailer (2 weeks)
- Support trailer/doghouse (2 weeks)
- Backhoe (6 weeks)
- Fluid containment tanks (4 weeks)
- Cement delivery trucks (4 days)
- Geophysical logging van (2 days)
- Pump setting rig (2 days)
- Up to three crew-member vehicles (6 weeks)
- Fuel delivery vehicles (4 days)

2.2.3 Construction Schedule

Installation of the 500-foot-deep wells would require approximately 30 working days, with ten 24-hour shifts during weekdays and weekends. The remaining 20 working days would require 10- to 12-hour shifts. Personnel requirements for the first 10 days of well installation would include two crews, each consisting of one rig operator and two laborers. One construction superintendant would oversee both crews. Personnel for well development and testing would require one operator, two laborers, and one construction superintendant working a maximum 12-hour shift per day (that is, one shift).

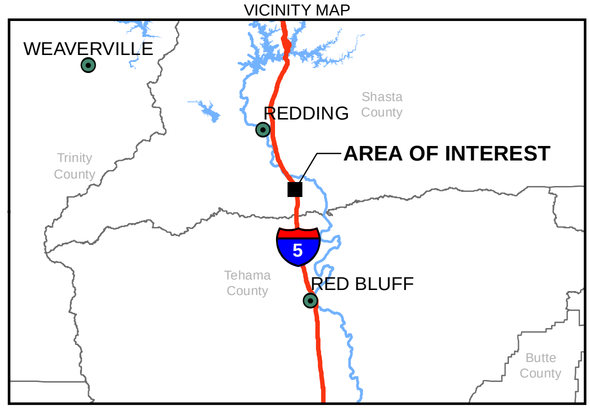
In addition to manufacturer representatives, engineering construction management and contractor personnel would be required onsite for installation of conveyance piping. Construction of aboveground facilities, including the conveyance pipeline, would take up to 10 working days and would require two operators, two laborers, and one construction superintendant. Total personnel for each well installation would not likely exceed 12 people on any given day. On an average day, five people would be onsite.



LEGEND

- PRODUCTION WELL
- EXISTING POWER POLE
- PROPOSED POWER POLE
- ACID CANAL
- EXISTING ACCESS ROUTE
- PROPOSED CONVEYANCE LINE TO CANAL
- PROPOSED POWER LINE
- PROJECT AREA

VICINITY MAP

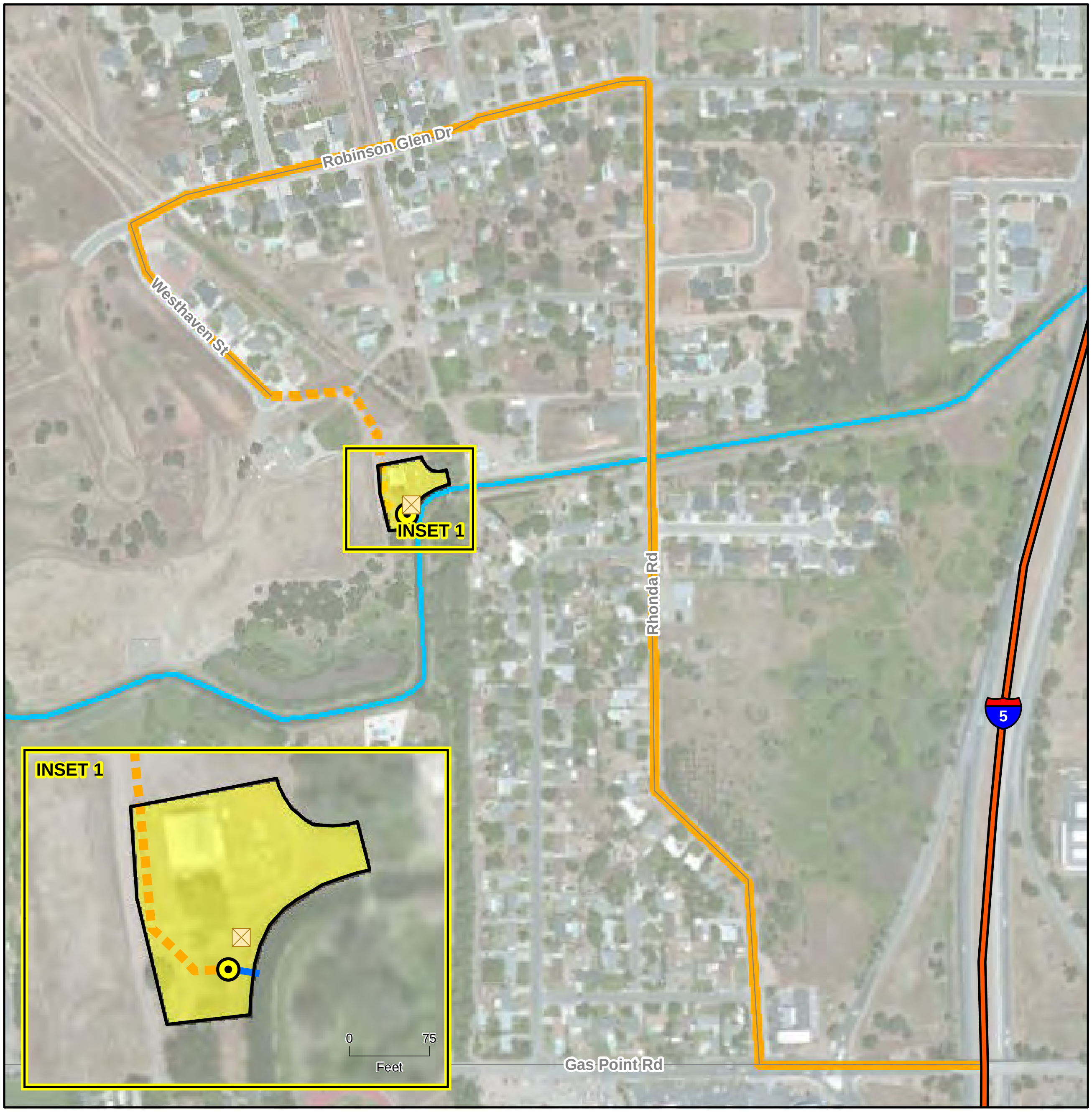


N

0 250
Feet

FIGURE 2-1
GROUNDWATER PRODUCTION WELL No. 1 LOCATION MAP
EA/IS AND FONSI/MND FOR ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

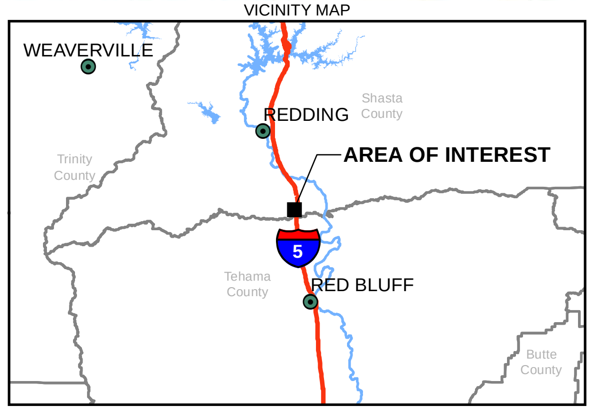
CH2MHILL



LEGEND

- PRODUCTION WELL
- EXISTING POWER POLE
- ACID MAIN CANAL
- EXISTING ACCESS ROUTE
- PRIVATE ACCESS ROAD
- PROPOSED CONVEYANCE LINE TO CANAL
- PROJECT AREA

VICINITY MAP



N

0 500
Feet

FIGURE 2-2
GROUNDWATER PRODUCTION WELL No. 2 LOCATION MAP
EA/IS AND FONSI/MND FOR ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

CH2MHILL

2.2.4 Project Operations

Each well would have a target capacity of 3,500 gallons per minute (gpm) and would require a 100- to 150-horsepower pump motor. The wells would operate 24 hours per day under the following schedule:

- **Noncritical water year[4]:** Proposed Well No. 2 would operate from June through October to augment water supply in an area where water conveyance is seasonally limited by aquatic vegetative growth in the canal (aquatic vegetation increases in growth throughout the delivery season, decreasing canal capacity). Proposed Well No. 1 would only be operated in critical dry years and would not be operated in normal years.
- **Critical water year:** Both proposed wells would operate from April through October during critical dry years to augment water supply.

2.3 Environmental Commitments Incorporated into the Proposed Action/Proposed Project

Several environmental commitments associated with the siting and operation of the proposed wells are included as part of this project.

2.3.1 Well-siting Criteria

New wells and related facilities would generally be located within previously disturbed areas that are currently used for agricultural purposes. Proposed well locations were surveyed to identify any potential historical or biological resources (species and habitat). The survey data for the selected well location were used to confirm compliance with state and federal laws for historical and biological resources. The following measures have been incorporated into the project design to minimize and avoid potential impacts on biological and cultural resources:

- Groundwater – monitoring and remedial action plans would be implemented.
- Surface water – the contractor would be required to develop and implement a stormwater pollution prevention plan (SWPPP) to reduce the potential for any offsite discharge.
- Land use – project design assumes cooperation and coordination with willing landowners to site the wells.
- Biological resources – preconstruction siting surveys were performed on February 15, 2011, to assure avoidance or minimization of impacts on sensitive habitat and species.
- Cultural – preconstruction siting surveys were performed on February 15, 2011, to assure avoidance or minimization of impacts on cultural resources. A cultural resources investigation was conducted, and the results are summarized in the cultural resources

[4] ACID receives its full Sacramento River Settlement Contract amount in every year type except years designated as Shasta Critical Years.

section (Section 3.4) of this document. The cultural resources investigation report is a confidential report on file with Reclamation, and is available upon request.

- Air quality – proposed wells would be electrically powered. Construction exhaust emissions would be controlled using mitigation measures established by Shasta County Air Quality Management District.
- Noise – noise curtains would be used during construction to minimize noise impacts on nearby sensitive receptors.

2.3.2 Specific Actions to Minimize Potential Impacts on Groundwater Resources

ACID is an active member of water management groups within the Redding Basin, including the Redding Area Water Council. ACID has worked in cooperation with DWR to monitor levels in the basin since 2003. Groundwater activities by the District are consistent with the ACID Groundwater Management Plan and with the Shasta County Assembly Bill 3030 Plan. The ACID service area would be covered by the California Statewide Groundwater Elevation Monitoring Program through Shasta County. These activities support ACID's intent to be good neighbors and stewards of the water resource, including groundwater.

The level of pumping associated with the proposed action/proposed project is not anticipated to adversely affect local users. Promptly addressing potential impacts through open communication with local groundwater users would result in mitigation of impacts. Upon notification of a potential adverse impact, ACID would (within 5 days) contact the affected party and obtain available information as to the nature and extent of the potential impact. After the party has been contacted and relevant information received regarding the potential impact, ACID would evaluate whether an impact had actually occurred and whether the impact appears related to operation of the ACID project. ACID would then take one of the following actions:

- If ACID and affected party mutually determine that the reported adverse impact resulted from implementation of the project, ACID would mitigate the impact in a mutually agreeable manner, possibly including a temporary reduction in groundwater pumping.
- If ACID determines that the reported impact was not likely caused by implementation of the project, then ACID would provide information to the affected party that reasonably demonstrates the lack of causation between the specific project and the reported impact.

2.3.3 Specific Actions to Minimize Potential Impacts on Surface Water Resources

Soil erosion or loss of topsoil during construction activities would be minimized through adherence of best management practices (BMP) and preventive measures as outlined in the contractor's SWPPP. The contractor would file a Notice of Intent with the State Water Resources Control Board in accordance with the General Permit for Stormwater Discharges Associated with Construction Activity. ACID would confirm that the SWPPP is kept on the project site and that water quality standards are followed. The SWPPP would incorporate sediment and erosion controls such as silt fences and erosion control blankets.

Following the completion of construction activities, disturbed areas would be stabilized. BMPs would include, but not be limited to, the following:

- Activities that increase erosion potential would be restricted, to the extent practicable, to the summer and early fall to minimize potential for rainfall events to transport sediment to the adjacent surface water features. If these activities must take place during the late-fall, winter, or spring, then temporary erosion and sediment control BMPs would be placed and operational at the end of each construction day, and maintained until permanent erosion control features are in place.
- When construction is complete, stabilizers such as weed-free mulch would be applied to disturbed areas within 10 days to reduce the potential for short-term erosion. Prior to a rain event or when National Weather Service forecasts greater than 50 percent chance of rain during the following 24 hours, soil stabilizers would be applied to exposed areas upon completion of the day’s activities. Soils would not be left exposed during the rainy season.
- BMPs such as filter fences and catch basins would be placed below construction activities near a stock pond or other open water to intercept sediment before it reaches the waterway. These structures would be installed prior to any clearing or grading activities.
- Spoil sites would be located where they do not drain directly into a surface water feature. Temporary spoil sites would be protected from erosion using BMPs.
- Sediment control measures would be in place prior to the onset of the rainy season and would be monitored and maintained in good working condition until disturbed areas have been stabilized.
- Erosion and sediment control measures listed in permits obtained for the project would be implemented.

2.3.4 Specific Actions to Minimize Potential Impacts on Land Use

Well locations were selected through the cooperation and coordination with willing landowners to site the wells either on District-owned lands in areas that would not substantially interfere with agricultural operations, require rezoning or substantial local approvals, or in mutually agreeable locations on private land.

2.3.5 Specific Actions to Minimize Potential Impacts on Biological Resources

During the planning and design phase for the proposed project, a qualified biologist visited the proposed location to determine the occurrence of native habitats, including vernal pools, wetlands, riparian habitat, oak woodlands, and special-status species. If native habitats were found at the project site, the location of the project was changed.

New facilities and construction support areas (for example, new temporary access roads, new staging areas, and new stockpile areas) would be situated the specified distance from the outer edge or dripline of habitat (see Table 2-1).

TABLE 2-1
Avoidance Distances by Habitat Type

Habitat	Buffer Distance
Riparian Forest and Scrub	100 feet from dripline
Oak Woodlands	100 feet from dripline

The habitat avoidance measures contribute to avoiding impacts on listed and proposed species, but listed species might use non-native habitats or require larger buffers, or certain seasonal restrictions. To avoid impacts, during the planning and design phase of project facilities, project sites were visited to assess the potential for suitable habitat for listed or proposed species to occur at the project sites. If native habitats were found at the project site, impacts on listed species and species proposed for listing could be avoided by relocating new facilities and construction activities outside of a species-specific buffer area around potential habitat, to the extent possible. No further action or avoidance restrictions are warranted, because no listed or proposed species were identified for the two well locations.

2.3.6 Specific Actions to Minimize Potential Impacts on Air Quality

New wells would be powered by electricity to eliminate air quality impacts associated with emissions from diesel generators.

The following minimization measures would be implemented to reduce construction emissions from fugitive dust and exhaust:

- Adequate dust control measures would be implemented in a timely and effective manner during phases of project development and construction.
- Material excavated, stockpiled, or graded would be sufficiently watered to prevent fugitive dust from leaving property boundaries and causing a public nuisance or a violation of an ambient air standard. Watering would occur at least twice daily with complete site coverage, preferably in the mid-morning and after work is completed each day.
- Areas (including unpaved roads) with vehicle traffic would be watered periodically or have dust palliatives applied to stabilize dust emissions.
- Onsite vehicles would be limited to a speed of 15 miles per hour on unpaved roads.
- Land clearing, grading, earth moving, and excavation activities for the project would be suspended when winds are expected to exceed 20 miles per hour.
- Areas subject to excavation, grading, and other construction activity would be restricted at any given time.
- The hours of operating heavy-duty equipment and the amount of equipment in use would be restricted.

- Idling times would be minimized either by shutting vehicles off when not in use or by reducing the maximum idling time to 5 minutes (as required by California Code of Regulations Title 13, Chapter 9, Section 2449 and Chapter 10, Section 2485).
- Fleets of diesel-fueled off-road vehicles would comply with particulate matter and nitrogen oxide (NO_x) emissions standards in accordance with California Code of Regulations Title 13, Chapter 9, Section 2449.

2.3.7 Actions to Minimize Potential Noise Impacts

Drilling operations would occur 7 days per week (24 hours per day) for 10 days, and operations would include noise mitigation in the form of sound curtains to reduce impacts on nearby sensitive receptors (located within 200 yards of the proposed wells) as necessary.

SECTION 3

National Environmental Policy Act – Affected Environment and Environmental Consequences

This section presents the NEPA analysis portion of the potentially affected environment and the environmental consequences involved with the proposed action and the no action alternative.

3.1 Water Resources

3.1.1 Affected Environment

The Sacramento River Hydrologic Region is the main water supply source for much of California's urban and agricultural areas. The proposed action is located in the Redding Groundwater Basin (RGB), which extends from the Klamath Mountains to the Red Bluff Arch and includes portions of Shasta and Tehama Counties (DWR, 2003a). The 510-square-mile RGB is bordered to the east by the Cascade Mountains and to the west by the Coast Range. Between Cottonwood and Red Bluff, the Red Bluff Arch separates the RGB from the Sacramento Valley Groundwater Basin to the south. DWR Bulletin 118 subdivides the RGB into six subbasins: Anderson, Enterprise, Millville, Rosewood, Bowman, and South Battle Creek (DWR, 2003b) (Figure 3-1).

The land surface regionally slopes south and toward the main surface water feature in the basin, which is the Sacramento River. Locally, the land surface topography is also affected by smaller scale features, such as lakes and tributaries of the Sacramento River, and by a variety of constructed features and structures. Land surface elevations generally range from 400 feet above mean sea level along the Sacramento River to 800 feet above mean sea level in the upland portions of the valley (DWR, 2003a).

The RGB has mild winters with hot, dry summers. Average annual precipitation in the RGB ranges from 27 to 41 inches in the higher elevations (DWR, 2003c). Typically, 80 to 90 percent of the basin's precipitation occurs from November to April (Bertoldi, 1991).

3.1.1.1 Hydrology

Annual runoff in the Sacramento River Hydrologic Region averages approximately 22.4 million ac-ft, which is nearly one-third of the state's total natural runoff (DWR, 2003b). The area overlying the RGB yields an estimated average annual runoff of 850,000 ac-ft (CH2M HILL, 2003). The Sacramento River is the primary drainage for the RGB. The other principal surface water features in the basin are tributaries of the Sacramento River: Battle, Cow, Little Cow, Clear, Dry, and Cottonwood Creeks. The ACID main canal flows southward for approximately 35 miles from the diversion dam in the City of Redding and acts as a source of water to the underlying aquifer during the agricultural season. Surface water and groundwater interact along most of these surface water features. Several factors affect streamflow in the RGB, including reservoir releases, climatic cycles, stream diversions, and groundwater levels. The Sacramento River and its major tributaries flow year-round and can provide a source of recharge to the aquifer system. Many of the smaller tributaries have significantly reduced streamflow (and in some instances go dry) during the summer and fall, particularly during drought conditions.

3.1.1.2 Hydrogeology

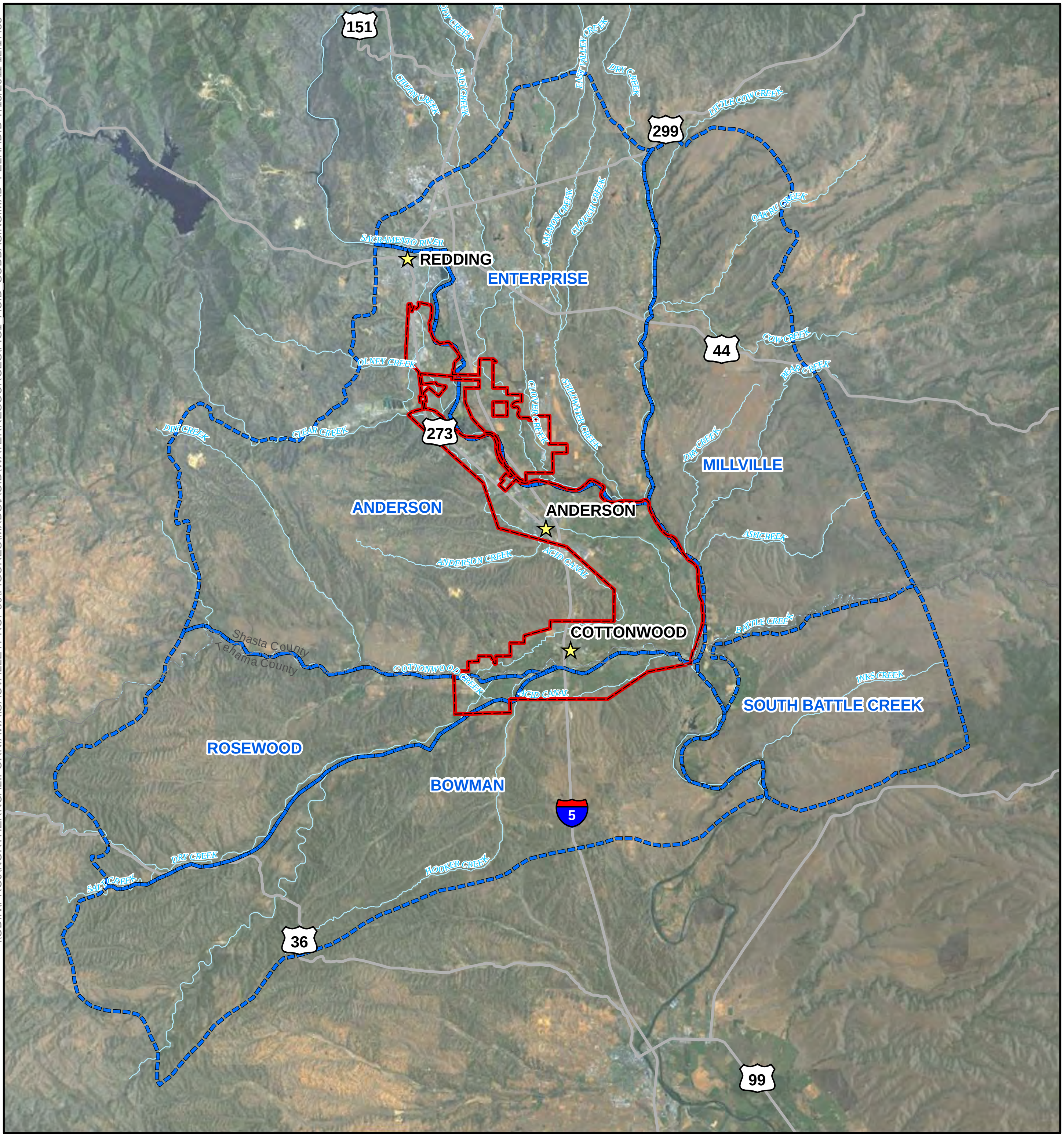
The RGB consists of a sediment-filled, southward-plunging, symmetrical trough (DWR, 2003a). Simultaneous deposition of material from the Coast Range and the Cascade Range created two different formations, which are the principal freshwater-bearing formations in the basin. In the east, the Tuscan Formation is derived from Cascade Range volcanic sediments, and the Tehama Formation, in the western and northwest portion of the basin, is derived from Klamath Mountains and Coast Range sediments. These permeable formations are up to 2,000 feet thick near the confluence of the Sacramento River and Cottonwood Creek, resulting in a productive aquifer in this area. The Tuscan Formation is generally more permeable and productive than the Tehama Formation (DWR, 2003a).

The ACID service area lies predominantly within the Anderson Subbasin in the west-central portion of the RGB. Smaller portions of the service area are located in the Enterprise, Rosewood, and Bowman Subbasins. Groundwater in the Anderson Subbasin recharges through deep percolation of applied water and precipitation, infiltration from surface water bodies, and lateral inflow along the subbasin boundaries. Under current conditions, most of the groundwater system near the proposed action is generally within about 65 feet of the land surface (DWR, 2003d). Most of the Anderson Subbasin’s groundwater system is full and discharges excess groundwater to streams. The saturated thickness of permeable sediments in the vicinity of the proposed ACID production wells is estimated at more than 1,000 feet, which results in the area being quite productive. Seasonally, groundwater levels typically decline during the hot, dry summer months when regional groundwater production occurs at its seasonal maximum, but these levels recover annually during the wet season. California has experienced a variety of climate conditions since 1970, including a critical drought during 1976 and 1977, and a 6-year drought from approximately 1987 through 1992. Groundwater elevations in the Anderson Subbasin declined slightly during these droughts, but recovered during subsequent above normal and wet water years (DWR, 2003c). Overall, there does not appear to be any long-term increasing or decreasing trends in groundwater levels.

The nature of surface water-groundwater interaction across the RGB is complex, both spatially and temporally, but in most areas shallow groundwater levels lead to groundwater discharge to surface streams. During pronounced drought conditions, groundwater levels may decline to a level such that streams that formerly gained streamflow from groundwater discharge now recharge the groundwater system through streambed infiltration. If streams dry up (either seasonally or during drought conditions) they would no longer provide a source of recharge to the underlying aquifer system.

3.1.1.3 Water Use

Municipal, industrial, and agricultural water demands in the larger Sacramento River Hydrologic Region, that encompasses the RGB, are approximately 8 million ac-ft (DWR, 2003b). Major water supplies in the hydrologic region are provided through surface



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LEGEND

- CITY
- STREAM/CANAL LOCATION
- ACID SERVICE AREA
- GROUNDWATER SUBBASIN

0 5 10 Miles

N

NOTE:

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE 3-1
REDDING GROUNDWATER BASIN SUBBASIN LOCATION MAP
EA/IS AND FONSI/MND FOR
ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

CH2MHILL

storage reservoirs. Within the project area, the primary source of water supply occurs in Reclamation's Shasta Reservoir (Central Valley Project facility) on the upper Sacramento River. Groundwater is also a major source of water supply in the hydrologic region. The exact quantity of groundwater that is pumped from the RGB is unknown; however, it is estimated that approximately 50,000 ac-ft of water is pumped annually from domestic, municipal, industrial, and agricultural production wells (CH2M HILL, 2003). This magnitude of pumping represents approximately 6 percent of the average annual runoff (850,000 ac-ft) in the basin. Agricultural, industrial, and municipal groundwater users in the RGB pump primarily from deeper continental deposits; whereas, domestic groundwater users in the basin generally pump from shallower deposits.

A DWR well survey reported yields for seven wells within the ACID service area of 300 gpm or less, but two wells yielding over 1,800 gpm have been recorded (DWR, 2003a). Municipal, industrial, and irrigation wells range in total depth from 50 to 550 feet below ground surface (bgs), averaging approximately 230 feet bgs. Domestic wells in the ACID service area range in total depth from 20 to 683 feet bgs, averaging 95 feet bgs. Seasonal fluctuations in groundwater levels are generally less than 5 feet and can be up to 16 feet during drought years.

3.1.1.4 Land Subsidence

Land subsidence is the decline in ground-surface elevation resulting from natural forces (such as earthquakes) and anthropogenic activities (for example, groundwater, oil, and gas extraction). Land subsidence can be elastic (temporary compaction of subsurface material that rebounds as groundwater levels recover) or inelastic (permanent compaction of subsurface material). Land subsidence has never been monitored in the RGB, but is expected to be small, given the lack of chronically depressed groundwater levels and because the current magnitude of groundwater pumping in the basin represents a very small fraction of the amount of water available for groundwater recharge.

3.1.1.5 Groundwater Quality

DWR monitors groundwater quality in seven wells throughout the ACID service area, located in the Anderson and Enterprise Subbasins (DWR, 2003a). The overall groundwater quality of those wells is considered good; no areas of poor groundwater quality have been identified in the vicinity of the proposed action.

3.1.2 Environmental Consequences

3.1.2.1 Environmental Measures Incorporated into the Project

Groundwater. See Section 2.3.2, Specific Actions to Minimize Potential Impacts on Groundwater Resources.

Surface Water. See Section 2.3.3, Specific Actions to Minimize Potential Impacts on Surface Water Resources.

3.1.2.2 Assessment Methods

Groundwater of economic importance moves through the subsurface from a place of groundwater recharge to a place of groundwater discharge. When a pump is operated and lifts water to the land surface through its riser pipe inside a groundwater well, it is removing groundwater from aquifer storage as well as intercepting groundwater that would have otherwise moved to a different place of groundwater discharge. Thus, groundwater temporarily discharged from a groundwater well is initially removed from storage in the aquifer, which is eventually balanced by a temporary loss of water from somewhere else. The decline in the water level inside the pumping well creates a hydraulic gradient (slope) toward the well within the surrounding groundwater system outside the well. This slope causes groundwater from the surrounding groundwater system to flow radially (laterally and vertically) to the well, resulting in a declining water table (unconfined aquifer) or potentiometric surface (confined aquifer) in the surrounding aquifer. The feature formed by the decline in surrounding groundwater levels from groundwater pumping is referred to as the cone of depression. Operation of existing production wells, located within the cone of depression of a proposed well and streams that overlie this cone of depression, have the potential to be adversely affected.

Potential effects on groundwater and surface water resources were forecast using a numerical groundwater flow model, known as the Redding Groundwater Basin Finite-Element Model (REDFEM) (Appendix D). REDFEM was developed using the MicroFEM (Hemker, 2011) modeling code, which is capable of simulating three-dimensional, transient, single-density groundwater flow in layered systems. REDFEM was developed specifically to evaluate potential effects on surface water and groundwater resources associated with proposed conjunctive water management projects across the basin.

REDFEM is composed of a groundwater model and a surface water budgeting module that computes the monthly agricultural pumping and groundwater recharge due to applied water and precipitation. The model is calibrated to groundwater levels measured in monitoring wells during a 10-year period (1999 through 2008). Forecasts of project-related effects use the same 10-year period along with an appended synthetic four-year climate cycle that includes a severe drought (see Appendix E). This approach allows for evaluation of the proposed project under a broad range of hydrologic conditions, because this predictive simulation period includes a variety of water-year[5] types, including a severe drought period and above normal, below normal, and wet years. Appendix D presents complete documentation of REDFEM. Appendix E provides a discussion of technical details associated with the proposed action simulations using REDFEM. Pre-existing municipal and industrial (M&I) production wells are typically spaced no closer than 0.25 mile near the proposed pumping locations. It is assumed in this evaluation that proposed well locations are also at least 0.25 mile from any active pre-existing M&I production wells. Therefore, the approach for forecasting groundwater-level impacts of the proposed action includes evaluating the incremental drawdown[6] at distances of 0.25 mile and greater from a proposed project well.

[5] A water year runs from October 1 of the previous calendar year through September 30 of the current calendar year (for example, water year 1976 includes October 1, 1975 through September 30, 1976).

[6] For the purpose of this evaluation, “incremental drawdown” was computed through the following method: A SACFEM simulation was initially conducted during water years 1970 through 2003 simulation period and referred to as the baseline simulation. A project simulation was then conducted with the baseline model, but with the proposed project pumping added at the appropriate monthly rates, locations, and depths. The incremental drawdown was then computed by subtracting the project groundwater levels from baseline groundwater levels at each model node and for each month during water years 1970 through 2003 simulation period. Forecasting groundwater-level-related impacts in this manner facilitates assessment of incremental project-related impacts on groundwater and surface water resources with consideration of dynamic hydrologic conditions (such as droughts and wet periods).

Operation of the proposed action could also result in reduced streamflow by increasing streambed infiltration, intercepting groundwater that would have otherwise discharged to surface water bodies, or some combination thereof. Streams with the greatest potential impact were identified by delineating areas with forecast incremental drawdowns in the shallow aquifer of 1 foot or greater due to implementation of the proposed action. Available historical streamflow data were obtained for streams located within these areas and compared with simulated streamflow depletions to assess the potential magnitude of streamflow effects.

3.1.2.3 No Action

ACID would continue to operate under the provisions of its contract with Reclamation and face cutbacks of up to 25 percent of its base and project water supply during critically dry water years. However, as water shortages occur, ACID anticipates that groundwater pumping would increase both within the District’s service area and in adjacent areas to meet future water demands. Groundwater provides approximately 10 percent of the overall supply required to meet the RGB water purveyor demands (CH2M HILL, 2003). Overall, municipal and industrial water demand (including groundwater use) is assumed to increase with urban and industrial basin growth and development. Agricultural water use within the RGB is anticipated to remain generally flat through 2030 (CH2M HILL, 2003). Groundwater pumping within the basin is assumed to increase in both non-critical and dry years by nearly two-fold and three-fold, respectively, to meet the basin’s water demand (CH2M HILL, 2007). Groundwater is projected to supply approximately 20 percent of the basin’s total water demand in 2030 (CH2M HILL, 2007).

3.1.2.4 Proposed Action

Construction. Effects on surface water quality could occur during the construction phase of the proposed action because of stockpile erosion and spoil piles, which, if not properly placed and managed, could result in sedimentation and associated effects on water quality. Prior to construction activities commencing, the contractor would develop and implement an SWPPP to reduce sediment discharged from the site. Implementing the SWPPP, in conjunction with the use of BMPs (as outlined in Section 2.3.3 of the proposed action), would reduce potential effects on surface water quality, thus resulting in no adverse effects from construction activities.

No effects on local groundwater levels are anticipated as part of the well drilling and installation process.

Operation.

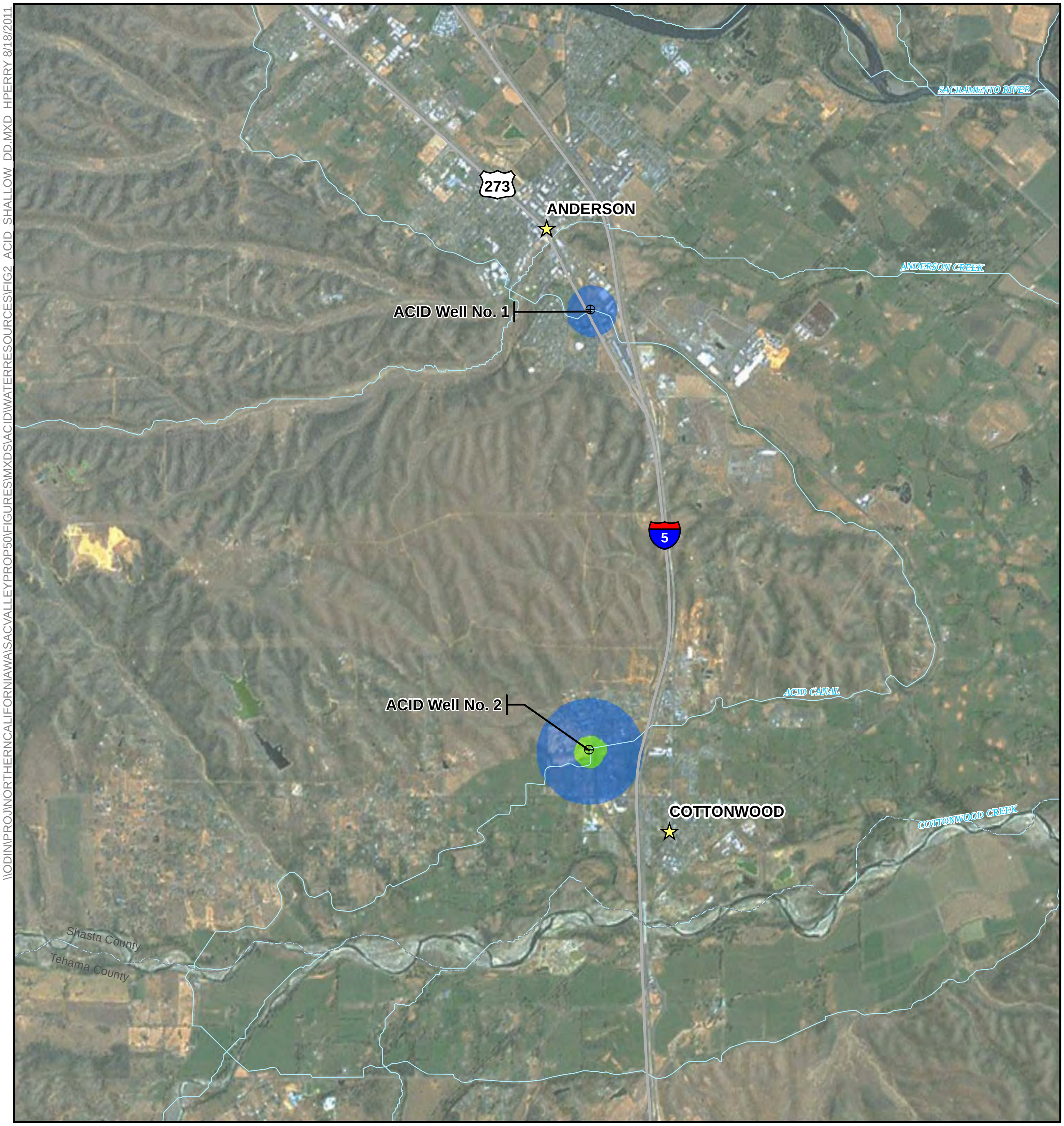
Groundwater. Model simulations were performed to forecast potential effects that could result from implementing the proposed action. The ACID project would include annual groundwater production from June 1 through October 31 from proposed Well No. 2 during noncritical water years. The project would include groundwater production from April 1 through October 1 from both wells during critical water years. The assumed total project volume ranges from approximately 2,400 ac-ft per year during noncritical water years to 6,600 ac-ft per year during critical water years (proposed annual pumping rate of 3,500 gpm apportioned over the 153- to 214-day pumping period). Model results were used to forecast the incremental drawdown that could occur in both the shallow (upper 50 feet of the unconfined aquifer associated with typical domestic well depths) and regional (depth interval associated with the majority of groundwater production) aquifers. It was assumed that the ACID proposed wells would pump groundwater from a depth interval of nominally less than 500 feet bgs, which is similar to the pumping intervals associated with typical area wells. As discussed in Section 3.1.2.2, there are no known M&I wells located within 0.25 mile from the proposed ACID production wells.

Figure 3-2 presents the forecast maximum incremental drawdown in the shallow aquifer that occurs at the end of the pumping period during the final year of the predictive simulation period, corresponding to the end of a 2-year critical drought (consistent with the 1976 to 1977 period). Figure 3-2 displays the anticipated incremental drawdown of 5 feet or greater associated with each well. The maximum incremental drawdown forecast at 0.25 mile from ACID Well No. 1 is 4.5 feet and is forecast to dissipate to less than 3 feet within 0.5 mile of the well. The maximum incremental drawdown forecast at 0.25 mile from ACID Well No. 2 is 7 feet and is projected to dissipate to 4 feet within 0.5 mile of the well.

Figure 3-3 presents the distribution of forecast incremental drawdown resulting from project implementation in the regional aquifer at the end of a 2-year critical drought. A maximum incremental drawdown of approximately 4.6 feet is forecast at 0.25 mile from ACID Well No. 1 and is forecast to dissipate to less than 3 feet within 0.5 mile of the well. At 0.25 mile from ACID Well No. 2, the maximum incremental drawdown forecast is 7 feet and is projected to dissipate to 4 feet within 0.5 mile of the well.

The magnitude of forecast effects on shallow and regional groundwater levels is projected to be less than significant. Additionally, groundwater elevations would return to pre-project levels, because the subbasin would refill each spring, except possibly during multi-year droughts.

Projected increases in M&I groundwater pumping are assumed to remain concentrated in the City of Redding's well fields (the largest urban area in the RGB). These wells are located approximately 5 miles or more from the proposed ACID wells. Additionally, the ACID project wells would be located in highly transmissive areas of the RGB that could accommodate increased groundwater pumping with limited additional drawdown in groundwater levels. As previously described, the saturated thickness of permeable sediments near the proposed ACID production wells is estimated at more than 1,000 feet, resulting in a productive aquifer. Incremental drawdowns of no more than tens of feet resulting from project implementation would not significantly reduce the overall aquifer system productivity. Wells currently operated by the City of Anderson are also located at a sufficient distance from the proposed project wells, such that desired increases in groundwater pumping by the City of Anderson should not be affected by the operation of the proposed ACID wells. The extent and magnitude of the incremental impact on groundwater levels due to the proposed action during the year 2030 would likely be similar to the impact on current conditions. Because of the limited areal extent and magnitude of forecast incremental drawdown, the proposed action would not have an adverse effect on local groundwater levels or existing users within the RGB.



LEGEND

☆ CITY

⊕ PROPOSED PRODUCTION WELL

STREAM/CANAL LOCATION

INCREMENTAL DRAWDOWN (feet)

- 5 to 10
- 10 to 15
- 15 to 20
- 20 to 30

NOTE:
SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

N

0 1 Miles

FIGURE 3-2
FORECAST SHALLOW AQUIFER DRAWDOWN
EA/IS AND FONSI/MND FOR
ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

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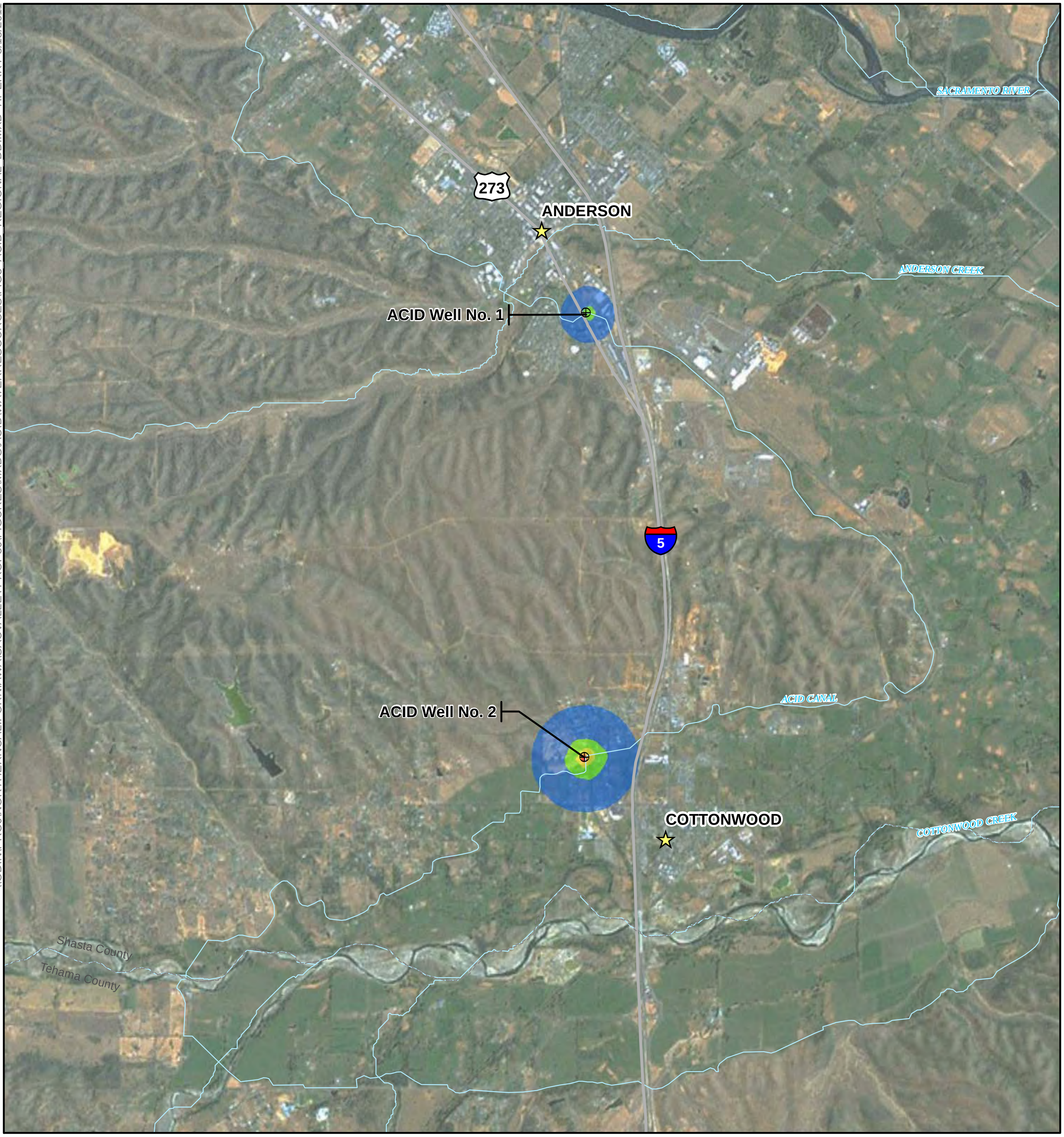

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LEGEND

- ☆ CITY
- ⊕ PROPOSED PRODUCTION WELL
- STREAM/CANAL LOCATION

INCREMENTAL DRAWDOWN (feet)

- 5 to 10
- 10 to 15
- 15 to 20
- 20 to 30

NOTE:
SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

Miles
0 1

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FIGURE 3-3
FORECAST REGIONAL AQUIFER DRAWDOWN
EA/IS AND FONSI/MND FOR
ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

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Surface Water. Model results were used to forecast the stream effects that could occur in response to operation of the proposed action. The only streams located within the area of forecast incremental drawdown of 1 foot or greater in the shallow aquifer were Cottonwood Creek and Anderson Creek. Although this magnitude of forecast incremental drawdown does not extend beneath the Sacramento River, it is the primary drainage within the RGB and was included in the effect analysis. A time series of measured streamflow data for Anderson Creek is unavailable; therefore, potential effects on this stream were not estimated. According to REDFEM, peak streamflow reductions would represent less than 2 percent of the total streamflow measured within the Sacramento River and Cottonwood Creek. This percent-reduction forecast represents a small fraction of the total streamflows and is anticipated have no adverse effects to streamflow within the project area.

REDFEM was not configured to forecast impacts on the ACID main canal. Main canal seepage is specified on a monthly basis (see Appendix D). As a result, canal seepage does not increase in response to declining groundwater levels in the model. This approach is conservative in terms of forecast groundwater-level impacts, because it may overestimate the decline in groundwater levels from proposed pumping. Where the ACID main canal is in contact with the water table, more seepage would occur in response to declining groundwater levels, thereby reducing the amount of groundwater-level decline. A smaller decline in groundwater levels would also result in less forecast impact on nearby streams.

Land Subsidence. The proposed action would not cause a permanent lowering of groundwater levels, because the subbasin would refill each spring, with the possible exception of multi-year droughts. Given the forecast minimal drawdown effects, no inelastic land subsidence is anticipated.

Groundwater Quality. Implementation of the proposed action would not result in regional changes in groundwater flow patterns in the RGB. It is not anticipated that operation of the project wells would alter the pre-existing distribution of groundwater quality in the RGB; therefore, project operations would have no adverse effects on groundwater quality.

3.1.2.5 Cumulative Effects

No substantial cumulative effects on water resources are anticipated, given the lack of other known groundwater development projects anticipated within the project vicinity. Additionally, minimal effects on water resources are expected from the implementation of the proposed action, and would not cause a cumulatively considerable effect on existing groundwater and surface water users.

3.2 Land Use/Agricultural Resources

3.2.1 Affected Environment

ACID's service area encompasses approximately 32,000 acres and extends south from the City of Redding in Shasta County to northern Tehama County, encompassing the City of Anderson and the town of Cottonwood. Although approximately 90 percent of ACID's customers irrigate pasture for haying or livestock, some orchard and field crops are also grown.

3.2.1.1 Shasta County

In 2010, Shasta County had a population of 177,223 (California Department of Finance [DOF], 2011). Forecasts show that by the year 2030, Shasta County's population will reach approximately 260,179 (DOF, 2010a). Of the 1,021,213 acres mapped in Shasta County in 2006, 435,343 acres were used for agriculture; 36,525 acres were urbanized; 5,875 acres were water; and 543,470 acres were used for other purposes (California Department of Conservation [CDC], 2010a). During the past few decades, the number of farms in the county has increased, but the average farm size has decreased. With an increasing population trend in the county, farmland is anticipated to be converted to urban uses over the next several decades. Tables 3-1 and 3-2 show the land use summary and change by land use category and the 2004 to 2006 land use conversion for Shasta County.

TABLE 3-1
Shasta County Land Use Summary and Change by Land Use Category

Land Use Category	Total Acreage Inventoried		2004 to 2006 Acreage Changes			
	2004	2006	Acres Lost (-)	Acres Gained (+)	Total Acreage Changed	Net Acreage Changed
Prime Farmland	14,846	13,282	1,739	175	1,914	-1,564
Farmland of Statewide Importance	4,058	3,444	658	44	702	-614
Unique Farmland	763	488	286	11	297	-275
Farmland of Local Importance	9,171	8,513	823	165	988	-658
Important Farmland Subtotal	**28,838**	**25,727**	**3,506**	**395**	**3,901**	**-3,111**
Grazing Land	408,927	409,616	2,072	2,761	4,833	689
Agricultural Land Subtotal	**437,765**	**435,343**	**5,578**	**3,156**	**8,734**	**-2,422**
Urban and Built-up Land	35,524	36,525	699	1,700	2,399	1,001
Other Land	542,049	543,470	1,754	3,175	4,929	1,421
Water Area	5,875	5,875	0	0	0	0
Total Area Inventoried	**1,021,213**	**1,021,213**	**8,031**	**8,031**	**16,062**	**0**

Source: CDC, 2010a.

The total acreage in Shasta County designated as Prime Farmland is 13,282 acres, which is less than 2 percent of the total county acreage. Prime Farmland decreased by 1,564 acres from 2004 to 2006. Farmland designated as Local Importance in Shasta County includes farmland that is irrigated but does not meet the soil characteristics of Prime or Statewide Importance (CDC, 2010a).

TABLE 3-2
Shasta County Land Use Acreage Conversion from 2004 to 2006

Land Use Category		Prime Farmland	Farmland of Statewide Importance	Unique Farmland	Farmland of Local Importance	Subtotal Important Farmland	Grazing Land	Total Agricultural Land	Urban and Built-up Land	Other Land	Water Area	Total Converted to Another Use
Prime Farmland [a]	to:	--	1	2	71	74	1,339	1,413	67	259	0	1,739
Farmland of Statewide Importance	to:	3	--	0	1	4	501	505	7	146	0	658
Unique Farmland	to:	2	1	--	42	45	204	249	1	36	0	286
Farmland of Local Importance	to:	17	2	8	--	27	503	530	8	285	0	823
Important Farmland Subtotal		**22**	**4**	**10**	**114**	**150**	**2,547**	**2,697**	**83**	**726**	**0**	**3,506**
Grazing Land[b]	to:	65	3	1	37	106	--	106	119	1,847	0	2,072
Agricultural Land Subtotal		87	7	11	151	256	2,547	2,803	202	2,573	0	5,578
Urban and Built-up Land[c]	to:	31	0	0	1	32	65	97	--	602	0	699
Other Land	to:	57	37	0	13	107	149	256	1,498	--	0	1,754
Water Area	to:	0	0	0	0	0	0	0	0	0	--	0
Total Acreage Converted	**to:**	**175**	**44**	**11**	**165**	**395**	**2,761**	**3,156**	**1,700**	**3,175**	**0**	**8,031**

[a]Conversion to Grazing Land primarily because of land left idle for three or more updated cycles.

[b]Conversion to Other Land primarily because of the delineation of low-density housing, primarily in rural areas of the county.

[c]Conversion from Urban and Built-up Land primarily resulting from the use of detailed digital imagery to delineate more distinct urban boundaries.

Source: CDC, 2010a.

3.2.1.2 Tehama County

In 2010, Tehama County had a population of 63,463 (DOF, 2011). Forecasts show that by the year 2030, Tehama County's population will reach approximately 93,477 (DOF, 2010a). Of the 1,839,494 acres mapped in Tehama County in 2006, 1,781,608 were used for agriculture; 13,254 acres were urbanized; 6,181 acres were water; and 38,449 acres were used for other purposes (CDC, 2010a).

Tehama County's Prime Farmland decreased from 64,788 acres in 2004 to 63,707 acres in 2006. Prime Farmland accounts for approximately 3.5 percent of the total county acreage. Farmland of Local Importance includes land not included in Prime, Statewide Importance, or Unique Farmland that is cropped continuously or on a cyclic basis; and nonirrigated land that has soil mapping units listed for Prime Farmland or Statewide Importance. Tables 3-3 and 3-4 show the 2004 to 2006 land use summary and change by land use category, and the land use conversion for Tehama County.

TABLE 3-3
Tehama County Land Use Summary and Change by Land Use Category

			2004 to 2006 Acreage Changes			
	Total Acreage Inventoried					
Land Use Category	**2004**	**2006**	**Acres Lost (-)**	**Acres Gained (+)**	**Total Acreage Changed**	**Net Acreage Changed**
Prime Farmland	64,788	63,707	2,065	984	3,049	-1,081
Farmland of Statewide Importance	17,336	17,284	497	445	942	-52
Unique Farmland	18,773	18,085	877	189	1,066	-688
Farmland of Local Importance	131,842	132,437	2,368	2,963	5,331	595
Important Farmland Subtotal	**232,739**	**231,513**	**5,807**	**4,581**	**10,388**	**-1,226**
Grazing Land	1,549,708	1,550,095	645	1,032	1,677	387
Agricultural Land Subtotal	**1,782,447**	**1,781,608**	**6,452**	**5,613**	**12,065**	**-839**
Urban and Built-up Land	12,939	13,254	39	354	393	315
Other Land	37,883	38,449	397	963	1,360	566
Water Area	6,223	6,181	45	3	48	-42
Total Area Inventoried	**1,839,492**	**1,839,492**	**6,933**	**6,933**	**13,866**	**0**

Source: CDC, 2010a.

TABLE 3-4
Tehama County Land Use Acreage Conversion from 2004 to 2006

Land Use Category		Prime Farmland	Farmland of Statewide Importance	Unique Farmland	Farmland of Local Importance	Subtotal Important Farmland	Grazing Land	Total Agricultural Land	Urban and Built-up Land	Other Land	Water Area	Total Converted to Another Use
Prime Farmland	to:	--	5	11	1,928	1,944[a]	11	1,955	48	62	0	2,065
Farmland of Statewide Importance	to:	7	--	1	465	473	1	474	0	23	0	497
Unique Farmland	to:	5	0	--	317	322	472	794	6	77	0	877
Farmland of Local Importance	to:	920	382	30	--	1,332	433	1,765	131	469	3	2,368
Important Farmland Subtotal		**932**	**387**	**42**	**2,710**	**4,071**	**917**	**4,988**	**185**	**631**	**3**	**5,807**
Grazing Land	to:	4	0	99	144	247	--	247	69	329	0	645
Agricultural Land Subtotal		936	387	141	2,854	4,318	917	5,235	254	960	3	6,452
Urban and Built-up Land	to:	4	0	0	6	10	26	36	--	3	0	39
Other Land	to:	44	58	48	100	250	47	297	100	--	0	397
Water Area	to:	0	0	0	3	3	42	45	0	0	--	45
Total Acreage Converted	**to:**	**984**	**445**	**189**	**2,963**	**4,581**	**1,032**	**5,613**	**354**	**963**	**3**	**6,933**

[a]Conversions to Farmland of Local Importance are primarily caused by land left idle for three or more update cycles.

Source: CDC, 2010a.

3.2.1.3 Well No. 1

Proposed Well No. 1 is located in the City of Anderson, in Shasta County, California. As established by the City of Anderson Planning Department, land use on the project site is designated as Public/Semi-Public. Public/Semi-Public allows for project uses such as park and recreation facilities or public parking lots. The project site is bounded on the east by the Interstate 5 off-ramp and on the west by the ACID canal. Deschutes Road is south of the project site, and directly south of the road is a shopping center zoned for general commercial uses by the City of Anderson. North of the project site is industrial property zoned for light industrial uses by the City of Anderson. The project site and surrounding areas are designated as “Urban and Built-up Land” by the CDC, Division of Land Resource Protection (CDC, 2011).

3.2.1.4 Well No. 2

Proposed Well No. 2 is located approximately 0.5 mile northwest of the town of Cottonwood in Shasta County, California. The project location is bounded on the north, west, and south by rural residential properties and on the east by the ACID canal. As established by Shasta County Planning Department, the zoning for the project site and surrounding properties is designated as R-1-B-15. R-1 is defined as “One-family Residential,” with a minimum lot size of 15,000 square feet. The project site and surrounding areas are designated as “Other Land” by the CDC, Division of Land Resource Protection (CDC, 2011).

3.2.2 Environmental Consequences

3.2.2.1 Environmental Measures Incorporated into the Project

See Section 2.3.4, Specific Actions to Minimize Potential Impacts on Land Use.

3.2.2.2 No Action

Under the no action alternative, ACID would continue to implement its current water management program. Surrounding land uses would remain consistent with current uses, and land uses within the ACID service area would continue to adjust according to water availability within the District. Land use in the Redding Basin subarea is anticipated to experience the greatest amount of change within Shasta County by 2030, with population projected to increase by approximately 43 percent from 2004 levels (DOF, 2004). The population centers of Redding, Anderson, Shasta Lake City, and the town of Cottonwood would continue to expand, and land would be developed for urban uses. Future non-agricultural development within Tehama County and the general ACID service territory is anticipated to be limited to residential growth in the Bowman area near the community of Cottonwood (NCWA et al., 2006).

3.2.2.3 Proposed Action

Construction. No land use impacts would result from the construction of the proposed action. The proposed well locations are both unoccupied, and neither site is currently in use for agricultural purposes. No other projects are anticipated on these project locations within the near future, and construction would not hinder the existing or planned use of either project site.

Operation. Operation of the proposed action would not conflict with existing land use designations and would have no effect on existing land use. The proposed action would be implemented to maintain existing agricultural land uses within the surrounding ACID service area; therefore, resulting in a minor beneficial effect on existing land uses and agricultural resources.

3.2.2.4 Cumulative Effects

No substantial cumulative effects on land use or agricultural resources are anticipated with this project.

3.3 Biological Resources

3.3.1 Affected Environment

A reconnaissance-level field survey was conducted on February 15, 2011, to characterize the project locations to assess the potential for wildlife occurrence. During the field reconnaissance, information on the biological resources such as dominant vegetation type, bird species present, and overall site conditions was noted. The results of the survey are summarized below and provided in Appendix B, *Biological Site Assessment for Groundwater Production Wells No. 1 and 2, Anderson-Cottonwood Irrigation District*. Additional information used to prepare this document includes review of aerial photographs; CDFG California Natural Diversity Database (CNDDB) search results; CNDDB, California Native Plant Society (CNPS), and U.S. Fish and Wildlife Service (USFWS) species lists; and historical documents for the area. Figures 3-4 and 3-5 list the species identified within each project area.

A description of biological resources, special-status species, and sensitive habitat observed during the field reconnaissance survey, and species potentially occurring in the project area is presented below.

3.3.1.1 Flora

Well No. 1. Annual ruderal, routinely disturbed grassland habitat occurs throughout the project area and along the ACID main canal. Within the project area, vegetation appears to be routinely disturbed by ACID activities (such as, dirt/rock and stockpile movement, equipment usage, and mowing). Much of the site is a stockpile of rock, dirt, and other construction debris generated by ACID projects in the region. The ruderal vegetation is characterized by non-native annual vegetation such as ripgut brome *(Bromus diandrus)*, soft chess *(Bromus hordeaceus)*, rat-tail fescue *(Vulpia myuros)*, storksbill (*Erodium botrys*), and yellow star-thistle *(Centaurea solstitialis)*. A large valley oak *(Quercus lobata)* is in the northeast corner of the project area. Attachment B3 (Table B3-1) to Appendix B lists the plant species observed within the project area.

Well No. 2. Annual ruderal grassland habitat occurs throughout the project area and along the ACID main canal. Vegetation is routinely sprayed or mowed within much of the project area. The ruderal grassland community is characterized by non-native annual vegetation such as ripgut brome, soft chess, rat-tail fescue, and yellow star-thistle. Interior live oaks *(Quercus wislizenii)* are scattered throughout the southern portion of the property.

Vegetation associated with the residential properties consists of horticultural plants such as pines *(Pinus* spp.*)* and American privet *(Ligustrum* sp.*)*. East of the project site, riparian vegetation along Crowley Gulch is dominant and characterized by Fremont cottonwoods *(Populus fremontii)* and Gooding's willow *(Salix goodingii)* in the overstory with an understory dominated by Himalayan blackberry *(Rubus discolor)* and scattered arroyo willow *(Salix lasiolepis)*. Attachment B3 (Table B3-1) to Appendix B lists the plant species observed within the project area.

3.3.1.2 Sensitive Habitats

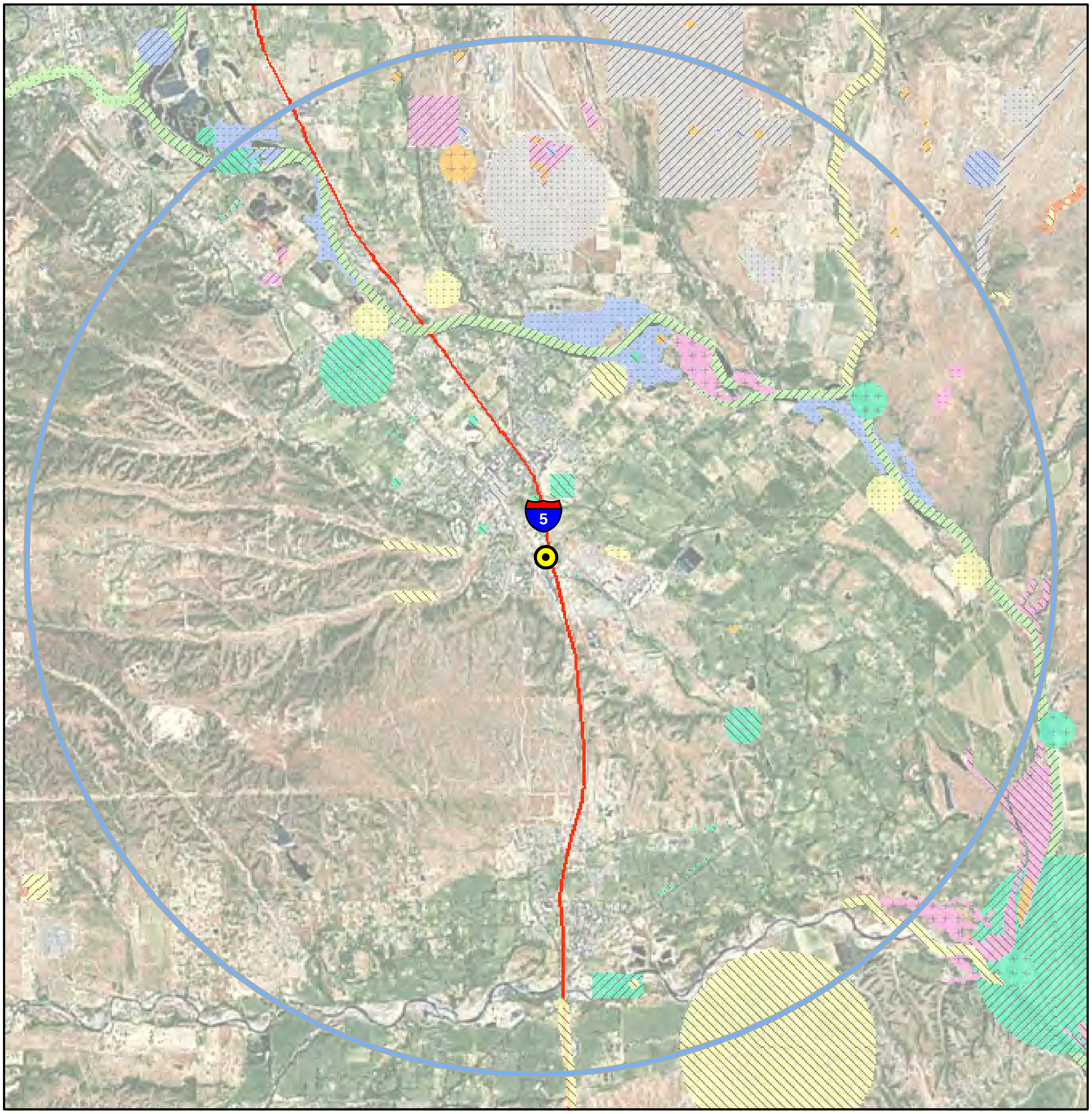
Well No. 1. No sensitive habitats were identified within the proposed Well No. 1 project area or adjacent areas that would be affected by the proposed work.

Well No. 2. The following sensitive habitats were observed at the proposed Well No. 2 project area:

- **Waters of the U.S.** – Crowley Gulch is mapped as an intermittent water feature on the USGS Cottonwood 7.5-minute quadrangle. The gulch is on the eastern edge of the study area and has a well-defined channel with steep banks. Large Fremont cottonwoods and dense Himalayan blackberry intermixed with small arroyo and Gooding's willows occur along the banks (see Attachment B1 to Appendix B). The substrate of the gulch contains a large amount of organic debris of wood and coarse plant material. The stream has an inorganic substrate of cobble (2.5 to 10 inches) and gravel (0.1 to 2.5 inches) under the organic material and exposed in various locations. Crowley Gulch is considered an arid ephemeral stream, flowing only during storm events and remaining dry for most of the year. The bed and banks within the Crowley Gulch are cleared of vegetation approximately 60 feet upstream and 120 feet downstream (see Attachment B1 to Appendix B). Crowley Gulch flows south to Cottonwood Creek approximately 1.25 river miles south of the project area.
- **Cottonwood-Willow Riparian Forest** – Riparian vegetation along Crowley Gulch is characterized by large, mature cottonwoods and Gooding's willow in the overstory with an understory dominated by Himalayan blackberry and scattered arroyo willow as shown in Attachment B1 to Appendix B.
- **Oak Woodlands and Other Native Hardwood Habitats** – A stand of interior live oak woodland is located south of the project site. A mixed stand of native oaks and non-native tree species are found east and south of the ACID main canal, across from the project site. Large, scattered valley oaks occur within and outside the project area. No large stick nests were observed in the canopies; however, small and medium-sized stick nests were present.

3.3.1.3 Fauna

Fauna species observed were limited for both proposed well sites, possibly due to weather conditions during the survey and lack of suitable habitat. Common species for this area consist of raccoon *(Procyon lotor)*, gray fox *(Urocyon cinereoargenteus)*, western scrub jay (*Aphelocoma californica)*, red-tailed hawk *(Buteo jamaicensis)*, coyote *(Canis latrans*), and yellow-rumped warbler *(Dendroica coronata).* Attachment B3 (Table B3-2) to Appendix B lists the wildlife species observed within the project area.



LEGEND

PRODUCTION WELL

5-MILE BUFFER

CALIFORNIA NATURAL DIVERSITY DATABASE

- Ahart's paronychia
- California linderiella
- Great Valley Cottonwood Riparian Forest
- Great Valley Mixed Riparian Forest
- Great Valley Valley Oak Riparian Forest
- Great Valley Willow Scrub
- Henderson's bent grass
- Red Bluff dwarf rush
- Yuma myotis
- bald eagle
- bank swallow
- brown fox sedge
- Chinook salmon - Central Valley spring-run ESU
- Chinook salmon - Sacramento River winter-run ESU
- hoary bat
- legenere
- osprey
- pink creamsacs
- pointed broom sedge
- silky cryptantha
- silver-haired bat
- slender Orcutt grass
- tricolored blackbird
- valley elderberry longhorn beetle
- vernal pool fairy shrimp
- vernal pool tadpole shrimp
- western pond turtle
- western red bat
- woolly meadowfoam

NOTE:
ESU = EVOLUTIONARY SIGNIFICANT UNIT

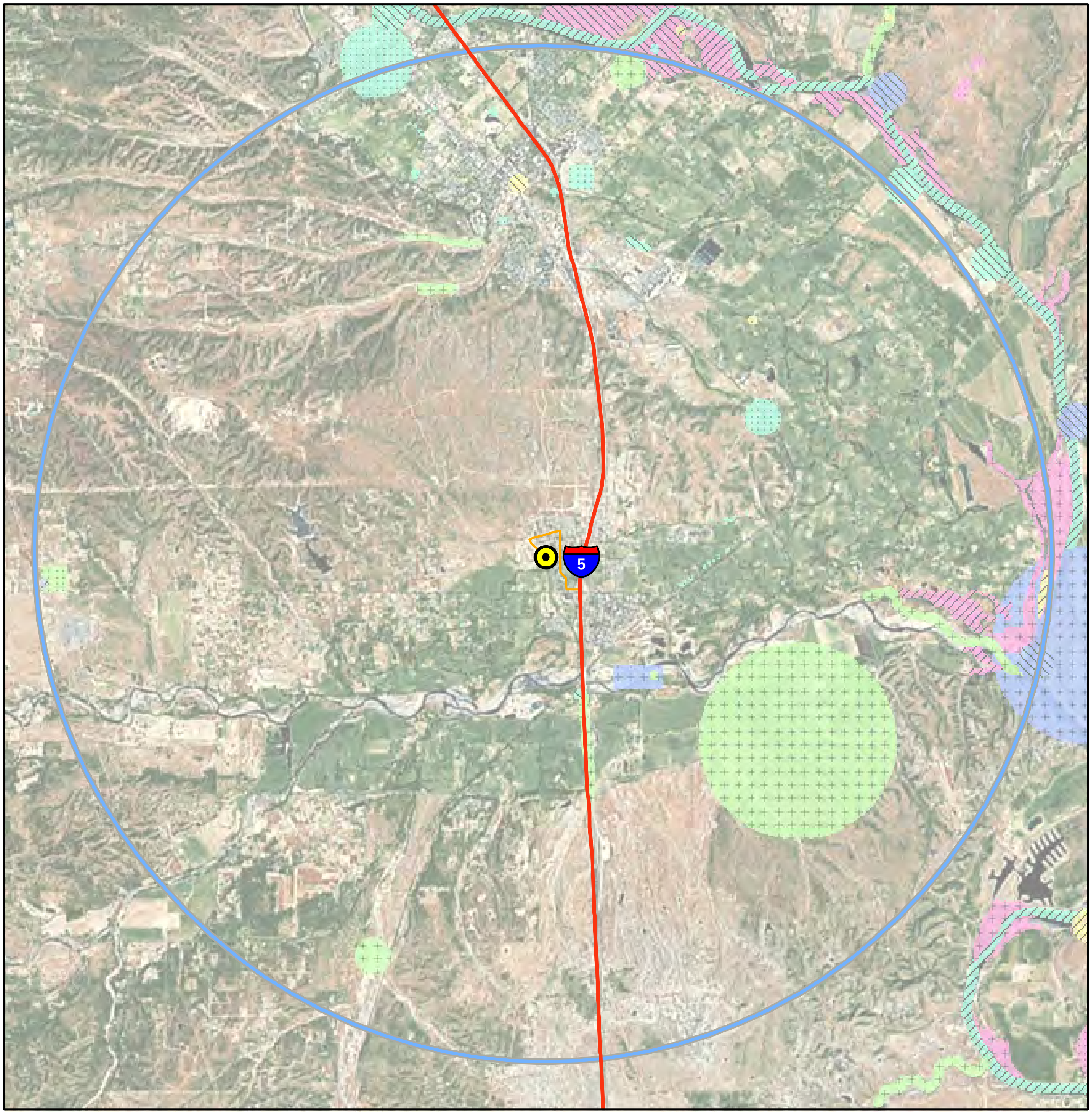
N

0 8,500
Feet

FIGURE 3-4
WELL No. 1 BIOLOGICAL RESOURCES

EA/IS AND FONSI/MND FOR ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

CH2MHILL



LEGEND

- PRODUCTION WELL
- ACCESS ROAD
- 5-MILE BUFFER

CALIFORNIA NATURAL DIVERSITY DATABASE

- Ahart's paronychia
- Great Valley Cottonwood Riparian Forest
- Great Valley Mixed Riparian Forest
- Great Valley Valley Oak Riparian Forest
- Red Bluff dwarf rush
- Yuma myotis
- bald eagle
- bank swallow
- brown fox sedge
- Chinook salmon - Sacramento River winter-run ESU
- hoary bat
- osprey
- pink creamsacs
- pointed broom sedge
- silky cryptantha
- silver-haired bat
- tricolored blackbird
- valley elderberry longhorn beetle
- western pond turtle
- western red bat
- western spadefoot
- woolly meadowfoam

N

0 8,500
Feet

NOTE: ESU = EVOLUTIONARY SIGNIFICATN UNIT

FIGURE 3-5
WELL No. 2 BIOLOGICAL RESOURCES

EA/IS AND FONSI/MND FOR ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

CH2MHILL

3.3.1.4 Special-status Species

Special-status species potentially occurring in the project area were identified through a site assessment conducted on February 15, 2011, review of aerial photographs, CNDDB search results, CNPS and USFWS species lists, and historical documents for the area.

3.3.1.5 Rare Plants

Rare plants that have the potential to occur within the project area were identified using the CNDDB and CNPS database and are listed in Attachment B2 to Appendix B. Nine plant and one moss species were identified on the Cottonwood, Hooker, Balls Ferry, and Bend quadrangles. Five of the plant species are vernal pool endemics; these five species are not likely to occur, because neither proposed well site has vernal pools. No suitable habitat for the moss species occurs within the project area.

Although not observed during the site visit, the following four plant species have the potential to occur within Crowley Gulch or within the ACID main canal at both proposed well sites: Red Bluff dwarf rush (*Juncus leiospermus* var. *leiospermus)*, a CNPS 1b species; brown fox sedge (*Carex vulpinoidea)*, a CNPS 2 species; pointed broom sedge *(Carex scoparia),* a CNPS 2 species; and pink creamsacs *(Castilleja rubicundula ssp. Rubicundula),* a CNPS 1b species. CNPS status codes are defined in Attachment B2 (Table B2-1) to Appendix B. Red Bluff dwarf rush occurs in vernal pools, seeps, and meadows. Brown fox sedge occurs in freshwater marshes, swamps, and riparian woodlands. Pointed broom sedge occurs in meadows, stream banks, fens, and woodland edges. Pink creamsacs occurs in valley grasslands, cismontane woodlands, and seasonally wet soils in meadows, seeps, and grassland habitats.

3.3.1.6 Fishery Resources

Well No. 1. Because the well is not located next to any active waterways, no fishery resources would be affected by proposed Well No. 1.

Well No. 2. Crowley Gulch, near proposed Well No. 2, flows to Cottonwood Creek, which contains anadromous fish species. However, special-status fish species are not expected within the project area and would not be affected by the project.

3.3.1.7 Raptors and Migratory Birds

Both well sites were inspected for raptors and migratory birds and associated suitable nesting habitat. During the field visit, several raptor and migratory bird species were observed. However, the surveys occurred before the breeding season, so no active nests were observed. Several historical nest sites were observed within the woodland and riparian canopy near proposed Well No. 2 project area. Both well sites have the potential to support ground- and tree-nesting birds, such as killdeer (*Charadrius vociferus*) and red-tailed hawk during the breeding season.

3.3.1.8 Roosting Bats

Well No. 1. No roosting bats would be affected by proposed Well No. 1.

Well No. 2. Near the proposed Well No. 2 project area, an old wooden barn and old-growth cottonwoods could provide roosting sites for two special-status bat species identified in the

CNDDB search. The western red bat *(Lasiurus blossevillii)*, a California species of special concern, roosts in broad-leafed woodlands in riparian areas. The pallid bat *(Antrozous pallidus),* also a California species of special concern, roosts in buildings and caves. The western red bat could roost in the cottonwood riparian trees on the eastern edge of the site. The pallid bat could roost in the wooden barn within the project area. Under the proposed action configuration, Well No. 2 and the water conveyance line to the ACID canal would not affect the barn and cottonwood trees onsite.

3.3.2 Environmental Consequences

3.3.2.1 Environmental Measures Incorporated into the Projects

See Section 2.3.5, Specific Actions to Minimize Potential Impacts on Biological Resources.

3.3.2.2 No Action

Under the no action alternative, ACID would continue to implement its current water management program. Resulting effects on biological resources would be similar to what is presently occurring within the District.

3.3.2.3 Proposed Action

Construction. Construction activities would not result in effects on biological resources, sensitive species, or habitats at the proposed Well No. 1 location due to lack of habitat for any such species. Construction activities could result in effects on biological and special-status species at the proposed Well No. 2 location. If construction activities occur during the nesting season, construction of the proposed action could result in effects on nesting birds, such as red-tailed hawk, at the Well No. 2 location. Construction of Well No. 2 would commence during the non-breeding season for nesting birds (September 1 through February 14) to avoid potential effects on nesting birds.

No other listed species were observed within either project impact areas; therefore, no adverse effects on biological resources or sensitive species and habitat are anticipated.

Operation. There would be no effects on biological resources as a result of operational activities associated with this project.

3.3.2.4 Cumulative Effects

Once project construction is complete, and the site is restored, the well locations would appear largely unchanged from their existing conditions. No substantial cumulative effects on biological resources or sensitive species are anticipated, given no effects on these resources are expected from the implementation of the proposed action.

3.4 Cultural Resources

A cultural resource is a broad term that includes prehistoric, historic, architectural, and traditional cultural properties. The National Historic Preservation Act (NHPA) of 1966, as amended (16 United States Code 470 et seq.), is the primary federal legislation that outlines the federal government's responsibility to cultural resources. Section 106 of NHPA requires the federal government to consider the effects of an undertaking on cultural resources listed on, or eligible for inclusion in, the National Register of Historic Places (NRHP). Resources listed on, or eligible for inclusion in, the NRHP are referred to as historic properties.

The Section 106 process is outlined in the federal regulations (36 *Code of Federal Regulations* [CFR] Part 800). These regulations describe the process that Reclamation uses to identify cultural resources and the level of effect that the proposed undertaking would have on historic properties. Reclamation must first determine if the action is a type of action with the potential to affect historic properties; if so, Reclamation must identify the area of potential effects (APE), determine if historic properties are present within the APE, determine the effect the undertaking would have on historic properties, and consult with the State Historic Preservation Office (SHPO) to seek concurrence on the findings and determinations. Reclamation is also required through the Section 106 process to consult with American Indian Tribes (Tribes) concerning the identification of sites of religious or cultural significance and consult with individuals or groups entitled to be, or requesting to become, consulting parties.

3.4.1 Affected Environment

The general trend throughout California prehistory has been an increase in human population density over time, coupled with greater sedentism and the use of more diverse food resources. Several chronologies have been proposed for central California archaeology. The earliest sites in the Sacramento Valley are Fluted Point Tradition and Western Pluvial Lakes Tradition sites. These sites are few in number and remain undated by scientific means, but the artifact types indicate probable ages of 11,500 to 7,500 years old. Deposition in the Sacramento Valley is quite active; many older sites are likely buried under rapidly building alluvial deposits (Moratto, 1984). The Windmiller Pattern generally coincides with Fredrickson’s Early Horizon (1974), and the majority of the known Windmiller Pattern sites date to approximately 5,000 to 2,250 years ago. Windmiller Pattern sites are characterized by tools related to hunting, fishing, and milling, and include mortars, baked clay balls, trident fish spears, two types of angling hooks, pecan-sized baked clay objects (previously used as fish-line sinkers), bone awls and needles, polished charmstones, shell working and shell appliqué, and flaked tools including projectile points. The Berkeley Pattern roughly coincides with the Middle Horizon, and the majority of known Berkeley Pattern sites date to approximately 2,500 to 1,250 years ago. The Berkeley Pattern subsistence relied less on hunting and fishing than the Windmiller Pattern; rather, the focus appears to have been on acorns. The Augustine Pattern coincides approximately with the Late Horizon and generally dates from 1,250 to 250 years ago. Augustine Pattern sites are much more widespread than Berkeley Pattern sites and are characterized by intensive fishing, hunting, and acorn gathering. The Shasta Complex was defined on the basis of work conducted by Smith and Weymouth (1952) in the Shasta Dam area and is considered by some archaeologists to be the northern Sacramento Valley expression of the Augustine Pattern (probably representing the Wintu Indians).

Prior to the eighteenth century, the Central Valley supported extensive populations of Native Americans in the prehistoric period, one being the Bald Hills Wintu, whose traditional territory encompassed parts of present day Shasta, Tehama, Siskiyou, and Trinity Counties, including the upper Sacramento River, Beegum Creek, Cottonwood Creek, parts of the Trinity River, and Cow and Little Cow Creeks (CH2M HILL, 2011). The conversion of land and intensive farming practices in and around the APE over the last century has likely disturbed many Native American cultural sites as well as other cultural resources.

The present character of the APE and its surrounding area north of the town of Robbins seems to derive primarily from the development of agricultural, beginning with the Mexican land grants and progressing through the rural towns and farms of the early 1900s. One of the primary necessities for such development revolved around water, water rights, and the infrastructure to convey that water for the purpose of agricultural and residential development. ACID was formed under Division 11 of the California Water Code in 1914, and was one of the earliest irrigation districts organized in the Sacramento Valley. The ACID main canal was constructed between 1914 and 1918, although water was conveyed through the canal by 1917.

In an effort to identify historic properties, ACID contracted CH2M HILL to complete an inventory and evaluation of cultural resources within the APE. CH2M HILL requested a records search at the Northeast Information Center on February 3, 2011, which identified two previous studies that encompass the APE. No previously recorded resources were identified within the APE. A pedestrian survey of the APE was conducted on February 16, 2011, by CH2M HILL archaeologist Natalie Lawson. Two new cultural resources were identified within the APE: two segments of the ACID main canal and the Rolland Robinson residence (CH2M HILL, 2011).

The ACID main canal is approximately 35 miles long. Almost 98 percent of the canal is an unlined earthen structure. The main canal includes six inverted siphons to cross streams, such as Clear Creek; three flume sections across smaller streams and lowland areas; and an aqueduct at Anderson Gulch (designated as a Point of Historical Interest). The segments of the ACID main canal within the APE at both proposed well locations are unlined earthen structures. These two segments were recorded on Department of Parks and Recreation forms.

CH2M HILL applied the NRHP evaluation criteria (36 CFR Part 60.4) to the two segments of the ACID main canal located within the APE. As a whole, these two segments were determined to be eligible for listing on the NRHP as contributing elements of the ACID main canal under Criterion A for their association with the history of early settlement, ranching, and agriculture in Shasta County near the town of Cottonwood and City of Anderson.

The Rolland Robinson residence is 1.5 stories high on a raised foundation with a square footprint. This residence is located northwest of the town of Cottonwood, along the Cottonwood Canal. Archival research failed to identify an original permit for construction of this residence, information regarding the occupants, architects or builders of this property, or information regarding its original appearance. The house was recorded on Department of Parks and Recreation forms. Given that the house outside the area of direct impact for the proposed well construction project, this cultural resource was not evaluated for inclusion on the NRHP.

Reclamation identified the Enterprise Rancheria of Maidu Indians, Greenville Rancheria of Maidu Indians, Paskenta Band of Nomlaki Indians, and the Redding Rancheria as tribes who might attach religious and cultural significance to historic properties within the APE pursuant to the regulations in 36 CFR Part 800.3(f)(2). Reclamation sent letters to these tribes on July 27, 2011, to invite their assistance in identifying sites of religious and cultural significance pursuant to 36 CFR Part 800.4(a)(4).

Reclamation will consult with SHPO regarding this determination. Concurrence from the SHPO to conclude the Section 106 compliance process is pending.

3.4.2 Environmental Consequences

3.4.2.1 Environmental Measures Incorporated into the Projects

Preconstruction siting surveys were performed on February 15, 2011, to assure avoidance or minimization of impacts on cultural resources. A cultural resources investigation was conducted (CH2M HILL, 2011), and the results are summarized in Section 3.4.1. The cultural resources investigation report is a confidential report on file with Reclamation, and is available upon request.

3.4.2.2 No Action

Under the no action alternative, there would be no impacts on cultural resources because the well would not be constructed and there would be no change in operations. Conditions related to cultural resources would remain the same as existing conditions.

3.4.2.3 Proposed Action

The proposed action is the type of activity that has the potential to affect historic properties. A records search, a cultural resources survey, and Tribal consultation identified historic properties within the APE. All project activities would not adversely affect historic properties pursuant to 36 CFR Part 800.5(b). Constructing the proposed well and connecting the discharge pipeline to the ACID main canal would not diminish the structural integrity and would not adversely affect the historic characteristics that make the canal eligible for listing on the NRHP under Criterion A. The function of the canal would not change. Because no historic properties would be affected, no cultural resources would be affected as a result of implementing the proposed action. Concurrence from the SHPO to conclude the Section 106 compliance process is pending.

3.4.2.4 Cumulative Effects

The proposed action is the type of activity with potential to affect cultural resources. Reclamation determined that no historic properties would be affected; no cultural resources would be affected as a result of implementing the proposed action. Reclamation will consult with SHPO regarding this determination. The project will not be implemented until the Section 106 compliance process is complete.

3.5 American Indian Trust Assets

ITAs are legal interests in assets that are held in trust by the United States government for federally recognized Tribes or American Indian individuals. The trust relationship usually stems from a treaty, executive order, or act of Congress. The Secretary of the Interior is the trustee for the United States on behalf of federally recognized Tribes. “Assets” are anything owned that holds monetary value. “Legal interests” refers to a property interest for which there is a legal remedy (such as a compensation or injunction) if there is improper interference. Assets can be real property, physical assets, or intangible property rights (such as a lease or right to use something). ITAs cannot be sold, leased, or otherwise alienated without approval from the United States. Trust assets may include lands, minerals, natural resources, and hunting, fishing, and water rights. American Indian reservations, rancherias, and public domain allotments are examples of lands that are often considered ITAs. In some cases, ITAs may be located off trust land.

Reclamation shares the Indian trust responsibility with other agencies of the Executive Branch to protect and maintain ITAs reserved by or granted to Tribes or American Indian individuals by treaty, statute, or executive order.

3.5.1 Affected Environment

The nearest ITA is the Redding Rancheria, which is located within the ACID service area approximately 10 miles northwest of the proposed action location. The Redding Rancheria encompasses approximately 40 acres and includes members of Wintu, Pit-River, and Yana descent.

3.5.2 Environmental Consequences

3.5.2.1 No Action

Under the no action alternative, ACID would continue to implement its current water management program and continue to address any potential effects on ITAs as part of the program as necessary.

3.5.2.2 Proposed Action

There would be no effects on ITAs, because the Redding Rancheria is 10 miles from the proposed wells and would not be affected by either project construction or operation.

3.5.2.3 Cumulative Effects

The closest ITA is 10 miles away from the proposed wells and would not be affected by the construction or operation of the proposed wells; no cumulative effects on ITAs, are anticipated.

3.6 Environmental Justice

Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations” (February 11, 1994), requires agencies to identify and address disproportionately high and adverse human health or environmental effects of their actions on minorities and low-income populations and communities, as well as the equity of the distribution of the benefits and risks of their decisions. Environmental justice addresses the fair treatment of people of all races and income levels with respect to actions affecting the environment. Fair treatment implies that no person or group of people should bear a disproportionate share of negative impacts resulting from an environmental action. To comply with the environmental justice policy established by the Secretary of the Interior, U.S. Department of Interior agencies are to identify and evaluate any direct or indirect anticipated effects (from the proposed action or decision) on minority and low-income populations and communities, including the equity of the distribution of the benefits and risks. This section examines the anticipated impacts associated with the alternatives with respect to potentially affected minority and economically disadvantaged groups.

3.6.1 Affected Environment

3.6.1.1 Unemployment, Income, and Demographic Information

In recent years, the unemployment rate has been higher in Shasta and Tehama Counties than in the state as a whole. For example, the 2010 unemployment estimates indicate that Shasta County was at 16 percent and Tehama County was at 15.8 percent, as compared to 12.4 percent statewide (California Employment Development Department, 2011). In 2008, an estimated 17.7 percent of the population in Shasta County and 16.5 percent of the population in Tehama County was living in poverty, as compared to a statewide estimate of 13.3 (U.S. Census Bureau, 2010a). The 2008 estimated median household income for Shasta County was approximately $42,362 per year and the median household income for Tehama County was approximately $38,160 per year. By comparison, California's median household income was approximately $61,017 (U.S. Census Bureau, 2008).

According to the 2009 U.S. Census Bureau estimates, the vast majority of the population in both Shasta and Tehama Counties consists of Caucasians (approximately 90 and 93 percent, respectively). The remainder of the populace composed of primarily persons of Hispanic or Latino origin. The majority of each county's population is centered around the cities of Redding and Red Bluff, and along the Interstate 5 corridor.

The 2007 Census of Agriculture reported that 388 of the 1,473 farms located within Shasta County were operated by women, and 154 were operated by Spanish, Hispanic, or Latinos. The market value of products sold in Shasta County for the year 2007 totaled $44,675,000 (U.S. Department of Agriculture, 2007). The 2007 Census of Agriculture reported that 360 of the 1,752 farms located within Tehama County were operated by women. The majority of farms in Tehama County were operated by Caucasians. The market value of products sold in Tehama County for the year 2007 totaled $142,958,000 (U.S. Department of Agriculture, 2007).

3.6.2 Environmental Consequences

3.6.2.1 No Action

General employment, income, and demographic trends would continue under the no action alternative. The no action alternative would not alter these trends and have no impact on environmental justice.

3.6.2.2 Proposed Action

Construction. Construction activities associated with the proposed action would require a local or regional contractor, who would likely employ local or regional workers. If workers were temporarily relocated into the area during the construction phase, the construction effort would likely result in local revenue for lodging, food, and construction-related materials and equipment. Construction-related environmental justice effects are expected to be positive; no adverse effects would occur.

Operation. Implementing the proposed action would increase water supply reliability resulting in beneficial effects on agricultural production-related employment. Project-related environmental justice effects are expected to be positive; no adverse effects would occur.

3.6.2.3 Cumulative Effects

No substantial cumulative environmental justice effects are anticipated given no effects on this resource is expected from the implementation of the proposed action.

3.7 Socioeconomic Resources

3.7.1 Affected Environment

3.7.1.1 Population and Housing

Table 3-5 shows historical trends in population for the City of Redding, Shasta County, Tehama County, and the State of California since 1990. Population trends indicate that the City of Redding has grown more rapidly than either county.

TABLE 3-5
Population Estimates and Growth in the City of Redding, Shasta County, Tehama County, and the State of California

	Population Estimates			
Area Evaluated	**1990**	**2000**	**2010**	**Growth**
Redding	66,462	80,865	91,561	15%
Shasta County	147,036	163,256	184,247	11%
Tehama County	49,625	56,039	63,100	11%
California	29,758,213	33,873,086	38,648,090	12%

Source: DOF, 2010b.

There were approximately 77,234 housing units in Shasta County and 26,629 housing units in Tehama County in 2008 (U.S. Census Bureau, 2008). During the same year, Shasta County had an estimated 7.8 percent vacancy, and Tehama County had an estimated 10.9 percent vacancy.

3.7.1.2 Economic Base

Table 3-6 provides the employment profile for Shasta and Tehama Counties, as compared to the State of California (as of July 2010).

TABLE 3-6
Employment Profile for Shasta County, Tehama County, and the State of California

Area	Total Civilian Labor Force	No. of Employed (Civilian)	No. of Unemployed (Civilian)	Unemployment Percentage	Total Farm	Total Nonfarm
Shasta County	85,500	72,200	13,200	15.5%	800	58,100
Tehama County	25,590	21,580	4,010	15.7%	1,210	14,680
California	18,366,300	16,025,600	2,340,700	12.7%	423,000	13,782,800

Source: California Employment Development Department, 2010a.

Unemployment rates for both Shasta and Tehama Counties are higher than the state average. Table 3-7 shows estimated employment by industry for each county, as compared to the State of California (as of July 2010).

TABLE 3-7
Shasta County, Tehama County, and State of California Employment by Industry Sector and Percent of Total Employment by Industry Sector – July 2010

	Shasta County Employment		Tehama County Employment		California Employment	
Industry[a]	**Total**	**Percent of Total**	**Total**	**Percent of Total**	**Total**	**Percent of Total**
Total, Industries	58,900		15,180		14,205,800	
Total Farm	800	1	1,210	8	423,000	3
Total Nonfarm	58,100	99	14,170	93	13,782,800	97
Goods Producing	5,500	9	2,370	16	1,835,100	13
Mining and Logging	3,000	5	240	2	26,200	0.2
Construction	2,600	4	450	3	563,100	4
Manufacturing	2,500	4	1,680	11	1,245,800	9
Service Providing	52,600	89	11,800	78	11,947,700	84
Information	600	1	60	0.4	447,400	3
Financial Activities	2,500	4	360	2	780,100	5
Professional & Business Services	5,500	9	890	6	2,052,000	14
Educational & Health Services	10,300	17	1,710	11	1,726,600	12
Leisure & Hospitality	6,500	11	1,260	8	1,509,800	11
Other Services	2,400	4	340	2	481,900	3
Government	13,200	22	4,150	27	2,375,700	17

[a]Industry employment refers to place of work; excludes self-employed individuals, unpaid family workers, household domestic workers, and workers on strike.

Source: California Employment Development Department, 2010b.

The majority of the workforce in both Shasta and Tehama Counties is in the service providing industry, which is similar to California's workforce proportion. Of the three counties, Tehama County has the largest per capita percentage of farm employment, with 7 percent of the total industry employment.

3.7.2 Environmental Consequences

Potential impacts on socioeconomic resources are identified by considering how implementation of the proposed action could alter existing socioeconomic conditions (either locally or regionally). The extent of the potential socioeconomic impact that could occur is related to the operation of the groundwater production wells and associated drawdown and pumping costs. To estimate the potential impacts on socioeconomic resources, the potential increase in pumping costs per ac-ft of lift was estimated for electric and diesel pumps using a pumping cost formula (Anderson, 1961) in combination with the anticipated maximum increment of anticipated additional drawdown and pumping. The estimated cost per ac-ft for electric pumps is approximately $0.38 for 1 foot of lift. Dollars per kilowatt-hour are based on an average of the estimated blended rates published by Pacific Gas and Electric Company for small agricultural users, $0.26 per kilowatt-hour (Pacific Gas and Electric Company, 2011). Estimated cost per ac-ft for diesel pumps is also projected to be approximately $0.38 for one foot of lift. The price of diesel fuel per gallon was obtained from the U.S. Department of Energy's Monthly Retail On-Highway Diesel Prices for California (U.S. Department of Energy, 2011). For the last 5 years ending in April 2011, the average price of a gallon of diesel fuel was $3.22. Pump efficiency is assumed to be 82 percent and motor efficiency 85 percent for both electric and diesel pumps.

Table 3-8 shows the estimated increase in pumping costs per ac-ft of groundwater for the range of groundwater surface elevation changes anticipated during operation of the proposed wells (see Section 3.1, Water Resources). The estimated increase in pumping cost would be greatest adjacent to the production wells (where drawdown would be the greatest). The magnitude of costs would decrease with increased distance from the production wells.

TABLE 3-8
Estimated Increase in Per-acre-foot Pumping Costs

	Change in Pumping Cost Per Acre-foot with a Change in Groundwater Surface Elevation	
Energy Type	**10-foot Elevation Change**	**15-foot Elevation Change**
Electric	$3.77	$5.65
Diesel	$3.85	$5.77

Note:

Although the cost per ac-ft per of foot lift is the same for both pump types, variation occurs when evaluating a range of lift, because of rounding.

3.7.2.1 No Action

In general, agricultural economies in the proposed action area are not anticipated to substantially change. It is anticipated that some lands, primarily those near the urban areas located adjacent to Redding, would be converted to non-agricultural use in accordance with local general plans and zoning constraints; however, the conditions under the no action alternative generally reflect current conditions.

3.7.2.2 Proposed Action

Construction. Construction of the wells associated with the proposed action would result in temporary beneficial effects as a result of increased labor needs for construction and increased spending at local businesses. Small construction crews would work for specific periods, resulting in increased spending by workers at local businesses and suppliers. Materials and equipment needed for construction and actual facilities (such as, pumps, piping, and motors) would be obtained from the project area when feasible and available.

Construction of the proposed action would result in a minor beneficial impact on the local economy.

Operation. Increased drawdown near the groundwater production wells would potentially increase groundwater pumping costs. The projected shallow aquifer drawdown (resulting from implementation) is expected to range from 10 to 15 feet, with decreasing drawdown as distance from the proposed groundwater production wells increases.

Effects on socioeconomic conditions would be significant if the proposed action resulted in displacement of a business or residence from its established location, or resulted in substantial disruption of existing agricultural operations. The potential significance of the increase in groundwater pumping costs was based on the change in groundwater pumping costs relative to baseline agricultural conditions. The average operating cost, net revenue, groundwater, and applied water use were estimated for agricultural production in the study area (Table 3-9).

TABLE 3-9
Agricultural Conditions in the Study Area

Agricultural Conditions	Parameter
Percent of Crop Water Demand Met with Groundwater[a]	28 percent
Average Agricultural Operating Costs[b]	$1,654/acre
Average Agricultural Net Revenue[c]	$720/acre
Average Agricultural Applied Water Use[d]	3.36 ac-ft/acre

[a]DWR, 2010.
[b]University of California Cooperative Extension, 2011; DWR, 2007.
[c]University of California Cooperative Extension, 2011; U.S. Department of Agriculture, 2011.
[d]DWR, 2007.

The percentage of groundwater used to meet total crop demand and crop type would create varying effects. The estimated average increase in operating costs resulting from increased pumping costs would be less than 1 percent. Increases in operation costs would be only local in nature.

Land surrounding the proposed groundwater production wells is primarily agricultural; however, domestic wells in the study area could also be affected. The average annual water use per household is typically less than 1 ac-ft per year (DWR, 2010). The change in groundwater pumping costs would at most increase domestic water use costs for a typical household by no more than $6.00 a year, which represents less than 1 percent of median household income in the study area (U.S. Census Bureau, 2008).

The relatively minimal increase in pumping costs would not be expected to threaten the economic viability of crop production or adversely affect groundwater pumping for domestic use. Effects would be limited to the local area; no regional effects would occur. The area affected by the proposed action would remain productive farmland and would not adversely affect socioeconomic resources, despite a marginal increase in pumping costs.

3.7.2.3 Cumulative Effects

The proposed action would likely result in small, but beneficial, social and economic effects during the construction phase. No substantial cumulative socioeconomic effects are anticipated given no effects on this resource are expected from the implementation of the proposed action.

3.8 Air Quality

The federal Clean Air Act (CAA) requires the U.S. Environmental Protection Agency (EPA) to establish and maintain national ambient air quality standards (NAAQS), used to manage air quality across the country. The State of California has also adopted ambient air quality standards (CAAQS), and CAAQS are generally more stringent than NAAQS. Pollutants for which standards have been established are termed "criteria" pollutants, because the standards are based on criteria that show a relationship between pollutant concentrations and impacts on health and welfare. From this relationship, EPA and the state establish acceptable pollutant concentration levels to serve as ambient air quality standards.
Table 3-10 describes the criteria pollutants of primary concern (ozone [O_3], carbon monoxide [CO], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], and particulate matter) and the state and federal standards.

TABLE 3-10
Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards[a]	National Standards[b]	
			Primary[c]	Secondary[d]
O_3	1-hour	0.09 ppm	---	Same as primary
	8-hour	0.070 ppm	0.075 ppm	
PM_{10}	24-hour	50 μg/m^3	150 μg/m^3	Same as primary
	Annual arithmetic mean	20 μg/m^3	---	
$PM_{2.5}$	24-hour	---	35 μg/m^3	Same as primary
	Annual arithmetic mean	12 μg/m^3	15.0 μg/m^3	
CO	8-hour	9.0 ppm	9 ppm	None
	1-hour	20 ppm	35 ppm	
NO_2	Annual Arithmetic Mean	0.030 ppm	100 μg/m^3	Same as primary
	1-hour	0.18 ppm (339 μg/m^3)	0.100 ppm (188 μg/m^3)	None
SO_2	24-hour	0.04 ppm	---	---
	1-hour	0.25 ppm (655 μg/m^3)	0.075 ppm (196 μg/m^3)	---
Lead	30-day average	1.5 μg/m^3	---	---
	Calendar Quarter	---	1.5 μg/m^3	Same as primary
	Rolling 3-month average	---	0.15 μg/m^3	
Visibility-reducing Particles	8-hour	See note	---	---

TABLE 3-10
Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards[a]	National Standards[b]	
			Primary[c]	Secondary[d]
Sulfates	24-hour	25 $\mu g/m^3$	---	---
Hydrogen Sulfide	1-hour	0.03 ppm	---	---
Vinyl Chloride	24-hour	0.01 ppm	---	---

[a]California standards for O_3, CO, SO_2 (1-hour and 24-hour), NO_2, and suspended particulate matter (PM_{10}, $PM_{2.5}$, and visibility-reducing particles) are values that are not to be exceeded; other values are not to be equaled or exceeded.

[b]National standards, other than O_3, particulate matter, and those based on annual averages or annual arithmetic means, are not to be exceeded more than once per year. The O_3 standard is attained when the fourth highest 8-hour concentration in a year, averaged over 3 years, is equal to or less than the standard. The 24-hour standard for PM_{10}, is attained when the expected number of days per calendar year with a 24-hour average concentration above 150 $\mu g/m^3$ is equal to or less than 1. The 24-hour standard for $PM_{2.5}$ is attained when 98 percent of the daily concentrations, averaged over 3 years, is equal to or less than the standard.

[c]National Primary Standards are the levels of air quality necessary, with an adequate margin of safety, to protect the public health.

[d]National Secondary Standards are the levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

Source: California Air Resources Board (CARB), 2010a.

Notes:

--- = no established standard
$\mu g/m^3$ = micrograms per cubic meter
PM_{10} = particulate matter less than 10 micrometers in aerodynamic diameter
$PM_{2.5}$ = particulate matter less than 2.5 micrometers in aerodynamic diameter
ppm = parts per million (by volume)

If ambient concentrations of any of the criteria pollutants in an area exceed the state or federal standards established for those pollutants, the area is designated a “nonattainment” area. An area can be designated a basic, moderate, serious, severe, or extreme nonattainment area for some pollutants, depending on the level of pollutant concentrations. If standards for pollutants are met in a particular area, the area is designated an “attainment” area. The designation is “unclassified” where standards might not be established, or monitoring data do not exist for certain criteria pollutants.

3.8.1 Affected Environment

The project elements are located within the Shasta County Air Quality Management District (Shasta AQMD). Shasta AQMD is the local agency charged with preparing, adopting, and implementing mobile, stationary, and area air emission control measures and standards. The Shasta AQMD is bounded by the county boundary lines. It is surrounded in the northwest, northeast, and east by the Klamath and Coastal Mountains, which creates the potential for significant air pollution when coupled with relatively calm winds and fairly stable atmospheric conditions (particularly for O_3 and PM_{10}). Shasta AQMD does not currently meet the state ambient air standards for O_3 or PM_{10}. Table 3-11 shows the attainment status for the criteria pollutants that are designated for the state and national standards.

TABLE 3-11
Attainment Status for the Shasta County Air Quality Management District

	Designation/Classification	
	Shasta AQMD	
Pollutant	**Federal Standard**	**State Standard**
O_3 – 1-hour	No federal standard	Nonattainment/moderate
O_3 – 8-hour	Attainment/unclassified	Nonattainment
PM_{10}	Unclassified	Nonattainment
$PM_{2.5}$	Attainment/unclassified	Unclassified
CO	Attainment/unclassified	Attainment/unclassified
NO_2	Attainment/unclassified	Attainment
SO_2	Attainment/unclassified	Attainment
Lead (Particulate)	No designation	Attainment
H_2S	No federal standard	Unclassified
Sulfates	No federal standard	Attainment
Visibility-reducing Particles	No federal standard	Unclassified

Source: CARB, 2010b.
Note:
H_2S = hydrogen sulfide

3.8.2 Environmental Consequences

3.8.2.1 Environmental Measures Incorporated into the Projects

See Section 2.3.6, Specific Actions to Minimize Potential Impacts on Air Quality.

3.8.2.2 No Action

ACID would continue to implement its current water management program under the no action alternative. Annual local and regional groundwater use and the resulting impact on air quality would remain the same as existing conditions and would vary by year type.

3.8.2.3 Proposed Action

Construction. The construction phase of a project produces many types of emissions, but PM_{10} is the pollutant of greatest concern (Shasta AQMD, 2003). PM_{10} emissions can result from a variety of construction activities, including excavation, grading, demolition, vehicle travel on paved and unpaved surfaces, and vehicle exhaust (Shasta AQMD, 2003). Short-term construction emissions were estimated in units of pounds per day and total tons. Construction emissions were estimated using the URBEMIS2007 model and a 30-day construction duration (Rimpo and Associates, 2007). Table 3-12 presents construction emissions in units of total tons. The measures described in the CEQA checklist section would be implemented to minimize fugitive dust and exhaust emissions during construction. The short-term increase in emissions during construction would not have an adverse effect on air quality, because construction for the proposed action would generate minimal emissions, and incremental emissions would be less than federal and state standards.

TABLE 3-12
Total Construction Emissions

Construction Activity	Emissions (tons)					
	ROG	CO	NO_x	SO_2	PM_{10}	$PM_{2.5}$
Construct Well No. 1	0.04	0.17	0.40	0.00003	0.02	0.02
Construct Well No. 2	0.04	0.18	0.40	0.00004	0.02	0.02
Total	0.08	0.4	0.8	0.00007	0.04	0.04

Note:
ROG = reactive organic gas

Operation. As described for the no action alternative, operation activities for existing conditions would be the same as expected for no action. Operation activities associated with the proposed action would also be similar to the no action alternative, because the proposed production wells would be electrically operated. Therefore, there would be no effects on air quality as a result of operational activities associated with the proposed action.

3.8.2.4 Cumulative Effects

Construction of the proposed action would only result in minor, short-term increases in emissions; therefore, construction would not have an adverse, cumulative effect on air quality. Operation of the project involves operation of electric-powered pumps and would not result in a cumulative effect on air quality.

3.9 Global Climate Change

3.9.1 Affected Environment

Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from the following (EPA, 2011):

- Natural factors (such as changes in the sun's intensity or slow changes in Earth's orbit around the sun)
- Natural processes within the climate system (such as changes in ocean circulation)
- Human activities that change the atmosphere's composition (such as through burning fossil fuels) and the land surface (such as deforestation, reforestation, urbanization, and desertification)

Greenhouse gases (GHG) include the following pollutants (EPA, 2011):

- Carbon dioxide (CO_2) is a naturally occurring gas, and also a by-product of burning fossil fuels and biomass, as well as land-use changes, and other industrial processes. It is the principal anthropogenic GHG that affects the Earth's radiative balance.

- Methane has a global warming potential approximately 20 times that of CO_2. Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion.
- Nitrous oxide has a global warming potential approximately 300 times that of CO_2. Major sources of nitrous oxide include soil cultivation practices (especially the use of commercial and organic fertilizers) fossil fuel combustion, nitric acid production, and biomass burning.
- Hydrofluorocarbons (HFC) are compounds containing only hydrogen, fluorine, chlorine, and carbon. HFCs have been introduced as a replacement for the chlorofluorocarbons identified as O_3-depleting substances.
- Perfluorocarbons (PFC) are compounds containing only fluorine and carbon. Similar to HFCs, PFCs have been introduced as a replacement for chlorofluorocarbons. PFCs are also used in manufacturing and emitted as by-products of industrial processes. PFCs are powerful GHGs.
- Sulfur hexafluoride (SF6) is a colorless gas soluble in alcohol and ether, and slightly soluble in water. SF6 is a very powerful GHG used primarily in electrical transmission and distribution systems, and dielectrics in electronics.

3.9.1.1 Federal Regulatory Background

The EPA Mandatory Reporting Rule became effective on December 29, 2009, and sources required to report were to begin collecting data on January 1, 2010. In general, suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of CO_2 equivalent emissions are required to submit annual reports to EPA. The EPA reporting requirements continue to be updated.

In addition, the Supreme Court decision in *Massachusetts et al. v. Environmental Protection Agency et al.* (Supreme Court Case 05-1120) found that EPA has the authority to list GHGs as pollutants and to regulate emissions of GHGs under the federal CAA. On April 17, 2009, EPA found that CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and SF6 may contribute to air pollution and may endanger public health and welfare.

3.9.1.2 State and Regional Regulatory Background

In 2006, the California State Legislature signed the Global Warming Solutions Act of 2006 (AB 32), which provides the framework for regulating GHG emissions in California. This law requires CARB to design and implement emission limits, regulations, and other measures to reduce statewide GHG emissions in a technologically feasible and cost-effective manner to 1990 levels by 2020. The statewide 2020 emissions limit is 427 million metric tons CO_2 equivalent (CARB, 2007). CO_2 emissions account for approximately 90 percent of the statewide GHG emissions (CARB, 2007). Methane, nitrous oxide, HFCs, PFCs, and SF6 emissions account for the remainder of the statewide GHG emissions (CARB, 2007).

Currently, a Regional Climate Action Plan is being developed for Shasta County (County of Shasta, 2011). Part of the plan will identify state mandates used to create regional and local opportunities.

3.9.2 Environmental Consequences

3.9.2.1 No Action

Under the no action alternative, ACID would continue to implement its current water management program. Local and regional groundwater use each year and the resulting impact on global climate change would remain the same as existing conditions and would vary by year.

3.9.2.2 Proposed Action

Climate change is by definition, global in scope. Construction and operation of the proposed action could generate GHG emissions. Construction activities would include activities that emit GHGs, such as exhaust emissions from heavy equipment and associated construction vehicles. Construction would result in a minor, short-term increase in GHG emissions (approximately 100 metric tons of CO_2). Operation of the proposed action would include using electricity-operated pumps. Operation is not expected to generate additional indirect GHG emissions associated with the electricity use for the new pumps (to the extent that it would cause an adverse effect. According to the draft NEPA guidance for considering direct GHG emissions, a value of 25,000 metric tons of CO_2 equivalent would indicate whether a qualitative or quantitative assessment could be meaningful for decision makers under NEPA (Council on Environmental Quality, 2010). Emissions from electricity use are considered indirect emissions, and the proposed action would not include a direct GHG emissions source, such as a stationary source. Under NEPA, construction and operation of the proposed action would not have an adverse effect on GHG emissions.

3.9.2.3 Cumulative Effects

No substantial cumulative GHG effects are anticipated, given the proposed action would not result in an appreciable increase in GHG emissions during construction or operation of the project.

SECTION 4

Consultation and Coordination

Several federal and state laws, permits, licenses, and policy requirements have directed, limited, or guided the NEPA and CEQA analyses and decision-making processes of this EA/IS and are listed below.

4.1 Endangered Species Act

Section 7 of the Endangered Species Act (ESA) (16 United States Code 1531 et seq.) requires federal agencies, in consultation with the Secretary of the Interior and/or Commerce, to confirm that their actions do not jeopardize the continued existence of endangered or threatened species, or result in the destruction or adverse modification of the critical habitat of these species.

There would not be a requirement for consultation under Section 7 of the ESA because of lack of suitable habitat and absence of sensitive species.

4.2 California Department of Fish and Game

California Endangered Species Act (CESA) and CDFG Code (Sections 2050 to 2097) are similar to ESA. CDFG Commission is responsible for maintaining lists of threatened and endangered species under CESA. The CESA prohibits the "take" of listed and candidate (petitioned to be listed) species. Take, under California law, means to "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch capture, or kill" (see CDFG Code, Section 86).

There would not be a requirement for consultation because of lack of suitable habitat and absence of sensitive species.

4.3 Regional Water Quality Control Board

The Regional Water Quality Control Board, issues permits for activities that could cause impacts on surface water and groundwater, including construction activities. The Regional Water Quality Control Board, requires that a National Pollutant Discharge Elimination System permit be obtained if pollutants would be discharged to surface water. Prior to construction commencing, a stormwater pollution prevention plan would be prepared by the contractor to comply with the National Pollutant Discharge Elimination System permit.

4.4 National Historic Preservation Act

Section 106 of the NHPA requires federal agencies to consider the effects of federal undertakings on historic properties (properties determined eligible for inclusion in the NRHP). Compliance with Section 106 follows a series of steps that are designed to identify interested parties, determine the APE, identify if historic properties are present within the APE, and assess effects on any identified historic properties.

4.5 Shasta County Ordinance No. SCC 98-1

Shasta County Ordinance No. SCC 98-1 requires a permit for extraction of groundwater within the underlying lands of Shasta County, either directly or indirectly. The exception to the ordinance applies to water users who intend to use the water within the boundaries of a local agency, which is located in part in Shasta County and in part in another county where the extraction quantities and use are consistent with historical practice. ACID would fully comply with this ordinance.

4.6 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act requires that Reclamation consult with fish and wildlife agencies (federal and state) on all water development projects that could affect biological resources. This is not a water development project; therefore, the Fish and Wildlife Coordination Act does not apply.

4.7 Migratory Bird Treaty Act

The Migratory Bird Treaty Act implements various treaties and conventions between the United States and Canada, Japan, Mexico and the former Soviet Union for the protection of migratory birds. Unless permitted by regulations, the Act provides that it is unlawful to pursue, hunt, take, capture or kill; attempt to take, capture or kill; possess, offer to or sell, barter, purchase, deliver or cause to be shipped, exported, imported, transported, carried or received any migratory bird, part, nest, egg or product, manufactured or not. Subject to limitations in the Act, the Secretary of the Interior may adopt regulations determining the extent to which, if at all, hunting, taking, capturing, killing, possessing, selling, purchasing, shipping, transporting or exporting of any migratory bird, part, nest or egg will be allowed, having regard for temperature zones, distribution, abundance, economic value, breeding habits and migratory flight patterns. The proposed action would not affect migratory birds therefore no further coordination is needed under the Migratory Bird Treaty Act.

SECTION 5

California Environmental Quality Act – Environmental Factors and Mandatory Findings of Significance

This section includes the CEQA analysis portion of potentially affected issues that may result from implementation of the proposed project. Reference to the "proposed project" in this section is synonymous with the term "proposed action" used in other sections. Appendix A contains the CEQA impact determination signature page.

5.1 Discussion of Potentially Affected Environmental Factors

This checklist identifies physical, biological, social, and economic factors that might be affected by the proposed project. Although some project elements could result in an environmental affect, modifications were made to the project description (or mitigation measures have been proposed) that would reduce impacts to less than significant. The words "significant" and "significance," used throughout the following checklist and section, are related to CEQA, not NEPA, impacts.

5.2 Evaluation of Environmental Impacts

1. A brief explanation is required for all answers except "No Impact" answers that are adequately supported by the information sources a lead agency cites in the parentheses following each question. A "No Impact" answer is adequately supported if the referenced information sources show that the impact simply does not apply to projects like the one involved (for example, the project falls outside a fault rupture zone). A "No Impact" answer should be explained where it is based on project-specific factors as well as general standards (for example, the project would not expose sensitive receptors to pollutants, according to a project-specific screening analysis).
2. All answers must take account of the whole action involved, including offsite as well as onsite, cumulative as well as project-level, indirect as well as direct, and construction as well as operational impacts.
3. After the lead agency has determined that a particular physical impact might occur, then the checklist answers must indicate whether the impact is "Potentially Significant," "Less than Significant with Mitigation," or "Less than Significant." "Potentially Significant Impact" is appropriate if there is substantial evidence that an effect might be significant. If there are one or more "Potentially Significant Impact" entries when the determination is made, an environmental impact report is required.
4. "Negative Declaration: Less than Significant with Mitigation Incorporated" applies where the incorporation of mitigation measures has reduced an effect from "Potentially

Significant Impact" to a "Less than Significant Impact." The lead agency must describe the mitigation measures, and briefly explain how they reduce the effect to a less than significant level.

5. Earlier analyses may be used where, pursuant to the tiering, program environmental impact report, or other California Environmental Quality Act process, an effect has been adequately analyzed in an earlier environmental impact report or negative declaration (Section 15063(c)(3)(D). In this case, a brief discussion should identify the following:
    a) Earlier Analysis Used. Identify and state where they are available for review.
    b) Impacts Adequately Addressed. Identify which effects from the above checklist were within the scope of and adequately analyzed in an earlier document pursuant to applicable legal standards, and state whether such effects were addressed by mitigation measures based on the earlier analysis.
    c) Mitigation Measures. For effects that are "Less than Significant with Mitigation Incorporation," describe the mitigation measures that were incorporated or refined from the earlier document and the extent to which they address site-specific conditions for the project.
6. Lead agencies are encouraged to incorporate into the checklist references to information sources for potential impacts (for example, general plans and zoning ordinances). Reference to a previously prepared or outside document should, where appropriate, include a reference to the page or pages where the statement is substantiated.
7. Supporting Information Sources: A source list should be attached, and other sources used or individuals contacted should be cited in the discussion.
8. This is only a suggested form, and lead agencies are free to use different formats; however, lead agencies should normally address the questions from this checklist that are relevant to a project's environmental effects in whatever format is selected.
9. The explanation of each issue should identify the following:
    a) The significance criteria or threshold, if any, used to evaluate each question
    b) The mitigation measure identified, if any, to reduce the impact to less than significant

5.3 Initial Study/Environmental Impacts Checklist

	Potentially Significant Impact	**Less than Significant with Mitigation Incorporation**	**Less than Significant Impact**	**No Impact**
I. AESTHETICS. Would the proposed project:				
(a) Have a substantial adverse effect on a scenic vista?	☐	☐	☐	☒
(b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings,	☐	☐	☐	☒

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
and historic buildings within a state scenic highway?				
(c) Substantially degrade the existing visual character or quality of the site and its surroundings?	☐	☐	☒	☐
(d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	☐	☐	☐	☒
Discussion: **a, b, c, d.** The project site is not considered a unique scenic vista, nor is the proposed project located within the vicinity of a state-designated scenic highway. The proposed project is consistent with the existing visual character of each property and surroundings. Construction equipment would be temporarily visible during construction. A limited number of residents are adjacent to the proposed project location; however, the visual characteristics of the site would remain consistent with the existing setting once construction is complete. No additional aesthetic analysis is necessary for the proposed project.				
II. AGRICULTURE AND FORESTRY RESOURCES. Would the proposed project:				
(a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☐	☒
(b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☐	☒
(c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)), timberland (as defined by Public Resources Code section 4526), or timberland zoned Timberland Production (as defined by	☐	☐	☐	☒

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
Government Code section 51104(g))				
(d) Result in the loss of forest land or conversion of forest land to non-forest use?	☐	☐	☐	☒
(e) Involve other changes in the existing environment which, because of their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?	☐	☐	☐	☒
Discussion: See Section 3.2 for a complete discussion of land uses within the project area.				
III. AIR QUALITY. Would the proposed project:				
(a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☒	☐
(b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☒	☐	☐
(c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard (including releasing emissions that exceed quantitative thresholds for ozone precursors)?	☐	☐	☒	☐
(d) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☒	☐
(e) Create objectionable odors affecting a substantial number of people?	☐	☐	☐	☒

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact

Discussion:

a. Construction and operation of the project would not conflict with or obstruct implementation of an air quality plan. The Shasta AQMD Air Quality Attainment Plan for O_3 was first adopted in 1991, with the most recent update in 2004. The Shasta County General Plan also has an air quality element, which was reviewed for consistency (Shasta County, 2004). Construction would result in a minor, short-term increase in emissions. Measures would be implemented during construction to reduce emissions. Operation would not be expected to result in a net increase in emissions when compared to existing conditions. Therefore, the project would be consistent with applicable air quality plan and the impact would be less than significant.

b. Construction of the project would result in a short-term increase in emissions. Table 5-1 presents maximum daily construction emissions, as compared to the Shasta AQMD thresholds. Construction emissions were estimated using the URBEMIS2007 model and a 30-day construction duration (Rimpo and Associates, 2007). A 10-day portion of the construction period would require working 24 hours per day. During this period, it was assumed construction equipment would operate 20 hours per day. During the remaining construction period, it was assumed construction equipment would operate 12 hours per day. Emissions of ROG and PM_{10} would not exceed Level A thresholds; maximum daily NO_x emissions may exceed the Level A threshold. According to Shasta AQMD, mitigation measures must be implemented when the Level A threshold is exceeded (Shasta AQMD, 2003). The avoidance and minimization measures listed in Section 2.3 would be implemented to reduce construction emissions. ROG, NO_x, and PM_{10} emissions from construction would be less than the Level B threshold and mitigation measures would be implemented. The air quality impact would be less than significant.

TABLE 5-1
Maximum Daily Construction Emissions

	Emissions (lbs/day)					
Construction Activity	**ROG**	**CO**	**NO_x**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**
Construct Well No. 1	3.2	14.5	28.1	0.003	1.5	1.3
Construct Well No. 2	3.2	15.3	28.2	0.004	1.5	1.3
Shasta AQMD Level A Threshold	25	NA	25	NA	80	NA
Shasta AQMD Level B Threshold	137	NA	137	NA	137	NA

Source: Shasta AQMD, 2003.

Notes:

lbs/day = pounds per day
NA = CEQA threshold has not been established

	Potentially Significant Impact	**Less than Significant with Mitigation Incorporation**	**Less than Significant Impact**	**No Impact**
Operation of the project would involve electric-powered pumps and would include continuation of existing activities at the well locations. Therefore, operation of the project would not affect air quality. **c.** Construction emissions with implementation of mitigation measures would be less than the Shasta AQMD thresholds (see Table 5-1). Therefore, construction and operation of the project would not result in a cumulatively considerable net increase in emissions and the impact would be less than significant. **d.** Construction of the project would generate emissions, such as diesel and particulate matter from trucks and construction equipment. Current models and methodologies for conducting health risk assessments are associated with longer term exposure periods of 9, 40, and 70 years, which do not correlate well with the temporary and highly variable nature of construction activities (Bay Area Air Quality Management District, 2010). Construction of the project would occur over a 30-day period, and particulate matter emissions would be less than the Level A thresholds. Therefore, the impact on air quality would be less than significant. Operation of the project would not generate emissions and would not expose sensitive receptors to substantial pollutant concentrations; therefore, the impact on air quality would be less than significant. **e.** Temporary use of vehicles and construction equipment would not generate significant odors during project construction. Operation of the project would not include operation of sources that create odors. Therefore, construction and operation of the project would not create objectionable odors affecting a substantial number of people, and there would be no impact.				
IV. BIOLOGICAL RESOURCES. Would the proposed project:				
(a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG or USFWS?	☐	☐	☒	☐
(b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the CDFG or USFWS?	☐	☐	☒	☐
(c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean	☐	☐	☒	☐

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?				
(d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☒	☐
(e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☒
(f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☒
Discussion: See Section 3.3 for a complete discussion on biological resources impacts.				
V. CULTURAL RESOURCES. Would the proposed project:				
(a) Cause a substantial adverse change in the significance of a historical resource as defined in Section 15064.5?	☐	☐	☐	☒
(b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to Section 15064.5?	☐	☐	☐	☒
(c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☐	☒
(d) Disturb any human remains,	☐	☐	☐	☒

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
including those interred outside of formal cemeteries?				
Discussion: See Section 3.4 for a complete discussion on cultural resources.				
VI. GEOLOGY AND SOILS. Would the proposed project:				
(a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
(i) Rupture of a known earth-quake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☐	☒
(ii) Strong seismic ground shaking?	☐	☐	☐	☒
(iii) Seismic-related ground failure, including liquefaction?	☐	☐	☐	☒
(iv) Landslides?	☐	☐	☐	☒
(b) Result in substantial soil erosion or the loss of topsoil?	☐	☐	☒	☐
(c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the proposed project, and potentially result in on- or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse?	☐	☐	☐	☒

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
(d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	☐	☐	☐	☒
(e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of wastewater?	☐	☐	☐	☒

Discussion:

a, b. The proposed project does not fall within an Alquist-Priolo Earthquake Fault Zone, as shown by the CDC, Division of Mines and Geology (CDC, 2010b). Soil erosion could occur during construction if appropriate BMPs are not implemented. See Section 3.1 for a complete discussion of water quality impacts related to soil erosion.

To assure no significant impact, ACID would confirm proper implementation of applicable BMPs to prevent soil erosion.

c, d, e. The project would not be located on an unstable geologic unit or soil, nor would the project be located on expansive soil as defined in Table 18-1-B of the Uniform Building Code. No septic tanks are associated with the project; therefore, there is no impact.

VII. GREENHOUSE GAS EMISSIONS. Would the proposed project:

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
(a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?	☐	☐	☒	☐
(b) Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?	☐	☐	☐	☒

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
Discussion: See Section 3.9 for a complete discussion on global climate change and GHG emissions. **a, b.** The project would not generate GHG emissions that would have a significant impact on the environment, nor would the project conflict with any applicable plan, policy, or regulation adopted for the purpose of reducing GHG emissions.				
VIII. HAZARDS AND HAZARDOUS MATERIALS. Would the proposed project:				
(a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☒	☐
(b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☐	☒	☐
(c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☒
(d) Be located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☐	☒
(e) If located within an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport, result in a safety hazard for people residing or working in the project site?	☐	☐	☐	☒

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
(f) For a project located within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☒
(g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒
(h) Expose people or structures to a significant risk of loss, injury, or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☐	☒

Discussion:

a, b. A very minor amount of hazardous waste, if any, would be generated by construction activities related to project implementation. Hazardous materials (such as, gasoline, oil, and lubricants) used during construction could potentially be released. However, this impact is considered less than significant because of the small amount of such materials that would be used during construction. See Section 3.1 for a complete discussion of water quality impacts and implementation of BMPs during project construction.

To assure no significant impact, ACID would confirm proper implementation of applicable BMPs to prevent impacts on water quality due to unexpected hazardous materials releases.

c, d, e, f, g, h. The proposed project is not within 0.25 mile of any schools, nor would it be located on a site that is listed in Government Code Section 65962.5. None of the proposed project locations are within the vicinity of a public or private airport or airstrip. The project would not impair an adopted emergency plan, nor would the project expose people or structures to any risk.

IX. HYDROLOGY AND WATER QUALITY. Would the proposed project:

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
(a) Violate any water quality standards or waste discharge requirements?	☐	☐	☒	☐
(b) Substantially deplete groundwater supplies or interfere	☐	☐	☒	☐

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
substantially with groundwater recharge causing a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted[7])?				
(c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on- or offsite?	☐	☐	☐	☒
(d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or offsite?	☐	☐	☐	☒
(e) Create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	☐	☐	☒	☐
(f) Otherwise substantially degrade water quality?	☐	☒	☐	☐

[7] Well yield is defined as the maximum sustainable pumping rate that can be supplied by a well, without inducing a decline in water levels that exceeds the available drawdown. Available drawdown is defined as the height of the column of water between the static water level and the total depth of the well or the depth of the pump intake.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
(g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☐	☒
(h) Place within a 100-year flood hazard area structures that would impede or redirect flood flows?	☐	☐	☐	☒
(i) Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam?	☐	☐	☐	☒
(j) Inundation by seiche, tsunami, or mudflow?	☐	☐	☐	☒
(k) Substantially reduce in-stream flows of rivers and streams?	☐	☐	☒	☐
(l) Cause permanent land subsidence due to water level declines?	☐	☐	☐	☒

Discussion:

See Section 3.1 for a complete discussion of impacts on water resources as a result of the proposed project.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
X. LAND USE AND PLANNING. Would the proposed project:				
(a) Physically divide an established community?	☐	☐	☐	☒
(b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the proposed project (including, but not limited to, the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☐	☒
(c) Conflict with any applicable Habitat Conservation Plan or Natural Community Conservation Plan?	☐	☐	☐	☒
Discussion: See Section 3.2 for a complete discussion of land use impacts associated with the proposed project.				
XI. MINERAL RESOURCES. Would the proposed project:				
(a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☐	☐	☒
(b) Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?	☐	☐	☐	☒
Discussion: **a, b.** There are no known mineral resources on either proposed project location; therefore, there would be no impact on mineral resources.				

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
XII. NOISE. Would the proposed project:				
(a) Expose persons to or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☒	☐
(b) Expose persons to or generation of excessive ground-borne vibration or ground-borne noise levels?	☐	☐	☒	☐
(c) Result in a substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the proposed project?	☐	☐	☐	☒
(d) Result in a substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the proposed project?	☐	☐	☒	☐
(e) If within an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public use airport, expose people residing or working in the project site to excessive noise levels?	☐	☐	☐	☒
(f) If within the vicinity of a private airstrip, expose people residing or working in the project site to excessive noise levels?	☐	☐	☐	☒

Discussion:

a, b, c, d. Shasta County does not have a noise ordinance; however, the noise standards established by the county require a maximum daytime noise decibel level of 55 from 7 a.m. to 10 p.m. There would be a temporary increase in noise levels in the project vicinity above existing ambient noise levels during construction. The most noticeable construction noise would likely be related to vehicle backup warning devices and general construction noise. The

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
proposed project area includes a limited number of sensitive receptors. Proposed Well No. 1 is over 0.25 mile from the nearest sensitive receptor, and proposed Well No. 2 is less than 0.1 mile from the nearest sensitive receptor. Construction activities would be temporary (maximum duration of 6 weeks). The majority of construction activities would take place during weekdays from 7 a.m. to 7 p.m. However, drilling operations are scheduled to occur on a continuous basis, consisting of twenty 4-hour shifts, for 10 consecutive days. Noise curtains would be installed around the drill rig to reduce noise impacts in the event that nearby sensitive receptors complain about noise impacts. This impact is considered less than significant. **e, f.** The proposed project is not located within the vicinity of a public airport or private airstrip.				
XIII. POPULATION AND HOUSING. Would the proposed project:				
(a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☐	☐	☐	☒
(b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
(c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒
Discussion: **a, b, c.** The proposed project would not induce population growth, or displace housing or people.				
XIV. PUBLIC SERVICES. Would the proposed project:				
(a) Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the				

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the following public services:				
(i) Fire protection?	☐	☐	☐	☒
(ii) Police protection?	☐	☐	☐	☒
(iii) Schools	☐	☐	☐	☒
(iv) Parks	☐	☐	☐	☒
(v) Other public facilities?	☐	☐	☐	☒
Discussion: **a.** No public services would be affected by the proposed project.				
XV. RECREATION. Would the proposed project:				
(a) Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☐	☒
(b) Include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?	☐	☐	☐	☒
Discussion: **a, b.** No recreational facilities would be constructed or affected by the proposed project.				
XVI. TRANSPORTATION/TRAFFIC. Would the proposed project:				
(a) Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation	☐	☐	☐	☒

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths and mass transits?				
(b) Conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?	☐	☐	☒	☐
(c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	☐	☐	☐	☒
(d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☐	☒
(e) Result in inadequate emergency access?	☐	☐	☐	☒
(f) Conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?	☐	☐	☐	☒

Discussion:

a, b. There would be a slight increase in local traffic, on Barney Road and Canal Road to proposed Well No. 1, and Rhonda Road and Westhaven Road to proposed Well No. 2, during the construction period because of construction workers entering and exiting the sites (and general construction traffic such as dump trucks hauling material to and from the site). This

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
traffic increase would be temporary (a maximum duration of 8 weeks), minimal, and would not affect local roadways. This impact is considered less than significant. **c, d, e, f.** The proposed project would not modify the level of service in the area, affect air traffic patterns, or create traffic hazards or incompatible uses. Emergency access would not be affected, and the project would not conflict with adopted policies or plans as established by Shasta County Department of Public Works.				
XVII. UTILITIES AND SERVICE SYSTEMS. Would the proposed project:				
(a) Exceed wastewater treatment requirements of the applicable Water Board?	☐	☐	☐	☒
(b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
(c) Require or result in the construction of new stormwater drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☐	☐	☒
(d) Have sufficient water supplies available to serve the proposed project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☐	☒
(e) Result in a determination by the wastewater treatment provider that serves or may serve the proposed project that it has adequate capacity to serve the project’s projected demand in addition to the providers existing commitments?	☐	☐	☐	☒

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
(f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☐	☐	☐	☒
(g) Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☐	☒

Discussion:

a, b, c, d, e, f, g. Wastewater and stormwater facilities would not be affected by the proposed project. Excavated material would be disposed of onsite, at a location approved by the property owner, and in accordance with state and federal laws.

XVIII. MANDATORY FINDINGS OF SIGNIFICANCE.

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
(a) Does the proposed project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory?	☐	☒	☐	☐
(b) Does the proposed project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	☐	☒	☐	☐

	Potentially Significant Impact	Less than Significant with Mitigation Incorporation	Less than Significant Impact	No Impact
(c) Does the proposed project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☒	☐	☐

Discussion:

The proposed avoidance and minimization measures would reduce the overall impact on the proposed project to a level of less than significant.

SECTION 6

List of Preparers and Reviewers

6.1 Bureau of Reclamation

Shelly Hatleberg, Natural Resources Specialist
Amy Barnes, Archaeologist
Chip Parrot, Hydrogeologist

6.2 Anderson-Cottonwood Irrigation District

Stan Wangberg, District Manager

6.3 CH2M HILL Consultant Staff

Holly Dawley, Project Manager
Brett Isbell, Project Manager
Mark Oliver, Senior Planner
Heather Perry, Hydrogeologist
Nate Brown, Senior Hydrogeologist
Peter Lawson, Senior Hydrogeologist
Mike Basial, Hydrogeologist
Titi Ala, Planner
Heather Waldrop, Planner
Amy Clymo, Air Quality
Natalie Lawson, Archaeologist
Clint Helton, Senior Archaeologist
Victor Leighton, Biologist
Marjorie Eisert, Senior Biologist
Tom Henderson, Project Engineer
Celeste Brandt, Technical Editor
Heather Nichols, Technical Editor

SECTION 7

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Appendix A
CEQA Checklist Signature Page

The environmental factors checked below would be potentially affected by the proposed project, involving at least one impact that is a "Potentially Significant Impact" as indicated by the checklist on the following pages.

☐ Aesthetics	☐ Agriculture and Forestry Resources	☒ Air Quality
☐ Biological Resources	☐ Cultural Resources	☐ Geology/Soils
☐ Greenhouse Gas Emissions	☐ Hazards and Hazardous Materials	☒ Hydrology/Water Quality
☐ Land Use/Planning	☐ Mineral Resources	☐ Noise
☐ Population/Housing	☐ Public Services	☐ Recreation
☐ Transportation/Traffic	☐ Utilities/Service Systems	☒ Mandatory Findings of Significance

DETERMINATION: (To be completed by the lead agency)
On the basis of this initial evaluation:

☐ I find that the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared.

☒ I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the proposed project have been made by or agreed to by the project proponent. A MITIGATED NEGATIVE DECLARATION will be prepared.

☐ I find that the proposed project MIGHT have a significant effect on the environment, and an ENVIRONMENTAL IMPACT REPORT is required.

☐ I find that the proposed project MIGHT have a "Potentially Significant Impact" or "Potentially Significant Unless Mitigated" impact on the environment, but at least one effect (1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and (2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An ENVIRONMENTAL IMPACT REPORT is required, but it must analyze only the effects that remain to be addressed.

☐ I find that although the proposed project could have a significant effect on the environment, because all potentially significant effects (1) have been analyzed adequately in an earlier ENVIRONMENTAL IMPACT REPORT or NEGATIVE DECLARATION pursuant to applicable standards, and (2) have been avoided or mitigated pursuant to that earlier ENVIRONMENTAL IMPACT REPORT or NEGATIVE DECLARATION, including revisions or mitigation measures that are imposed on the proposed project, nothing further is required.

[signature] 11-14-11
Stan Wangberg, General Manager Date

Signature Date

Appendix B
Biological Site Assessment

Biological Site Assessment for Groundwater Production Wells No. 1 and 2, Anderson-Cottonwood Irrigation District

PREPARED FOR: Anderson-Cottonwood Irrigation District

PREPARED BY: Victor Leighton/SAC

DATE: April 14, 2011

Introduction

This technical memorandum identifies potential biological constraints/issues associated with ground-disturbing activities related to the proposed construction of Groundwater Production Wells No. 1 and 2, part of Anderson-Cottonwood Irrigation District's (ACID) Integrated Regional Water Management Program Proposition 50 Groundwater Well Production Element Project (proposed project). This information is based on a preliminary site assessment conducted on February 15, 2011, and review of aerial photographs; California Department of Fish and Game California Natural Diversity Database (CNDDB) search results; CNDDB, California Native Plant Society (CNPS), and U.S. Fish and Wildlife (USFWS) species lists; and historical documents for the area.

Information from these sources would be used in the planning and design phase of the proposed project. The site assessment was conducted to determine the occurrence of native habitats, including vernal pools, wetlands, and riparian habitat, and special-status species at the proposed well sites.

Project Summary

ACID proposes to install two new groundwater production wells near its main canal. Figure 1 shows the general location of the proposed wells.

ACID Well No. 1 would be in Anderson in Shasta County, California (Township 30 North, Range 04 West, Section 23; Mount Diablo Meridian; 122° 17′ 19.15″ West longitude, 40˚ 26′ 19.34″ North latitude [North American Datum of 1983] in the U.S. Geological Survey [USGS] Cottonwood 7.5-minute quadrangle). The well would be north of Deschutes Road, as shown on Figure 2.

ACID Well No. 2 would be approximately 0.5 mile northwest of Cottonwood in Shasta County, California (Township 29 North, Range 04 West, Section 2; Mount Diablo Meridian; 122° 17′ 30.03″ West longitude, 40° 23′ 39.08″ North latitude [North American Datum of 1983] in USGS Cottonwood 7.5-minute quadrangle). The well would be north of Gas Point Road and west of Rhonda Road, as shown on Figure 3.

Each well would have a target capacity of 3,500 gallons per minute (gpm) and would require a 100- to 150-horsepower pump motor. The wells would operate 24 hours per day under the following schedule:

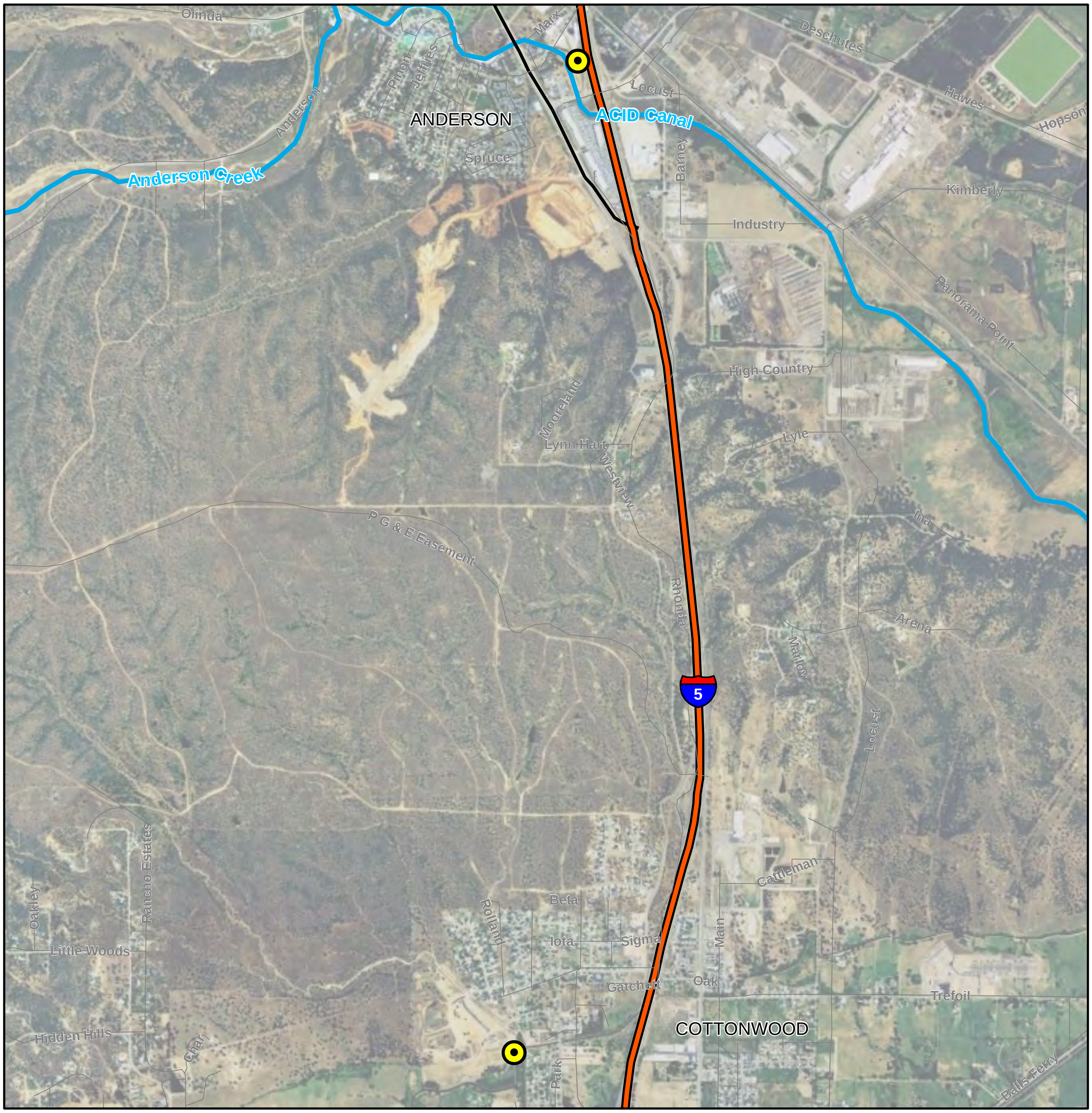
- Noncritical water years: Proposed Well No. 1 would operate in critical dry years and would not operate in normal years. Proposed Well No. 2 would operate annually from June through October to augment water supply in an area where water conveyance is seasonally limited by aquatic vegetative growth in the canal (aquatic vegetation increases in growth throughout the delivery season, which decreases canal capacity).
- Critical water years: Both wells would operate annually from April through October during periods of curtailment to augment water supply.

Construction Activities

Each well would require a 100-foot by 200-foot construction staging area. The final footprint of each well would not exceed 25 feet by 25 feet, with an estimated well depth of 500 feet. Conveyance piping would be required for each pump. A maximum of 100 feet of conveyance piping, 12 to 14 inches in diameter, would be installed approximately 12 to 24 inches underground at each well. The pipelines would discharge directly into the ACID main canal via open-ended discharge through the canal bank. The wells would be powered by electricity and could require a maximum 1,000 feet of overhead service line and one new power pole (approximately 12 inches in diameter) installed within 50 feet of each new well. Figures 1 and 2 identify existing power poles from which electricity would take off. The method of construction for the conveyance pipeline would be open trench. Existing roads would allow access to both wells, and would not require improvements. Final project design and construction are expected in fall 2011. Drill cuttings and fluids would be disposed of onsite at a location previously agreed upon by the property owner.

The following equipment is expected to be required for each proposed well installation:

- Self-propelled or trailer-mounted reverse circulation drilling rig (2 weeks)
- Pipe trailer (2 weeks)
- Support trailer/doghouse (2 weeks)
- Backhoe (6 weeks)
- Fluid containment tanks (4 weeks)
- Cement delivery trucks (4 days)
- Geophysical logging van (2 days)
- Pump setting rig (2 days)
- Up to three crew-member vehicles (6 weeks)
- Fuel delivery vehicles (4 days)



LEGEND

- PROPOSED PRODUCTION WELL
- LOCAL ROAD
- STATE HIGHWAY 273
- WATER FLOW

N

0 0.5
Miles

VICINITY MAP

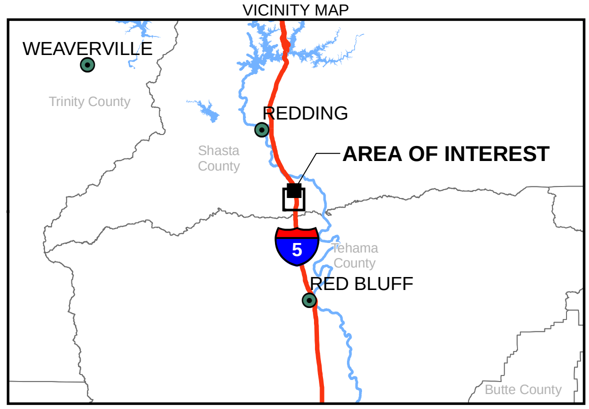
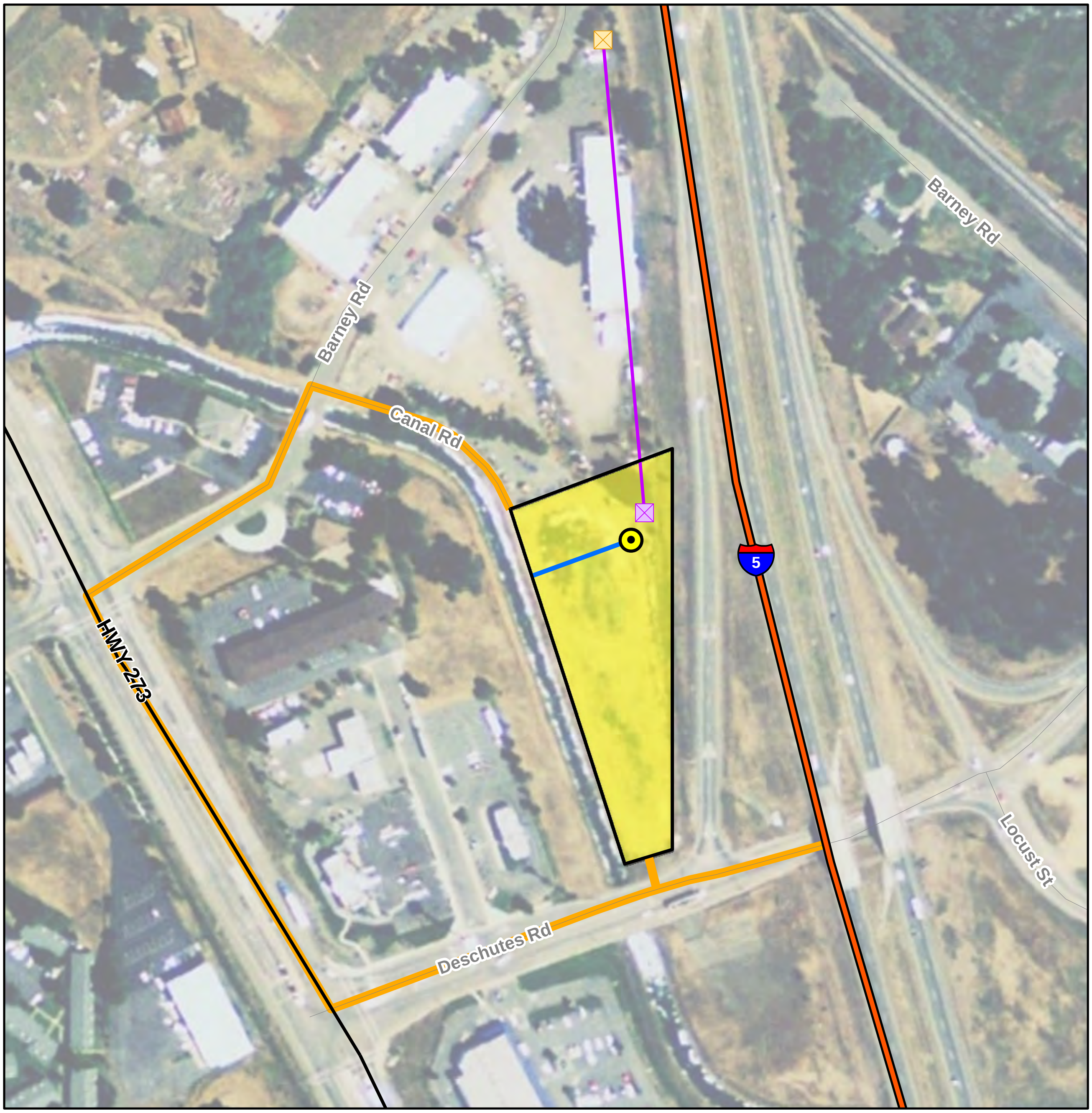


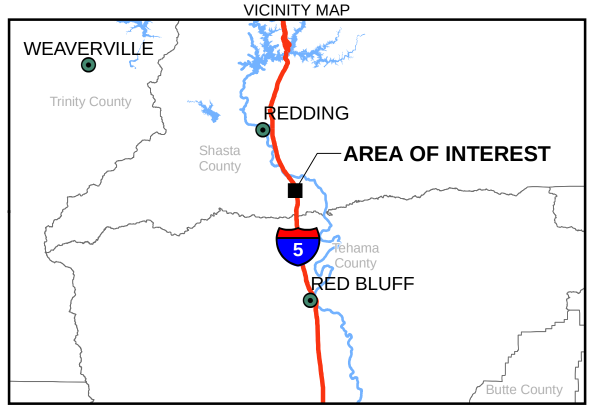
FIGURE 1
ACID PROPOSED WELL LOCATIONS
ACID GROUNDWATER PRODUCTION ELEMENT PROJECT



LEGEND

- PRODUCTION WELL
- EXISTING POWER POLE
- PROPOSED POWER POLE
- ACCESS ROUTE
- PROPOSED CONVEYANCE LINE TO CANAL
- PROPOSED POWER LINE
- PROJECT AREA

VICINITY MAP



N

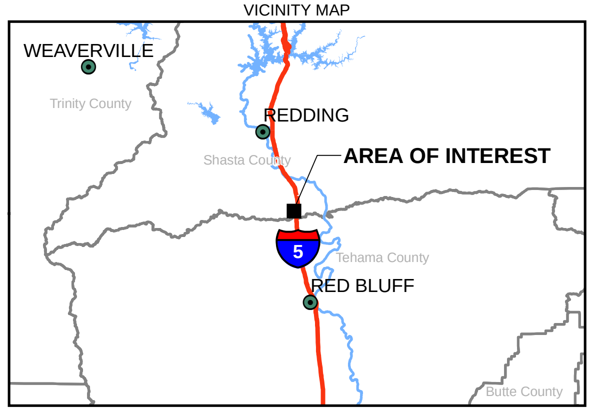
0 250
Feet

FIGURE 2
ACID GROUNDWATER PRODUCTION WELL No. 1 LOCATION MAP
ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

LEGEND

- PRODUCTION WELL
- EXISTING POWER POLE
- ACCESS ROUTE
- PRIVATE ACCESS ROAD
- PROPOSED CONVEYANCE LINE TO CANAL
- PROJECT AREA

VICINITY MAP



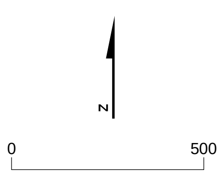


FIGURE 3
ACID GROUNDWATER PRODUCTION WELL No. 2 LOCATION MAP

ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

Construction Schedule

Installation of the 500-foot-deep wells would require approximately 30 working days, with ten 24-hour shifts during weekdays and weekends. The remaining 20 working days would require 10- to 12-hour shifts. Personnel requirements for the first 10 days of well installation would include two crews, each consisting of one rig operator and two laborers. One construction superintendant would oversee both crews. Personnel for well development and testing would require one operator, two laborers, and one construction superintendant working a maximum 12-hour shift per day (that is, one shift).

In addition to manufacturer representatives, engineering construction management and contractor personnel would be required onsite for installation of conveyance piping. Construction of aboveground facilities, including the conveyance pipeline, would take up to 10 working days and would require two operators, two laborers, and one construction superintendant. Total personnel for each well installation would not likely exceed 12 people on any given day. On an average day, five people would be onsite.

Survey Methods

The site survey was conducted on February 15, 2011, between 11:00 a.m. and 1:00 p.m. Air temperatures were between 37 and 40 degrees Fahrenheit, with overcast skies, intermittent rain and hail, and negligible wind speeds. The site was systematically evaluated on foot throughout the project area to identify biological resources and environmental constraints. Photographs taken during the site survey are provided in Attachment B1. The CNDDB search results (Figures 4 and 5) and the CNDDB, USFWS, and CNPS species lists are provided in Attachment B2.

Results

Flora

Well No. 1. Annual ruderal, routinely disturbed grassland habitat occurs throughout the project area and along the ACID main canal. Within the project area, vegetation appears to be routinely disturbed by ACID activities (e.g., dirt/rock and stockpile movement, equipment usage, and mowing). Much of the site is a stockpile of rock, dirt, and other construction debris generated by ACID projects in the region. The ruderal vegetation is characterized by non-native annual vegetation such as ripgut brome *(Bromus diandrus)*, soft chess *(Bromus hordeaceus)*, rat-tail fescue *(Vulpia myuros)*, storksbill (*Erodium botrys*), and yellow star-thistle *(Centaurea solstitialis)*. A large valley oak *(Quercus lobata)* is in the northeast corner of the project area. Attachment B3 (Table B3-1) lists the plant species observed within the project area.

Well No. 2. Annual ruderal grassland habitat occurs throughout the project area and along the ACID main canal. Within much of the project area, vegetation is routinely sprayed or mowed. The ruderal grassland community is characterized by non-native annual vegetation such as ripgut brome, soft chess, rat-tail fescue, and yellow star-thistle. Interior live oaks *(Quercus wislizenii)* are scattered throughout the southern portion of the property. Vegetation associated with the residential properties consists of horticultural plants such as pines *(Pinus* spp.*)* and American privet *(Ligustrum* sp.*)*. East of the project site is dominated by riparian vegetation along Crowley Gulch and is characterized by Fremont cottonwoods

(Populus fremontii) and Gooding's willow *(Salix goodingii)* in the overstory with an understory dominated by Himalayan blackberry *(Rubus discolor)* and scattered arroyo willow *(Salix lasiolepis)*. Attachment B3 (Table B3-1) lists the plant species observed within the project area.

Sensitive Habitats

Well No. 1. No sensitive habitats were identified within the Well No. 1 project area or adjacent areas that would be affected by the proposed work.

Well No. 2. The following sensitive habitats were observed at Well No. 2.

Waters of the U.S.

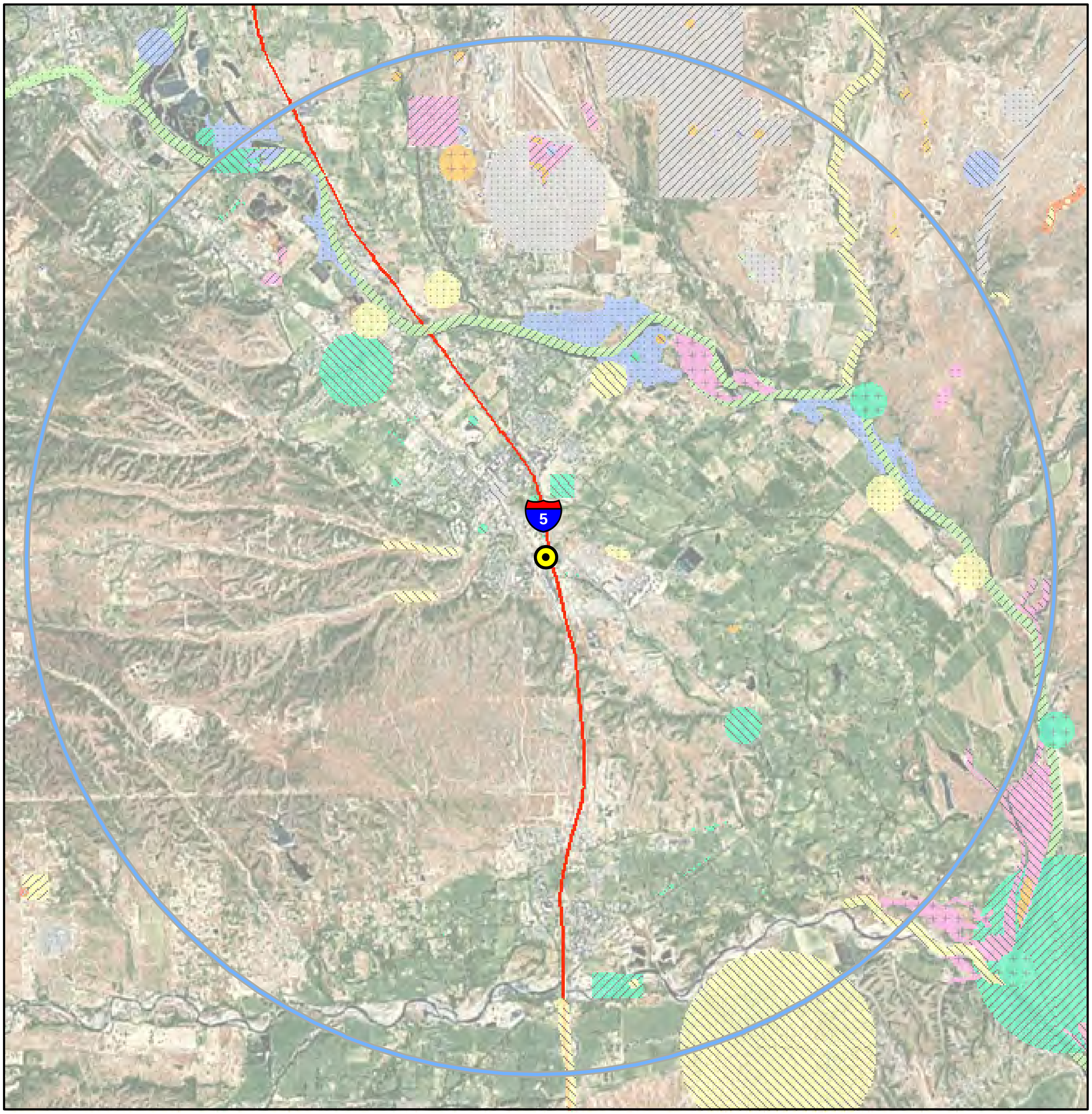
Crowley Gulch is mapped as an intermittent water feature on the USGS Cottonwood 7.5-minute quadrangle. The gulch is on the eastern edge of the study area and has a well-defined channel with steep banks. Large Fremont cottonwoods and dense Himalayan blackberry intermixed with small arroyo and Gooding's willows occur along the banks (see Attachment B1). The substrate of the gulch contains a large amount of organic debris consisting of wood and coarse plant material. Under the organic material and exposed in various locations, the stream has an inorganic substrate of cobble (2.5 to 10 inches) and gravel (0.1 to 2.5 inches). Because of temporal and spatial variability of rainfall in the Cottonwood area, Crowley Gulch is considered an arid ephemeral stream, flowing only during storm events and remaining dry for most of the year. Because of seepage from the flashboards at the ACID weir bays during the water delivery season (April through October), atypical water conditions appear upstream of the weir and for an undefined distance downstream. These conditions support heavy growth of facultative wetland to obligate vegetation species (Reed, 1988) within the channel bed, including a small patch of cattails *(Typha latifolia)*. The bed and banks within the Crowley Gulch have been cleared of vegetation approximately 60 feet upstream and 120 feet downstream (see Attachment B1). Crowley Gulch flows south to Cottonwood Creek, approximately 1.25 river-miles south of the project area.

Cottonwood-Willow Riparian Forest

Riparian vegetation along Crowley Gulch is characterized by large mature cottonwoods and Gooding's willow in the overstory with an understory dominated by Himalayan blackberry and scattered arroyo willow as shown in Attachment B1.

Oak Woodlands and Other Native Hardwood Habitats

A stand of interior live oak woodland is south of the project site. East and south of the ACID main canal, across from the project site, is a mixed stand of native oaks and non-native tree species. Large, scattered valley oaks occur within and outside the project area. No large stick nests were observed in the canopies; however, small and medium-sized stick nests were present.



LEGEND

- PRODUCTION WELL
- 5-MILE BUFFER

CALIFORNIA NATURAL DIVERSITY DATABASE

- Ahart's paronychia
- California linderiella
- Great Valley Cottonwood Riparian Forest
- Great Valley Mixed Riparian Forest
- Great Valley Valley Oak Riparian Forest
- Great Valley Willow Scrub
- Henderson's bent grass
- Red Bluff dwarf rush
- Yuma myotis
- bald eagle
- bank swallow
- brown fox sedge
- chinook salmon - Central Valley spring-run ESU
- chinook salmon - Sacramento River winter-run ESU
- hoary bat
- legenere
- osprey
- pink creamsacs
- pointed broom sedge
- silky cryptantha
- silver-haired bat
- slender Orcutt grass
- tricolored blackbird
- valley elderberry longhorn beetle
- vernal pool fairy shrimp
- vernal pool tadpole shrimp
- western pond turtle
- western red bat
- woolly meadowfoam

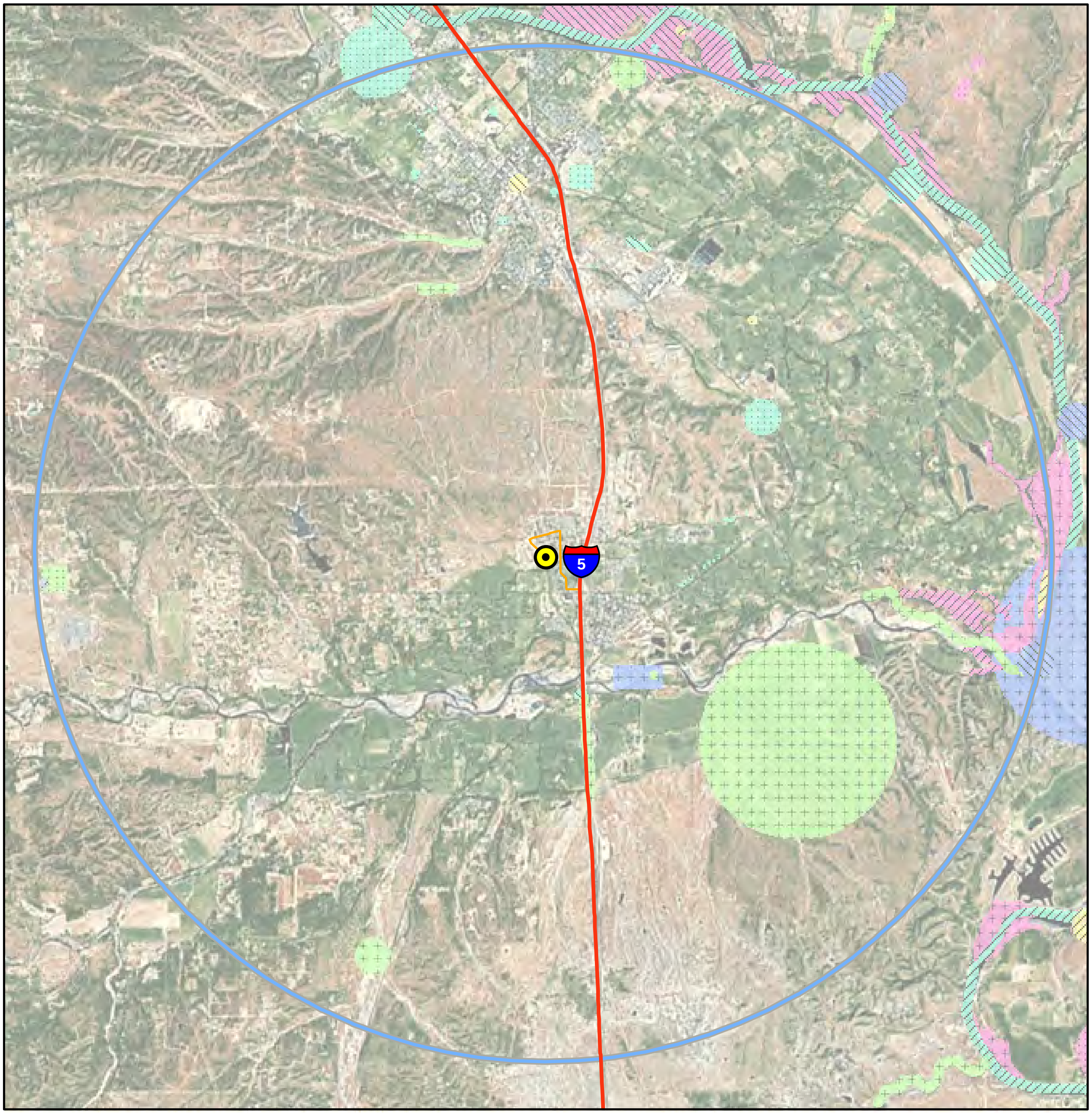
N

0 8,500

Feet

FIGURE 4
ACID WELL No. 1
BIOLOGICAL RESOURCES
ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

CH2MHILL



LEGEND

PRODUCTION WELL
ACCESS ROAD
5-MILE BUFFER

CALIFORNIA NATURAL DIVERSITY DATABASE

Ahart's paronychia
Great Valley Cottonwood Riparian Forest
Great Valley Mixed Riparian Forest
Great Valley Valley Oak Riparian Forest
Red Bluff dwarf rush
Yuma myotis
bald eagle
bank swallow
brown fox sedge
chinook salmon - Sacramento River winter-run ESU
hoary bat
osprey
pink creamsacs
pointed broom sedge
silky cryptantha
silver-haired bat
tricolored blackbird
valley elderberry longhorn beetle
western pond turtle
western red bat
western spadefoot
woolly meadowfoam

N

0 8,500
Feet

FIGURE 5
ACID WELL No. 2
BIOLOGICAL RESOURCES
ACID GROUNDWATER PRODUCTION
ELEMENT PROJECT

CH2MHILL

Fauna

Fauna species observed were limited for both well sites, possibly due to weather conditions during the survey. Common species for this area consist of raccoon *(Procyon lotor)*, grey fox *(Urocyon cinereoargenteus)*, western scrub jay (*Aphelocoma californica)*, red-tailed hawk *(Buteo jamaicensis)*, coyote *(Canis latrans*), and yellow-rumped warbler *(Dendroica coronata).* Attachment B3 (Table B3-2) lists the wildlife species observed within the project area.

Special-status Species

Rare Plants

Rare plants that have the potential to occur within the project area were identified using the CNDDB and CNPS database and are listed in Attachment B2. Nine plant and one moss species were identified on the Cottonwood, Hooker, Balls Ferry, and Bend quadrangles. Five of the plant species are vernal pool endemics. As neither well site has vernal pools, these five species are not likely to occur. Additionally, no suitable habitat for the moss species occurs within the project area.

Although not observed during the site visit, the following four plant species have the potential to occur within Crowley Gulch or within the ACID main canal at both well sites: Red Bluff dwarf rush (*Juncus leiospermus* var*. leiospermus)*, a CNPS 1b species; brown fox sedge (*Carex vulpinoidea)*, a CNPS 2 species; pointed broom sedge *(Carex scoparia),* a CNPS 2 species; and pink creamsacs *(Castilleja rubicundula ssp. Rubicundula),* a CNPS 1b species. CNPS status codes are defined in Attachment B2 (Table B2-1). Red Bluff dwarf rush occurs in vernal pools, seeps, and meadows. Brown fox sedge occurs in freshwater marshes, swamps, and riparian woodlands. Pointed broom sedge occurs in meadows, stream banks, fens, and woodland edges. Pink creamsacs occur in valley grasslands, cismontane woodlands, and seasonally wet soils in meadows, seeps, and grassland habitats.

Fishery Resources

No fishery resources are associated with Well No. 1.

Crowley Gulch, near Well No. 2, flows to Cottonwood Creek, which contains anadromous fish species. However, special-status fish species are not expected within the project area and would not be affected by the project.

Raptors and Migratory Birds

Both well sites were inspected for raptors and migratory birds and suitable nesting habitat. During the field visit, several raptor and migratory bird species were observed; however, because the surveys occurred before the breeding season, no active nests were observed. Several historical nest sites were observed within the woodland and riparian canopy near Well No. 2. Both well sites have the potential to support ground- and tree-nesting birds, such as killdeer (*Charadrius vociferus*) and red-tailed hawk during the breeding season. The majority of bird species are protected under the Migratory Bird Treaty Act (MTBA).

Roosting Bats

Near Well No. 2, an old wooden barn and old-growth cottonwoods could provide roosting sites for two special-status bat species identified in the CNDDB search. The western red bat

(Lasiurus blossevillii), a California species of special concern, roosts in broad-leafed woodlands in riparian areas. The pallid bat *(Antrozous pallidus),* also a California species of special concern, roosts in buildings and caves. The western red bat could roost in the cottonwood riparian trees on the eastern edge of the site. The pallid bat could roost in the wooden barn within the project area. Under the proposed project configuration, Well No. 2 and the water conveyance line to the ACID canal would not affect the barn and cottonwood trees onsite. Therefore, the project is not expected to affect roosting bat species.

Avoidance and Minimization of Biological Impacts

To the extent possible, new facilities and construction support areas (e.g., new temporary access roads, new staging areas, and new stockpile areas) would be located outside the outer edge or drip line of sensitive habitats listed in Table B1.

TABLE B-1
Avoidance Distances by Habitat Type
ACID Groundwater Production Element Project

Habitat	Buffer Distance
Riparian Forest and Scrub	100 feet from drip line
Oak Woodlands	100 feet from drip line

These habitat avoidance measures minimize impacts to special-status species; however, these species may use non-native habitats, require larger habitat buffers, or require seasonal restrictions. Therefore, to further minimize impacts, the potential for suitable habitat for listed or proposed species to occur at the project sites was assessed. If native habitats (i.e., vernal pools, wetlands, riparian vegetation, native grasslands, oak woodlands) were found at the project sites, new facilities and construction activities would be relocated outside a species-specific buffer area around potential habitat, to the extent possible. No listed or proposed species have been identified for the two well locations; therefore no further action or avoidance restrictions are warranted.

Conclusion and Recommendations

Avoidance and minimization measures would reduce the overall project footprint to a level that would not result in take of special-status species. The overall project footprint would not affect potential waters of the United States or waters of the State of California. Formal consultation is neither warranted nor required for the project, and the avoidance and minimization measures described herein would adequately protect special-status species that could be affected by the project.

The following measures are recommended to avoid impacts to known listed species potentially occurring within the project area:

- If construction occurs during the nesting season, preconstruction nesting surveys should be conducted within 14 days prior to construction. If construction occurs during the non-breeding season for nesting birds (September 1 through February 14), preconstruction surveys are not required.

- If the proposed project configuration changes, preconstruction bat surveys might be required. Construction activities should be restricted to buffer zones at least 100 feet from active bat roosts during the breeding season (March 1 through September 30). If construction occurs during the non-breeding season (October 1 and February 28), preconstruction surveys for bats are not required.

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Attachment B1
Site Photographs

PHOTOGRAPH 1
ACID Well No. 1, View South

PHOTOGRAPH 2
ACID Well No. 1, View East

PHOTOGRAPH 3
ACID Canal West of Study Area, Well No. 1, View South

PHOTOGRAPH 4
ACID Well No. 1 Southern End of Study Area, View South

PHOTOGRAPH 5
ACID Approximate Location for Well No. 1 in Northeast End of Study Area, View North

PHOTOGRAPH 6
Crowley Gulch East of Study Area Well No. 2, View North

PHOTOGRAPH 7
Crowley Gulch Downstream of Well No. 2 Study Area, View South

PHOTOGRAPH 8
ACID Canal East of Well No. 2, Power Pole Approximate Location of New Well, View West

PHOTOGRAPH 9
ACID Canal at Edge of Well No. 2, View South

PHOTOGRAPH 10
View along Access Route to Well No. 2, North of Study Area, View South

Attachment B2
CNDDB, CNPS, and USFWS Species Lists

TABLE B2-1
Special-status Plant and Animal Species Reported Near the ACID Well No. 1 and 2 Project Area
ACID Groundwater Production Element Project

Scientific Name	Common Name	Federal/ State/CNPS Status	Habitat Requirements	Breeding/Nesting–Bloom Season	Potential for Species within Project Area
Birds					
Agelaius tricolor	Tricolored black bird	--/CSC/--	Breeds near fresh water, preferably in emergent wetlands, with tall, dense cattails or tules, but also in thickets of willow, blackberry, wild rose, and tall herbs. Feeds in grassland and cropland habitats.	February to May	Highly unlikely – no suitable nesting habitat is in the project vicinity; suitable foraging habitat is present.
Coccyzus americanus occidentalis	Western yellow-billed cuckoo (nesting)	FC/SE/--	Riparian woodlands composed of dense cottonwoods and willows.	June to September	Highly unlikely – no suitable nesting habitat or foraging habitat is in the project vicinity.
Haliaeetus leucocephalus	Bald eagle (nesting and wintering)	FD/SE/--	Requires large bodies of water or free-flowing rivers with abundant fish and adjacent snags or other perches. Nests in large, old-growth, or dominant live tree with open branchwork, especially ponderosa pine.	January to March	Highly unlikely – no suitable nesting habitat or foraging habitat is in the project vicinity.
Pandion haliaetus	Osprey (nesting)	--/--/--	Forages along ocean shore, bays, freshwater lakes, and large streams. Nests built in tops of large trees within 15 miles of good fish-producing bodies of water.	March to September	Highly unlikely – no suitable nesting habitat or foraging habitat is in the project vicinity.
Riparia riparia	Bank Swallow	--/ST/--			
Mammals					
Antrozous pallidus	Pallid bat	--/CSC/--	Grasslands, shrublands, woodlands, and forests from sea level up through mixed conifers. Rocky areas with caves or tunnels. Occasionally inhabit old buildings.	October to February	Moderate – habitat present, building would not be disturbed.
Lasionycteris noctivagans	Silver-haired bat	--/--/--	Lives in forested areas; roosts under bark and in tree hollows. Solitary bat, slow flyer. Usually migrates south for winter, or hibernates in trees, crevices, buildings, mines, or other sheltered location.	Gives birth in the early summer	Low – no apparent cavities or snags in or near the project area. No riparian trees would be removed.

TABLE B2-1
Special-status Plant and Animal Species Reported Near the ACID Well No. 1 and 2 Project Area
ACID Groundwater Production Element Project

Scientific Name	Common Name	Federal/ State/CNPS Status	Habitat Requirements	Breeding/Nesting–Bloom Season	Potential for Species within Project Area
Lasiurus blossevillii	Western red bat	--/CSC/--	Broad-leafed woodlands, usually in riparian areas. Roosts in tree foliage. Primarily found at mid-elevations.	March to June	Moderate – habitat present, no riparian trees would be removed.
Lasiurus cinereus	Hoary bat	--/--/--	Generally roosts in dense foliage of medium to large trees. Prefers open habitats or habitat mosaics with access to trees for cover and open areas or habitat edges for foraging.	Mid-May through early July	Moderate – habitat present, no trees would be removed.
Myotis evotis	Long-eared myotis	--/--/--	Lives in coniferous forest in mountain areas. Roosts in small colonies in caves, buildings, and under tree bark.	Unknown; young are born June to July	Low – generally occur at higher elevations.
Myotis yumanensis	Yuma myotis	--/--/--	Day roosts are found in cavities in buildings, trees, mines, caves, bridges, and rock crevices. Night roosts are usually associated with buildings, bridges, and other open manmade structures.	May to September	Low – no apparent cavities or snags in or near the project area. No riparian trees would be removed.
Reptiles					
Emys (=Clemmys) marmorata	Northwestern pond turtle	--/CSC/--	Requires some slack- or slow-water aquatic habitat. Often reaches higher densities where many aerial and aquatic basking sites are available. Hatchlings require shallow-water habitat with relatively dense submergent or short emergent vegetation in which to forage. Also requires an upland oviposition site (high clay or silt fraction soil, on an unshaded slope) near the aquatic site.	April to May	Highly unlikely – no suitable habitat in the project area.

TABLE B2-1
Special-status Plant and Animal Species Reported Near the ACID Well No. 1 and 2 Project Area
ACID Groundwater Production Element Project

Scientific Name	Common Name	Federal/ State/CNPS Status	Habitat Requirements	Breeding/Nesting–Bloom Season	Potential for Species within Project Area
Amphibians					
Rana draytonii	California red-legged frog	FT/CSC/--	Found in humid forests, woodlands, grasslands, and streamsides with plant cover. Most common in lowlands or foothills. Frequently found in woods adjacent to streams. Breeding habitat is in permanent water sources; lakes, ponds, reservoirs, slow streams, marshes, bogs, and swamps. Typically without predatory fish, requires adequate hibernacula such as small mammal burrows and moist leaf litter. From sea level to 8,000 feet.	November to April; eggs hatch within 4 weeks and tadpoles metamorphose within 4 to 7 months	Low – no temporary pools and stream flows for breeding.
Spea (=Scahiopus) hammondii	Western spadefoot (toad)	--/CSC/--	Occurs primarily in grasslands, but occasional populations occur in valley foothill hardwood woodlands. Requires temporary rainpools with water temperatures between 9°C and 30°C that last 3 weeks, and that lack fish, bullfrogs, and crayfish. Soil characteristics of burrow refuge sites have not been studied, but if they are similar to those of S. multiplicatus, soil could become fairly compact and hard during summer aestivation.	January to May; metamorphose within 3 to 11 weeks	Low – no temporary pools for breeding.
Invertebrates					
Branchinecta conservatio	Conservancy fairy shrimp	FE/--/--	Occurs in large, generally playa-like vernal pools with highly turbid water.	October to May	Highly unlikely – no suitable habitat in the project area.
Branchinecta lynchi	Vernal pool fairy shrimp	FT/--/--	Found in vernal pools (seasonal wetlands).	October to May	Highly unlikely – no suitable habitat in the project area.
Desmocerus californicus dimorphus	Valley elderberry longhorn beetle	FT/--/--	Host plant elderberry (Sambucus ÿexicana). Generally found in riparian stands of clustered host plant.	April to June	Highly unlikely – no suitable host plant in the project area.

TABLE B2-1
Special-status Plant and Animal Species Reported Near the ACID Well No. 1 and 2 Project Area
ACID Groundwater Production Element Project

Scientific Name	Common Name	Federal/ State/CNPS Status	Habitat Requirements	Breeding/Nesting–Bloom Season	Potential for Species within Project Area
Fluminicola seminalis	Nugget pebblesnail	--/--/--	Found in the Pit and McCloud rivers, California. Formerly known from the mainstem Sacramento River, from its mouth upstream to Pit River, including large spring-fed tributaries. Found in river reaches and springs that have cold, well-oxygenated, clear water, generally with cobble or boulder substrates.	Spring (further research required)	Highly unlikely – no suitable habitat in the project area.
Lanx patelloides	Kneecap lanx	--/--/--	Freshwater streams and rivers.	Unknown	Highly unlikely.
Legenere limosa	Legenere	--/--/-- CNPS 1B	Occurs in vernal pools. Many historical occurrences are extirpated.	May to June	Highly unlikely – no suitable habitat in the project area.
Lepidurus packardi	Vernal pool tadpole shrimp	FE/--/--	Inhabits vernal pools and swales in the Sacramento Valley and San Joaquin Valley containing clear to highly turbid water. Commonly found in grass-bottomed swales of unplowed grasslands. Some inhabit mud-bottomed and highly turbid pools.	October to May	Highly unlikely – no suitable habitat in the project area.
Linderiella occidentalis	California linderiella	--/--/--	Inhabits clear to tea-colored water in seasonal ponds, which range from square feet to many acres, and are typically in grasslands or in depressions of sedimentary rock.	October to May	Highly unlikely – no suitable habitat in the project area.
Fish					
Acipenser medirostris	Green sturgeon	FT[a]/CSC[b]/--	Sturgeon use both freshwater and saltwater habitat. Green sturgeons spawn in deep pools or “holes” in large, turbulent, freshwater river mainstems. Specific spawning habitat preferences are unclear, but eggs likely are broadcast over large cobble substrates, but range from clean sand to bedrock substrates.	Adults typically migrate into fresh water beginning in late February; spawning occurs from March to July, with peak activity from April to June	Highly unlikely – no suitable habitat in the project area.

TABLE B2-1
Special-status Plant and Animal Species Reported Near the ACID Well No. 1 and 2 Project Area
ACID Groundwater Production Element Project

Scientific Name	Common Name	Federal/ State/CNPS Status	Habitat Requirements	Breeding/Nesting–Bloom Season	Potential for Species within Project Area
			Adults live in oceanic waters, bays, and estuaries when not spawning. Green sturgeons are known to forage in estuaries and bays ranging from San Francisco Bay to British Columbia.		
Hypomesus transpacificus	Delta smelt	FT/--/--	Found only in the Sacramento-San Joaquin Estuary. Resides primarily in the interface between salt water and fresh water. Decline in population caused by reductions in Delta water outflow.	May	Not within home range of this species.
Oncorhynchus mykiss	Central Valley steelhead	FT/--/--	Found in tributaries to the San Francisco Bay, including the South Bay. Pass through the San Francisco Estuary during migration to streams for spawning, and during outmigration to the ocean. Spawns in small streams and tributaries with cold, clean water flowing over graveled bottoms and deep pools.	Migrates July to May; spawns December to April	Low – salmonids have been observed in Crowley Gulch when canal water has been inadvertently directed downstream from the ACID canal weir. No sustained breeding habitat present.
Oncorhynchus tshawytscha	Winter-run Chinook salmon	FE/SE/--	Sacramento River and tributaries. Spawning takes place in swift, moderately shallow riffles or in areas along fast-moving banks with plentiful gravelly substrate. The gravel needs to be clean, loose, and stable for the duration of the larval stage.	Migrates December through early August; spawns in the upper mainstem Sacramento River from mid-April through August	Low – salmonids have been observed in Crowley Gulch when canal water has been inadvertently directed downstream from the ACID canal weir. No sustained breeding habitat present.
Oncorhynchus tshawytscha	Central Valley spring-run Chinook salmon	FT/--/--	Found in tributaries to the San Francisco Bay including the Sacramento River watersheds. Passes through the San Francisco Estuary during migration to streams for spawning, and during outmigration to the ocean. Spawns in well-oxygenated water in swift, shallow riffles, or at edges of fast runs with loose gravel.	Migrates during spring; holds in headwaters areas, and spawns during late summer and early fall	Low – salmonids have been observed in Crowley Gulch when canal water has been inadvertently directed downstream from the ACID canal weir. No sustained breeding habitat present.

TABLE B2-1
Special-status Plant and Animal Species Reported Near the ACID Well No. 1 and 2 Project Area
ACID Groundwater Production Element Project

Scientific Name	Common Name	Federal/ State/CNPS Status	Habitat Requirements	Breeding/Nesting–Bloom Season	Potential for Species within Project Area
Plants					
Anomobryum julaceum	Slender silver moss	--/--/CNPS 2.2	Moss found in broad-leafed upland forest and lower montane coniferous forest on damp rock soil on outcrops and along road cuts.	None	Highly unlikely – no suitable habitat in the project area.
Carex scoparia	Pointed broom sedge	--/--CNPS 2.2	Meadows, stream banks, ferns, and woodland edges.	May to August	Moderate – this species was not observed during survey. Potential to occur in Crowley Gulch.
Carex vulpinoidea	Brown fox sedge	--/--/CNPS 2.2	Occurs almost always under natural conditions in wetlands, riparian, and freshwater marsh.	May to June	Moderate – this species was not observed during survey. Potential to occur in Crowley Gulch.
Castilleja rubicundula ssp. rubicundula	Pink creamsacs	--/--/CNPS 1B.2	Occurs in openings of chaparral, cismontane woodland, meadows, seeps, and valley grasslands.	April to June	Moderate – this species was not observed during survey. Seasonally moist habitats.
Cryptantha crinita	Silk cryptantha	--/--/CNPS 1B.2	Cismontane woodland, valley and foothill grasslands, lower montane coniferous forest, riparian forest, and riparian woodland; often in gravelly streambeds.	April to May	Low – habitat along Crowley Gulch is not the typical habitat community in which this species is found.
Gratiola heterosepala	Boggs Lake hedge-hyssop	--/--CNPS 1B.2	Vernal pools, lake or reservoir margins in shallow water or moist ground on adobe soil. In grasslands, oak woodlands, sagebrush-juniper to pine forest type. Found at elevations from 650 to 5,600 feet.	April to August	Highly unlikely – no suitable habitat in the project area.
Juncus leiospermus var. leiospermus	Red Bluff dwarf rush	--/--/CNPS 1B.1	Vernal pools and swales, seeps, and other seasonally moist sites in chaparral, cismontane woodland, and valley and foothill grasslands.	March to May	Low – this species was not observed during wetland survey. Low potential to occur in Crowley Gulch.
Legenere limosa	Legenere	--/--/CNPS 1B.1	Vernal pools.	April to June	Highly unlikely – no suitable habitat in the project area.
Orcuttia tenuis	Slender orcutt grass	--/--/CNPS 1B.1	Vernal pools.	May to September	Highly unlikely – no suitable habitat in the project area.

TABLE B2-1
Special-status Plant and Animal Species Reported Near the ACID Well No. 1 and 2 Project Area
ACID Groundwater Production Element Project

Scientific Name	Common Name	Federal/ State/CNPS Status	Habitat Requirements	Breeding/Nesting–Bloom Season	Potential for Species within Project Area
Paronychia ahartii	Ahart's paronychia	--/--/CNPS 1B.1	Vernal pools, shallow or poorly drained soil in Cismontane woodland, and valley and foothill grasslands.	March to June	Highly unlikely – no suitable habitat in the project area.

[a]Federal listing includes all spawning populations south of the Eel River

[b]National Marine Fisheries Service "special concern" refers to all spawning populations north of the Eel River

Sources:

California Department of Fish and Game CNDDB, 2011.
CNPS, 2011.
USFWS, 2011.

Notes:

--/--/-- = No federal, state, or CNPS status

Federal:
FC = Federal Candidate for Listing as Threatened or Endangered
FD = Federally Delisted Species
FE = Federal Endangered
FT = Federal Threatened

State:
CSC = California Species of Concern
SE = State Endangered
ST = State Threatened

CNPS:
CNPS 1A = Species is Presumed Extinct in California
CNPS 1B = Plants Rare, Threatened, or Endangered in California and Elsewhere
CNPS 2 = Plants Rare, Threatened, or Endangered in California but More Common Elsewhere

CNPS Threat Ranks:
.1-Seriously threatened in California (high degree/immediacy of threat)
.2-Fairly threatened in California (moderate degree/immediacy of threat)
.3-Not very threatened in California (low degree/immediacy of threats or no current threats known)

Attachment B3
Flora and Fauna Species Observation Lists

TABLE B3-1
Plant Species Observed at the Project Site
ACID Groundwater Production Element Project

Scientific Name	Common Name	Growth Habitat	Indicator Status[a]
Asteraceae			
Centaurea solstitialis	Yellow star-thistle	Herb	NL
Lactuca serriola	Prickly lettuce	Herb	FAC
Silybum marianum	Milk thistle	Herb	NL
Brassicaceae			
Brassica nigra	Black mustard	Herb	NL
Raphanus sativus	Radish	Herb	NL
Cyperaceae			
Cyperus esculentus	Yellow nutgrass	Herb	FACW
Fabaceae			
Acacia sp.	Acacia	Tree	NL
Fagaceae			
Quercus wislizenii	Interior live oak	Tree	NL
Quercus lobata	Valley oak	Tree	FACU
Geraniaceae			
Erodium botrys	Broadleaf filaree	Herb	NL
Juncaceae			
Juncus balticus	Baltic rush	Herb	OBL
Oleaceae			
Ligutrum sp.	Privet	Shrub	NL
Pinaceae			
Pinus radiata	Monterey pine	Tree	NL
Poaceae			
Avena fatua	Wild oat	Herb	NL
Bromus diandrus	Ripgut brome	Herb	NL
Bromus hordeaceus	Soft chess	Herb	UPL
Paspalum dilatatum	Dallisgrass	Herb	NL
Vulpia myuros	Rat-tail fescue	Herb	NL
Polygonaceae			
Rumex crispus	Curly dock	Herb	FACW
Rosaceae			
Rubus discolor	Himalayan blackberry	Shrub	FACW[b]

TABLE B3-1
Plant Species Observed at the Project Site
ACID Groundwater Production Element Project

Scientific Name	Common Name	Growth Habitat	Indicator Status[a]
Salicaceae			
Populas fremontii	Fremont cottonwood	Tree	FACW
Salix goodingii	Gooding's willow	Tree	OBL
Salix lasiolepis	Arroyo willow	Tree	FACW
Typhaceae			
Typha latifolia	Broad-leaved cattail	Herb	OBL

[a]Indicator Status from the National List of Plant Species that Occur in Wetlands; California (Region 0) (Reed, 1988).

[b]Indicates a tentative status code assignment.

Source: USFWS, 2011.

Notes:

+/- = Indicates greater (+) or lesser (-) tendency to occur in wetlands.

FAC = Facultative Status Species; Estimated probability of 33 to 67 percent chance of occurring in wetlands. Species not considered to be typically adapted for life in anaerobic soil conditions.

FACU = Facultative Upland Status; Estimated probability of 1 to 33 percent chance of occurring in wetlands.

FACW = Facultative Wetland Status; Estimated probability of 67 to 99 percent chance of occurring in wetlands.

NL = Not included on the 1988 list.

OBL = Obligate Species; Estimated probability of 99 percent chance of occurring in wetlands.

UPL = Obligate Upland; Estimated probability of less than 1 percent chance of occurring in wetlands.

TABLE B3-2
Wildlife Species Observed at the Project Site
ACID Groundwater Production Element Project

Scientific Name	Common Name	Observation Type
Birds		
Carpodacus mexicanus	House finch	Visual
Dendroica coronata	Yellow-rumped warbler	Visual
Sturnus vulgaris	European starling	Visual
Pica nuttalli	Yellow-billed magpie	Visual
Corvus brachyrhynchos	American crow	Visual
Sayornis nigricans	Black phoebe	Visual
Buteo jamaicensis	Red-tailed hawk	Visual
Mammals		
Procyon lotor	Raccoon	Tracks

Appendix C
Construction Emission Calculations

APPENDIX C

Construction Emission Summary – Well 1

EA/IS and FONSI/MND for ACID Groundwater Production Element Project

Emission Source	Emissions (lb/day)						Emissions (tons)					
	ROG	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$	ROG	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Well Drilling	3.2	14.5	28.1	0.0025	1.45	1.33	0.016	0.073	0.141	0.00001	0.007	0.007
Well Development/ Aboveground Facilities Construction	2.7	9.4	25.5	0.0016	1.12	1.03	0.027	0.094	0.255	0.00002	0.011	0.010
Maximum Emissions	3.2	14.5	28.1	0.0025	1.4	1.3	0.043	0.167	0.396	0.00003	0.018	0.017

NA = Not applicable

NE = Threshold has not been established

Worker Commute Trips				Emissions (lb/day)					
Construction Phase	# of Workers/day	Days of Work	Miles Travelled per Round Trip	ROG	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Well Drilling	7	10	20	0.016	0.60	0.056	0.0009	0.003	0.002
Well Development	4	20	20	0.009	0.34	0.032	0.0005	0.002	0.001
Aboveground Facilities	5	10	20	0.0115	0.431	0.0401	0.0007	0.0020	0.0018

Round trip mileage represents the distance from the construction site to the nearest city, (in this case, Redding, CA).

Well drilling emissions are based on the assumption that well drilling will occur 7 days per week, with two work crews operating 12 hours each per day.

Well development and aboveground facilities construction emissions are based on the assumption that crews will work 7 days per week, 12 hours per day.

It is assumed that the well development and aboveground facilities construction activities will occur simultaneously.

Offsite Vehicle Emissions			Emissions (lb/day)					
Construction Phase	# of Vehicle Trips	Miles Travelled Roundtrip	ROG	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Cement Delivery Trucks	3	20	0.044	0.712	0.069	0.001	0.010	0.009
Fuel Delivery Trucks	1	20	0.015	0.237	0.023	0.000	0.003	0.003

It is assumed that cement truck deliveries will occur on 4 days during the aboveground construction phase of the project, with three deliveries per day.

It is assumed that fuel truck deliveries will occur weekly during all phases of construction (4 days total).

Emission Source	Emissions (lb/day)						Emissions (tons)					
	ROG	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$	ROG	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Well Drilling	3.2	15.3	28.2	0.0038	1.46	1.34	0.016	0.077	0.141	0.00002	0.007	0.007
Well Development/ Aboveground Facilities Construction	2.7	9.9	25.5	0.0024	1.12	1.03	0.027	0.099	0.255	0.00002	0.011	0.010
Maximum Emissions	3.2	15.3	28.2	0.0038	1.5	1.3	0.044	0.176	0.396	0.00004	0.018	0.017

NA = Not applicable
NE = Threshold has not been established

Worker Commute Trips				Emissions (lb/day)					
Construction Phase	# of Workers/day	Days of Work	Miles Travelled per Round Trip	ROG	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Well Drilling	7	10	30	0.024	0.91	0.084	0.0014	0.004	0.004
Well Development	4	20	30	0.014	0.52	0.048	0.0008	0.002	0.002
Aboveground Facilities	5	10	30	0.0172	0.647	0.0602	0.0010	0.0030	0.0026

Round trip mileage represents the distance from the construction site to the nearest city (in this case, Redding, CA).
Well drilling emissions are based on the assumption that well drilling will occur 7 days per week, with two work crews operating 12 hours each per day.
Well Development and aboveground facilities construction emissions are based on the assumption that crews will work 7 days per week, 12 hours per day.
It is assumed that the well development and aboveground facilities construction activities will occur simultaneously.

Offsite Vehicle Emissions			Emissions (lb/day)					
Construction Phase	# of Vehicle Trips	Miles Travelled Roundtrip	ROG	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$
Cement Delivery Trucks	3	30	0.066	1.067	0.104	0.002	0.014	0.013
Fuel Delivery Trucks	1	30	0.022	0.356	0.035	0.001	0.005	0.004

It is assumed that cement truck deliveries will occur on 4 days during the aboveground construction phase of the project, with three deliveries per day.
It is assumed that fuel truck deliveries will occur weekly during all phases of construction (4 days total).

APPENDIX C

Road Emission Factors – Exhaust Emission Factors

EA/IS and FONSI/MND for ACID Groundwater Production Element Project

Vehicle	Vehicle Type in EMFAC2007	2011 Emission Factors (lb/mile)						
		ROG	CO	NOx	SO_x	PM_{10}	$PM_{2.5}$	CO_2
Work Trucks (unpaved roads)	Light-duty truck, gasoline	0.0007	0.0119	0.0012	0.00002	0.0002	0.0001	1.9507
Employee Commute Paved Road	Passenger vehicles, gasoline	0.0001	0.0043	0.0004	0.00001	0.0000	0.00002	0.6320
Vehicle	**Vehicle Type in EMFAC2007**	**2011 Emission Factors (g/mile)**						
		ROG	CO	NO_x	SO_x	PM_{10}	$PM_{2.5}$	CO_2
Work Trucks (unpaved roads)	Light-duty truck, gasoline	0.334	5.38	0.523	0.009	0.1	0.07	884.86
Employee Commute	Passenger vehicles, gasoline	0.052	1.956	0.182	0.003	0.009	0.008	286.666

Emission factors are from the California Air Resources Board's EMFAC 2007 model for Shasta County.

It was assumed that vehicles would travel at 10 miles per hour on unpaved roads and 45 miles per hour on paved roads.

4/29/2011 03:06:46 PM

Urbemis 2007 Version 9.2.4

Detail Report for Summer Construction Unmitigated Emissions (Pounds/Day)

File Name: C:\Projects\Waldrop\ACID urbemis.urb924

Project Name: ACID

Project Location: California State-wide

On-road Vehicle Emissions Based on: Version : Emfac2007 V2.3 Nov 1 2006

Off-road Vehicle Emissions Based on: OFFROAD2007

CONSTRUCTION EMISSION ESTIMATES (Summer Pounds Per Day, Unmitigated)

	ROG	NOx	CO	SO2	PM10 Dust	PM10 Exhaust	PM10 Total	PM2.5 Dust	PM2.5 Exhaust	PM2.5 Total	CO2
Trenching 06/01/2011-06/10/2011	3.15	28.01	13.50	0.00	0.00	1.43	1.44	0.00	1.32	1.32	4,971.40
Trenching Off-road Diesel	3.14	27.99	12.99	0.00	0.00	1.43	1.43	0.00	1.32	1.32	4,920.30
Trenching Worker Trips	0.02	0.03	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	51.10
Mass Grading 06/11/2011-06/30/2011	2.72	25.44	9.18	0.00	0.00	1.11	1.12	0.00	1.02	1.02	2,567.06
Mass Grading Dust	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Off-road Diesel	2.69	25.40	8.41	0.00	0.00	1.11	1.11	0.00	1.02	1.02	2,490.42
Mass Grading On-road Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass Grading Worker Trips	0.02	0.04	0.76	0.00	0.00	0.00	0.01	0.00	0.00	0.00	76.64

Phase Assumptions

Phase: Mass Grading 6/11/2011 - 6/30/2011 - Well Development

Total Acres Disturbed: 0

Maximum Daily Acreage Disturbed: 0

Fugitive Dust Level of Detail: Default

0 lbs per acre-day

On-road Truck Travel (VMT): 0

Off-road Equipment:

2 Other Material Handling Equipment (191 hp) operating at a 0.59 load factor for 12 hours per day

1 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 12 hours per day

Phase: Trenching 6/1/2011 - 6/10/2011 - Well Drilling

Off-road Equipment:

1 Bore/Drill Rigs (291 hp) operating at a 0.75 load factor for 20 hours per day

1 Tractors/Loaders/Backhoes (108 hp) operating at a 0.55 load factor for 20 hours per day

Appendix D
Redding Groundwater Basin Finite-Element Model Documentation

Appendix D

Documentation of the Redding Groundwater Basin Finite-Element Model

July 2011

CH2MHILL
2525 Airpark Drive
Redding, California 96001

Contents

Contents, Continued

Acronyms and Abbreviations

ACID	Anderson-Cottonwood Irrigation District
CY	calendar years
DWR	California Department of Water Resources
ET	evapotranspiration
ft	foot or feet
ft^2	square foot or feet
ft^3	cubic foot or feet
GIS	geographic information system
gpd	gallons per day
gpm	gallons per minute
in.	inch or inches
K_h	horizontal hydraulic conductivity
K_v	vertical hydraulic conductivity
PRISM	Parameter-elevation Regressions on Independent Slopes Model
REDFEM	Redding Groundwater Basin Finite-Element Model
RMSE	root mean squared error
SACFEM	Sacramento Valley Finite-Element Groundwater Model
USGS	U.S. Geological Survey

APPENDIX D

Documentation of the Redding Groundwater Basin Finite-Element Model

1.0 Introduction

This report provides an overview of the development and calibration of the Redding Groundwater Basin Finite-Element Model (REDFEM). Rather than providing an exhaustive discussion of the parameter values that comprise REDFEM, the electronic modeling files serve as companion files to this report and are available upon request.

2.0 Modeling Objectives

The current objective for REDFEM is to develop a quantitative tool that forecasts effects of a groundwater production project on surface water and groundwater resources within the Redding Groundwater Basin. Following are additional potential uses of REDFEM:

- Help identify potential consequences of proposed actions before groundwater projects are implemented.
- Assess alternative approaches to proposed actions that could mitigate potential adverse effects on water resources.
- Assess combined effects from multiple proposed or existing projects.
- Help guide resource planning activities to address issues such as water supply reliability, water use efficiency, urbanization, and the environment.
- Enhance current and future water-level monitoring activities.
- Aid in public outreach efforts.

3.0 Model Code Description

MicroFEM (Hemker, 2011), a finite-element based, three-dimensional, integrated groundwater modeling package developed in The Netherlands, was chosen to simulate the groundwater flow system in the Redding Groundwater Basin. MicroFEM is capable of modeling saturated, single-density groundwater flow in layered systems. Horizontal flow is assumed in each layer, as is vertical flow between adjacent layers.

MicroFEM was the chosen modeling code for the following reasons:

- The finite-element scheme allows the construction of a model grid covering a large geographic area (over 822 square miles in the REDFEM domain) with coarse node spacings near the periphery of the basin and finer node spacings in the interior of the basin (such as near potential project areas). The finer node spacing provides greater resolution of simulated groundwater levels and stream impacts.

- The graphical interface allows rapid assignment of aquifer parameters and allows proofing of these values by graphical means.
- The flexible post-processing tools allow rapid evaluation of transient water budgets for model simulations and identification of changes to stream discharges and other groundwater fluxes across the model domain.
- REDFEM was constructed using codes and a methodology similar to those of the Sacramento Valley Finite-Element Groundwater Model (SACFEM) (CH2M HILL, 2009). The use of similar approaches provides consistency with methods used to forecast potential impacts on groundwater and surface water resources in other areas of the Sacramento Valley (including the Redding Groundwater Basin).
- MicroFEM is the product of more than 20 years of development and has been used in groundwater evaluations worldwide.
- MicroFEM has been benchmarked and verified, meaning numerical solutions generated by the code have been compared with one or more analytical solutions, subject to scientific review, and used on previous modeling projects. Verifying the code ensures that MicroFEM can accurately solve the governing equations that constitute the mathematical model.
- CH2M HILL has experience applying MicroFEM to assess complicated groundwater flow problems at numerous sites.

4.0 Geologic Setting

The Redding Groundwater Basin is located in the northernmost portion of the Sacramento Valley. Underlying Tehama and Shasta Counties, it is bordered by the Klamath Mountains to the north, the Coast Range to the west, and the Cascade Mountains to the east. The Red Bluff Arch, between Cottonwood and Red Bluff, separates the Redding Groundwater Basin from the Sacramento Valley Groundwater Basin to the south.

The Redding Groundwater Basin consists of a sediment-filled, southward-plunging symmetrical trough (California Department of Water Resources [DWR], 2003). Simultaneous deposition of material from the Coast Range and the Cascade Range resulted in two different formations, which are the principal freshwater-bearing formations in the basin. The Tuscan Formation in the east is derived from Cascade Range volcanic sediments, and the Tehama Formation in the western and northwest portion of the basin is derived from Coast Range sediments. These formations are up to 2,000 feet thick near the confluence of the Sacramento River and Cottonwood Creek, and the Tuscan Formation is generally more permeable and productive than the Tehama Formation (Pierce, 1983). The Redding Groundwater Basin covers approximately 510 square miles in parts of Shasta and Tehama Counties, and is the northernmost portion of California's Central Valley (Figure D-1; figures are located at the end of this report). The basin is bounded by the foothills of the Cascade Range to the east, by the Klamath Mountains to the north and northwest, by the northern

Coast Ranges to the southwest, and by the Red Bluff Arch to the south. The Red Bluff Arch is a subsurface uplift located north of the city of Red Bluff, and structurally separates the Redding Groundwater Basin from the Sacramento Valley Groundwater Basin (Pierce, 1983).

The base of freshwater in the basin coincides with the top of the Chico Formation, which is composed of marine deposits of sandstone, conglomerates, and shale, and contains salt water under artesian pressure. Fresh groundwater is found above the Chico Formation in the Tuscan Formation (in the eastern portion of the basin) and in the Tehama Formation in the western portion of the basin. The Tuscan and Tehama Formations are at most 2,000 feet thick near the confluence of the Sacramento River and Cottonwood Creek (Pierce, 1983).

The thick sand and gravel strata (derived from reworked mudflows) of the Tuscan Formation are generally more permeable and productive than the Tehama Formation's fluvial silt, sand, gravel, and clays. The Tuscan and Tehama Formations are generally overlain by the moderately permeable Red Bluff Formation, which is composed of coarse gravels and boulders in a sand, silt, and clay matrix. Unconsolidated moderately permeable alluvial deposits underlie the floodplains of the Sacramento River and its tributaries, and permeability is higher where gravels dominate (Pierce, 1983).

5.0 Hydrology

The Sacramento River is the main surface water feature in the Redding Groundwater Basin, with several tributaries draining the surrounding hills and mountains. The most significant tributaries are Battle, Churn, Clear, Cottonwood, Cow, Little Cow, Stillwater, and Dry Creeks. Groundwater and surface water interaction, and riparian vegetation occur along surface water features throughout the basin.

Seasonal groundwater fluctuations range from 2 to 3 feet in shallow, unconfined aquifers and 2 to 5 feet in semi-confined to confined aquifers in normal years. During drought years, unconfined aquifer levels can fluctuate by as much as 10 feet, and semi-confined and confined aquifer levels can fluctuate as much as 16 feet. In general, groundwater flows southeasterly on the west side of the basin and southwesterly on the east side, toward the Sacramento River.

6.0 Model Construction

This section discusses the development of the groundwater model grid and layering, the assignment of groundwater flux boundary conditions, and the basis for assignment of material properties to the aquifers within the model domain.

6.1 Areal Characteristics of Model Grid

The model boundary follows the Redding Groundwater Basin boundary (Pierce, 1983), except in the north and northwest locations, where the boundary was extended to encompass areas representing water purveyor service areas. This facilitates modeling evaluations of impacts on in-basin water transfers. The REDFEM grid consists of 55,938 nodes and 111,461 elements per layer (see Figure D-2). The current grid configuration supports evaluating potential conjunctive water management projects within the Redding

Groundwater Basin; however, REDFEM was designed to be grid-independent, and geographic information system (GIS)-based tools can be used to build a similar basinwide model on any grid needed to support a particular application. The current grid's nodal spacing varies from a nominal spacing of 1,500 feet near the model boundary, where groundwater projects are not currently being evaluated, to a nominal spacing of 500 feet in the central part of the basin, where groundwater production is being evaluated. The finer node spacing in the interior allows for more refined estimates of the effects of groundwater pumping on groundwater levels and groundwater and surface water interaction in the proposed project area.

6.2 Vertical Characteristics of Model Grid

REDFEM is vertically stacked into four layers to provide a three-dimensional representation of the subsurface system. These layers were developed to provide sufficient vertical resolution to facilitate the following:

- Evaluation of the effects of groundwater pumping on shallow and regional water resources
- Assignment of pumping stresses to appropriate depths within the aquifer that reflect the major producing zones within the aquifer system

The total model thickness represents the thickness of the freshwater aquifer above the Chico Formation, as modified from DWR's Bulletin 74-8, *Water Well Standards Shasta County* (DWR, 1968) (Figure D-3). The total modeled thickness was established by subtracting the depth to the Chico Formation from the average groundwater levels. Model Layer 1 was assigned a thickness of 50 feet; this layer thickness was limited to provide more accurate shallow groundwater elevations with which to support evaluations of the effects of changing groundwater levels on surface streams and wetland and riparian areas. Model Layers 2 and 3 represent the more regional groundwater-producing zones within the basin, where municipal and agricultural wells tend to be screened. These layers were assigned thicknesses of 100 and 200 feet, respectively, to provide multiple-depth zones to assign regional pumping. Model Layer 4 represents the remaining saturated thickness above the Chico Formation, which varies from 50 feet at the basin margins to approximately 1,800 feet near the confluence of the Sacramento River and Cottonwood Creek.

6.3 Aquifer Properties

The Redding Groundwater Basin distribution of aquifer properties is poorly understood. In areas with significant levels of groundwater production, the collection of aquifer test data and the measurement of historical groundwater-level trends, in response to known groundwater production rates, provided valuable information on aquifer properties. However, in the majority of the basin, such data are not available.

Several steps were taken to aid in assigning aquifer properties across the modeling domain representing the Redding Groundwater Basin. Various reports prepared by the Department, the U.S. Geological Survey (USGS), and area consultants were reviewed and, where available, aquifer property data were compiled. Hundreds of well completion logs were obtained from the Northern District of DWR and reviewed for well-construction and specific-capacity information. Aquifer properties were estimated for discrete-depth intervals in the Redding Groundwater Basin (based on the well construction information) and plotted on a basin map. Approximately 90 wells provided both well-construction and specific-capacity information that was used in this analysis. After the data set was finalized, the reported specific capacity data for each well were used to estimate aquifer transmissivity for each location. The following equation is a simplified version of the Jacob nonequilibrium equation (Driscoll, 1986) used to estimate aquifer trasmissivity (Equation -1):

$$SC=\frac{T}{2000} \qquad (1)$$

where:

SC = specific capacity of an operating production well (gallons per minute per foot of drawdown [gpm/ft])

T = aquifer transmissivity (gallons per day per foot [gpd/ft])

After a transmissivity estimate was computed for each location with both specific-capacity and well-construction information, the transmissivity value was then divided by the screen length of the production well to yield an estimate of the horizontal hydraulic conductivity (K_h) of the aquifer materials. The point values obtained by this process were then kriged to develop a K_h distribution across the model domain. The aquifer transmissivity at each model node within each model layer was then computed using the hydraulic conductivity value at that node multiplied by the thickness of the model layer. Insufficient data were available to attempt to subdivide the data set into depth-varying hydraulic conductivity distributions, and it was initially assumed that the computed mean hydraulic conductivity values were representative of the major aquifer units in all model layers. The ratio of the K_h to vertical hydraulic conductivity (K_v) ranges from 10 to 1, up to 100 to 1 in REDFEM. Figure D-4 shows the distribution of transmissivity used in REDFEM.

The specific yield of the upper 50 feet below the water table (Model Layer 1) was assigned a uniform value of 10 percent. This value was within the range previously reported by Olmsted and Davis (1961) and Pierce (1983). A uniform specific storage coefficient of $2x10^{-6}$ per ft (ft^{-1}) of aquifer thickness was assumed for the remaining levels. The storage coefficient for Model Layers 2 through 4 was computed by multiplying the model layer thickness by $2x10^{-6}$ ft^{-1}.

6.4 Boundary Conditions

Boundary conditions are mathematical statements describing either the groundwater elevation (such as head) or the groundwater flux at specific locations within the model domain (Anderson and Woessner, 1992). Boundary conditions can represent either physical boundaries, such as impermeable rock, or hydraulic boundaries, such as groundwater divides or streamlines. The three types of boundary conditions used in REDFEM are as follows:

- Head-dependent flux boundaries, where the groundwater flux across the boundary is calculated as a function of a calculated head and a conductance term (which regulates seepage)
- Specified-flux boundaries, where a constant groundwater flux is prescribed
- No-flow boundaries, where the groundwater flux across the boundary is prohibited

The following subsections describe the assignment of each of these boundary conditions in REDFEM.

6.4.1 Head-dependent Flux Boundaries

Streams. The MicroFEM wadi system was used to simulate the two-way exchange of water between the modeled streams and underlying aquifer in the study area. MicroFEM's wadi system calculates the magnitude and direction of nodal fluxes on the basis of relative values of stream stage and the modeled water table. For each model node, groundwater discharge to, or recharge from, a stream is calculated according to the following equations (Equations 2 through 4):

$$Q_{outflow} = a\frac{(h1 - wh1)}{wc1}, \text{ if } wh1 < 1 \tag{2}$$

$$Q_{inflow} = a\frac{(wh1 - h1)}{wc1}, \text{ if } wl1 < h1 < wh1 \tag{3}$$

$$Q_{inflow} = a\frac{(wh1 - wl1)}{wc1}, \text{ if } h1 < wl1 \tag{4}$$

where:

$Q_{outflow}$ = modeled groundwater flux from the aquifer to the stream (cubic feet per day [ft^3/day])

Q_{inflow} = modeled groundwater flux from the stream to the aquifer (ft^3/day)

a = nodal area (square-feet [ft^2])

h1 = modeled groundwater elevation (such as head) in Model Layer 1 (ft)

wh1 = modeled stream stage (ft)

wl1 = modeled stream bottom elevation (ft)

wc1 = resistance across the streambed (per day [day^{-1}])

Typically, the area surrounding a model node that represents a discrete reach of a stream is different than the actual surface area of that stream reach in the field. The wc1 term incorporates an areal correction factor to account for this discrepancy. An additional correction factor was incorporated into the wc1 term, to account for the additional flow resistance through sediments in the upper half of Model Layer 1, when calculating Q_{inflow} and $Q_{outflow}$. Thus, the wc1 term is calculated as follows (Equation 5):

$$wc1 = \left(\frac{b_s}{K_{vs}} + \frac{½ b_a}{K_{va}}\right)\left(\frac{a}{LW}\right) \tag{5}$$

where:

b_s = thickness of streambed sediments (ft)
K_{vs} = vertical hydraulic conductivity of streambed sediments (feet per day [ft/day])
b_a = thickness of aquifer represented by Model Layer 1 (ft)
K_{va} = vertical hydraulic conductivity of aquifer represented by Model Layer 1 (ft/day)
L = stream length represented by the model node (ft)
W = field-width of the wetted stream channel along L (ft)

Streams simulated in the model with the wadi system were those with perennial or nearly perennial streamflow, including the Sacramento River, Cow Creek, and Cottonwood Creek (Figure D-5). Stream locations were digitized from existing base maps and topographic quad sheets, and imported into the model domain. Streambed thickness was assumed to be 1 foot for all stream nodes. Streambed K_v assumptions were based on the type of streambed deposits expected, based on relative stream size. Wetted stream width was visually estimated by reviewing aerial photographs.

Drains. The MicroFEM drain system was specified at nodes across the top surface of Model Layer 1, excluding wadi nodes and nodes coinciding with the Anderson-Cottonwood Irrigation District (ACID) main canal. A drain boundary condition is a one-way head-dependent flux boundary allowing groundwater to discharge from the modeled aquifer to the drain, if the modeled water table elevation is greater than the prescribed drain elevation. The drain elevations were set at the land surface elevation to allow the model to simulate groundwater discharge to the land surface. Areas of groundwater discharge to the surface include 29 stream channels in the model domain that are implemented as drains (Figure D-5). Equations 6 and 7 simulate transfer of groundwater from the aquifer to a drain, as follows:

$$Q_{outflow} = a\frac{(h1\text{-}dh1)}{dc1}, \text{if } h1 > dh1 \tag{6}$$

$$Q_{outflow} = 0, \text{if } h1 \leq dh1 \tag{7}$$

The parameter dc1 represents the drain resistance and is a measure of the resistance to flow across the drain boundary. Equation 8 computes the dc1 parameter as follows:

$$dc1 = \frac{b_d}{K_d} \tag{8}$$

where:

$Q_{outflow}$	=	modeled groundwater flux from the aquifer to the drain (ft^3/day)
a	=	nodal area (ft^2)
h1	=	modeled groundwater elevation (such as head) in Model Layer 1 (ft)
dh1	=	modeled drain elevation (ft)
dc1	=	modeled resistance across the drain (day^{-1})
b_d	=	thickness of drain interface (ft)
K_d	=	hydraulic conductivity of drain interface (ft/day)

Evapotranspiration of Shallow Groundwater. The MicroFEM evapotranspiration (ET) system was specified at all nodes across the top surface of Model Layer 1. This particular boundary condition is a one-way head-dependent flux boundary that allows groundwater to discharge from the modeled aquifer, if the modeled water table elevation is located within a prescribed rooting depth below the land surface. The upper and lower ET elevations were set at the land surface elevation and 5 feet below the land surface elevation, respectively. Equations 9 through 11 simulate the groundwater loss to ET, as follows:

$$Q_{outflow} = a \cdot em1, \text{if } h1 > eh1 \tag{9}$$

$$Q_{outflow} = a \cdot em1\left(\frac{h1 - el1}{eh1 - el1}\right), \text{if } el1 < 1 < e1 \tag{10}$$

$$Q_{outflow}=0, \text{ if } h1 \leq el1 \qquad (11)$$

where:

$Q_{outflow}$ = modeled groundwater loss to ET (ft^3/day)
a = nodal area (ft^2)
h1 = modeled groundwater elevation (i.e., head) in Model Layer 1 (ft)
eh1 = modeled upper groundwater ET elevation (ft)
el1 = modeled lower groundwater ET elevation (ft)
em1 = modeled maximum ET rate (ft/day)

6.4.2 Specified-flux Boundaries

Three types of specified-flux boundary conditions used within REDFEM include (1) areal groundwater recharge from precipitation and applied water (where applicable), (2) groundwater recharge (such as seepage) from the ACID canal, and (3) groundwater pumping. A detailed discussion of these follows.

Areal Groundwater Recharge from Precipitation and Applied Water. Precipitation grids generated by the Parameter-elevation Regressions on Independent Slopes Model (PRISM) (PRISM Climate Group, 2010) were initially intersected with model nodes representing urban and native vegetation areas using GIS software to estimate rates of groundwater recharge from precipitation falling within areas mapped as urban and native vegetation in the model domain. The PRISM grids contained monthly precipitation rates on 0.5-mile (800-meter) centers. The annual groundwater recharge from precipitation in urban and native vegetation areas was then calculated with the aid of a HYDRUS-1D (Simunek et al., 2008 and 2009) model. Equation 12 shows the mathematical relationship developed from the HYDRUS-1D simulations, as follows:

$$DP_{PPT}=(0.001843)(PPT^{2.5076}) \qquad (12)$$

where:

DP_{PPT} = average annual groundwater recharge from precipitation (inches [in.])
PPT = annual precipitation (in.)

The DP_{PPT} was temporally distributed according to the monthly volume of rainfall for the year at a given REDFEM node, up to a maximum of approximately 26 inches per year.

The basis for the spatial distribution and magnitudes of groundwater recharge from applied water are described in full detail in the Agricultural Surface Water Budget and Urban Water Budget sections below.

Groundwater Pumping. Monthly groundwater pumping rates, attributed to municipal, industrial, agricultural, and domestic pumping, were specified at appropriate model nodes located in Model Layers 1 through 3 (typical depths for agricultural, municipal, industrial, and domestic pumping in the basin). The spatial distribution and magnitudes of these groundwater fluxes were derived from the surface water budget calculations, as detailed in the Agricultural Surface Water Budget and Urban Water Budget sections below.

Agricultural Surface Water Budget. An important component of the successful operation of REDFEM is computation of transient agricultural surface water budget. These water budget components were estimated by using a variety of spatial information, including land use, cropping patterns, irrigation water source, surface water availability in different year types and locations, and the spatial distribution of precipitation. Surface water budget components include groundwater recharge from precipitation, and applied water and agricultural pumping.

Agricultural surface water budgets were developed by intersecting available land use data developed by DWR with the groundwater model grid to assign land use for each model node. Figure D-6 depicts the water purveyor service areas in the model domain. The resulting intersection provided land use, water purveyor, and water source information for each of the REDFEM nodes.

The Integrated Water Flow Model Demand Calculator (DWR, 2011) developed by DWR's Bay-Delta Office and PRISM data were used to simulate root-zone processes and calculate the monthly applied water demand and the monthly groundwater recharge from applied water. The rate of groundwater recharge and the source water (applied water versus precipitation) depends on the season (month) and the availability of water from each source. Attachment D1 contains a technical memorandum (MBK Engineers, 2010) describing the process of estimating the relevant components of the agricultural surface water budget.

Some areas of the domain are supplied solely from groundwater, and calculated total applied-water demand represents groundwater pumping. Other areas are supplied by a mix of groundwater and surface water. For these areas, estimates of monthly surface water availability determined the fraction of applied-water demand met from surface water and groundwater. To estimate available surface water in these areas, additional information on the overlying water district was combined with district water rights and contracts. Any remaining applied-water demand, after consideration of available surface water, would be met by groundwater pumping divided between Model Layer 1 (20 percent), Model Layer 2 (60 percent), and Model Layer 3 (20 percent). Attachment D1 details the methods for computing the monthly groundwater recharge of applied water in agricultural areas and the associated monthly agricultural groundwater pumping rates.

Urban Water Balance. Another important component of the successful operation of REDFEM is computation of transient urban water balance. These water balance components were estimated by using a variety of spatial information including land use, irrigation water source, city and water district water-supply and water-demand records, wastewater disposal methods and records, surface water availability, and ET estimates. Urban water balance components in REDFEM include urban pumping and groundwater recharge from applied water, septic systems, and conveyance losses.

A water-balance accounting model and available historical records were used to estimate monthly groundwater recharge in urban areas. Figure D-7 presents a schematic overview of the urban water balance components considered in these calculations. When possible, monthly municipal and water district records were relied on for calculations. Groundwater pumping used for municipal and water district supply was either assigned to the locations of specific city/district wells in Model Layers 2 (50 percent) and 3 (50 percent), or to the overall water district area in Model Layers 1 (80 percent) and 2 (20 percent), in cases where groundwater was supplied by domestic wells.

Seepage from the ACID Canal. Monthly seepage rates were specified to surface nodes in the model along the ACID main canal. Seepage from the ACID canal system is estimated at approximately 44,000 acre-feet per year (CH2M HILL, 2001). Along the main canal, approximately 30,000 acre-feet per year of seepage were prescribed to surface nodes. The remaining 14,000 acre-feet per year of canal seepage was applied across the ACID service area, representing seepage from laterals of the main canal. Groundwater recharge from seepage in the main canal was distributed monthly from April through October. It was assumed that the groundwater recharge generated by canal operations declines over the course of the irrigation season, such that the recharge during each subsequent month was 83 percent of the previous month's canal seepage. This monthly decrease in canal seepage (between April and October) simulates the effects of wetting the fine-grained soils and the decrease in the permeability of the canal bottom during the agricultural season, resulting in less monthly seepage during the agricultural season. Seepage from canal laterals was applied through the year according to agricultural water demands.

6.4.3 No-flow Boundaries

A no-flow boundary was simulated along the margins of the model domain to simulate the lateral extent of freshwater-bearing sediments in the Redding Groundwater Basin. A no-flow boundary was also specified for the bottom boundary of the model, representing the bedrock contact of the Chico Formation.

7.0 Model Calibration

This section describes the approach used to calibrate REDFEM and the results of the calibration process. REDFEM was calibrated by first performing a steady-state calibration to average hydrologic conditions and then performing a transient calibration to data from a selected historical hydrologic period. Calibration was performed by making adjustments to the model construction both manually and by using PEST autocalibration software (Doherty, 2004 and 2010).

7.1 Steady-state Calibration

During the development of REDFEM, a detailed transient agricultural groundwater balance was quantified monthly from January 1999 through December 2008, a 10-year period for which groundwater usage data from districts and municipalities were most plentiful. The groundwater balance components for this period were averaged, and the model was calibrated to average groundwater levels that were measured at selected monitoring wells during the 10-year period.

7.1.1 Steady-state Calibration Targets

The averages of groundwater elevations measured during calendar years (CY) 1999 through 2008 at 67 selected monitoring wells were used as steady-state calibration targets. Figure D-8 depicts the calibration target well locations.

During the calibration process, it was discovered that many reference point elevations at monitoring well locations were not derived from accurate surveying methods, and could have been estimated by using approximate well locations and contour lines on USGS topographic maps. Groundwater elevations are calculated by subtracting the recorded depth-to-water measurements from the reference point elevations, so an unreliable reference point elevation results in the calculation of unreliable groundwater elevations. Groundwater elevation data for calibration target wells were identified as less reliable by comparing them to USGS topographic data and noting large mismatches, or by noting unlikely characteristics (such as four wells 300 feet apart in sloping terrain with the exact same reference point elevation). Of the 67 wells used for calibration, 26 were identified as having less reliable reference point elevations, leaving 41 wells with more reliable reference point elevations (see Figure D-8). Groundwater-level data, computed using the less reliable reference point elevations, were still used for calibration to short- and long-term trends in groundwater levels; however, the absolute groundwater levels computed from the less reliable reference point elevations were not used for calibration adjustment decisions.

7.1.2 Adjustments Made during Calibration

During the calibration process, the following parameters were adjusted to obtain an acceptable degree of calibration:

- Groundwater recharge from precipitation and applied water
- Horizontal and vertical hydraulic conductivity
- Streambed permeability

7.1.3 Steady-state Calibration Results

One way to illustrate the state of calibration using steady-state calibration targets is to develop a scattergram that plots the simulated versus the target groundwater elevation at each calibration well. Figure D-9 presents results for the 41 calibration wells with more reliable reference point elevations. A perfect fit between simulated and target groundwater elevations would plot along a 1:1 correlation line. As shown on Figure D-9, the simulated groundwater levels show good agreement with target groundwater levels. This implies that REDFEM provides accurate estimates of the steady-state groundwater elevations and flow directions in the vicinities of calibration target wells.

The calculation of the root mean squared error (RMSE) divided by the range of target groundwater elevations (Range) is another commonly used measure of calibration. As a rule of thumb, a well-calibrated regional model will have an RMSE to Range ratio (RMSE/Range) of less than 10 percent. The RMSE/Range of the steady-state calibration presented herein is 4.1 percent, well below the 10 percent criterion.

The gain in streamflow from baseflow in the Sacramento River between Keswick Reservoir and the outflow location at the south end of the Redding Groundwater Basin is estimated at approximately 700,000 acre-feet per year (CH2M HILL, 2001). Although REDFEM does not explicitly simulate streamflow, the gain in streamflow from baseflow (groundwater discharge to the stream) is estimated by adding the groundwater discharges to drain and wadi boundary condition nodes, and subtracting the stream seepage from the wadi boundary condition nodes. This combined net groundwater discharge to streams and drainages in the steady-state model is approximately 679,000 acre-feet per year, which is within 2.5 percent of the target value of 700,000 acre-feet per year. This close match indicates that the overall simulated groundwater balance is reasonable with regard to basin-scale groundwater recharge and discharge. Table D-1 summarizes the magnitudes of the groundwater balance components derived from the steady-state calibration.

TABLE D-1
Average Annual REDFEM Groundwater Balance Summary: Calendar Years 1999 through 2008
Documentation of the Redding Groundwater Basin Finite-Element Model

Groundwater Balance Component	1,000 acre-feet
Groundwater Recharge	
Groundwater Recharge from Precipitation	685
Groundwater Recharge from Applied Water (Agricultural)	59
Groundwater Recharge from Applied Water (Urban)	15
Groundwater Recharge from the ACID Main Canal	30
Groundwater Recharge from Streams	22
Total Groundwater Recharge	**811**
Groundwater Discharge	
Agricultural Groundwater Pumping	34
Urban Groundwater Pumping	41
Groundwater Discharge to Streams and Drainages	701
Groundwater Loss to ET	35
Total Groundwater Discharge	**811**

7.2 Transient Calibration

The next step in the calibration process was to perform a transient calibration to a historical hydrologic period. The hydrologic period chosen to perform the transient calibration was consistent with the CY 1999-2008 averaging period used for the steady-state calibration. This period was selected because it is a period when groundwater usage data from districts and municipalities were most plentiful.

The parameters adjusted during the transient calibration process were the aquifer storage properties. The magnitude of fluctuation in groundwater levels was reviewed after adjustment during each calibration simulation. An initial specific storage estimate for Model Layers 2 through 4 remained unchanged from the initial value of 2.0×10^{-6} per foot. An initial specific yield estimate of 0.1 was reduced to 0.08 near the Redding Municipal Airport and in the southwestern portion of the model.

The results of the transient calibration process were evaluated using two methods. The first was to develop a scattergram, similar to that used for the steady-state calibration that compares the simulated and target groundwater levels for each measurement recorded throughout the 10-year calibration period (CY 1999-2008). Figure D-10 shows the results of this comparison for all 835 groundwater-level measurements used in the transient calibration process for the 41 calibration wells with more reliable reference point elevations. Figure D-10 also presents the statistical parameters associated with this comparison. The R^2

goodness of fit between the simulated and observed values is 0.93, and the RMSE/Range is slightly more than 5 percent. Both of these summary statistics demonstrate that the model provides transient simulated groundwater elevations that closely match target groundwater elevations across the basin and throughout the 10-year calibration period.

The other method used to evaluate the quality of the transient calibration was to compare the simulated time-series groundwater elevations (hydrographs) for each of the 41 calibration monitoring wells that have more reliable reference point elevations. Wells with less reliable reference point elevations were evaluated for the magnitude of groundwater-level trends and fluctuations, as opposed to absolute groundwater levels. Figure D-11 presents the hydrograph comparisons. Figure D-8 depicts calibration wells with less reliable reference point elevations. Although some significant deviations remain between simulated and target groundwater levels during certain periods and at some well locations, REDFEM generally performs well in replicating the absolute groundwater elevations, fluctuations, and transient trends at most calibration monitoring wells.

8.0 Summary and Conclusions

A relatively high-resolution, three-dimensional numerical groundwater flow model of the Redding Groundwater Basin has been developed to support the evaluation of groundwater projects in the basin. Specifically, the model was developed to assess the transient effects of groundwater pumping on groundwater levels and to estimate changes in surface water and groundwater interaction.

The REDFEM grid has an approximate 500-foot spatial resolution in areas where the proposed project is being considered, and REDFEM is composed of four vertically integrated model layers. Model Layer 1 (uppermost model layer) was assigned a uniform thickness of 50 feet below the water table to assess impacts on streams, riparian habitat, and wetlands. The thicknesses of Model Layers 2 and 3 of 100 and 200 feet, respectively, were selected to represent typical groundwater production zones within the basin. The thickness of Model Layer 4 represents the deeper portion of the freshwater aquifer system down to the Chico Formation, which has not typically been used as a source of groundwater.

The surface water balance, including agricultural and urban pumping, and groundwater recharge from precipitation and applied water, was developed using a GIS-based analysis that considers 2005 land use, crop types, water source, seniority of water rights, and availability of surface water on a monthly basis. Areal groundwater recharge and pumping fluxes are independently computed for each node in the model. Surface stream stages were defined using available data, including USGS topographic maps and stream gage elevations, and assumed to be constant throughout the course of the model simulations.

REDFEM was calibrated to both steady-state and transient groundwater elevation data sets. Groundwater elevations recorded during CY 1999-2008 were used as transient calibration targets, and averages for that period were used as steady-state calibration targets. More qualitative calibration targets such as the magnitude of the water balance components and the pattern and magnitude of surface water and groundwater interaction were also considered.

REDFEM is a valuable analytical tool to estimate the effects of groundwater pumping on both groundwater levels and changes in surface water and groundwater interaction within the Redding Groundwater Basin.

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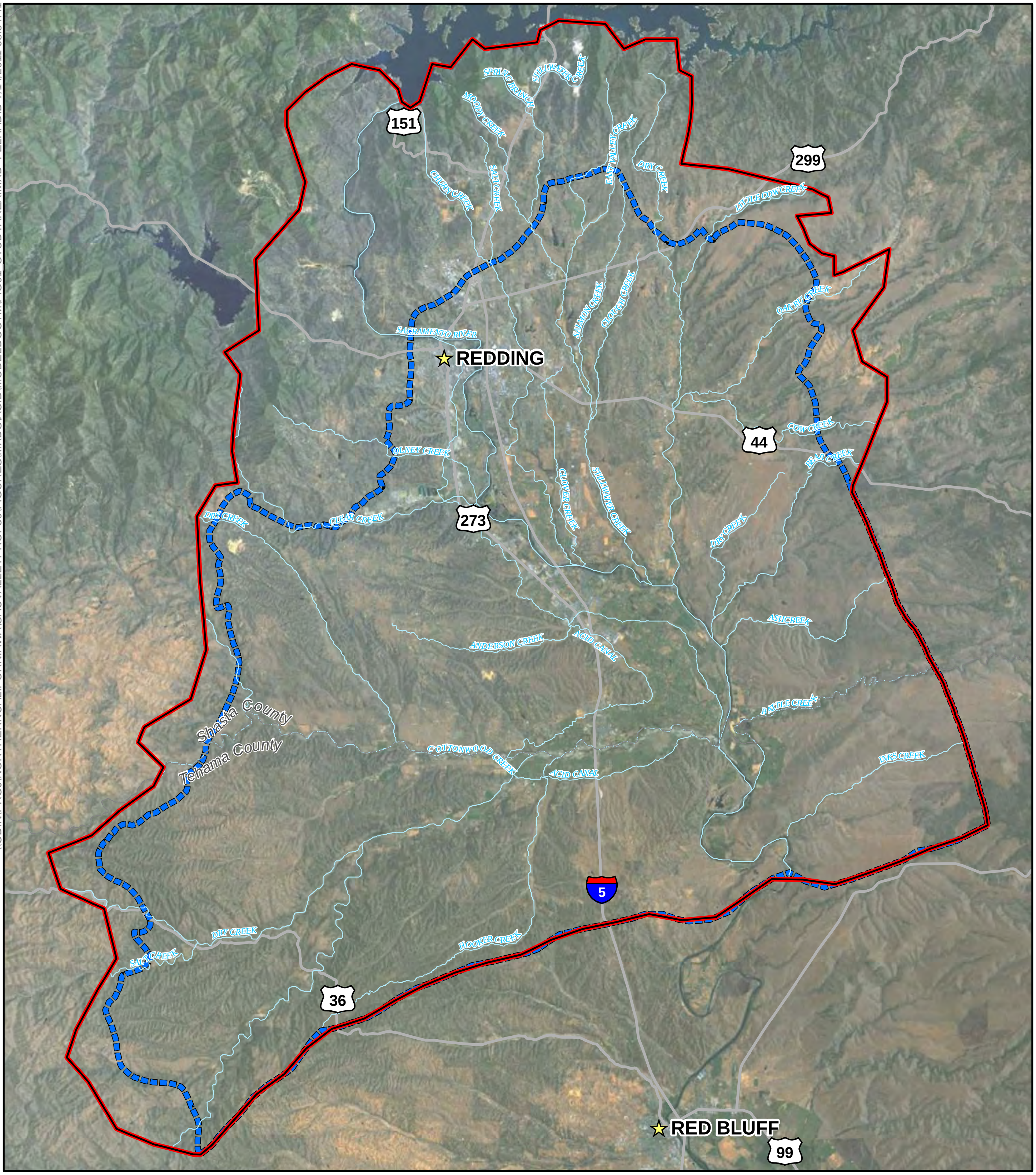
Figures

\\ODIN\PROJ\NORTHERNCALIFORNIAWA\SACVALLEYPROP50\FIGURES\MXDS\ACID\MODELDOCTM\FIG01_STUDYAREA.MXD FELHADID 7/14/2011 08:54:41



LEGEND

STUDY AREA AND REDFEM BOUNDARY

REDDING GROUNDWATER BASIN BOUNDARY

N

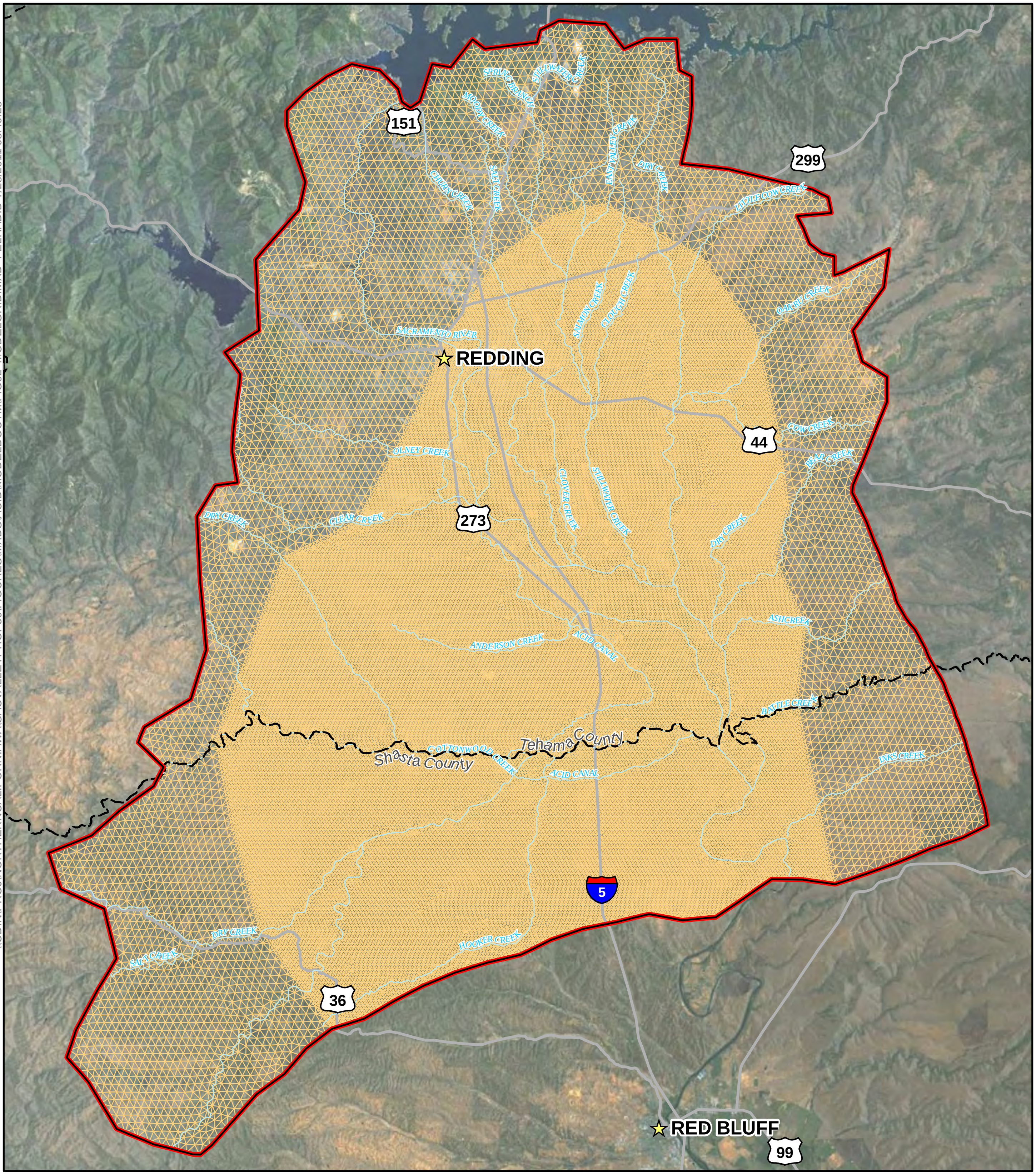
0 5 10 Miles

NOTE:

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE D-1
LOCATIONS OF THE REDDING GROUNDWATER BASIN AND THE STUDY AREA
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL



LEGEND

STUDY AREA AND REDFEM BOUNDARY

REDFEM GRID

0 5 10 Miles

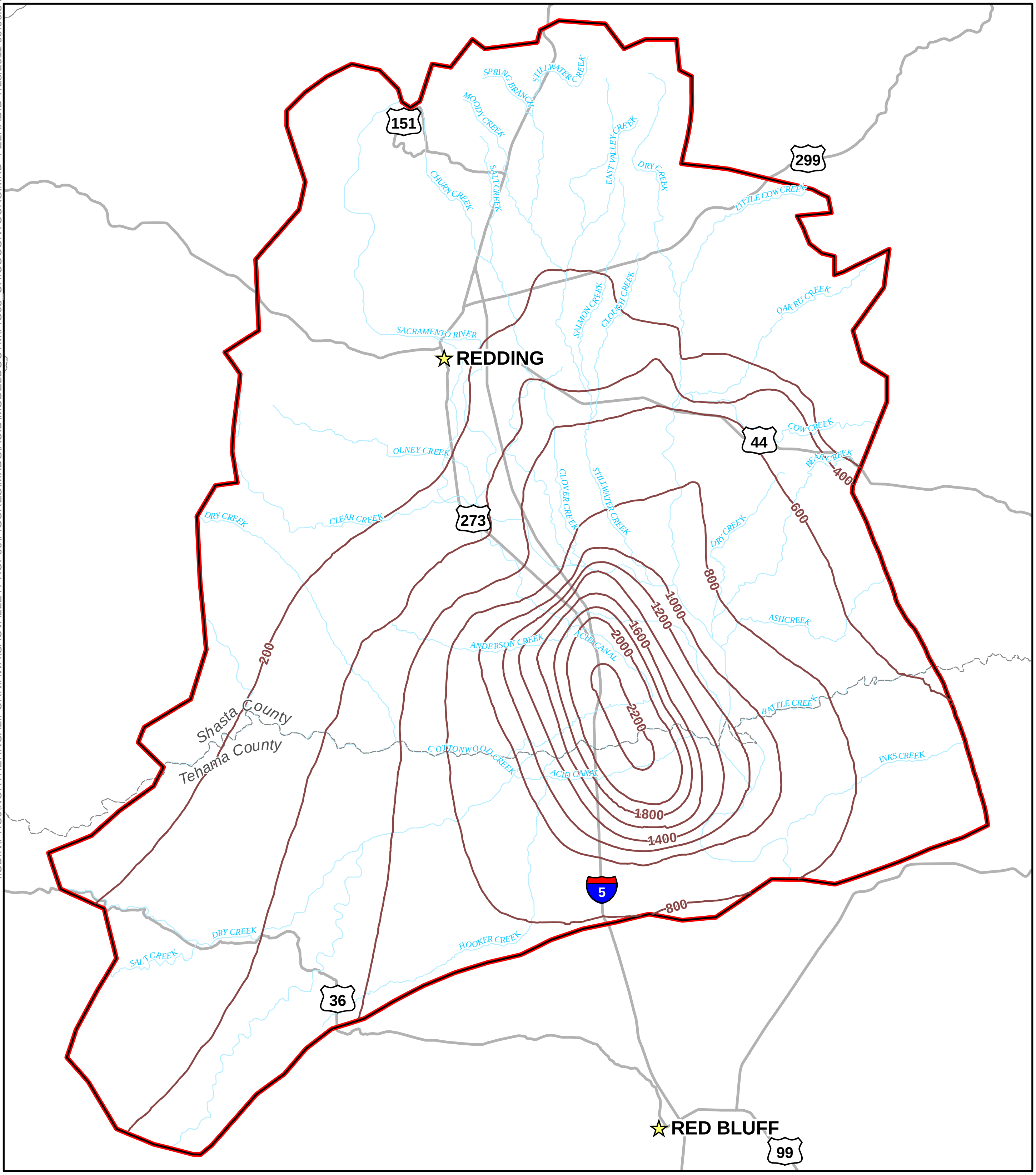
N

NOTE:

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE D-2
REDFEM GRID
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL



LEGEND

STUDY AREA AND REDFEM BOUNDARY

DEPTH TO TOP OF CHICO FORMATION CONTOUR (feet)

0 5 10 Miles

N

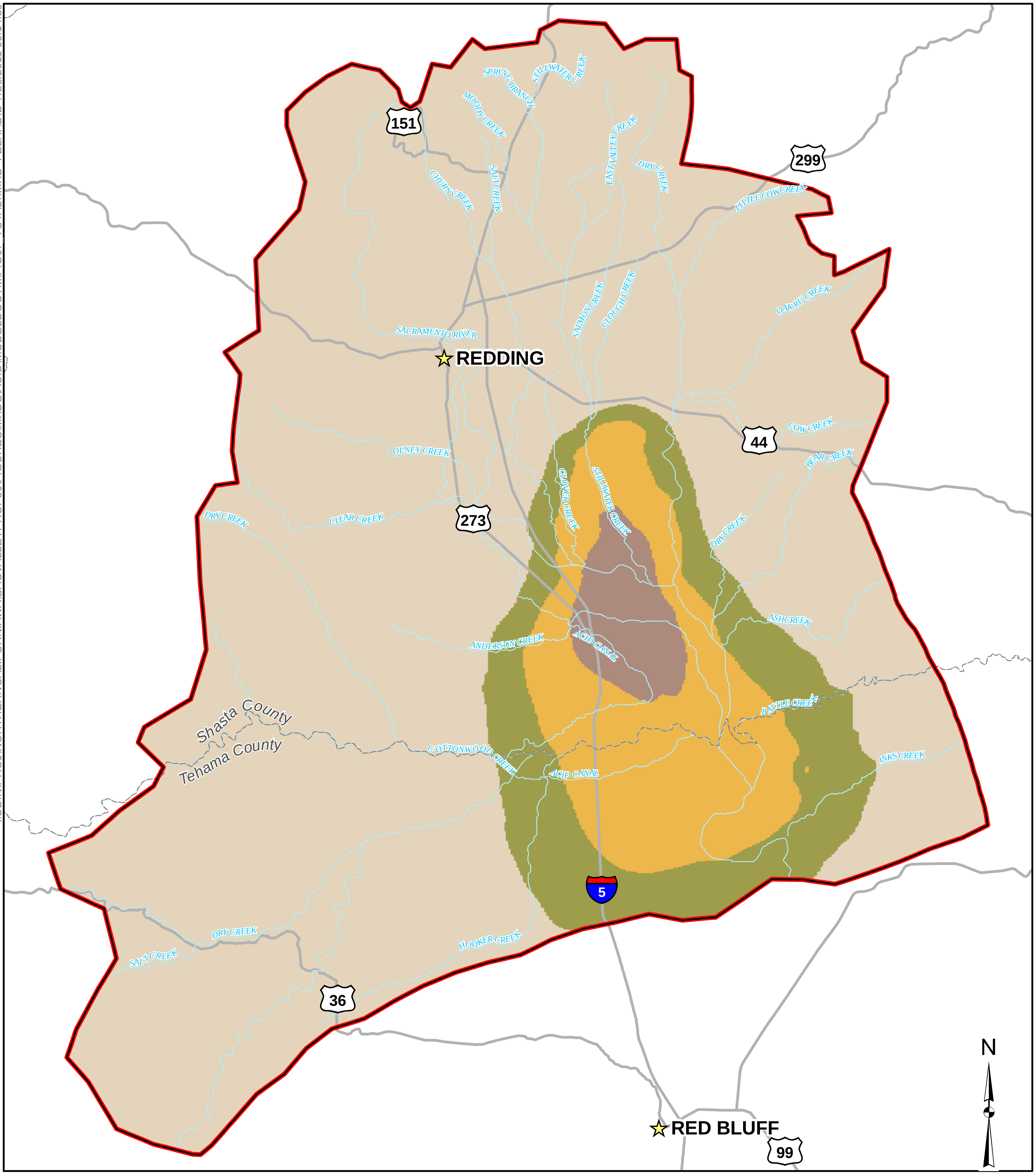
NOTE:

MODIFIED FROM BULLETIN 74-8 (DWR, 1968).

FIGURE D-3
DEPTH TO TOP OF CHICO FORMATION
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL

\\ODIN\PROJ\NORTHERNCALIFORNIAWA\SACVALLEYPROP50\FIGURES\MXDS\ACID\MODELDOCTM\FIG07_TOTALT.MXD FELHADID 7/28/2011 09:14:59



0 5 10 Miles

LEGEND

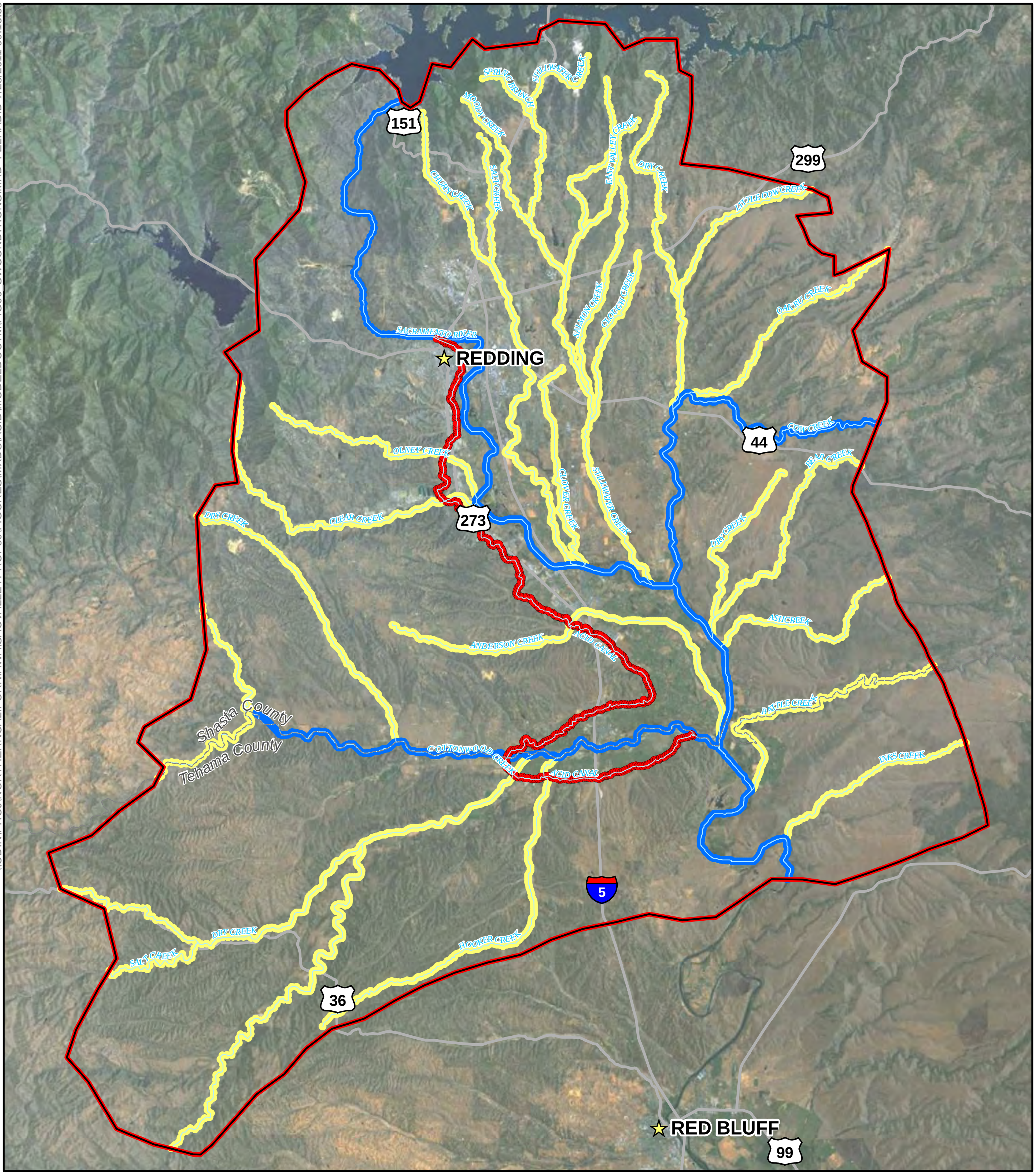
STUDY AREA AND REDFEM BOUNDARY

TOTAL TRANSMISSIVITY (feet²/day)

- < 50,000
- 50,000 to 100,000
- 100,000 to 250,000
- >250,000

FIGURE D-4
REDFEM TRANSMISSIVITY DISTRIBUTION
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL



LEGEND

STUDY AREA AND REDFEM BOUNDARY

BOUDARY CONDITION TYPE

- ONE-WAY HEAD-DEPENDANT FLUX (DRAIN)
- TWO-WAY HEAD-DEPENDANT FLUX (WADI)
- SPECIFIED FLUX

0 5 10 Miles

N

NOTE:

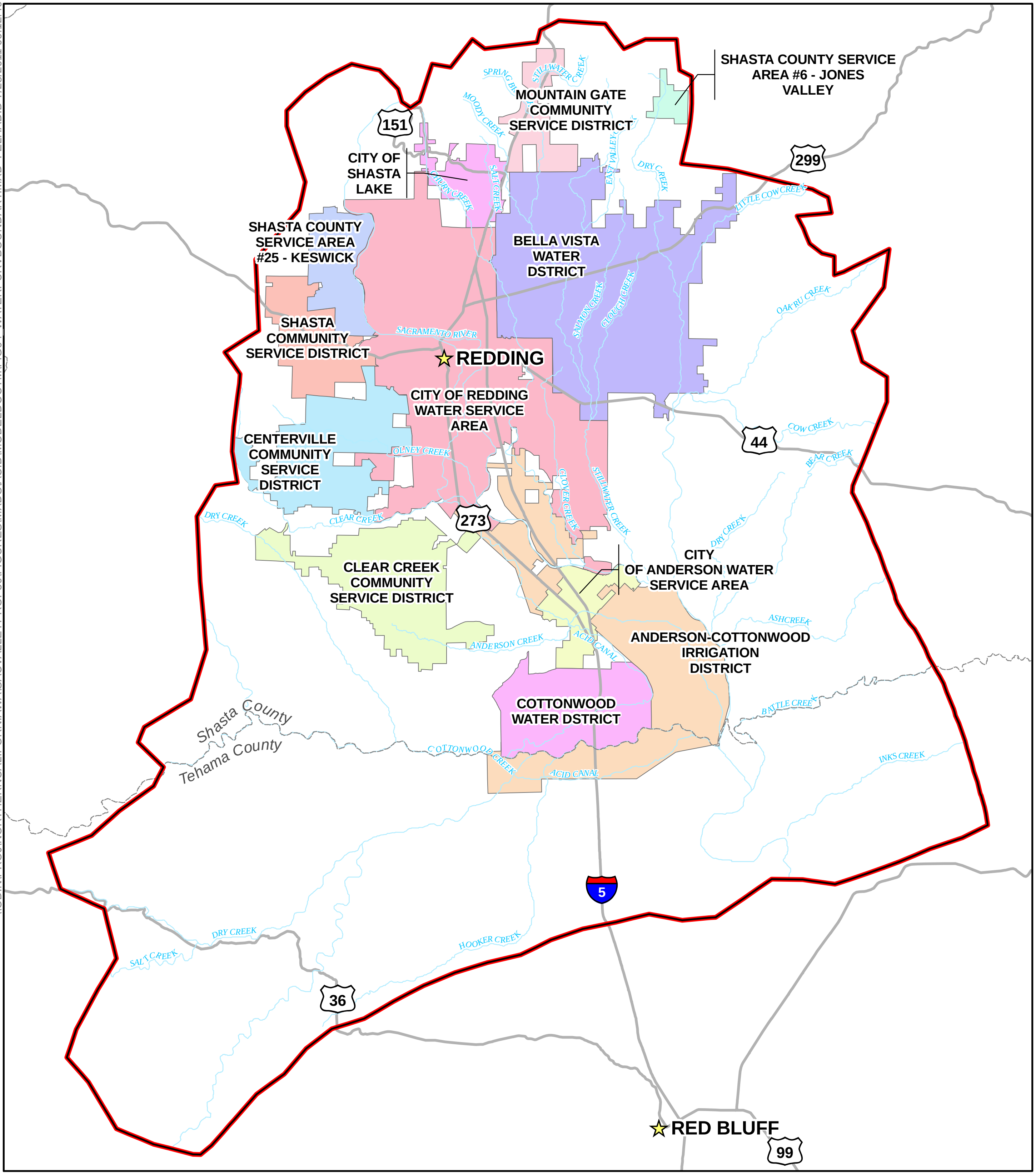
SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE D-5
BOUNDARY CONDITIONS ASSOCIATED WITH STREAMS AND CANALS

DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL

\\ODIN\PROJ\NORTHERNCALIFORNIAWASACVALLEYPROP50\FIGURES\MXDS\ACID\MODELDOCTM\FIG06_SWCONDITIONS.MXD FELHADID 7/28/2011 09:13:39

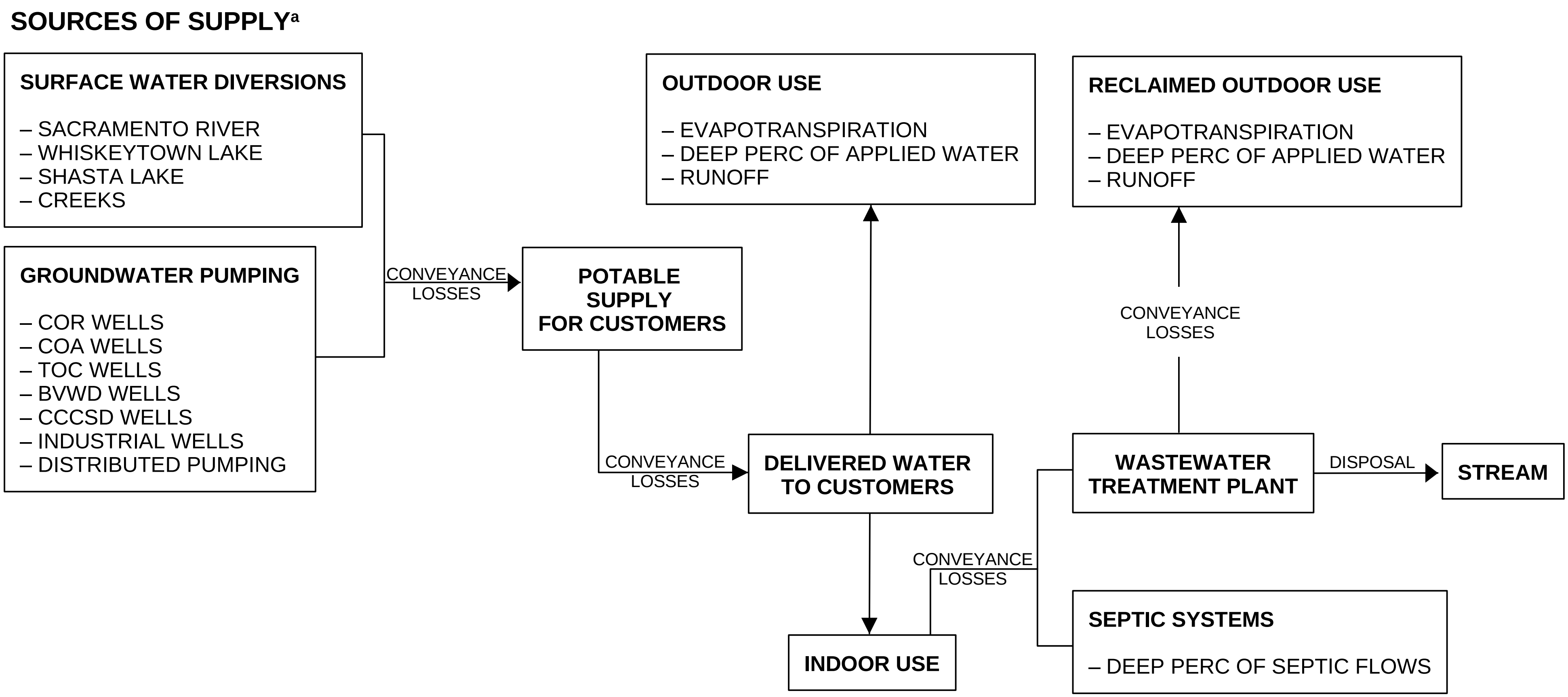


LEGEND

STUDY AREA AND REDFEM BOUNDARY

FIGURE D-6
WATER PURVEYOR SERVICE AREA BOUNDARIES
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL



[a]RECLAIMED WATER IS ALSO A MINOR SOURCE OF SUPPLY AND IS SHOWN AFTER THE WASTEWATER TREATMENT PLANT BOX IN THIS SCHEMATIC.

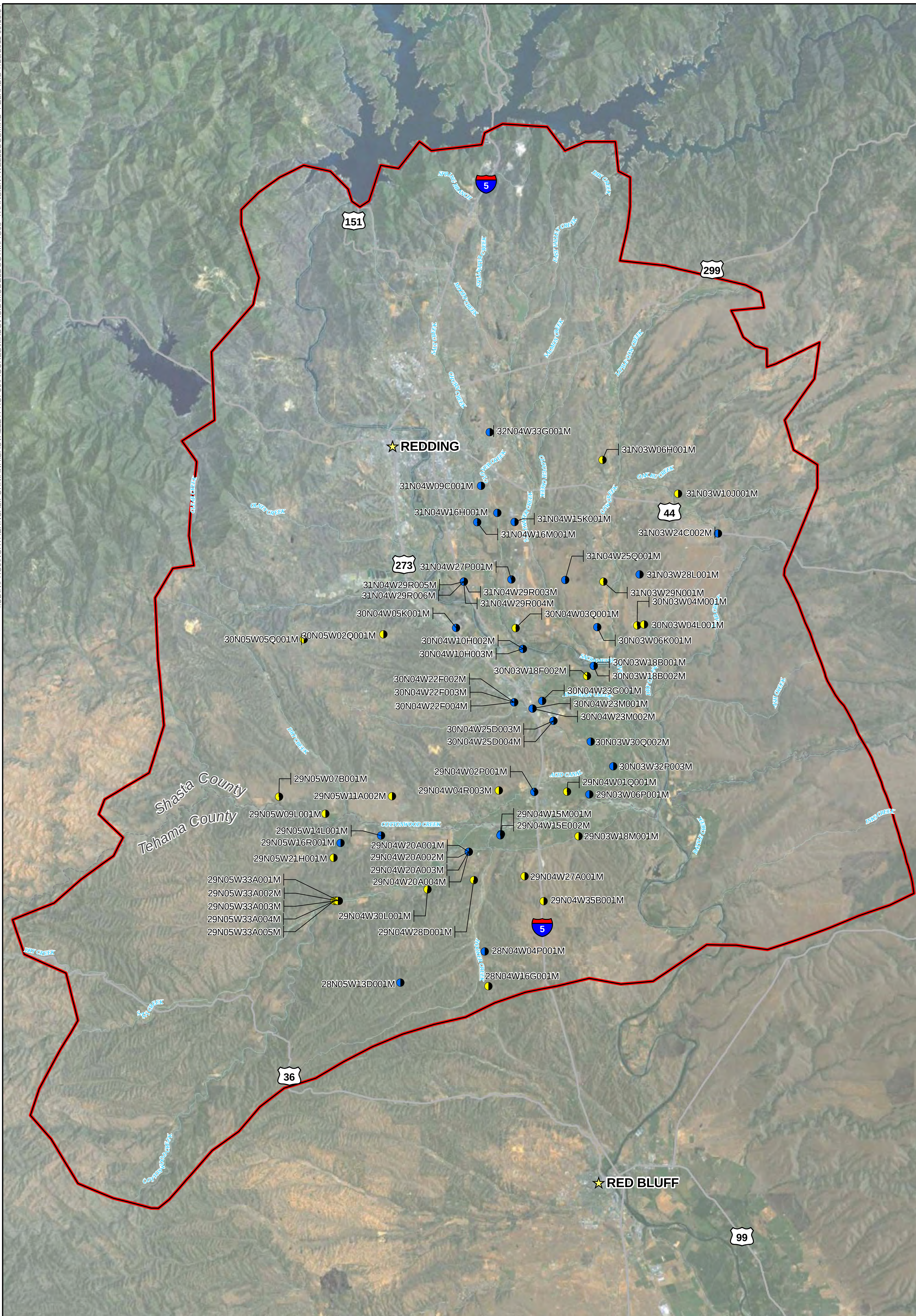
NOTES:

COR = CITY OF REDDING
COA = CITY OF ANDERSON
TOC = TOWN OF COTTONWOOD
BVWD = BELLA VISTA WATER DISTRICT
CCCSD = CLEAR CREEK COMMUNITY SERVICES DISTRICT

FIGURE D-7
REDDING BASIN URBAN WATER BUDGET COMPONENTS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL

FIG07_WaterBudget.grf



LEGEND

STUDY AREA AND REDFEM BOUNDARY

CALIBRATION TARGET WELL

MONITORING WELL WITH MORE RELIABLE REFERENCE ELEVATION

MONITORING WELL WITH LESS RELIABLE REFERENCE ELEVATION

0 3.5 7 Miles

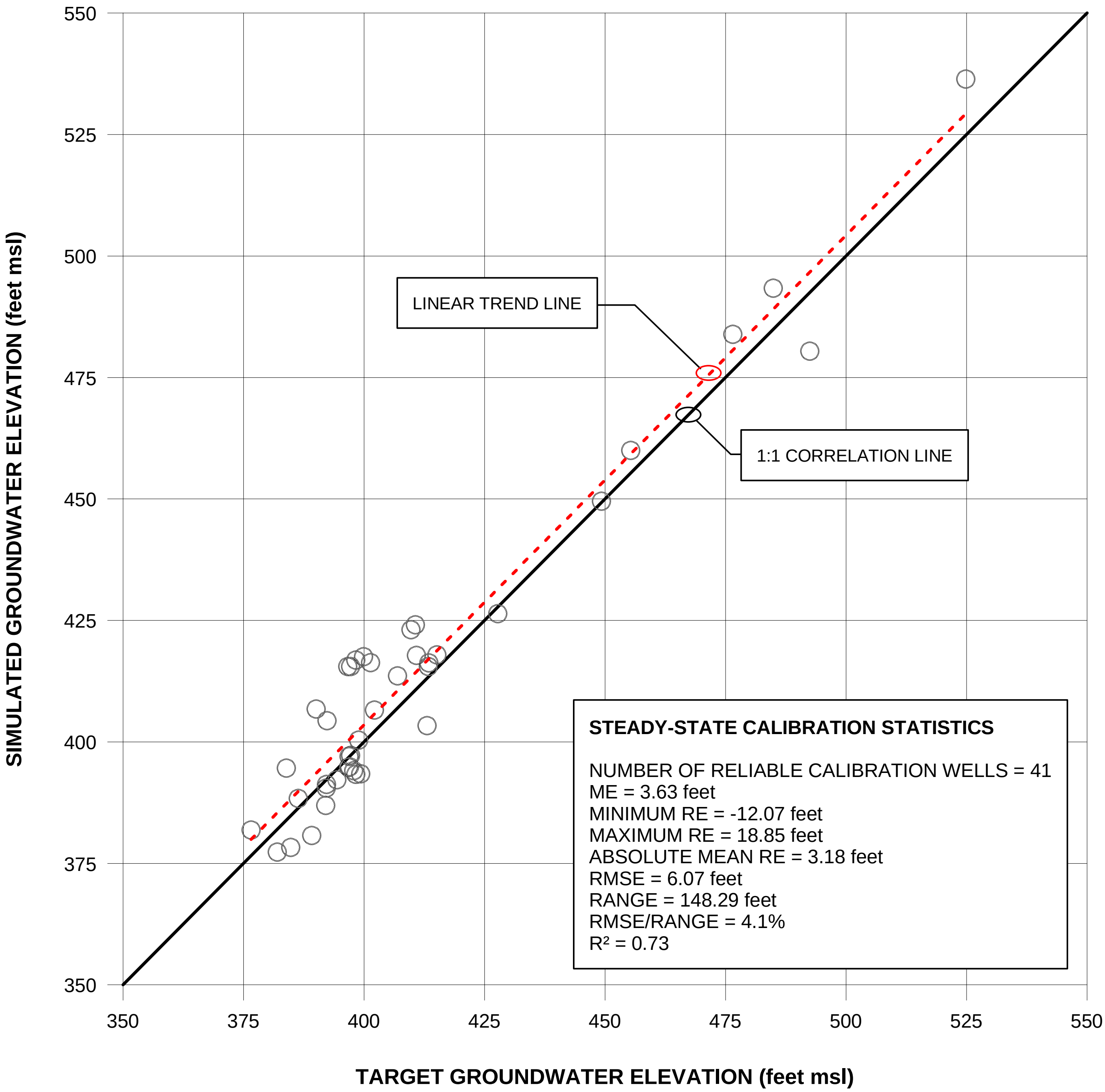
N

NOTE:

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE D-8
LOCATION OF CALIBRATION TARGET WELLS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL

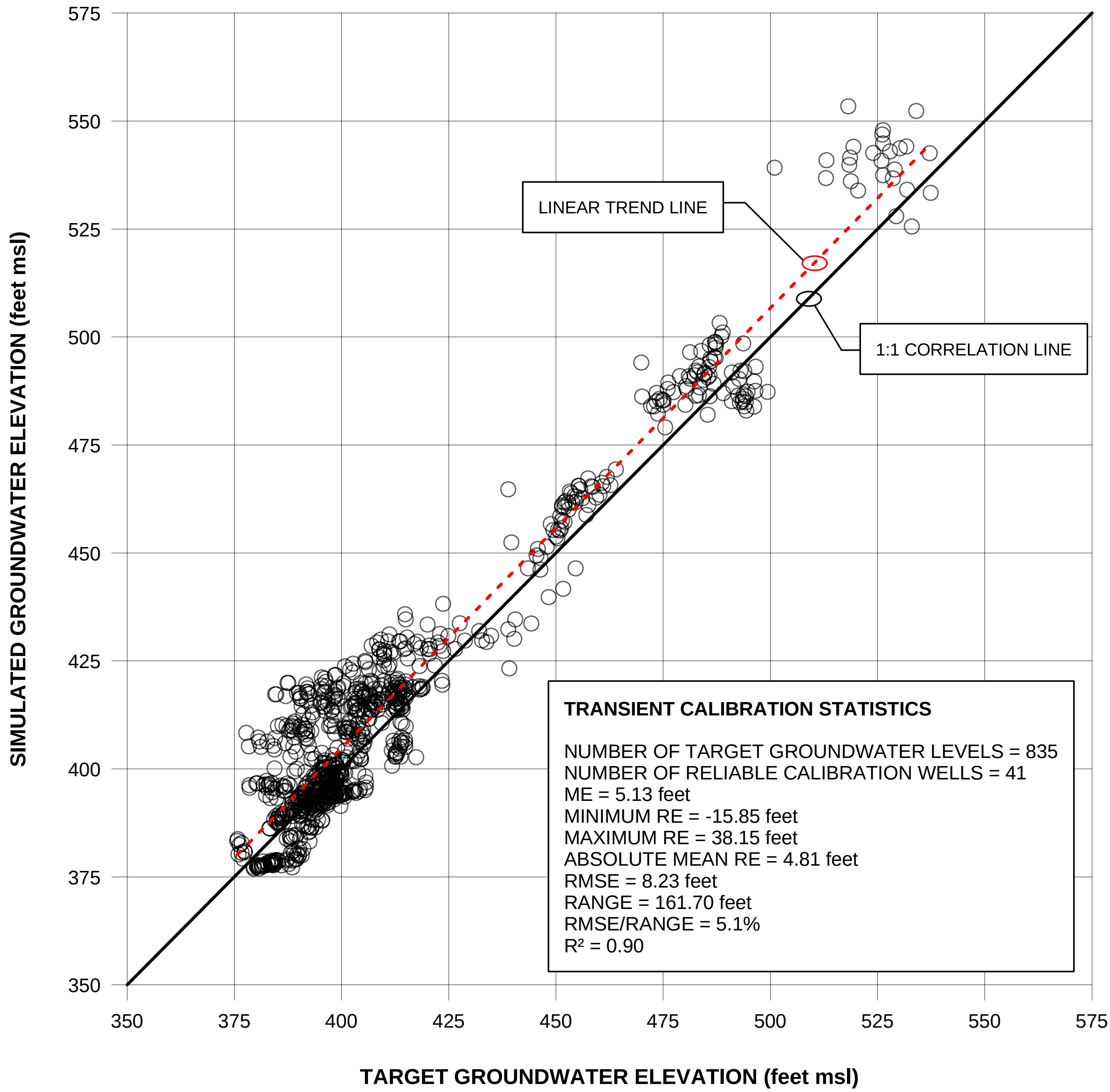


NOTES:

TARGET GROUNDWATER ELEVATION COMPUTED AS THE AVERAGE OF AVAILABLE GROUNDWATER LEVEL DATA FOR A GIVEN CALIBRATION WELL OVER THE CALENDAR YEARS 1999 THROUGH 2008.

ME = MEAN RESIDUAL ERROR
MSL = MEAN SEA LEVEL
RE = RESIDUAL ERROR
RMSE = ROOT MEAN SQUARE ERROR
RANGE = RANGE IN TARGET GROUNDWATER LEVELS
R^2 = SQUARE OF THE CORRELATION COEFFICIENT

FIGURE D-9
REDFEM STEADY-STATE CALIBRATION SCATTERGRAM
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL



NOTES:

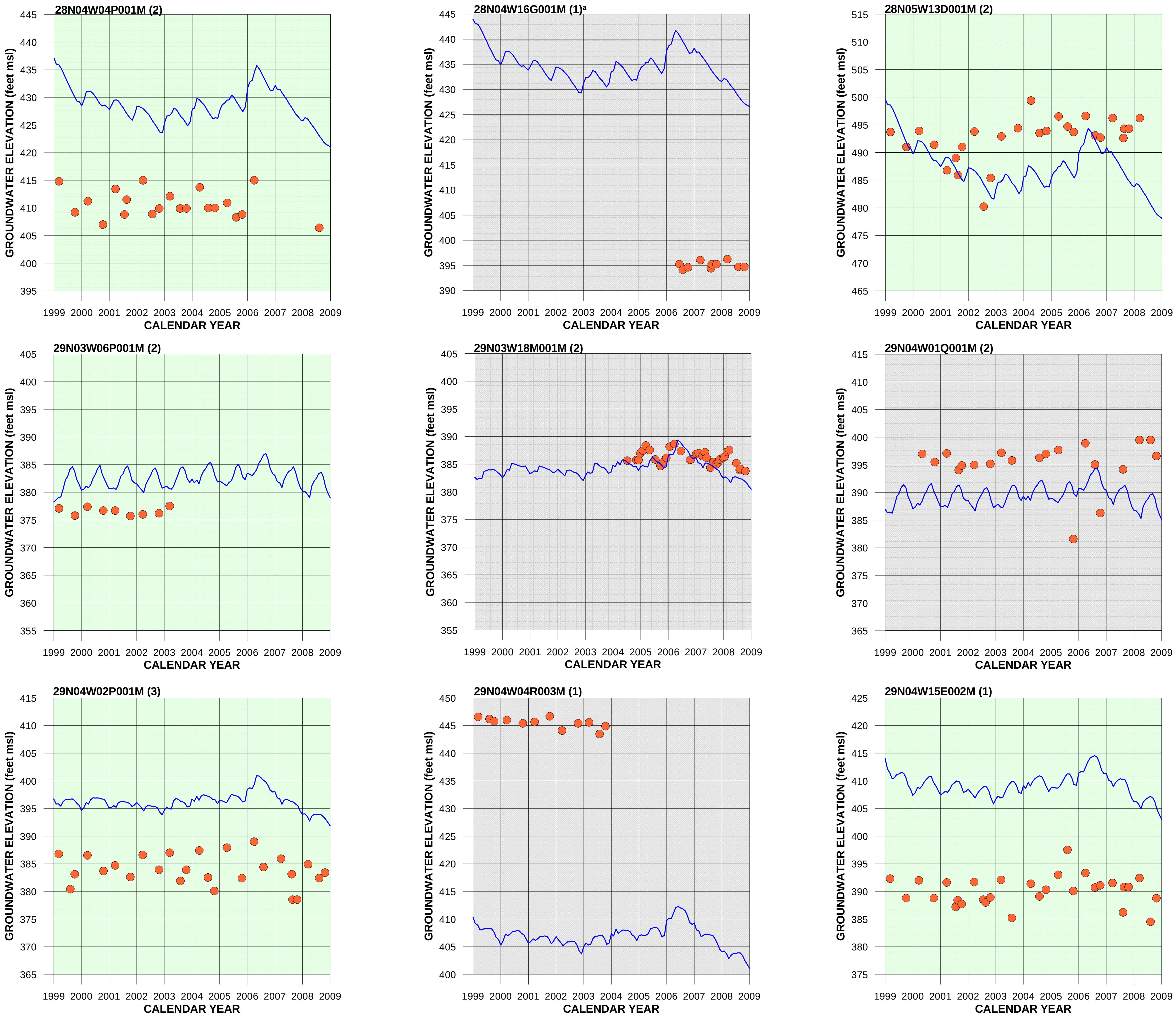
TARGET GROUNDWATER ELEVATION COMPUTED AS THE AVERAGE OF AVAILABLE GROUNDWATER LEVEL DATA FOR A GIVEN CALIBRATION WELL OVER THE CALENDAR YEARS 1999 THROUGH 2008.

ME = MEAN RESIDUAL ERROR
MSL = MEAN SEA LEVEL
RE = RESIDUAL ERROR
RMSE = ROOT MEAN SQUARE ERROR
RANGE = RANGE IN TARGET GROUNDWATER LEVELS
R^2 = SQUARE OF THE CORRELATION COEFFICIENT

FIGURE D-10
REDFEM TRANSIENT CALIBRATION SCATTERGRAM
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL

FIG10_Obs_Sim.grf



LEGEND

- TARGET GROUNDWATER ELEVATION (feet msl)
- SIMULATED GROUNDWATER ELEVATION (feet msl)
- MONITORING WELL WITH MORE RELIABLE REFERENCE POINT ELEVATION
- MONITORING WELL WITH LESS RELIABLE REFERENCE POINT ELEVATION

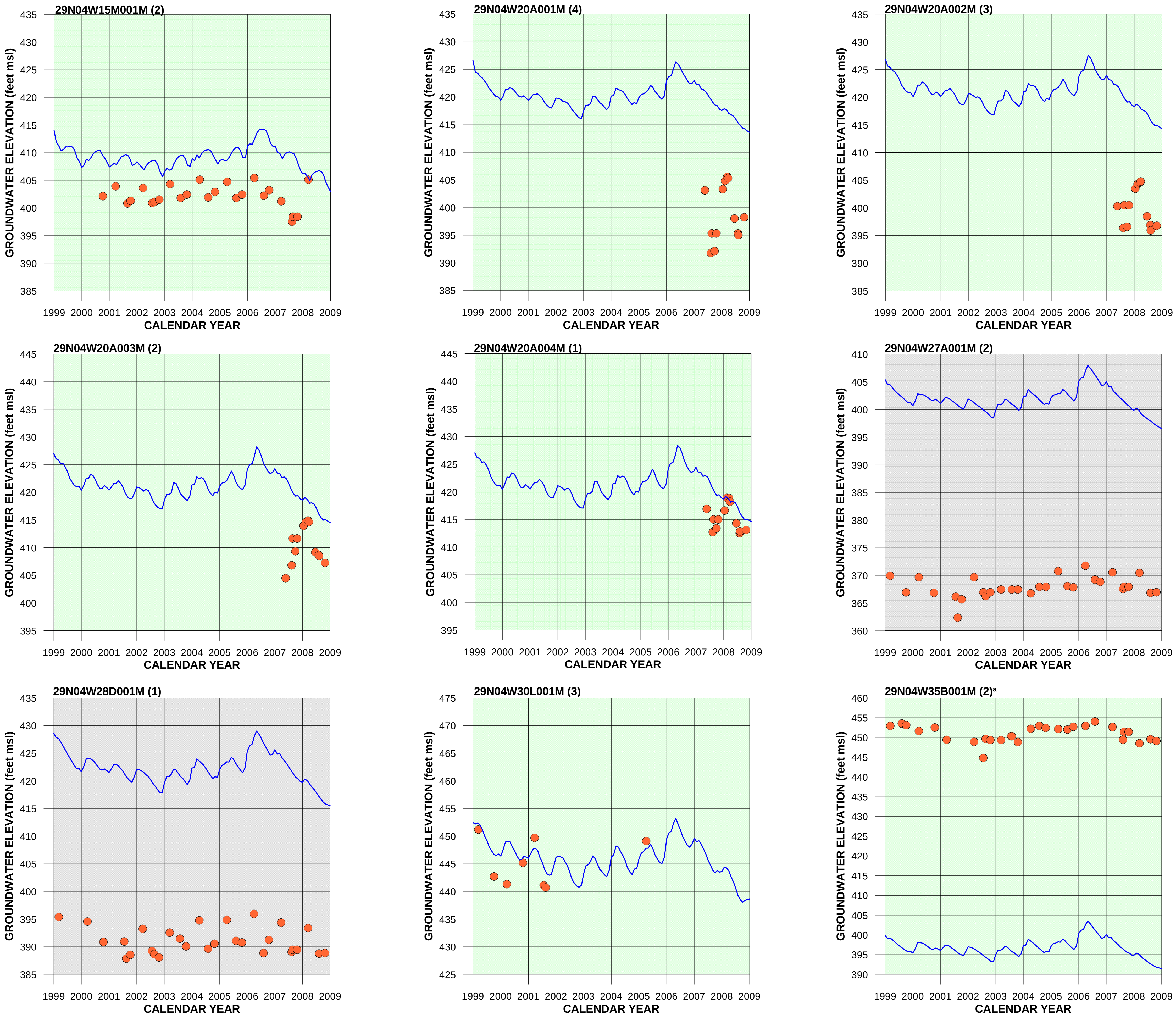
[a]THE RANGE IN Y-AXIS VALUES ON THIS PLOT IS GREATER THAN 50 FEET.

NOTES:

THE VALUE PROVIDED IN PARENTHESIS AFTER THE STATE WELL NUMBER INDICATES THE MODEL LAYER ASSOCIATED WITH THE WELL.

THE STANDARDIZED RANGE IN Y-AXIS VALUES ON EACH PLOT IS 50 FEET, UNLESS OTHERWISE NOTED.

FIGURE D-11 (PAGE 1 OF 8)
TRANSIENT CALIBRATION HYDROGRAPHS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL



LEGEND

- TARGET GROUNDWATER ELEVATION (feet msl)
- SIMULATED GROUNDWATER ELEVATION (feet msl)
- MONITORING WELL WITH MORE RELIABLE REFERENCE POINT ELEVATION
- MONITORING WELL WITH LESS RELIABLE REFERENCE POINT ELEVATION

[a]THE RANGE IN Y-AXIS VALUES ON THIS PLOT IS GREATER THAN 50 FEET.

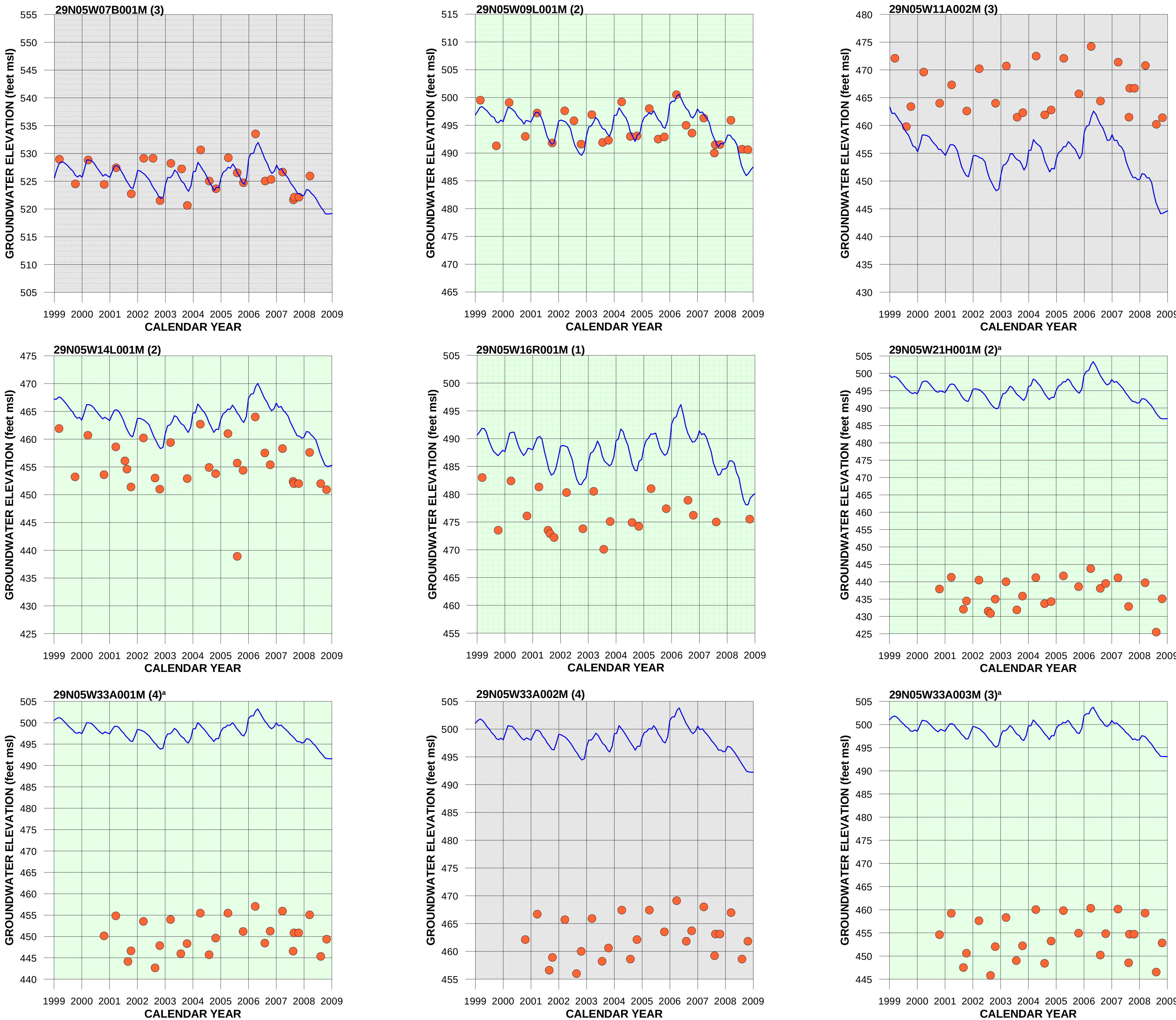
NOTES:

THE VALUE PROVIDED IN PARENTHESIS AFTER THE STATE WELL NUMBER INDICATES THE MODEL LAYER ASSOCIATED WITH THE WELL.

THE STANDARDIZED RANGE IN Y-AXIS VALUES ON EACH PLOT IS 50 FEET, UNLESS OTHERWISE NOTED.

FIGURE D-11 (PAGE 2 OF 8)
TRANSIENT CALIBRATION HYDROGRAPHS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL



LEGEND

TARGET GROUNDWATER ELEVATION (feet msl)

SIMULATED GROUNDWATER ELEVATION (feet msl)

MONITORING WELL WITH MORE RELIABLE REFERENCE POINT ELEVATION

MONITORING WELL WITH LESS RELIABLE REFERENCE POINT ELEVATION

[a]THE RANGE IN Y-AXIS VALUES ON THIS PLOT IS GREATER THAN 50 FEET.

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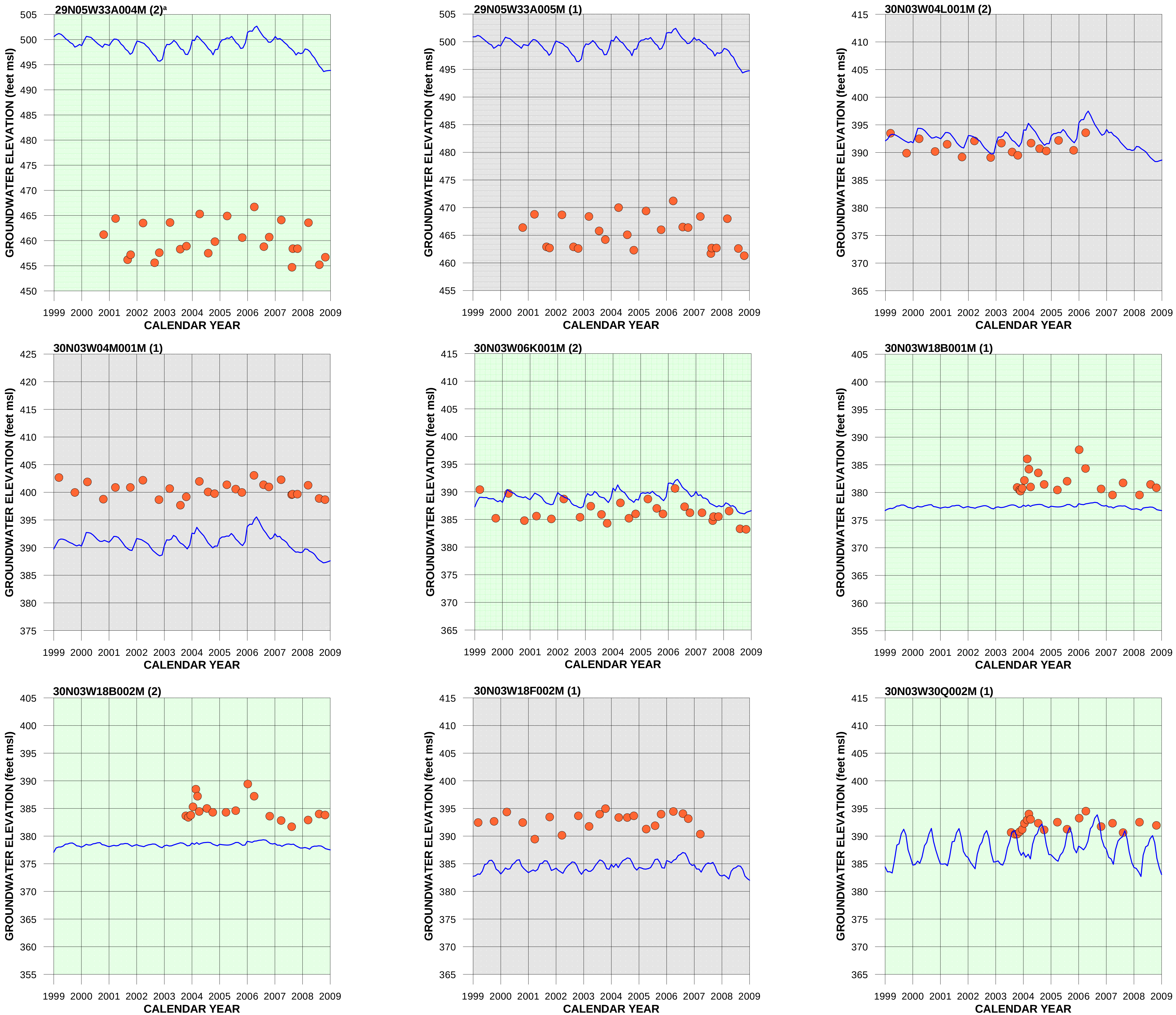
THE VALUE PROVIDED IN PARENTHESIS AFTER THE STATE WELL NUMBER INDICATES THE MODEL LAYER ASSOCIATED WITH THE WELL.

THE STANDARDIZED RANGE IN Y-AXIS VALUES ON EACH PLOT IS 50 FEET, UNLESS OTHERWISE NOTED.

FIGURE D-11 (PAGE 3 OF 8)
TRANSIENT CALIBRATION HYDROGRAPHS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL



LEGEND

- TARGET GROUNDWATER ELEVATION (feet msl)
- SIMULATED GROUNDWATER ELEVATION (feet msl)
- MONITORING WELL WITH MORE RELIABLE REFERENCE POINT ELEVATION
- MONITORING WELL WITH LESS RELIABLE REFERENCE POINT ELEVATION

[a]THE RANGE IN Y-AXIS VALUES ON THIS PLOT IS GREATER THAN 50 FEET.

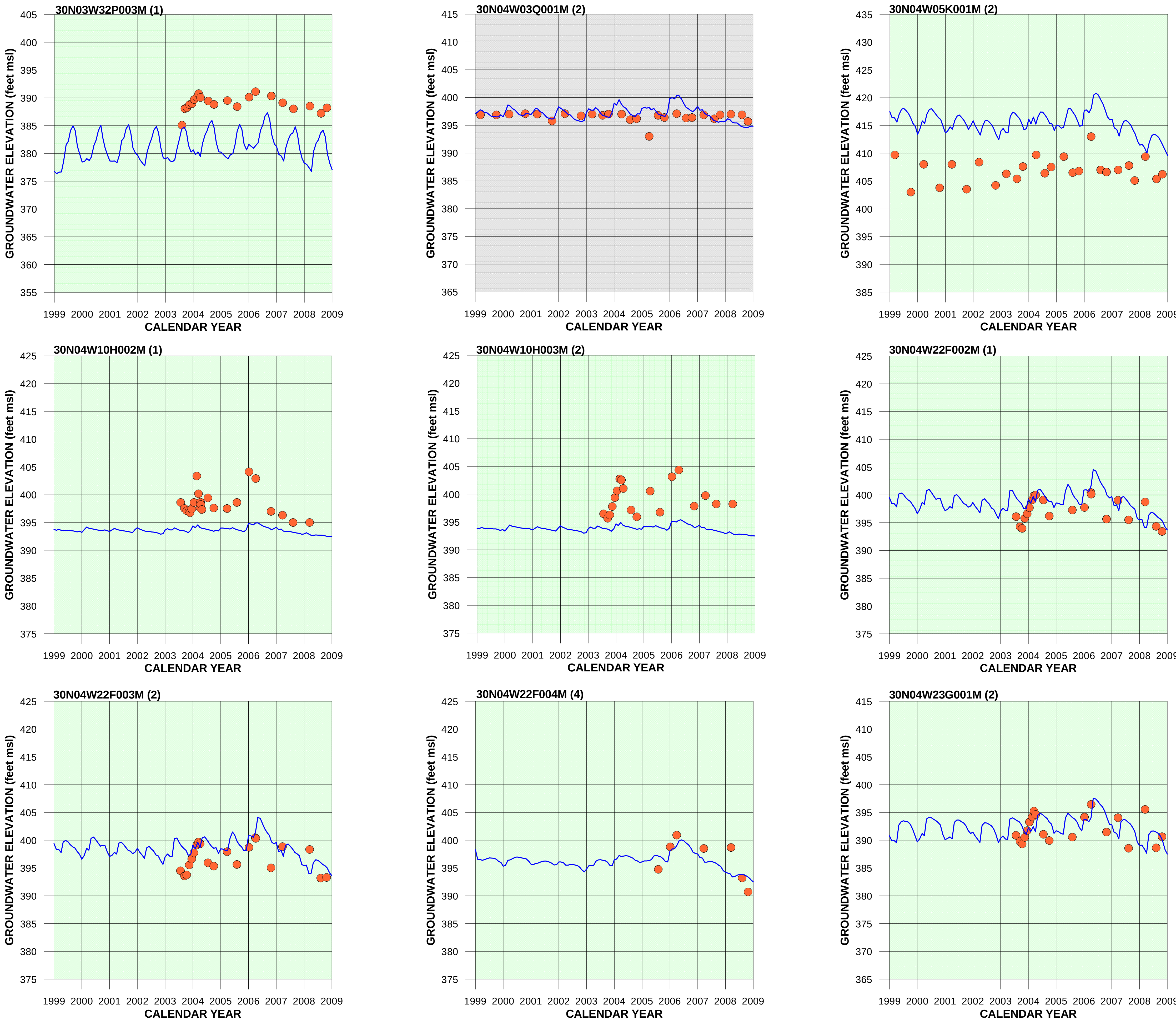
NOTES:

THE VALUE PROVIDED IN PARENTHESIS AFTER THE STATE WELL NUMBER INDICATES THE MODEL LAYER ASSOCIATED WITH THE WELL.

THE STANDARDIZED RANGE IN Y-AXIS VALUES ON EACH PLOT IS 50 FEET, UNLESS OTHERWISE NOTED.

FIGURE D-11 (PAGE 4 OF 8)
TRANSIENT CALIBRATION HYDROGRAPHS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL



LEGEND

- TARGET GROUNDWATER ELEVATION (feet msl)
- SIMULATED GROUNDWATER ELEVATION (feet msl)
- MONITORING WELL WITH MORE RELIABLE REFERENCE POINT ELEVATION
- MONITORING WELL WITH LESS RELIABLE REFERENCE POINT ELEVATION

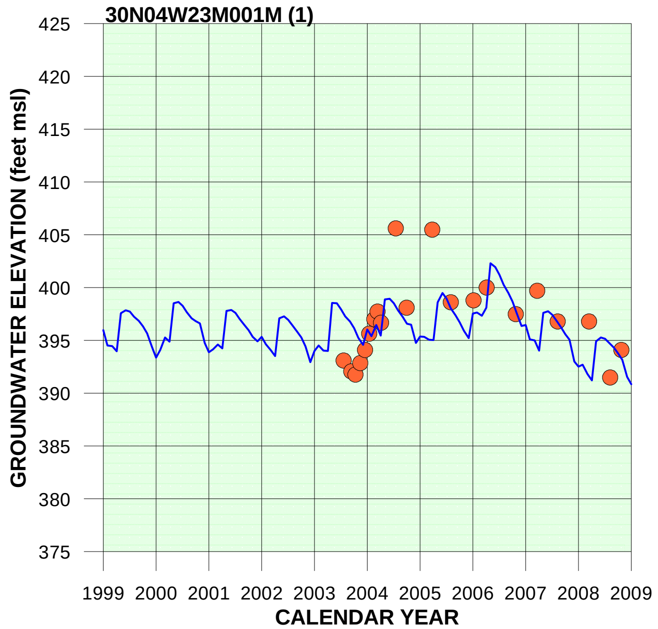
[a]THE RANGE IN Y-AXIS VALUES ON THIS PLOT IS GREATER THAN 50 FEET.

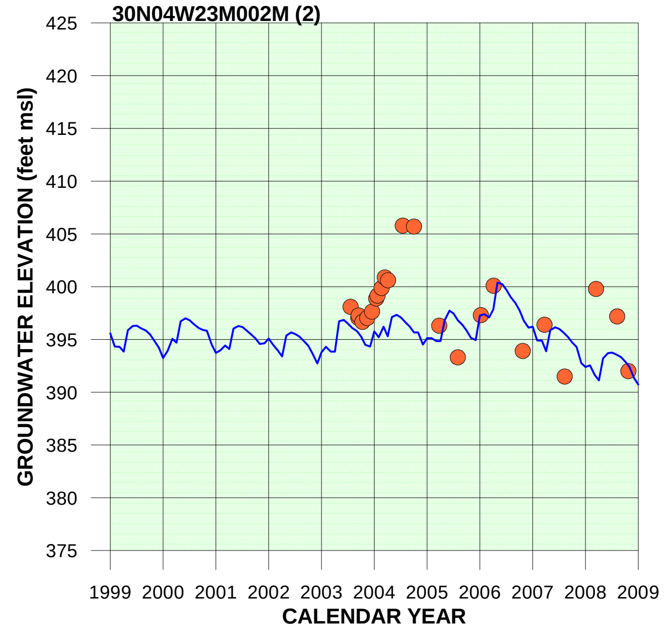
NOTES:

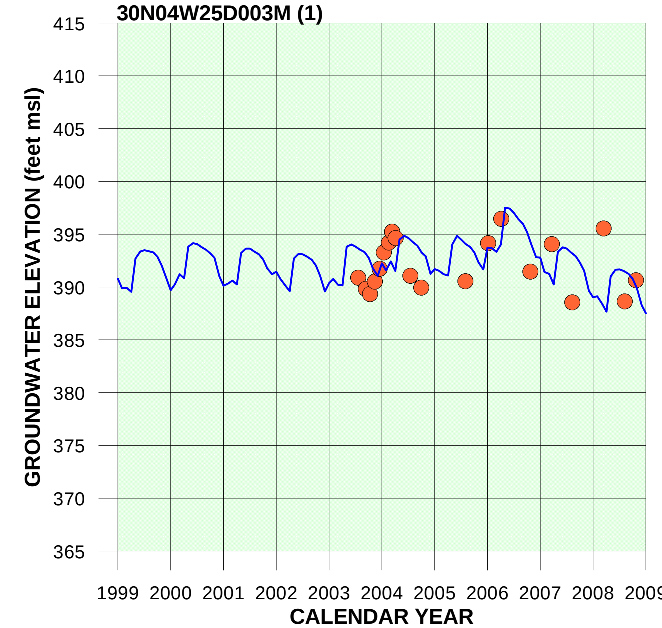
THE VALUE PROVIDED IN PARENTHESIS AFTER THE STATE WELL NUMBER INDICATES THE MODEL LAYER ASSOCIATED WITH THE WELL.

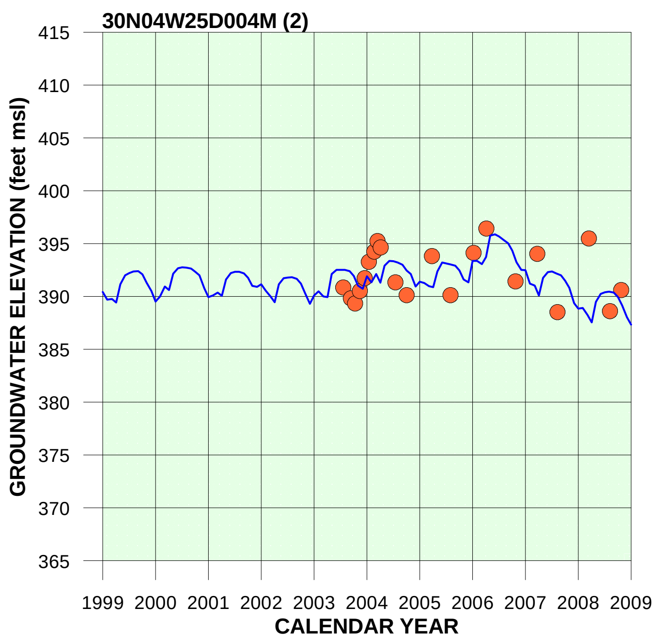
THE STANDARDIZED RANGE IN Y-AXIS VALUES ON EACH PLOT IS 50 FEET, UNLESS OTHERWISE NOTED.

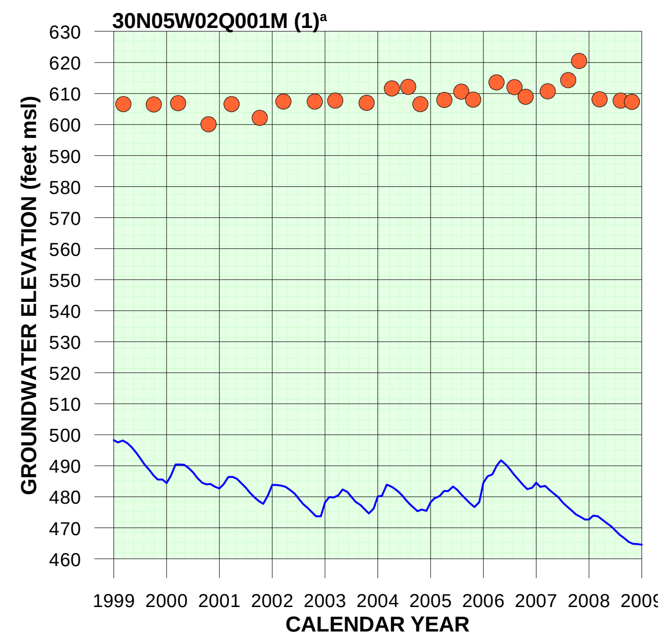
FIGURE D-11 (PAGE 5 OF 8)
TRANSIENT CALIBRATION HYDROGRAPHS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

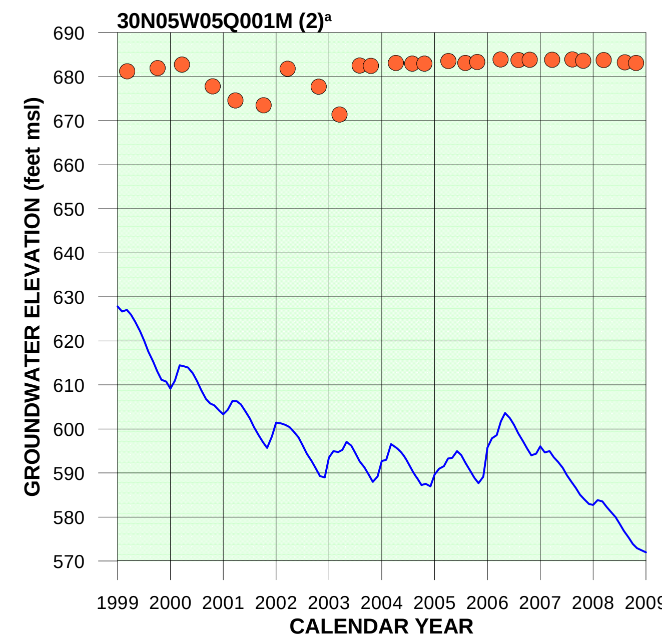


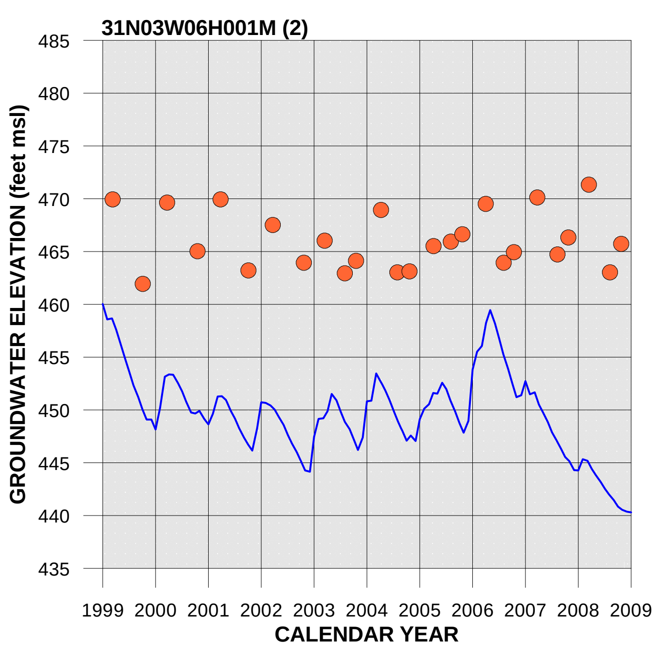


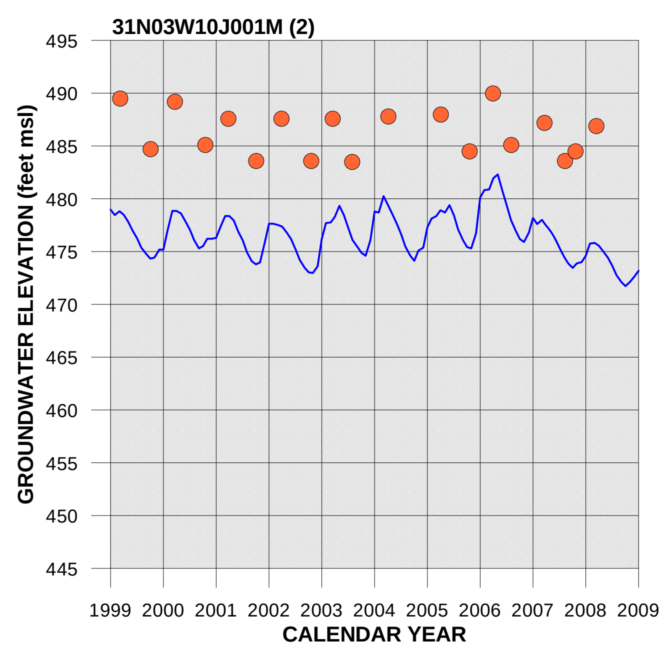


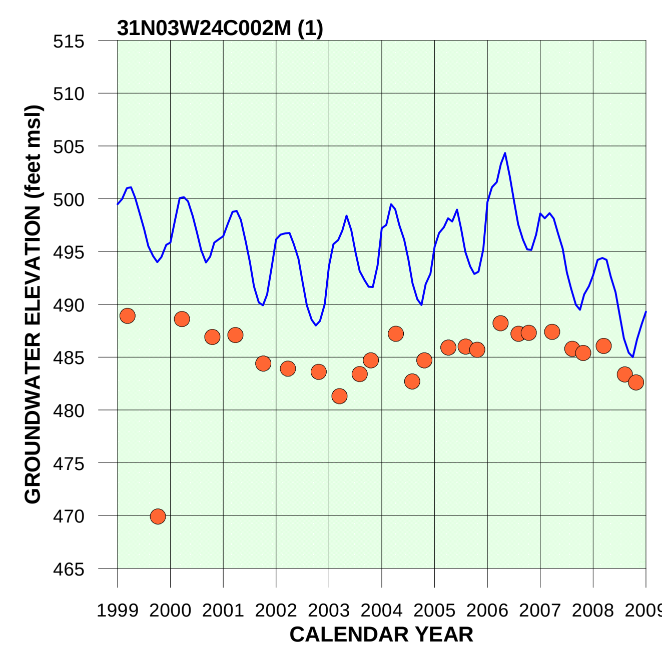












LEGEND

- TARGET GROUNDWATER ELEVATION (feet msl)
- SIMULATED GROUNDWATER ELEVATION (feet msl)
- MONITORING WELL WITH MORE RELIABLE REFERENCE POINT ELEVATION
- MONITORING WELL WITH LESS RELIABLE REFERENCE POINT ELEVATION

[a] THE RANGE IN Y-AXIS VALUES ON THIS PLOT IS GREATER THAN 50 FEET.

NOTES:

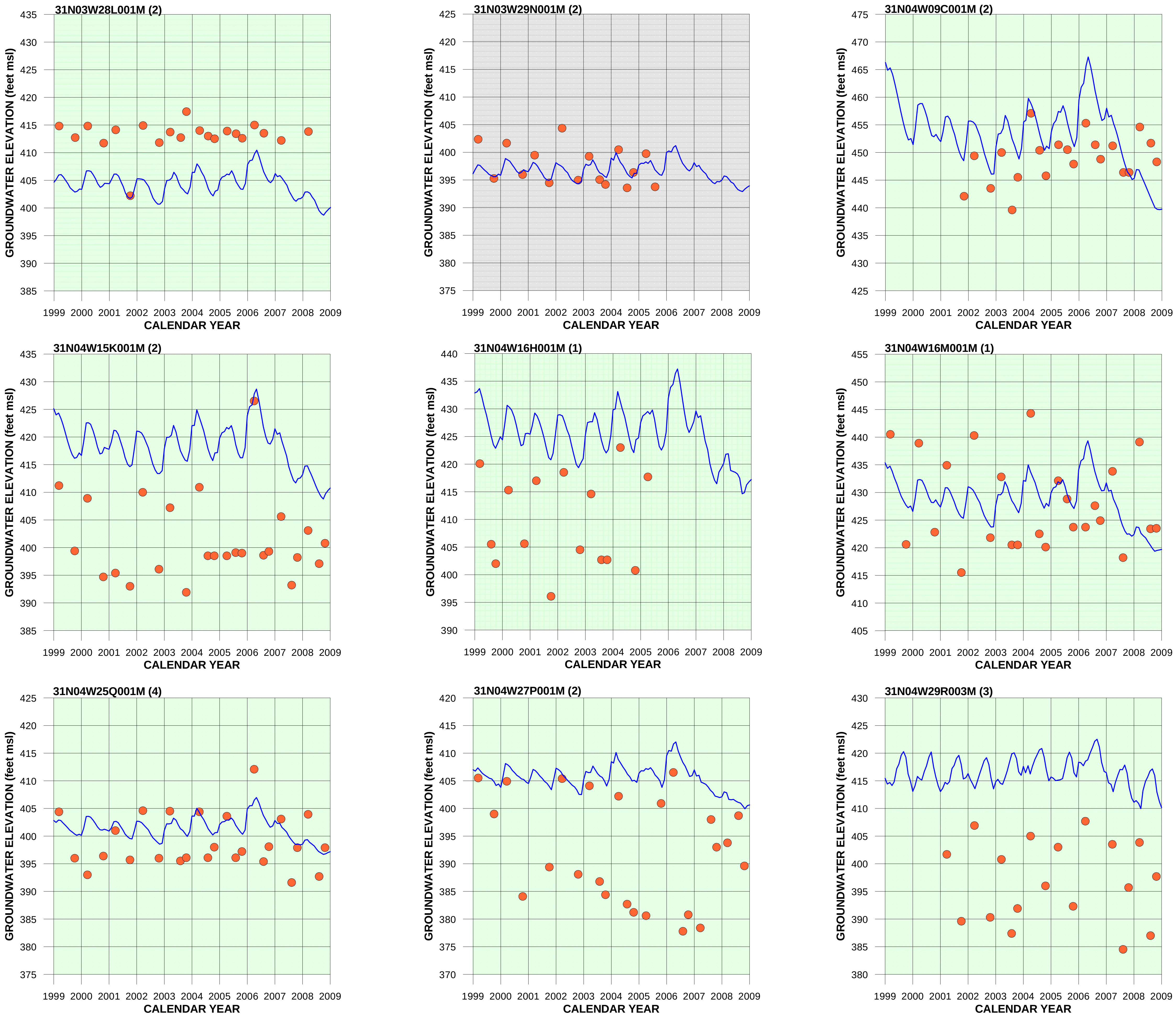
THE VALUE PROVIDED IN PARENTHESIS AFTER THE STATE WELL NUMBER INDICATES THE MODEL LAYER ASSOCIATED WITH THE WELL.

THE STANDARDIZED RANGE IN Y-AXIS VALUES ON EACH PLOT IS 50 FEET, UNLESS OTHERWISE NOTED.

FIGURE D-11 (PAGE 6 OF 8)
TRANSIENT CALIBRATION HYDROGRAPHS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

CH2MHILL

FIG11_Hydrographs_06.grf



LEGEND

- TARGET GROUNDWATER ELEVATION (feet msl)
- SIMULATED GROUNDWATER ELEVATION (feet msl)
- MONITORING WELL WITH MORE RELIABLE REFERENCE POINT ELEVATION
- MONITORING WELL WITH LESS RELIABLE REFERENCE POINT ELEVATION

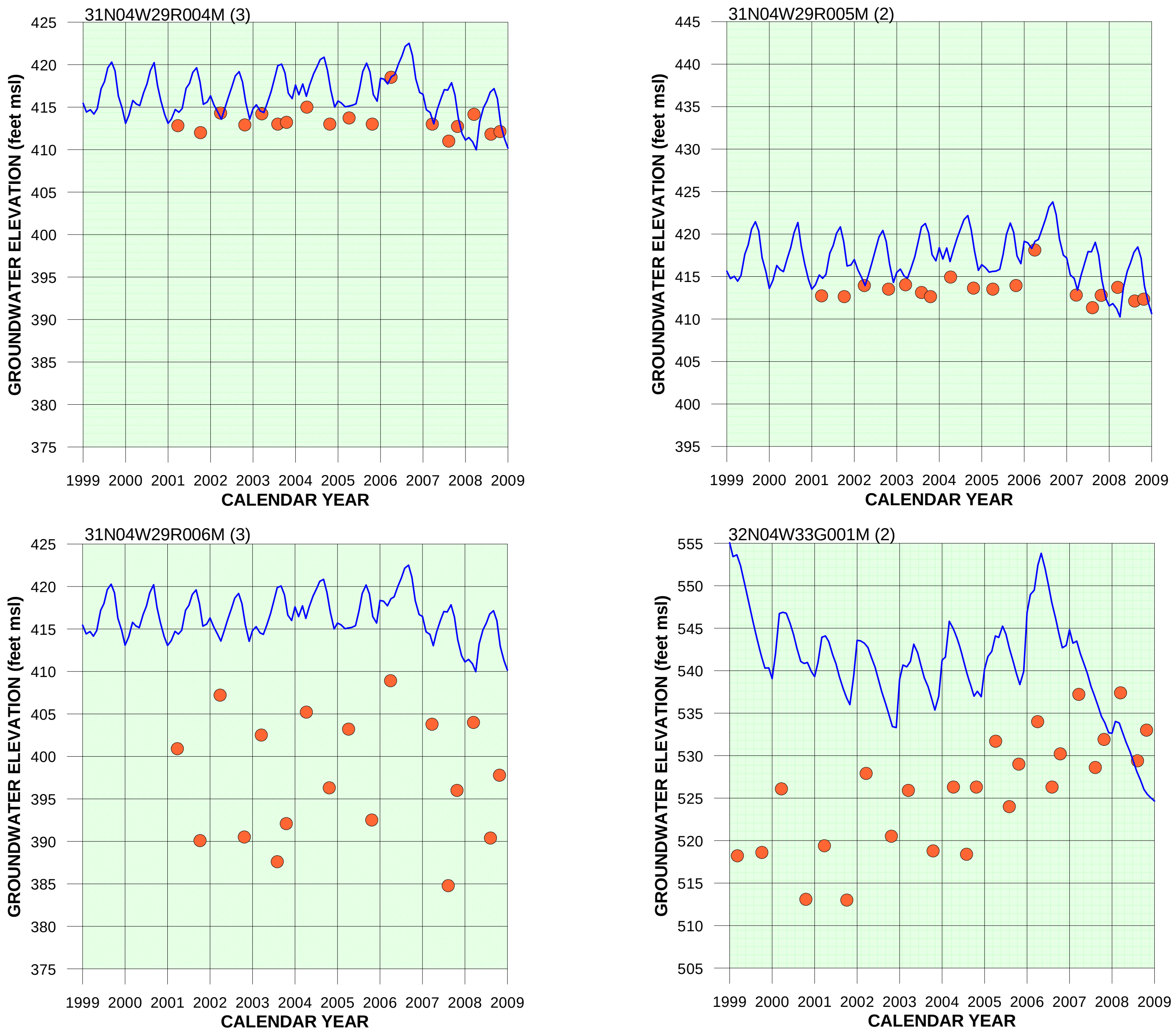
[a]THE RANGE IN Y-AXIS VALUES ON THIS PLOT IS GREATER THAN 50 FEET.

NOTES:

THE VALUE PROVIDED IN PARENTHESIS AFTER THE STATE WELL NUMBER INDICATES THE MODEL LAYER ASSOCIATED WITH THE WELL.

THE STANDARDIZED RANGE IN Y-AXIS VALUES ON EACH PLOT IS 50 FEET, UNLESS OTHERWISE NOTED.

FIGURE D-11 (PAGE 7 OF 8)
TRANSIENT CALIBRATION HYDROGRAPHS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL



LEGEND

- TARGET GROUNDWATER ELEVATION (feet msl)
- SIMULATED GROUNDWATER ELEVATION (feet msl)
- MONITORING WELL WITH MORE RELIABLE REFERENCE POINT ELEVATION
- MONITORING WELL WITH LESS RELIABLE REFERENCE POINT ELEVATION

[a]THE RANGE IN Y-AXIS VALUES ON THIS PLOT IS GREATER THAN 50 FEET.

NOTES:

THE VALUE PROVIDED IN PARENTHESIS AFTER THE STATE WELL NUMBER INDICATES THE MODEL LAYER ASSOCIATED WITH THE WELL.

THE STANDARDIZED RANGE IN Y-AXIS VALUES ON EACH PLOT IS 50 FEET, UNLESS OTHERWISE NOTED.

FIGURE D-11 (PAGE 8 OF 8)
TRANSIENT CALIBRATION HYDROGRAPHS
DOCUMENTATION OF THE REDDING GROUNDWATER BASIN FINITE-ELEMENT MODEL

Attachment D1
Redding Basin Water Budget Inputs

MBK ENGINEERS

Water Resources • Flood Control • Water Rights

TECHNICAL MEMORANDUM

DATE: September 15, 2010

TO: Peter Lawson
Michael Basial
Nate Brown

FROM: Lee G. Bergfeld

SUBJECT: Redding Basin Water Budget Inputs

This technical memorandum documents data and methods used in development of water budget inputs to a MicroFem groundwater model of the Redding Basin. Water budget inputs are time-series of monthly deep percolation, split between deep percolation of applied water and precipitation, and groundwater pumping for each of the 55,938 groundwater model nodes. Inputs described in this memorandum are for agricultural and native vegetation areas within the model domain and do not include urban areas. Water budget inputs were developed for the entire groundwater model simulation period from January 1980 through December 2008.

INPUT DATA

Water budget inputs were developed using a combination of data on land use, soil properties, precipitation, and a root zone soil moisture accounting model, the Integrated Water Flow Model Demand Calculator (IDC) developed the Department of Water Resources (DWR) Bay-Delta Modeling Office. The following sections document the source of this data and provide data summaries for the groundwater model domain.

Land Use Data

Water budgets were developed based on land use for areas contributing to each groundwater model node. Geographic information system (GIS) land use data were developed by Department of Water Resources (DWR) Northern District staff during field surveys conducted in 1999 for Tehama County and 2005 for Shasta County. These data are assumed to represent current level land uses and are constant throughout the simulation period. Table 1 summarizes land use data for the entire model domain by county for three broad land use categories; agricultural, urban, and native vegetation. Land use is further disaggregated within these three broad categories for specific crops and urban uses in the GIS data.

Table 1: Summary of Land Uses within Model Domain (acres)

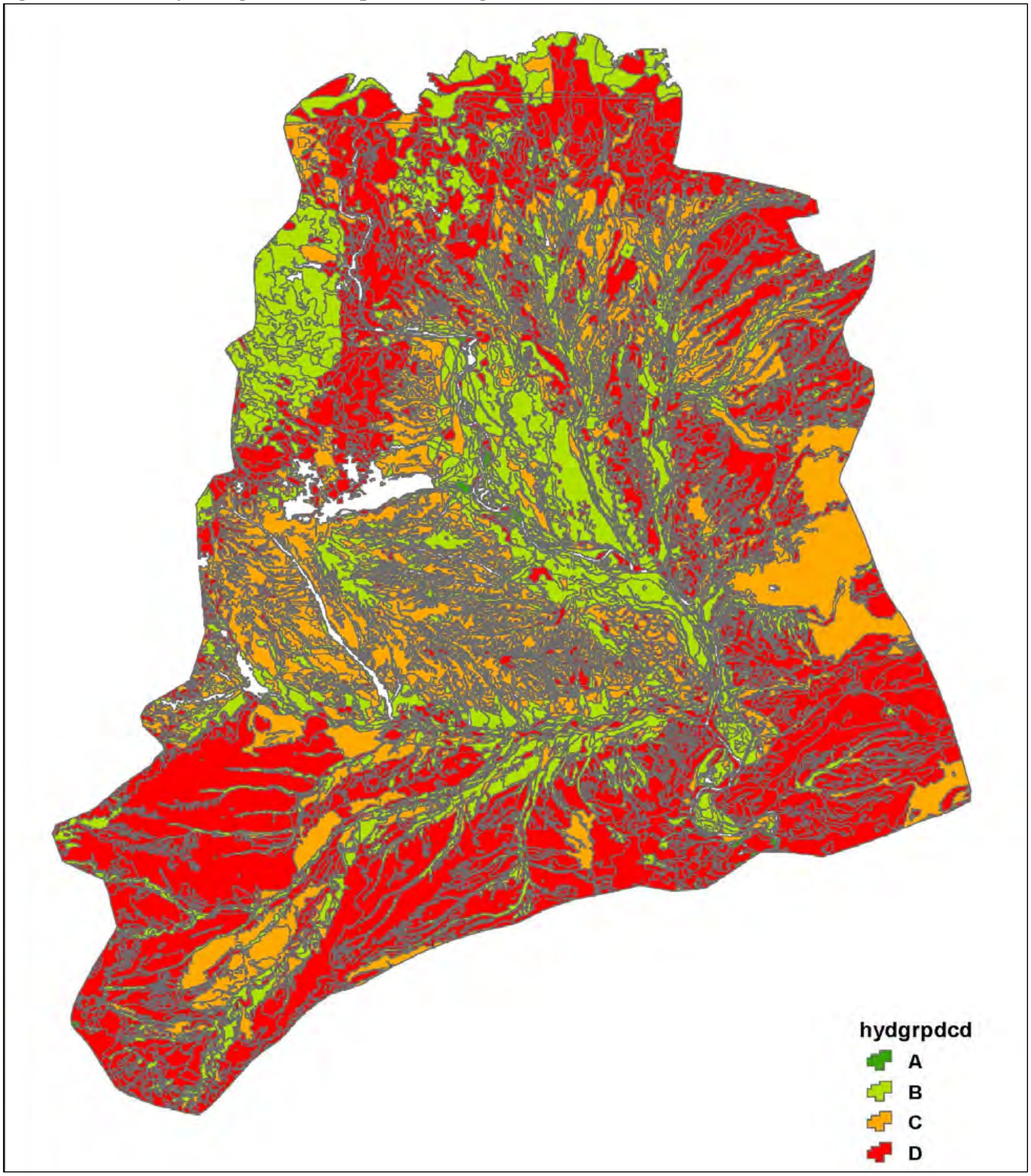
County	Agricultural	Urban	Native Vegetation	Total
Shasta	23,947	87,431	235,417	346,795
Tehama	5,864	2,610	170,992	179,466
Total	29,811	90,041	406,409	526,261

Data presented in Table 1 show approximately 77 percent of lands within the model domain are native vegetation, with 17 percent urban, and the remaining 6 percent in agriculture. Pasture is the primary agricultural land use, accounting for approximately two thirds of all agricultural land use in the model. Other crops include alfalfa, truck crops, grains, field crops, orchards, and vineyards.

Soil Data

Hydrologic soil group (HSG) data was extracted from the Natural Resources Conservation Service (NRCS) SSURGO Version 2.2 database. There are four HSGs; A, B, C, and D. HSGs are used to classify soils based on runoff potential with A soils having the lowest runoff potential and the highest saturated hydraulic conductivity and D soils having the highest runoff potential and lowest saturated hydraulic conductivity. HSG data for the model domain were combined with land use and precipitation data in GIS for use in IDC to estimate deep percolation and applied water demands based on the combination of these inputs.

Figure 1: NRCS Hydrologic Soil Groups in Redding Basin



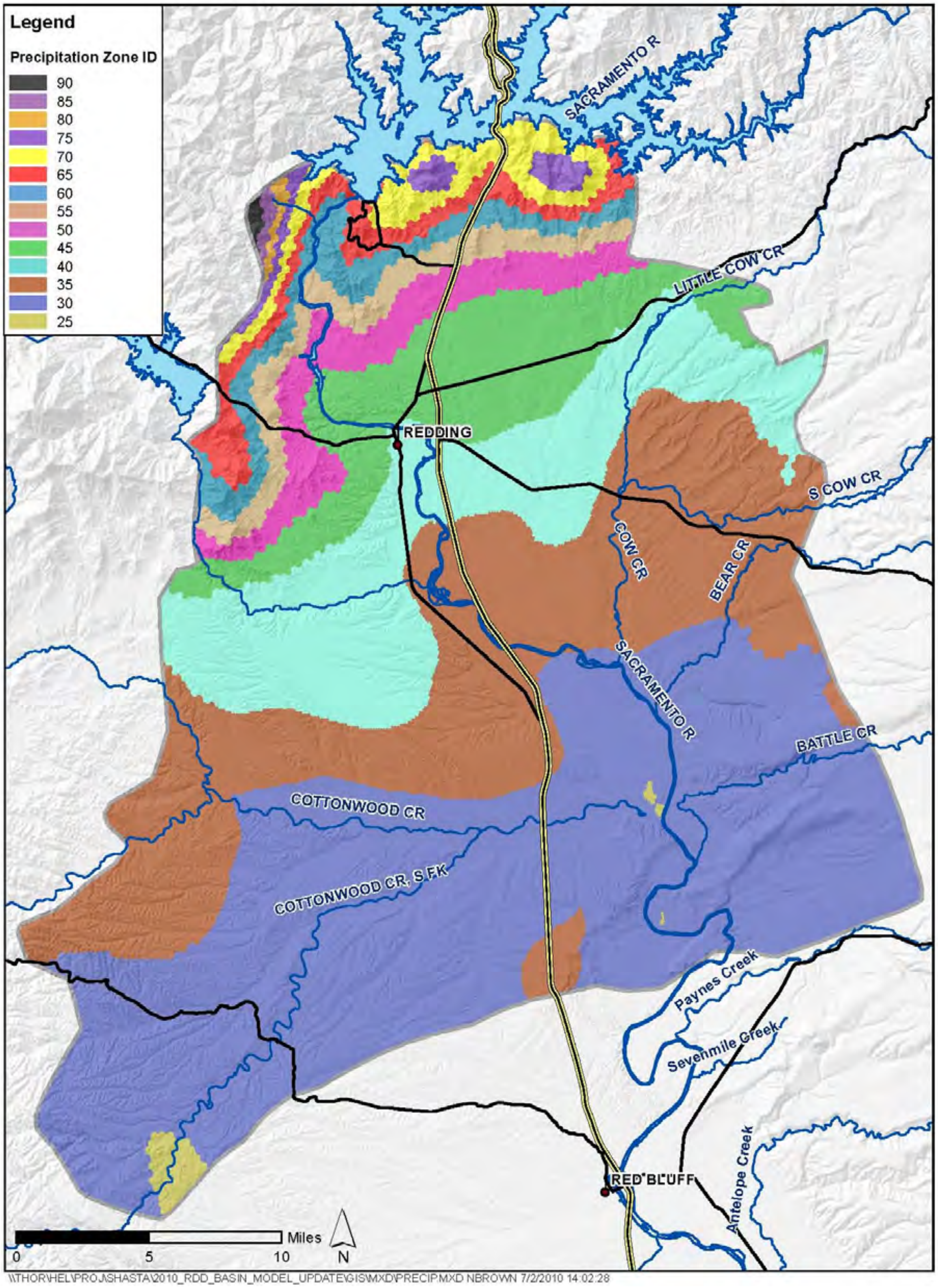
HSG data were used to estimate soil parameters used in IDC including field capacity, effective porosity, and the fraction of excess soil moisture (above field capacity) that deep percolates. HSG A soils have the lowest field capacity and the highest fraction of excess soil moisture that deep percolates while D soils have the highest field capacity and lowest fraction of excess soil moisture that deep percolates.

Precipitation Data

Time-series of monthly precipitation were developed for the entire model domain using Parameter-elevation Regression on Independent Slopes Model (PRISM) data from Oregon State University's PRISM Climate Group. These data were available at 800-meter grid spacing making it possible to provide individual time-series of precipitation to each model node. However, review of temporal and spatial variability of precipitation data indicated it was possible to aggregate areas of the model domain into precipitation regions and use a limited number of precipitation time-series. Precipitation zones were developed based on the average annual precipitation depth over the simulation period. Zones ranged from average annual precipitation of 25 inches to 90 inches in 5 inch intervals. Figure 2 illustrates the precipitation zones used in IDC.

Monthly precipitation time-series were used to calculate monthly time-series of infiltration to the root zone for use in IDC. Previous use of IDC indicated it overestimates infiltration of precipitation when performing simulations at a monthly time-step. Time-series of infiltration in the Redding Basin were developed from a previous simulation of daily precipitation, runoff, and infiltration in IDC. Daily calculated volumes were aggregated to monthly volumes to estimate the fraction of precipitation infiltrating the soil. These fractions were applied to monthly PRISM precipitation time-series for the fourteen precipitation zones and used directly in IDC.

Figure 2: Model Precipitation Zones



IDC

IDC is a root zone soil moisture accounting model that can be used to calculate time-series of applied water demands, deep percolation past the root zone, agricultural return flows, and runoff of precipitation. IDC was used to calculate time-series of deep percolation and applied water demand for agricultural areas and deep percolation for native vegetation areas. Agricultural applied water demands were compared with observed District diversions records and in some instances adjusted by modifying irrigation efficiencies used in IDC. Table 2 is a summary of IDC input data and the source of the data.

Table 2: Summary of IDC Inputs and Source

IDC Input Data	Source
Land use	DWR Field Surveys
Soil parameters	Estimated based on NRCS HSG
Precipitation/Infiltration	PRISM/IDC simulation at daily time-step
Evapotranspiration	DWR Consumptive Use Model
Minimum soil moisture requirement	DWR Consumptive Use Model
Irrigation efficiency	DWR and calibration parameter

IDC performs calculations at a sub-region level. Inputs for soil, precipitation, evapotranspiration, minimum soil moisture, and irrigation efficiency are specified for individual sub-regions. The IDC application for the Redding Basin used a total of 141 sub-regions to define unique combinations of HSG, precipitation zone, and agricultural water districts. Irrigation parameters for most agricultural water districts and agricultural lands outside of water district boundaries were constant with the exception of Anderson-Cottonwood Irrigation District (ACID) where irrigation efficiencies were lowered to match observed water demands.

IDC was run for one acre of each crop type and native vegetation area within each sub-region and unit factors time-series were output for use in final calculation for the land use associated with each groundwater model node.

CALCULATIONS

Groundwater Pumping

A total of approximately 7,000 acres of agricultural lands are supplied by groundwater in the Redding Basin, based on the DWR survey data. Unit factors for crop applied water demand were multiplied by land use for these areas supplied from groundwater. Time-series of applied water demand for these areas are one contribution to total calculated groundwater pumping and are approximately 25,000 acre-feet on an average annual basis.

Additional agricultural pumping is estimated for lands outside of water district boundaries that may rely on a combination of available surface water and groundwater pumping. Additional groundwater pumping was assumed to meet a fraction of the applied water demand based on an approximation of available surface water in local streams. Available surface water in local streams was estimated based on Sacramento Valley Water Year Type (40-30-30 Index).

Table 3 provides the monthly fraction of applied water demand assumed to be met from groundwater pumping in these non-district lands. Months not shown are zero.

Table 3: Percent of Applied Water Demand Met by Groundwater Pumping in Non-District Lands

40-30-30 Index	May	June	July	August	September	October
Wet	0	0	0	0	0	0
Above Normal	0	0	0	0	0	0
Below Normal	0	10	40	40	40	40
Dry	20	50	50	50	50	50
Critical	30	70	70	70	70	70

Additional groundwater pumping in non-district lands is approximately 8,000 acre-feet on an average annual basis, but as much as 22,000 acre-feet in critical years. Maximum fractions in Table 3 are 70 percent of applied water demand under the assumption that some non-district lands would not be irrigated in years when surface water is not available.

Applied water demands for water districts with known surface water contracts were calculated and compared with annual contract quantities. ACID has the largest agricultural water demand and largest annual contract in the Redding Basin. ACID's CVP contract is reduced from full contract supply of 128,000 acre-feet per year in certain years of below average inflow to Lake Shasta. In these years, the CVP contract is reduced to 75 percent of full contract supply or 96,000 acre-feet. Average annual ACID diversions over the past seven years have been approximately 105,000 acre-feet. Therefore, in years of reduced CVP contract supply unmet agricultural demand within ACID is approximately 10,000 acre-feet. It was assumed that this deficit would be met through changes in district operations without additional groundwater pumping.

Comparisons of annual agricultural water diversions with CVP contract quantities for agricultural service contractors such as Bella Vista Water District and Clear Creek Community Services District (CSD) indicate diversions are typically well below contract quantities and additional groundwater pumping due to less than full contract allocation would likely be minimal.

Deep Percolation

Unit factors for deep percolation for both agricultural and native vegetation areas were multiplied by land use areas for each groundwater model node. The result of this calculation was a time-series for each model node of total deep percolation. Total deep percolation was split between precipitation and applied water based on the ratio of precipitation to applied water for a given month. For example, if total water available to an area is 10 inches in April with 6 inches from precipitation and 4 inches from applied water, then it is assumed the 60 percent of any deep percolation that occurs in April is from precipitation and the remaining 40 percent is from applied water. All deep percolation from native vegetation lands is from precipitation.

SUMMARY OF WATER BUDGET INPUTS

The following three tables present monthly summaries of water budget inputs; deep percolation and agricultural groundwater pumping, for the entire model domain. These tables illustrate the temporal variation in water budget inputs due to differences in precipitation, irrigation season, and hydrology.

Table 4: Monthly Deep Percolation of Agricultural Applied Water (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	0	0	0	2,614	4,932	3,422	7,384	7,329	3,499	348	410	0	29,939
1981	0	0	0	1,814	2,995	5,144	7,462	7,391	1,919	0	0	0	26,725
1982	0	0	0	656	6,942	1,964	6,289	7,201	2,197	0	0	0	25,250
1983	0	0	0	21	4,884	4,070	7,328	6,285	1,244	332	0	0	24,163
1984	0	0	0	2,906	6,556	4,019	7,443	6,132	3,682	0	0	0	30,739
1985	0	0	0	4,995	6,106	4,560	7,265	7,151	390	16	0	0	30,483
1986	0	0	0	2,884	4,465	5,131	7,548	7,391	643	668	766	0	29,496
1987	0	0	0	4,621	7,116	5,125	7,224	7,379	4,209	814	0	0	36,489
1988	0	0	525	4,008	1,898	2,967	7,290	7,345	4,208	1,121	0	0	29,363
1989	0	0	0	1,253	5,415	4,449	7,557	7,189	0	0	18	0	25,881
1990	0	0	0	5,887	366	4,861	6,997	6,201	3,257	550	392	0	28,509
1991	0	0	0	3,005	5,175	4,899	7,398	7,319	4,194	164	60	0	32,214
1992	0	0	0	2,128	7,000	2,841	7,270	7,358	4,180	0	0	0	30,777
1993	0	0	0	287	186	3,034	7,399	6,032	4,183	0	0	0	21,123
1994	0	0	0	3,209	3,908	5,032	7,570	7,391	4,054	1,103	0	0	32,268
1995	0	0	0	252	3,893	2,544	7,224	7,391	4,216	1,216	1,042	0	27,778
1996	0	0	0	1,557	681	5,029	7,325	7,391	3,132	103	0	0	25,218
1997	0	0	1	3,967	6,389	2,790	7,237	6,359	2,115	0	0	0	28,858
1998	0	0	0	682	119	2,654	7,421	7,391	4,083	0	0	0	22,350
1999	0	0	0	2,463	6,797	4,138	7,545	7,140	4,218	413	0	0	32,714
2000	0	0	0	786	4,766	3,985	6,925	7,283	540	0	0	0	24,285
2001	0	0	0	1,962	6,985	4,146	7,485	7,391	3,280	391	0	0	31,642
2002	0	0	0	3,908	5,473	5,134	7,546	7,358	4,189	1,236	0	0	34,844
2003	0	0	0	1	4,321	5,194	7,600	6,238	4,210	1,237	0	0	28,802
2004	0	0	1	4,352	5,922	5,079	7,497	7,353	3,964	0	0	0	34,167
2005	0	0	0	1,185	109	3,908	7,488	7,391	4,079	776	0	0	24,935
2006	0	0	0	0	5,271	4,731	7,520	7,325	4,216	1,066	0	0	30,128
2007	0	0	1	4,180	5,691	5,038	5,003	7,355	3,387	0	3	0	30,659
2008	0	0	45	6,808	6,655	5,156	7,589	7,329	4,222	148	0	0	37,953
Avg	0	0	20	2,496	4,518	4,174	7,270	7,096	3,162	403	93	0	29,233

Table 4 illustrates deep percolation of applied water occurs only during the irrigation season. Comparisons of annual deep percolation and annual applied water demand show approximately 25 percent of applied water is estimated to deep percolate. This fraction varies by water district as a function of irrigation efficiency. Irrigation efficiencies vary due to differences in operations and soil parameters.

Table 5: Monthly Deep Percolation of Precipitation (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	70,945	177,112	32,724	3,677	668	370	0	0	182	75	140	30,531	316,423
1981	144,465	65,240	90,726	606	998	0	2	0	413	8,645	145,904	151,332	608,331
1982	92,394	65,549	113,769	28,791	3	444	286	9	449	10,395	109,406	122,031	543,526
1983	166,321	204,041	301,981	33,971	595	267	6	368	448	1,943	160,797	257,196	1,127,934
1984	500	55,319	21,637	716	154	259	0	398	73	92	150,828	43,092	273,069
1985	7,271	12,061	41,515	34	376	99	11	12	172	2,949	23,773	36,576	124,850
1986	139,391	214,503	90,566	570	858	0	0	0	716	1,460	845	10,567	459,474
1987	75,369	72,457	104,151	11	25	0	41	0	0	38	1,359	88,744	342,195
1988	143,007	188	267	4,159	3,669	393	1	1	0	1	59,956	63,106	274,749
1989	36,400	2,315	199,847	693	551	169	0	12	90	17,240	7,270	0	264,587
1990	73,425	24,072	13,679	251	17,389	31	131	382	210	81	404	154	130,208
1991	1,327	13,963	206,820	602	623	15	3	0	0	48	131	10,939	234,471
1992	22,369	167,347	67,995	5,589	9	481	1	0	0	704	5,057	83,511	353,063
1993	202,902	135,194	68,871	1,216	2,655	621	0	384	0	526	7,346	78,319	498,035
1994	72,253	110,809	911	3,827	1,078	7	0	0	6	0	10,270	73,816	272,977
1995	435,138	12,942	242,500	27,032	1,416	1,779	36	0	0	0	25	131,456	852,324
1996	162,492	157,744	25,076	5,206	14,538	4	8	0	271	70	54,019	276,787	696,214
1997	182,662	869	3,701	736	339	409	1	347	316	298	83,633	59,443	332,754
1998	290,873	346,102	108,295	10,369	88,339	579	1	0	7	0	145,075	52,191	1,041,831
1999	67,414	146,692	48,376	743	31	264	0	12	0	71	16,923	4,802	285,328
2000	139,260	236,071	44,465	7,380	723	262	150	0	209	6,491	6,055	18,866	459,933
2001	109,202	114,209	32,477	618	4	249	0	0	232	194	62,237	191,821	511,244
2002	75,954	34,027	27,608	580	616	0	0	0	0	0	1,589	198,208	338,582
2003	125,922	31,818	69,121	70,976	795	0	0	363	1	0	15,065	178,031	492,092
2004	71,128	190,392	12,151	932	494	5	0	0	9	3,400	7,131	138,895	424,538
2005	92,795	50,781	68,448	3,125	20,137	422	0	0	1	58	37,862	246,851	520,482
2006	131,779	69,632	147,313	68,150	515	52	0	0	0	2	4,652	65,187	487,282
2007	2,302	120,597	0	982	588	1	757	1	212	2,262	427	46,161	174,289
2008	191,410	56,066	0	239	261	0	0	0	0	444	4,367	15,161	267,948
Avg	114,713	99,590	75,345	9,717	5,464	248	49	79	139	1,982	38,709	92,199	438,232

Table 5 illustrates deep percolation of precipitation occurs primarily outside the irrigation season and can vary significantly on an annual basis with differences in precipitation. Deep percolation during wet years such as 1983 and 1998 can be approximately an order of magnitude greater than during dry years such as 1990 and 2007. Annual deep percolation of precipitation presented in Table 5 averages approximately 24 percent of annual precipitation.

Table 6: Monthly Agricultural Groundwater Pumping (acre-feet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	0	0	0	2,217	4,052	3,900	5,952	5,236	3,073	829	422	0	25,681
1981	0	0	0	1,730	4,214	8,366	10,206	9,158	4,114	0	0	0	37,788
1982	0	0	0	729	4,909	3,202	5,480	5,126	2,411	0	0	0	21,857
1983	0	0	0	76	3,935	4,253	5,862	4,706	1,880	736	0	0	21,449
1984	0	0	0	2,583	4,765	4,235	6,001	4,631	3,189	34	0	0	25,437
1985	0	0	0	3,443	5,955	7,745	10,037	8,876	2,248	470	0	0	38,775
1986	0	0	0	2,198	3,824	4,883	6,007	5,253	1,178	1,047	641	0	25,031
1987	0	0	0	3,106	6,389	8,396	9,968	9,153	6,173	2,144	0	0	45,329
1988	0	0	1,001	3,340	3,689	7,525	11,860	10,612	7,245	3,059	0	0	48,330
1989	0	0	0	1,224	5,515	7,634	10,348	8,883	282	0	117	0	34,004
1990	0	0	39	4,245	1,523	9,494	11,430	9,572	6,226	1,983	457	0	44,969
1991	0	1	0	2,235	5,975	9,361	11,785	10,683	7,233	1,405	154	0	48,834
1992	0	0	0	1,805	7,033	7,087	11,898	10,708	7,203	0	84	0	45,818
1993	0	0	0	884	1,554	3,750	6,012	4,635	3,501	220	0	0	20,556
1994	0	0	80	2,885	4,947	9,593	12,070	10,721	6,987	3,026	0	0	50,310
1995	0	0	0	406	3,378	3,377	5,932	5,253	3,516	1,581	754	0	24,196
1996	0	0	0	1,606	1,632	4,796	5,842	5,253	2,931	464	0	0	22,523
1997	0	0	234	3,522	4,747	3,581	5,932	4,746	2,551	206	0	0	25,519
1998	0	0	0	843	123	3,342	5,967	5,253	3,396	260	0	0	19,183
1999	0	0	0	2,121	4,881	4,272	6,020	5,081	3,516	880	0	0	26,771
2000	0	0	0	994	3,914	4,228	5,702	5,222	1,693	0	0	0	21,753
2001	0	0	0	1,993	6,475	7,404	10,321	9,158	5,290	1,352	0	0	41,993
2002	0	0	0	2,944	5,450	8,395	10,281	9,147	6,153	2,794	0	0	45,165
2003	0	0	0	8	3,505	4,901	5,982	4,700	3,462	1,589	0	0	24,147
2004	0	0	27	3,333	4,484	5,501	9,440	8,365	5,325	0	0	0	36,476
2005	0	0	0	1,253	873	4,286	6,020	5,253	3,424	1,177	0	0	22,285
2006	0	0	0	0	3,979	4,605	6,002	5,236	3,516	1,377	0	0	24,716
2007	0	0	293	3,267	5,530	8,270	8,062	9,144	5,388	0	245	0	40,200
2008	0	0	348	4,581	6,846	9,808	12,079	10,691	7,250	972	0	0	52,575
Avg	0	0	70	2,054	4,279	6,075	8,224	7,257	4,150	952	99	0	33,161

Table 6 shows annual agricultural groundwater pumping ranges between approximately 19,000 and 52,000 acre-feet. Pumping primarily occurs May through September with smaller quantities in March-April and October-November of some years.

COMPARISON WITH OBSERVED AND ESTIMATED VALUES

Several comparisons were made between observed or estimated values from other sources with calculated water budget inputs for select areas within the model domain. These comparisons were used to check the reasonableness of water budget inputs, not necessarily as targets for calibration.

Comparisons of applied water demands were similar to observed surface water diversions for ACID, Clear Creek CSD, and Bella Vista Water District. Calculated deep percolation of precipitation in native vegetation areas was compared to estimates of deep percolation based on relationships developed by Turner for native vegetation watersheds in California (Turner, 1985). This comparison showed calculated deep percolation in native vegetation areas was less than Turner estimates for drier precipitation zones, similar for moderate precipitation zones, and higher than Turner estimates for wetter precipitation zones. Across the entire model domain, calculated deep percolation in native vegetation areas was less than Turner estimates in dry years and more in wet years.

Comparisons of calculated applied water demand and deep percolation of applied water were made with water budgets developed by DWR Northern District for years 2002 through 2005. These comparisons were made by Detailed Analysis Unit (DAU) and county. DWR water budget data are for entire DAU-county areas while the model domain covers only a portion of DAU-county areas. However, the model domain covered the majority of DAU-county areas with significant agricultural lands in the Redding Basin. Applied water demands were similar for most DAU-county combinations. Calculated groundwater pumping exceeded DWR estimates due primarily to differences in agricultural acreage supplied from groundwater. DWR estimates were based on approximately 4,200 acres supplied from groundwater, compared to 7,000 acres based on the GIS data. Comparisons between calculated deep percolation of applied water and DWR estimates were similar for areas supplied by groundwater, but calculated values exceeded DWR estimates for areas supplied by surface water. A large disparity exists in DWR's estimate of the fraction of applied water that deep percolates between surface and groundwater sources. DWR estimates for groundwater sources were on the order of 15 to 30 percent of applied water, compared to 2 to 4 percent for surface water sources.

REFERENCES

Turner, 1985. "Water Loss from Forest and Range Lands in California", presented at the Chaparral Ecosystems Research: Meeting and Field Conference, University of California, Santa Barbara, May 16-17, 1985.

Appendix E
Redding Groundwater Basin Finite-Element Model Application

Appendix E

Application of REDFEM to the Anderson-Cottonwood Irrigation District Groundwater Production Element Project

August 2011

CH2MHILL
2525 Airpark Drive
Redding, California 96001

Contents

Acronyms and Abbreviations

ac-ft/yr	acre-feet per year
ACID	Anderson-Cottonwood Irrigation District
ACID-PW01	ACID Production Well No. 1
ACID-PW02	ACID Production Well No. 2
bgs	below ground surface
District	Anderson-Cottonwood Irrigation District
DWR	California Department of Water Resources
mg/L	milligrams per liter
REDFEM	Redding Groundwater Basin Finite-Element Model
TDS	total dissolved solids
USGS	U.S. Geological Survey

APPENDIX E

Application of REDFEM to the Anderson-Cottonwood Irrigation District Groundwater Production Element Project

1.0 Introduction

The Redding Groundwater Basin Finite-Element Model (REDFEM) was developed to forecast hydrologic system behavior resulting from implementation of proposed actions. The proposed action evaluated as part of this effort is implementation of the Anderson-Cottonwood Irrigation District (ACID or District) Proposition 50 proposed project. Appendix D to the main text (CH2M HILL, 2011) provides a complete description of the development and calibration of REDFEM. The following information describes modifications made to REDFEM to facilitate conducting the predictive simulations necessary to forecast potential impacts of the proposed project.

2.0 Model Modifications

The hydrology period used to construct and calibrate REDFEM includes January 1999 through December 2008, a period for which groundwater usage data from local districts and municipalities were most plentiful. When conducting predictive simulations, a future hydrology period must be developed. One method for developing a future hydrology period for predictive simulations is to repeat the hydrology period from the calibration simulation in the predictive simulations. The January 1999 through December 2008 hydrology period was not used with the predictive simulations because that period does not include a multi-year drought. This observation is important because groundwater use typically increases during multi-year drought periods, as surface water resources become less available. Thus, it is during dry conditions that groundwater and surface water resources are most vulnerable to impacts associated with increased groundwater use. Therefore, it is preferred to include at least one multi-year drought in the predictive simulation hydrology when forecasting impacts on groundwater resources from proposed project implementation.

The 1976 through 1977 period was critically dry in the Sacramento Valley, which includes the Redding Groundwater Basin (California Department of Water Resources [DWR], 2011). Unfortunately, municipal and water district records for the 1976 through 1977 period, and other critically dry periods before 1999, are not available for the Redding Groundwater Basin. Therefore, model input data representing a multi-year drought was synthesized to facilitate forecasting impacts of the proposed project over a variety of hydrologic conditions, including a multi-year drought.

A 14-year predictive simulation period was developed using the 1999 through 2008 data used to calibrate REDFEM, combined with 4 years of hydrology data to mimic a severe drought condition (similar to water years 1974 through 1977). Water years 1974 and 1975 were wet years in the Sacramento Valley. To replicate this 2-year period, boundary conditions reflecting 2006 (a wet year for which groundwater use data are available in the Redding Groundwater Basin) were simulated for 2 consecutive years. To replicate the 1976 critically dry water year, water budget components from 2008, another critically dry year, were used. However, the following 1977 critically dry year had even less rainfall than 1976. So, to create hydrologic inputs more closely analogous to 1977, monthly estimates of groundwater recharge for water year 1991, the lowest rainfall year for which spatially detailed precipitation data were available for the REDFEM domain (PRISM Climate Group, 2010), were modified. Precipitation during water year 1977 was 26 percent less than in 1991, according to precipitation data collected at Shasta Dam (National Climatic Data Center, 2011). Therefore, to generate a hydrology closely approximating 1977, the calculated 1991 groundwater recharge from precipitation was reduced by 26 percent (multiplied by 0.74).

Table E-1 lists the simulated years of agricultural and urban water balance components, groundwater recharge from precipitation, and hydrologic classifications of each simulated year.

TABLE E-1
Basis for Hydrology Conditions Used for the Predictive Simulations
Application of REDFEM to the ACID Groundwater Production Element Project

Predictive Simulation Year	Analogous Historical Water Year	Water-year Hydrologic Classification for the Sacramento Valley	Water-year Basis for Agricultural and Urban Water Balance	Water-year Basis for Groundwater Recharge from Precipitation
1	1999	Wet	1999	1999
2	2000	Above normal	2000	2000
3	2001	Dry	2001	2001
4	2002	Dry	2002	2002
5	2003	Above normal	2003	2003
6	2004	Below normal	2004	2004
7	2005	Above normal	2005	2005
8	2006	Wet	2006	2006
9	2007	Dry	2007	2007
10	2008	Critical	2008	2008
11	1974	Wet	2006	2006
12	1975	Wet	2006	2006
13	1976	Critical	2008	2008
14	1977	Critical	2008	74% of 1991

Note:

The predictive simulation begins on January 1 of water year 1999; all other years are simulated as full water years.

3.0 Model Application

The following sections describe how the proposed project was simulated in REDFEM and how potential impacts on groundwater resources were forecast.

3.1 Description of Proposed Project

The purpose of the proposed project is to improve the flexibility and reliability of ACID's water supply, particularly during dry and critically dry water years. In 2004, ACID's surface water rights were reduced from 165,000 acre-feet per year (ac-ft/yr) to 121,000 ac-ft/yr as part of the re-negotiation of their 40-year Settlement Contract. Furthermore, control of the District's surface water delivery system is maintained at the head of the 35-mile main canal located at its diversion on the Sacramento River in the City of Redding. The limited ability to manage water levels along intermediate portions of the canal presents difficulty with the timely delivery of water to users located near downstream portions of ACID's service area. Implementation of this proposed project would help improve the reliability of water delivery to meet agricultural water needs within ACID's service area.

REDFEM was used to evaluate a proposed project involving the installation and operation of two groundwater production wells in Shasta County, California. The proposed ACID Production Well No. 1 (ACID-PW01) would be located in the City of Anderson (Township 30 North, Range 4 West, Section 23; Mount Diablo Meridian; 122˚17'19.15"W longitude, and 40˚26'19.34"N latitude [North American Datum of 1983]) (see Figures E-1 and E-2; figures are located at the end of this report).

The proposed ACID Production Well No. 2 (ACID-PW02) would be located approximately 0.5 mile northwest of the town of Cottonwood, California (Township 29 North, Range 4 West, Section 2; Mount Diablo Meridian; 122°17'30.03"W longitude, and 40°23'39.08"N latitude [North American Datum of 1983]) (see Figures E-1 and E-3).

Both wells would be nominally 500 feet deep or less, each with a target capacity of 3,500 gallons per minute and a nominal screen length of approximately 300 feet. It is assumed the production wells would operate 24 hours per day according to the following schedule:

- **Noncritical water year[1]:** ACID-PW01 would not operate during noncritical water years. ACID-PW02 would operate from June through October to augment water supply in areas where water conveyance is seasonally limited by aquatic vegetative growth in the canal (aquatic vegetation grows in the canal throughout the delivery season, thereby limiting delivery capacity).
- **Critical water year:** Both production wells would operate from April through October during critically dry years to augment water supply and improve water delivery reliability.

[1] ACID receives its full Sacramento River Settlement Contract amount in all years other than years designated as "Shasta Critical Years."

3.2 Proposed Project Simulation

The predictive version of REDFEM carried forward the assumptions incorporated into the calibrated version of REDFEM described in Appendix D to the main text (CH2M HILL, 2011), except where modifications were made, as described in Section 2.0. This subsection describes additional changes to the predictive model that were necessary to simulate the proposed project.

To simulate implementation of the proposed project, groundwater production was assigned in accordance with the operational assumptions described in Section 3.1. Groundwater pumping was assigned spatially at the REDFEM node closest to the proposed well location. The proposed groundwater pumping was apportioned equally to Model Layers 2 and 3, which are 300 feet thick, collectively. At the locations of the proposed wells, the approximate model layer interfaces are as follows:

- Model Layer 1: 65 to 115 feet below ground surface (bgs) (0 to 50 feet below the water table)
- Model Layer 2: 115 to 215 feet bgs (50 to 150 feet below the water table)
- Model Layer 3: 215 to 415 feet bgs (150 to 350 feet below the water table)
- Model Layer 4: 415 to 2,095 feet bgs (350 to 2,030 feet below the water table)

3.3 Approach for Evaluating Impact on Hydrologic System

Four categories of potential groundwater-related impacts were considered when evaluating the proposed project:

- Decrease in groundwater levels
- Decrease in groundwater discharge to streams
- Subsidence of the land surface
- Degradation of groundwater quality

Two REDFEM simulations were conducted to forecast the potential incremental impacts of implementation of the proposed project. First, a baseline simulation was conducted that did not include the operation of the proposed project. Next, a project simulation was conducted that included the operation of the proposed project as described in Sections 3.1 and 3.2. Using the results of these simulations, the "incremental drawdown" in groundwater levels due to project operations was computed by subtracting the simulated groundwater levels from the with-project simulation from groundwater levels from the baseline simulation at each REDFEM node and for each month over the 14-year predictive simulation period. To be conservative with respect to third-party impacts, the maximum impact on groundwater levels was considered to be the period with the largest forecast magnitude of incremental drawdown near the pumping well, rather than the period with the largest spatial extent (although smaller magnitude) of incremental drawdown.

Incremental streamflow depletion that may result from project implementation was computed in a similar manner, except the difference in stream gains and losses between the with-project and baseline simulations was computed. Forecasting water resource impacts in this manner provides an assessment of incremental project-related impacts on groundwater and surface water resources with consideration of dynamic hydrologic conditions (such as droughts and wet periods). Groundwater-level impacts due to project operations are discussed in Section 3.4.1.

Operation of the proposed project would reduce streamflow by increasing streambed infiltration, intercepting groundwater that would have otherwise discharged to surface water bodies, or some combination thereof. Streams with the greatest potential for impact were identified by delineating areas with forecast incremental drawdowns in the shallow aquifer of 1 foot or greater as a result of implementing the proposed project. Available historical streamflow data were obtained for streams located within these areas and compared with simulated streamflow depletions to assess the potential magnitude of streamflow impacts. Discussion of stream impacts is included in Section 3.4.2.

Land subsidence has never been monitored in the Redding Groundwater Basin, but is expected to be negligible given the lack of chronically depressed groundwater levels, and because the current magnitude of groundwater pumping in the basin represents a small fraction of the amount of water available for groundwater recharge. Nonetheless, the potential for land subsidence was qualitatively evaluated and is discussed in Section 3.4.3.

The potential for changes to groundwater quality from project implementation was qualitatively evaluated by noting potential changes to groundwater flow patterns caused by the proposed project. Discussion of impacts on groundwater quality is included in Section 3.4.4.

Incremental impacts would be considered significant if any of the following conditions occur as a direct result of implementing the proposed project:

- Groundwater levels decrease enough such that well yields of pre-existing and nearby wells decrease to a rate that would not support existing land uses or planned uses for which permits have been granted (for example, lowering groundwater levels enough that a pre-existing and nearby production well can no longer operate at historical capacity).
- Streamflows decrease enough such that its rate would not support existing stream uses or planned uses for which permits have been granted (for example, reducing groundwater discharge to a stream enough that the diversions from a stream can no longer be operated at historical diversion rates by users with appropriate surface water rights).
- Groundwater levels in an area susceptible to subsidence decrease to below historical minimums.
- Groundwater flow directions in an area of poor groundwater quality change in a way that would tend to degrade areas of good groundwater quality.

3.4 Proposed Project Results

3.4.1 Groundwater Impacts

Figures E-4 and E-5 show the forecast incremental drawdown in the shallow and regional aquifer systems that result from implementing the proposed project. The distribution in incremental drawdown shown on Figures E-4 and E-5 represent conditions comparable to the end of the 1976 through 1977 historical drought (the end of September 1977). As described in Section 3.3, these forecasts represent the incremental drawdown that occurs solely from implementation of the proposed project.

Figure E-4 shows the maximum forecast incremental drawdown in the shallow aquifer that occurs as a result of the proposed project. Shallow aquifer incremental drawdown refers to changes in groundwater levels within approximately the upper 50 feet of the unconfined aquifer. This incremental drawdown is forecast to occur at the end of the water year (September 30), prior to the rainy season. Shallow aquifer incremental drawdown resulting from implementation of the proposed project is forecast to range from approximately 0 to 14 feet, with incremental drawdown not exceeding 5 feet in most areas. A maximum incremental drawdown of 14 feet is forecast in the immediate vicinity of ACID-PW02, and is projected to dissipate to 7.1 feet within 0.25 mile and to 4 feet within 0.5 mile of the well. Shallow aquifer incremental drawdown is projected to dissipate to 4.5 feet within 0.25 mile and to 3 feet within 0.5 mile of ACID-PW01.

Regional aquifer incremental drawdown, shown on Figure E-5, refers to maximum changes in groundwater levels at the depth interval where the majority of groundwater production from the proposed wells is assigned. As noted in Section 3.2, groundwater pumping for the proposed project was assigned to Model Layers 2 and 3. Forecast incremental drawdowns for each of these model layers were evaluated to determine which layer showed the largest forecast incremental drawdown. The most incremental impact was forecast in Model Layer 2. As shown on Figure E-5, the model results indicate that maximum regional aquifer incremental drawdown resulting from project implementation ranges from 0 to 25 feet by the end of the pumping season, with incremental drawdown not exceeding 5 feet in most areas. The areal extent of the regional aquifer incremental drawdown is similar to that of the shallow aquifer. A maximum incremental drawdown of 25 feet is forecast in the immediate vicinity of ACID-PW02, and is projected to dissipate to 7.2 feet within 0.25 mile and to 4 feet within 0.5 mile of the well. Regional aquifer incremental drawdown is projected to dissipate to 4.6 feet within 0.25 mile and to 3 feet within 0.5 mile of ACID-PW01.

Pumping wells in the District are not near enough to the proposed project wells to be adversely affected. Forecast incremental drawdowns dissipate with a relatively small distance from the proposed wells, and incremental drawdowns of a few feet or less is not expected to prevent normal operation of pre-existing production wells.

3.4.2 Surface Water Impacts

Operation of the proposed project could result in reduced streamflow by increasing streambed infiltration, intercepting groundwater that would have otherwise discharged to surface water bodies, or some combination thereof.

REDFEM was not configured to forecast impacts on the ACID main canal. Main canal seepage is specified on a monthly basis (see Appendix D). As a result, canal seepage does not increase in response to declining groundwater levels in the model. This approach is conservative in terms of forecast groundwater-level impacts because it may overestimate the decline in groundwater levels from proposed pumping. Where the ACID main canal is in contact with the water table, more seepage would occur in response to declining groundwater levels, thereby reducing the amount of the groundwater-level decline. A smaller decline in groundwater levels would also result in less forecast impact on nearby streams.

For the proposed project, Anderson and Cottonwood Creeks are the only simulated streams located within the area of forecast incremental drawdown of 1 foot or greater in the shallow aquifer. Because no stream gage data are available for Anderson Creek, comparison of forecast stream impacts on measured streamflow is not possible. Measured streamflow data are available for Cottonwood Creek. Because both Anderson and Cottonwood Creeks are tributary to the Sacramento River, which is the primary stream in the Redding Groundwater Basin with available measured streamflow data, forecast stream impacts are compared with available measured streamflow data from Cottonwood Creek and the Sacramento River on Figure E-6. Streamflow reductions would represent a small percentage (less than 0.5 percent) of the total streamflow, as measured at U.S. Geological Survey (USGS) Gage No. 11377100 above Bend Bridge near the southern end of the REDFEM domain. Streamflow reductions would also represent a small percentage (approximately 2 percent or less) of the total streamflow, as measured at USGS Gage No. 11376000 near the town of Cottonwood.

3.4.3 Land Subsidence

Land subsidence is the decline in ground-surface elevation resulting from natural forces (such as earthquakes) and anthropogenic activities (for example, groundwater, oil, and gas extraction). Land subsidence can be elastic (temporary compaction of subsurface material that rebounds as groundwater levels recover) or inelastic (permanent compaction of subsurface material).

Land subsidence has never been monitored in the Redding Groundwater Basin, but is expected to be negligible given the lack of chronically depressed groundwater levels, and because the current magnitude of groundwater pumping in the basin represents a small fraction of the amount of water available for groundwater recharge. In particular, the Anderson Subbasin, where the proposed project would operate, has been characterized as having low potential for subsidence (DWR, 2003a). No areas susceptible to land subsidence have been identified in the Redding Groundwater Basin.

3.4.4 Groundwater Quality

Groundwater quality in the Redding Groundwater Basin was evaluated in a USGS report published in 1983 (Pierce, 1983). That report summarized groundwater quality data from 85 wells that were sampled in 1979. Most of these wells were completed in the Tuscan or Tehama Formations. The report concluded that groundwater quality in these formations was generally good to excellent for most uses. Samples from 84 wells were analyzed for total dissolved solids (TDS), and 66 samples had TDS concentrations below 200 milligrams per liter (mg/L). The range of TDS concentrations was 95 to 424 mg/L. Wells along the eastern portion of the Redding Groundwater Basin typically have the best water quality because of Sierra Nevada’s low-salinity runoff. Areas with poorer groundwater quality occur primarily where some wells are completed in or near the marine sediments of the Chico Formation.

DWR monitors groundwater quality in seven wells in the Anderson Subbasin, where the proposed project would operate. The overall groundwater quality of those wells is considered good (DWR, 2003a). No areas of poor groundwater quality have been identified near the proposed project. Figures E-7 and E-8 illustrate the forecast groundwater flow directions at the end of the predictive baseline and project simulations, in the shallow and regional aquifers, respectively. The end of the predictive simulation corresponds to the end of a multi-year drought, similar to that which occurred in 1976 through 1977. As illustrated on Figures E-7 and E-8, according to REDFEM, temporary changes in groundwater flow directions would be localized around the proposed project wells in both the shallow and regional aquifers. Therefore, it is not anticipated that operation of the project wells would alter the pre-existing distribution of groundwater quality in the basin.

4.0 Outcome of Impacts Evaluation

Predictive versions of REDFEM were used to forecast potential impacts on water resources from implementation of the proposed project. The REDFEM simulations are imperfect in that they do not accurately describe all aspects of interrelated physical processes beneath the proposed project area. Future groundwater levels and flow directions will not necessarily follow those indicated with the predictive versions of REDFEM; however, the details included in REDFEM have resulted in a model that is suitable for its intended application. The predictions described in this appendix are considered plausible and reasonable, given the available data and modeling objectives.

5.0 References

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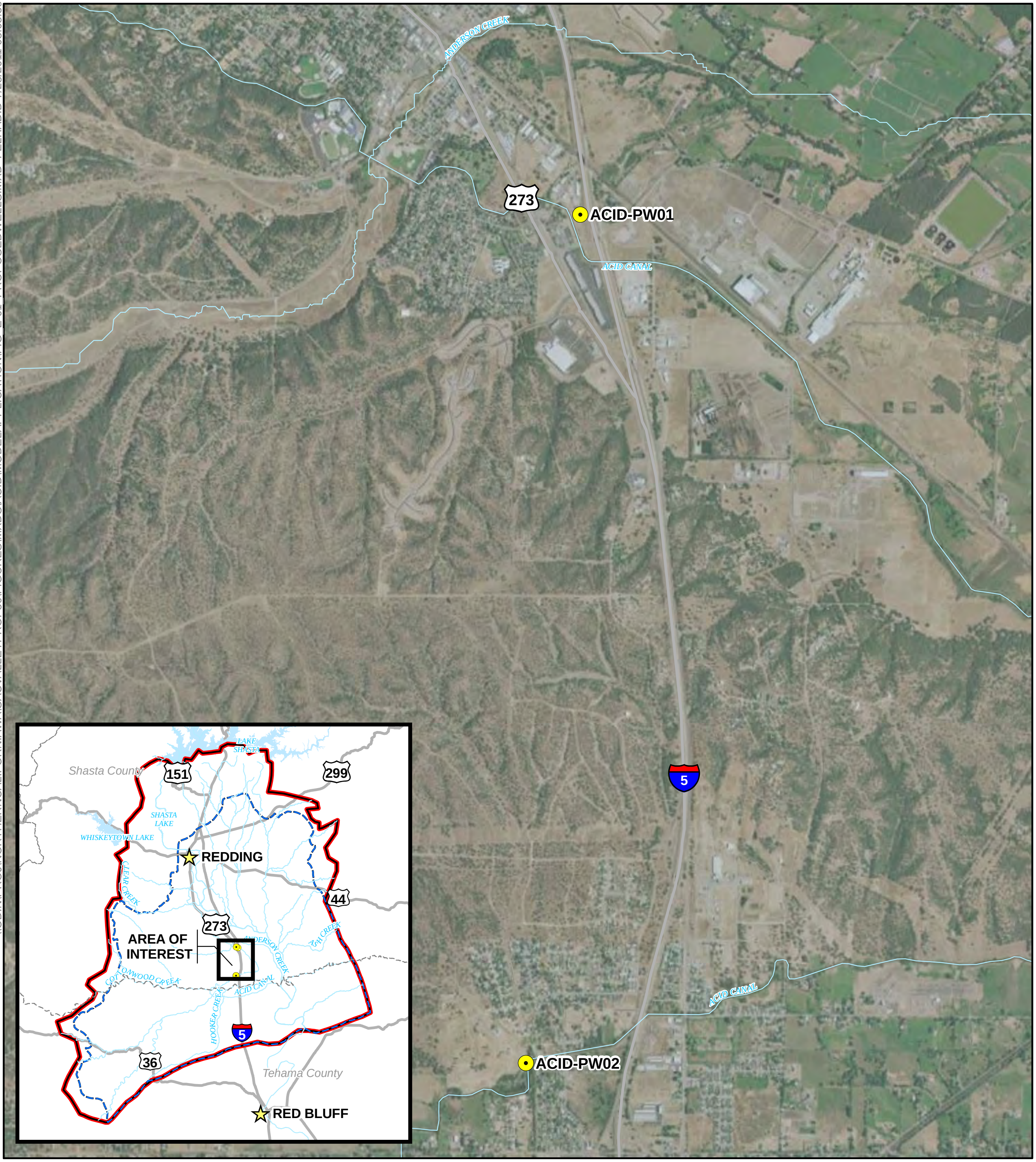
Figures



LEGEND

PROPOSED PRODUCTION WELL

REDDING GROUNDWATER BASIN BOUNDARY

STUDY AREA AND REDFEM BOUNDARY

STREAM/CANAL LOCATION

0 0.5 1 Miles

N

NOTE:

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE E-1
ACID PROPOSED WELL LOCATIONS
APPLICATION OF REDFEM TO THE ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

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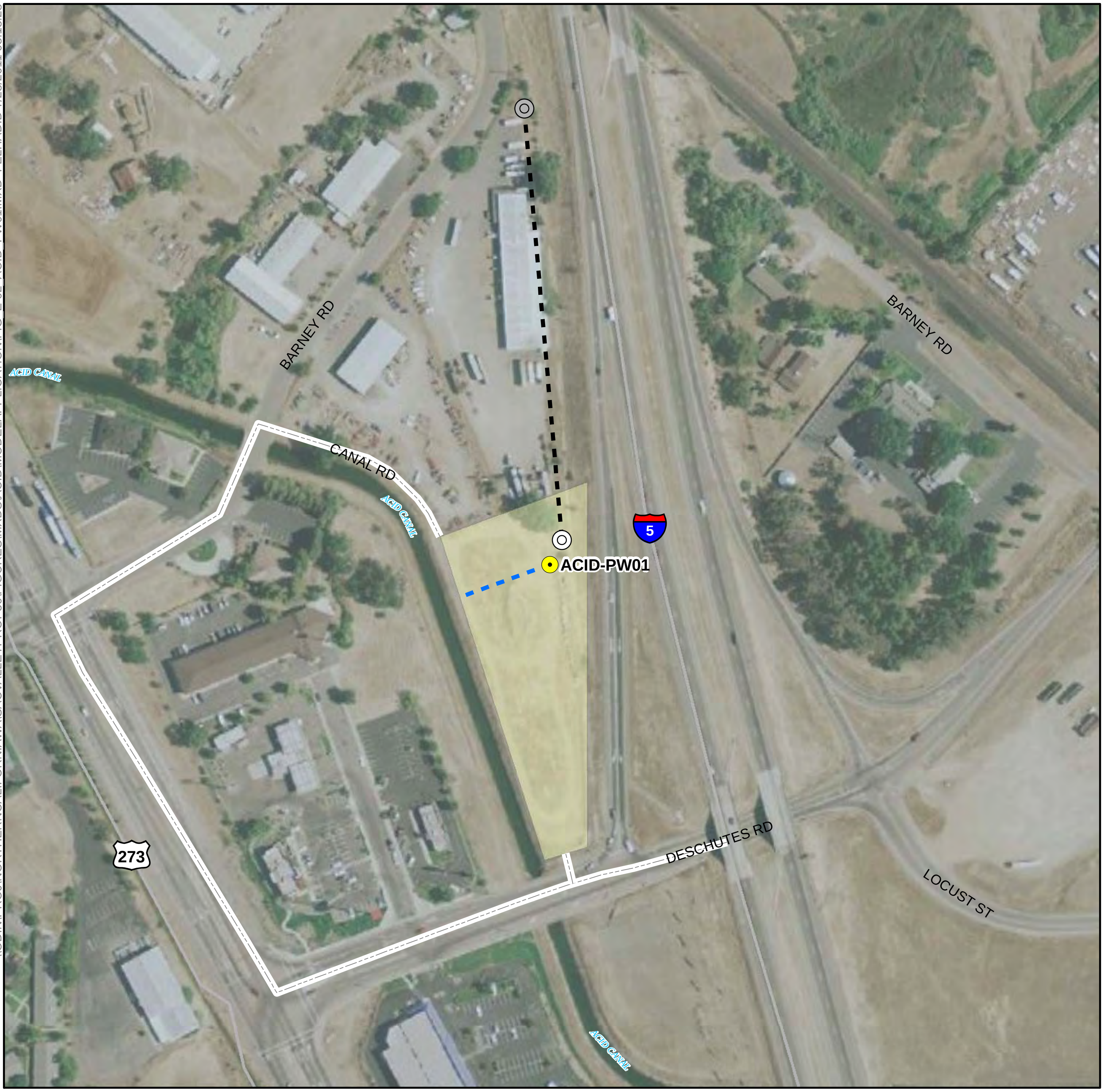

LEGEND

- PROPOSED PRODUCTION WELL
- PROPOSED POWER POLE
- EXISTING POWER POLE
- EXISTING ACCESS ROUTE
- PROPOSED CONVEYANCE LINE TO CANAL
- PROPOSED POWER POLE LINE
- PROJECT AREA

NOTE:

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

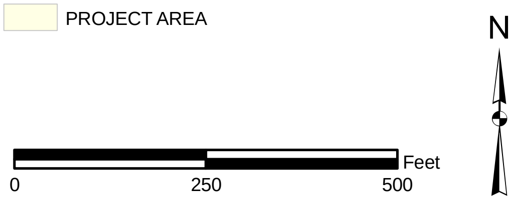

FIGURE E-2
ACID-PW01 LOCATION MAP
APPLICATION OF REDFEM TO THE ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

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LEGEND

- PROPOSED PRODUCTION WELL
- EXISTING POWER POLE
- EXISTING ACCESS ROUTE
- PRIVATE ACCESS ROAD
- PROPOSED CONVEYANCE LINE TO CANAL
- PROJECT AREA

NOTE:

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

N

0 500 1,000 Feet

FIGURE E-3
ACID-PW02 LOCATION MAP
APPLICATION OF REDFEM TO THE ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

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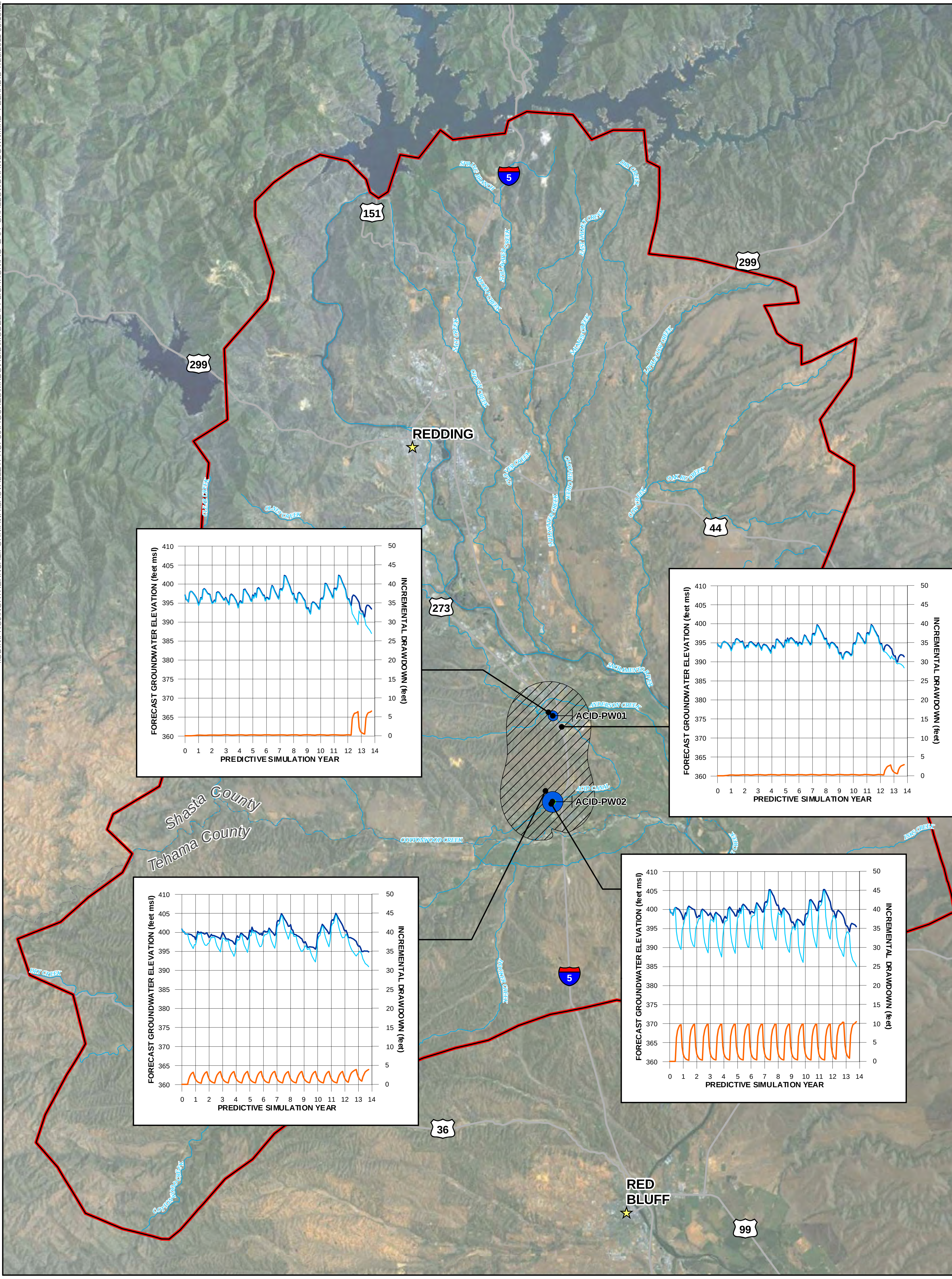


LEGEND

- LOCATION OF FORECAST GROUNDWATER ELEVATION AND INCREMENTAL DRAWDOWN

FORECAST INCREMENTAL DRAWDOWN (feet)

- 1 to 5
- 5 to 10
- 10 to 15
- 15 to 20
- 20 to 30
- STUDY AREA AND REDFEM BOUNDARY
- INCREMENTAL DRAWDOWN
- BASELINE GROUNDWATER ELEVATION
- PROJECT GROUNDWATER ELEVATION

N

0 3.5 7 Miles

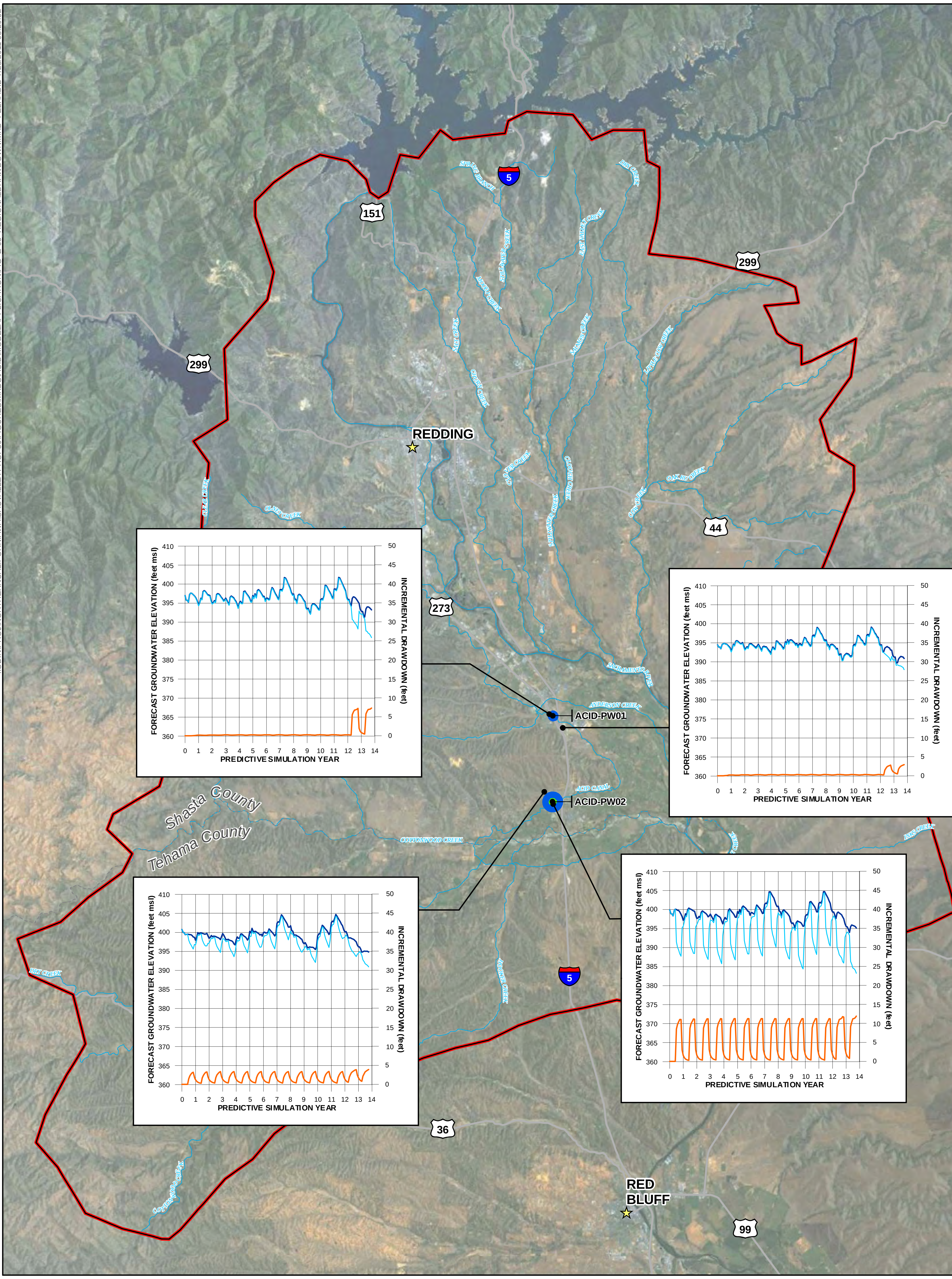
NOTES:

MSL = MEAN SEA LEVEL.

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE E-4
FORECAST INCREMENTAL DRAWDOWN IN THE SHALLOW AQUIFER
APPLICATION OF REDFEM TO THE ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

CH2MHILL



LEGEND

- LOCATION OF FORECAST GROUNDWATER ELEVATION AND INCREMENTAL DRAWDOWN

FORECAST INCREMENTAL DRAWDOWN (feet)

- 5 to 10
- 10 to 15
- 15 to 20
- 20 to 30
- STUDY AREA AND REDFEM BOUNDARY
- INCREMENTAL DRAWDOWN
- BASELINE GROUNDWATER ELEVATION
- PROJECT GROUNDWATER ELEVATION

N

0 3.5 7 Miles

NOTES:

MSL = MEAN SEA LEVEL.

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE E-5
FORECAST INCREMENTAL DRAWDOWN IN THE REGIONAL AQUIFER
APPLICATION OF REDFEM TO THE ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

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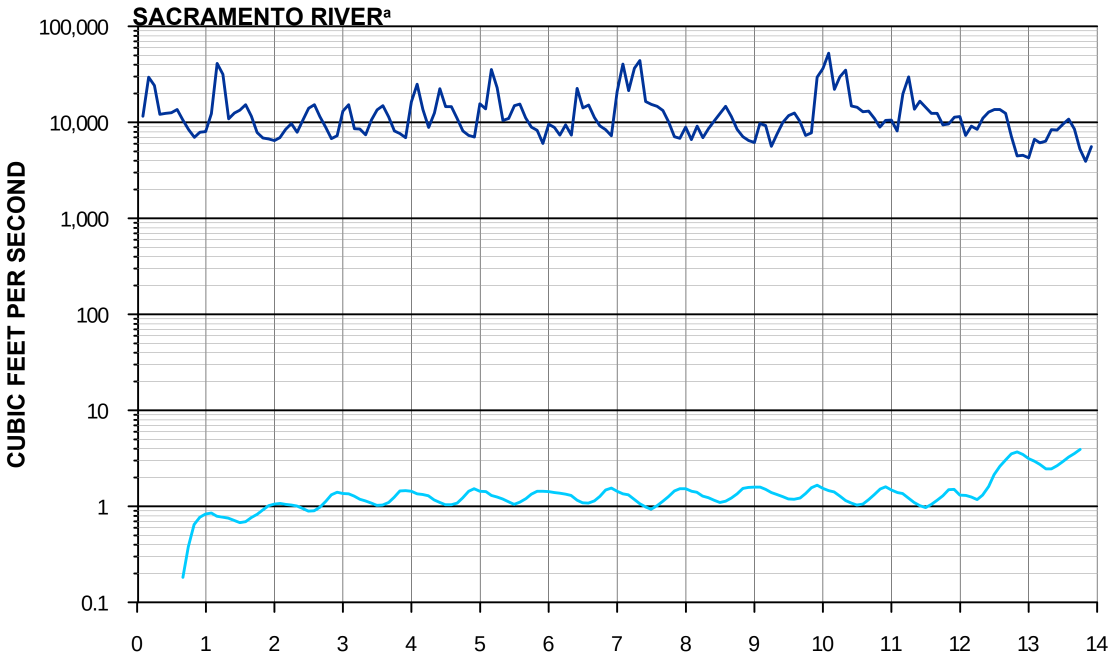
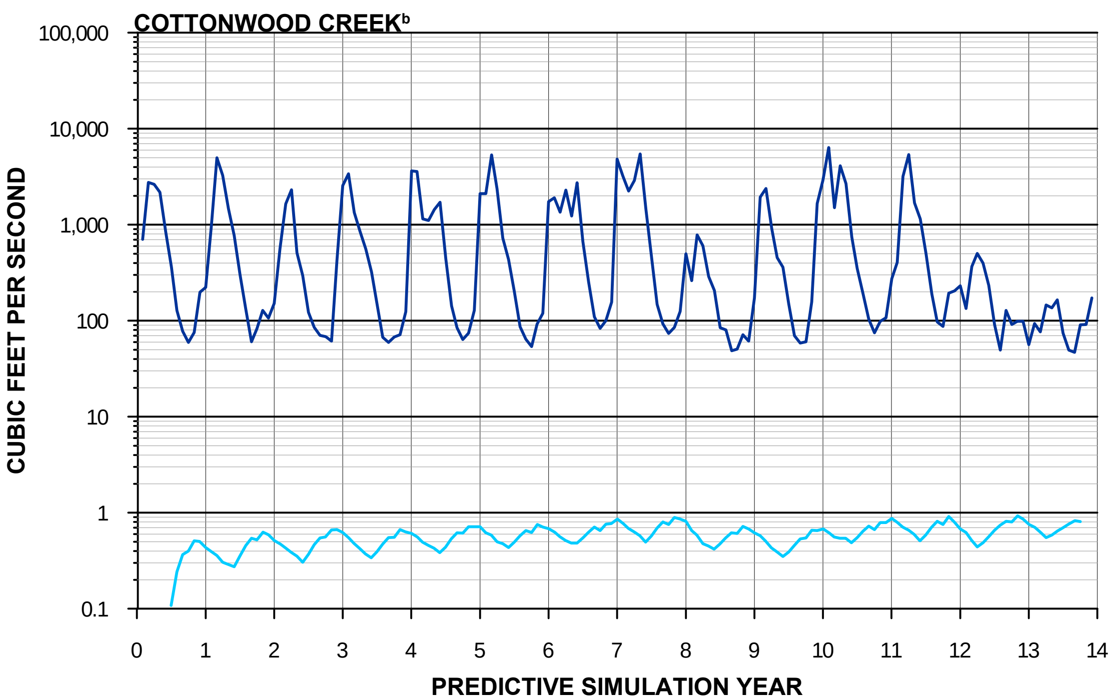




LEGEND

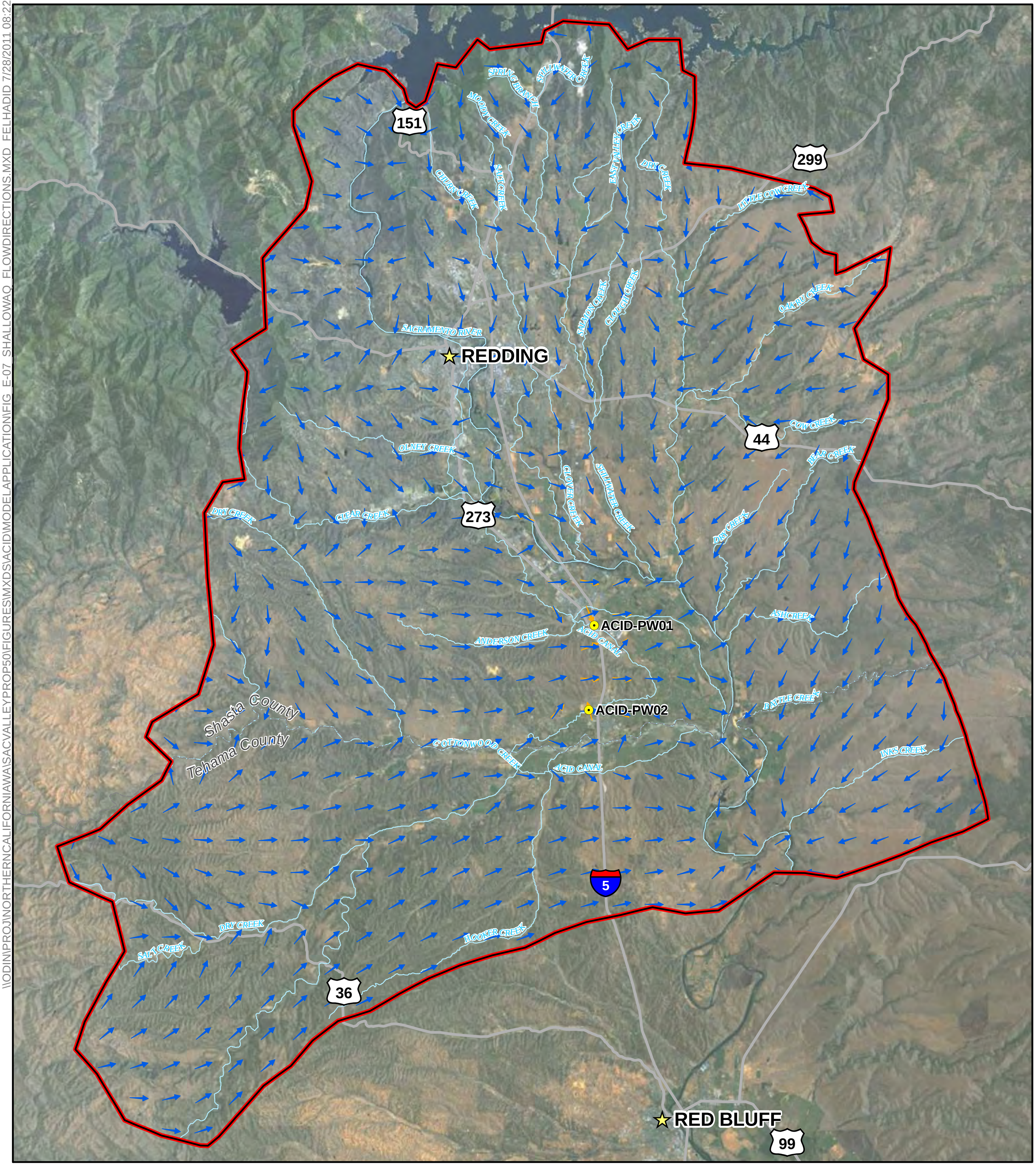
- MEASURED STREAMFLOW
- FORECAST STREAMFLOW REDUCTION

PREDICTIVE SIMULATION YEAR	WATER-YEAR HYDROLOGY
1	1999
2	2000
3	2001
4	2002
5	2003
6	2004
7	2005
8	2006
9	2007
10	2008
11	1974
12	1975
13	1976
14	1977

[a]MEASURED STREAMFLOW AT USGS GAGE 11377100,
SACRAMENTO RIVER ABOVE BEND BRIDGE NEAR RED BLUFF, CALIFORNIA.

[b]MEASURED STREAMFLOW AT USGS GAGE 11376000,
COTTONWOOD CREEK NEAR COTTONWOOD, CALIFORNIA.

FIGURE E-6
FORECAST STREAM IMPACTS
APPLICATION OF REDFEM TO THE ACID GROUNDWATER PRODUCTION ELEMENT PROJECT



LEGEND

- PROPOSED PRODUCTION WELL
- GROUNDWATER FLOW DIRECTION – BASELINE SIMULATION
- GROUNDWATER FLOW DIRECTION – PROJECT SIMULATION
- STUDY AREA AND REDFEM BOUNDARY

0 5 10 Miles

N

NOTE:

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE E-7
FORECAST GROUNDWATER FLOW DIRECTIONS IN THE SHALLOW AQUIFER
APPLICATION OF REDFEM TO THE ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

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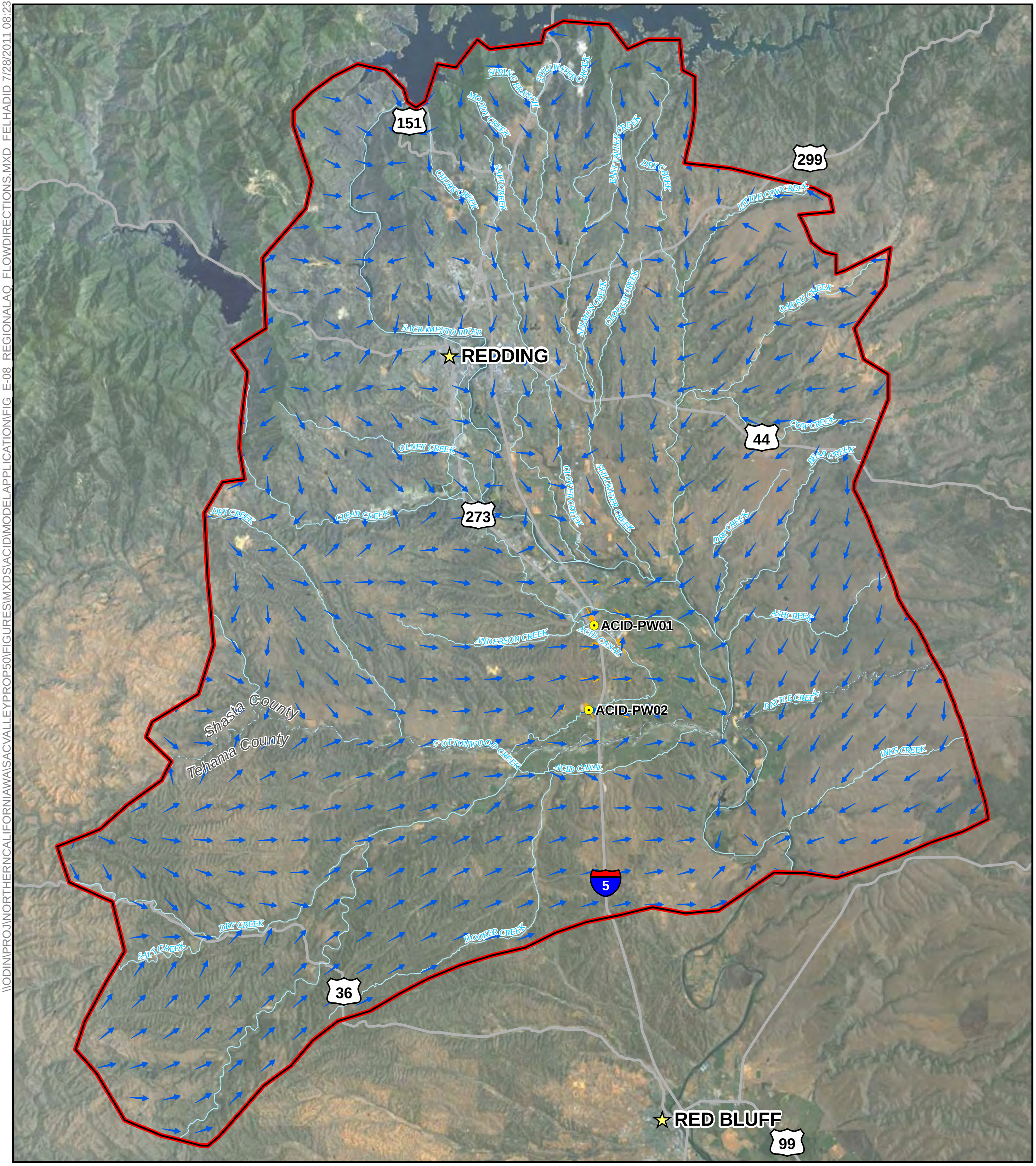

LEGEND

PROPOSED PRODUCTION WELL
GROUNDWATER FLOW DIRECTION – BASELINE SIMULATION
GROUNDWATER FLOW DIRECTION – PROJECT SIMULATION
STUDY AREA AND REDFEM BOUNDARY

0 5 10 Miles

N

NOTE:

SOURCE OF AERIAL PHOTOGRAPH, ESRI, 2011.

FIGURE E-8
FORECAST GROUNDWATER FLOW DIRECTIONS IN THE REGIONAL AQUIFER
APPLICATION OF REDFEM TO THE ACID GROUNDWATER PRODUCTION ELEMENT PROJECT

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