From:	Ben King
To:	Swanson, Matthew@CWC; Yun, Joseph@DWR
Cc:	Ben King; California Water Commission
Subject:	Background For Public Comment For California Water Commission Meeting October 18, 2023
Date:	Friday, October 13, 2023 4:06:59 PM
Attachments:	Colusa National Wildlife Water Manage (002).pdf Excerpt From USGS 1978 Report Chemical Quality of Groundwater In The Central Sacramento Valley, California.pdf

Dear Chairman Swanson and Executive Officer Yun,

My name is Ben King and I am currently a Director the Colusa County Resource Conservation District. My family has been farming on the riparian waterway of the Colusa Trough since 1860 which became to be known as the Colusa Basin Drain when the channel was excavated in the early 1920's. My family has protested the Sites Water Right Application partly because we have senior Appropriative and Riparian rights but also because we believe that the current design for the Sites Project will exasperate environmental harm to the riparian habitat of the Colusa Trough and especially the aquatic life and the aquatic food web due to detrimental water quality issues. We are small farmers and would expect to come to some reasonable resolution on the water rights issue, but our greatest concern is the long-standing environmental health of the Colusa Trough ecosystem and how water quality contamination that is present in the Trough could negatively impact the aqua food web for the lower Sacramento River and the Delta as a whole.

We would like to bring the contamination of the groundwater at the Colusa National Refuge and Sacramento National Refuge to the attention of the California Water Commission as it considers the environmental impact of the proposed Sites Reservoir Project and potential environmental mitigation actions. While we support the Sites Reservoir Project because it is a needed source of water storage for the State, it is our opinion that the Project design needs to be modified to incorporate part or all the proposed Delevan Interconnect which is necessary to bring running water back to the historical Colusa Trough. Running Water and the coincident higher levels of dissolved oxygen could possibly mitigate the environmental damage caused by poor drainage in the present Colusa Basin Drain.

As disclosed in the attached Colusa National Refuge Water Management Plan completed in 2011 the Bureau of Reclamation drilled test wells and found mercury contamination at the Colusa National Refuge and Mercury and Chromium groundwater contamination at the Sacramento National Refuge.

Here is the excerpt from Page 9 of the Colusa National Wildlife Management Plan as attached:

"5. Groundwater

Describe groundwater availability, quality and potential for use

USBR drilled four test wells on nearby Sacramento NWR in the early 1990s. ***Chemical analysis of these groundwater wells at Sacramento NWR and at Colusa NWR detected mercury levels above***

the EPA chronic criteria (both Sacramento NWR and Colusa NWR) and levels of the hexavalent form of chromium above the EPA chronic and acute criteria (Sacramento NWR). Due to these test results it is believed that the use of this water could have a detrimental effect on the aquatic and wildlife resources that utilize the area. *In addition, limited quantity (hundreds of gallons instead of thousands) was found for the test wells at Sacramento NWR. The groundwater basin under the refuge is considered to be of very limited usefulness."*

As you may be aware the Colusa Trough watershed is comprised of seventeen Coast Range ephemeral streams that naturally bring salts and metals into the channel of the Trough. Prior to Reclamation and the settlement on Patwin lands by families such as mine which emigrated to California in 1857, the Trough was divided into two large general area of wetland called the Upper Basin and the Lower Basin. My family's land was the high area between the two Basins which is located just south of the present-day Colusa National Wildlife Refuge and just northeast of the remnants of the historical town of College City. The presence of salt and salt water is well documented in the Coast Range such as the salt springs located on Funks Slough just west of the current day Funks Reservoir on the Peterson Salt Lake Ranch located north of the historical town of Sites. During the early 1900's this was the salt mine for the Crystal Salt Company which sold salt from this mine for domestic consumption. The geology of the Coast Range is very complex and there were many mining operations for everything from hydrocarbons to mercury and chromium which is probably the primary source of groundwater contamination under the Refuges. Of the seventeen streams, two are named "Salt" , one named "Petroleum" and one named "Freshwater" which is in the general area near the two named "Salt". Glenn County has a historical town named "Chrome" and Colusa County had an area and a school district named "Quicksilver". Regarding the presence of salt in the watershed, some of it which is from artesian up coning, here is an interesting excerpt from the April 30, 1892 weekly edition of the Colusa Sun Newspaper:

On Monday, the Directors of the Crystal Salt Company moved the principal place of business to Colusa. Wells are being sunk, vats built, and other work done to develop the business. The works are three miles north of Sites. Water will be pumped into a lake covering some 10 to 16 acres and drawn off into vats after it has become almost strong enough to begin to form salt. In addition to the employment of solar heat in making the salt, the natural gas that is found in great abundance will be used. The solar heat will be put in operation first. The supply of gas is inexhaustible as well as the supply of water from 15 to 40 per cent salt; the sea being only 3 per cent. The salt when made is some 3 per cent, purer than any other salt known to commerce. The bittern, or the water left after it has quit making salt, has from 20 to 30 grains of iodine to the gallon. This is stronger in iodine than any known water. The iodine is freed from the other substances by distillation and the natural gas will furnish the fuel for that. The outlook for the company is splendid. The Colusa and Lake railroad took the Directors of the company out on a special Monday morning, and returned in the evening, and Superintendent Harrington took occasion to extend a free excursion to the ladies. A number went out and took provisions for a picnic. Mr. Peter Peterson on whose farm the works are located, and Mr. J. P. Rathbun the company's Superintendent, were on hand with conveyances and took most of the ladies over to the works, where a dinner was served which was enjoyed by all. The ladies request us to extend sincere thanks to Superintendent Harrington for the courtesy of the trip, and to Messrs. Peterson and Rathbun for the pleasure of the trip from Sites to the works. . The ladies were emphatic in praise of Peter Peterson Jr., who took so much pains to contribute to their pleasure.

I mention the salt because it may impact the transmissivity of Chromium and the presence of the hexavalent form of Chromium in the groundwater contamination at the Sacramento Valley National Refuge.

Regarding the mercury contamination at both the Sacramento and Colusa National Refuge perhaps the presence of high levels of sulfate in the groundwater is a contributor to the contamination. I have attached an excerpt from a US Geological Survey Report Water- Resources Investigations 77-133 Prepared in cooperation with the California Department of Water Resources. The Report is **" Chemical Quality of Ground Water In The Central Sacramento Valley, California"** by Ronald P. Fogelman dated February 1978. I was not able to attach a PDF because of size so the attachment includes the Cover, the Figure Index and Figure 9 from Page 32 which details the high levels of sulfate in the Groundwater around the Colusa National Refuge and in the area northwest of Knights Landing which is where Sites Water from the proposed Dunnigan Pipeline will enter the lower Sacramento River. Sulfate may be of particular concern to environmental health and aquatic life water quality due to the presence of mercury and organic matter at the Refuges due to poor drainage and limited dissolved oxygen. The Colusa Basin Drain has been used to circulate drain water since the Six (now Seven) Party Agreement between the local irrigation districts was reached in 1954 on the reuse of drainage water north of the Davis Weir Dam on the southern border of the Colusa National Wildlife Refuge. One factor regarding mercury contamination and potentially methylmercury contamination is the interaction with mercury reducing microbes that are present in areas of high groundwater sulfate. Here is an explanation of the potential sulfate related risks from Chat GPT:

Groundwater contamination by mercury is a significant environmental concern. When mercury, carbon (in the form of organic matter), and high levels of sulfate are present in groundwater, the dynamics of mercury transformation and mobility can be significantly impacted. Here's how each factor can influence mercury contamination:

1. **Mercury**:
    - Mercury in groundwater can originate from various sources, including industrial discharges, atmospheric deposition, mining activities, and natural geologic sources.
    - The presence of mercury is a prerequisite for its transformation into more toxic forms, such as methylmercury.
2. **Carbon (Organic Matter)**:
    - Organic matter serves as an electron donor for certain microbial processes.
    - Microbial decomposition of organic matter in anoxic conditions can lead to the production of dissolved organic carbon (DOC), which can bind to mercury and affect its transport.
    - Organic matter can serve as a substrate for sulfate-reducing bacteria (SRBs) and methanogens, both of which can be involved in mercury methylation.
3. **High Levels of Sulfate**:
    - Sulfate can stimulate the growth and activity of sulfate-reducing bacteria (SRBs). SRBs are known to produce methylmercury from inorganic mercury under anoxic conditions.

- In the presence of organic matter, SRBs use sulfate as a terminal electron acceptor during their metabolic processes. This can create a favorable environment for mercury methylation.
- High sulfate concentrations can also lead to changes in the redox conditions of groundwater, potentially promoting anoxic conditions favorable for SRBs and mercury methylation.

Impacts on Groundwater Contamination:

1. **Enhanced Mercury Methylation**: The combined presence of mercury, organic matter, and sulfate can create a conducive environment for the methylation of mercury by SRBs. This can lead to the production of methylmercury, which is more toxic and bioavailable than inorganic mercury forms.
2. **Altered Mercury Mobility**: Organic matter, especially in the form of DOC, can bind to mercury and alter its mobility in groundwater. This can lead to enhanced transport of mercury in certain situations.
3. **Potential for Biomagnification**: Once methylmercury is produced, it can enter the food web, where it can biomagnify. This can pose risks to aquatic life and humans who consume contaminated water or aquatic organisms.
4. **Challenges for Remediation**: The presence of organic matter and sulfate can complicate remediation efforts. For instance, pumping and treating groundwater to remove mercury might not be sufficient if conditions remain conducive for continuous mercury methylation.

In summary, the co-occurrence of mercury, carbon (organic matter), and high levels of sulfate in groundwater can enhance the potential for mercury methylation, leading to increased risks associated with methylmercury. Proper understanding and management of these factors are essential to mitigate the impacts of mercury contamination in groundwater systems.

The potential for methylmercury contamination would appear to be a possible cause for the mercury contamination at the two Refuges but also a potential source of contamination in the drainage area northwest of Knights Landing if the proposed Dunnigan Pipeline transmits mercury into the area before the water enters the lower Sacramento River.

We are bringing the issue of the groundwater contamination at the Colusa and Sacramento National Refuges to the attention of the California Water Commission now because I am not confident that this contamination is well known. I have been an active Stakeholder in the development of the Colusa Subbasin Groundwater Sustainability Plan and this contamination was not discussed in the development of the GSP. To the extent that this contamination impacts the requirements for the Sites Project under California Water Code Section 79750 it is perhaps a good time to consider and examine this contamination, its potential cause and potential mitigation measures. In my opinion there is a great need for dissolved oxygen level management in the surface and groundwater in the Colusa Trough. Running Water is the cornerstone of the Public Trust doctrine for good reason.

Thank you for the opportunity to make Public Comment and the consideration of my comments.

Sincerely

Ben King
Manager
Pacific Gold Agriculture, LLC

Colusa National Wildlife Refuge

Water Management Plan

March 3, 2011

Section A - Background

1. *Identify the staff member responsible for developing and implementing the Plan. Provide their contact information*

   Name Mike Peters Title Wildlife Refuge Manager

   Address 752 County Road 99W, Willows, CA 95988

   Telephone 530-934-2801 Fax 530-934-7814

   E-mail mike_peters@fws.gov

2. *Year refuge established* 1945

Define year-type used consistently throughout plan USBR water year - March 1 through February 28

3. *Water supplies*

   List each annual entitlement of surface water under each water right and/or contract

Supplier	*Water source*	*Contract #*	*Contract restrictions*	*Acre-feet/year*
Federal level 2	GCID Canal	1525-98-FC-20-17620	None	25,000
Federal level 4	GCID Canal	1525-98-FC-20-17620	None	0
State	NA	NA	NA	0
Appropriative				
Other, riparian	2047 main drain	SWRCB	Apr 15 – Nov 1	8 cfs

4. *Provide a narrative on pre-CVPIA refuge water supplies and water management*

The history of water rights, contracts, and use on the Sacramento NWR Complex (Complex) is a complicated one. To summarize, until October of 1992, the Complex had no firm water supply and often suffered from lack of water availability from late November through early April.

In the mid 1980's, USBR began construction of a cross tie from Stony Creek to the Tehama Colusa Canal to divert 80 cfs to meet water contract demands from irrigation districts. The Refuge was promised utilization of any or all of this 80 cfs pending other current requests. The crosstie was scheduled for completion in late December of 1987. Unfortunately, the plight of the winter run Chinook salmon in the Sacramento River necessitated the raising of the Red Bluff Diversion Dam gates. This shut down any water deliveries via the Tehama Colusa Canal and eliminated any possibilities for winter water for the Complex. Each year the Diversion Dam is maintained in an open position during winter, until the end of February, to allow passage of the salmon.

The Glenn-Colusa Irrigation District (GCID) serves Sacramento NWR, Delevan NWR and Colusa NWR. GCID takes its water from the Sacramento River via lift pumps near Hamilton City. A problem with the taking of salmon via these pumps has been identified since 1920. This problem remained unresolved; and on

August 19, 1991, an injunction filed against GCID by the National Marine Fisheries Service for the taking of threatened winter run Chinook salmon took effect. GCID's pumping at the Hamilton City plant was immediately reduced from approximately 2,300 cfs to 1,100 cfs. This amount has since been increased due to work done by GCID to improve the efficiency of their fish screens at the Hamilton City pumping plant.

Prior to the CVPIA contract agreement between the USBR and GCID along with associated upgrades GCID made to their water delivery system as a result of the agreement, water deliveries to Sacramento NWR, Delevan NWR and Colusa NWR were limited primarily to the months of April through November. Generally, GCID shut down the main water delivery system for maintenance beginning in late November of each year. Usually, GCID water deliveries would resume beginning in mid- to late March of the following year. As a result, typical management strategy for the refuge's wetlands at that time was to ensure the wetlands were flooded to near maximum capacity prior to Thanksgiving to ensure units would continue to retain water throughout the GCID shut-down period during years with lower winter rainfall amounts. Although this management strategy generally ensured wetlands were available throughout the winter, the wetlands were often not maintained at an optimum (shallower) water level for use by wintering waterfowl. .; Because Colusa NWR is at the tail end of the GCID system it would receive water deliveries for about one additional week after the November shutdown. Colusa NWR also has two lift pumps on the Colusa Basin Drain, and this allows for water to be supplied to the West Lateral and Highway 20 canals which allowed for about 75% of the wetlands to get resupplied.

5. *Land use history--Identify habitat types specific to this refuge.*

Attach a refuge map showing habitat location and size

List refuge habitat-types with 5% or more of total acreage

Habitat type	*Original size*	*1992 acres*	*1997 acres*	*2010 acres*
Seasonal wetland – timothy (not irrig)	Not Avail	2851	2851	2851
Seasonal wetland – timothy (irrigated)	Not Avail	0	0	0
Seasonal wetland – smartweed	Not Avail	0	0	0
Seasonal wetland - watergrass	Not Avail	247	247	247
Permanent wetland	Not Avail	150	150	150
Semi-permanent wetland/brood pond	Not Avail	101	101	101
Reverse cycle wetlands	Not Avail	0	0	0
Riparian	Not Avail	4	4	4
Irrigated pasture	Not Avail	0	0	0
Upland	Not Avail	613	613	613
Upland (not irrigated)	Not Avail	613	613	613
Upland (managed)	Not Avail	?	?	613
Upland (grains)	Not Avail	0	0	0
Other (>5%)	Not Avail	424	424	424
Misc. habitat (<5%)	Not Avail	93	93	481
Sub-total – habitat acres	Not Avail	4483	4483	4871
Roads, buildings, etc.	Not Avail	143	143	143
Total (size of refuge)	4,040	4,626	4,626	5,014

Describe refuge habitat-type water use characteristics

Habitat type	*AF/ac*	*# of irrigations*	*Floodup date*	*Draw down date*
Seasonal wetland	5.0	0	8/1 – 12/1	4/1 – 6/1
Seasonal wetland - timothy	5.0	0	8/1 – 11/1	4/1 – 6/1
Seasonal wetland - watergrass	7.5	1	8/1 – 10/1	4/1 – 5/1
Permanent wetland	13.25	0	Continuous	Continuous
Semi-permanent wetland/brood pond	9.0	0	10/1 – 11//1	7/15 - 8/15
Riparian	0	0	NA	NA
Irrigated pasture	0	0	NA	NA
Upland (not irrigated)	0	0	NA	NA
Upland (managed)	0	0	NA	NA
Upland (grains)	0	0	NA	NA
Other (>5%)	0	0	NA	NA
Misc. habitat (<5%)	0	0	NA	NA

Section B - Water Management Related Goals and Objectives

1. *Describe the refuge mission relative to water management. (i.e. crop depredation, legislative mandates, service to landowners)*

The purposes for Colusa NWR involve habitat for wetland dependent species. In this artificially created and maintained system, efficient water management is critical to accomplishing these purposes.

Purposes for this Unit:
"... for use as an inviolate sanctuary, or for any other management purpose, for migratory birds. 16 U.S.C. 715d (Migratory Bird Conservation Act of 1929).

"…for the management and control of migratory birds and other wildlife …" 16 U.S.C. 695 (Lea Act of 1948).

"…to conserve (A) fish or wildlife which are listed as endangered or threatened species …. or (B) plants …" 16 U.S.C. 1534 (Endangered Species Act for 1973).

2. *Describe specific habitat management objectives. Include pertinent information from refuge management plans*

The following habitat types are managed on the Refuge:

Seasonal wetland – swamp timothy: By far the most numerous and diverse of the wetland habitat types, these units comprise about 70 percent of the wetland habitat base and are typically flooded from early September through mid-April. Their diversity is the product of a variety of water depths that result in diverse patterns of plant species (vegetation) that, in combination, provide habitat for the greatest number of wildlife species throughout the course of a year. Through the fall and winter, seasonally flooded marshes are used by spectacular concentrations of waterfowl and smaller numbers of egrets, herons, ibis, and grebes. In addition, a full complement of raptors descends upon the water-bird prey base for their winter food supply. As water is removed in the spring, large concentrations of shorebirds utilize the shallow depths and exposed mudflats on their northern migration. Seed producing plants germinate and grow to maturity on the moist pond bottoms

during the spring and early summer. Flood up in the fall makes this food available to early migrant waterfowl and other water-birds.

Seasonal wetland - watergrass/smartweed: Comprising approximately 12 to 15 percent of the wetland habitat base, these units are typically flooded from late August through early May. An irrigation is usually accomplished in mid-June to bring large quantities of watergrass, sprangletop, and smartweed plants to maturity. During these irrigation periods, these units are often utilized by locally nesting colonial water-birds (herons and egrets). Because this habitat type often results in thick monocultures, openings are disked or mowed prior to flood-up. Though not as diverse, once flooded these units provide an abundant food source for waterfowl at a very important (potential crop depredation) time of the year. In addition, a number of wading bird species frequent them throughout the year.

Semi-permanent wetland/brood pond: Combined with permanent ponds, these habitats make up 5 to 15 percent of the wetland base. During the summer growing season, water is often used to encourage growth in certain sparsely vegetated units. Two water management strategies are employed: in most units, water removal will not take place until late July; in others, normal drawdown (April) is done, scheduled work is completed, and then the unit is flooded for the remainder of the year. Both practices serve to promote plant growth while providing wetland habitat for "resident" wildlife during the hot summer months.

Permanent wetland: Combined with semi-permanent wetland/brood pond, these habitats make up 5 to 15 percent of the wetland base and remain flooded throughout the year. Characterized by both emergent and submergent aquatic plants, these units provide brood and molting areas for waterfowl, secure roosting and nesting sites for wading birds and other over water nesters, and feeding areas for species like cormorants and pelicans. These units are drawn down every four to five years in order to recycle nutrients to increase their productivity and discourage carp populations.

Riparian: Comprised primarily of black willow, but with patches of sandbar willow, valley oak, buttonbush, and Fremont's cottonwood, riparian habitat occurs along the Colusa Basin Drain (2047) and Powell Slough. Willows and cottonwoods also occur sparsely in and around some managed marsh units. The largest "riparian tract" is located adjacent the Colusa basin Drain at Tract 14, and has a large heron, egrey and cormorant rookery within it. Willows and cottonwoods provide nesting, roosting, and feeding habitat for passerine species and raptors, and shelter and screening for waterfowl. Deer, small mammals, duck broods, and giant garter snakes utilize creeks and water delivery systems during the summer, when most marsh units are dry.

Vernal pools and alkali meadows: Most plant species in these communities are natives and occur in a variety of patterns, which yield the most diverse vegetation on the Refuge. Nine Federal, State, and California Native Plant Society (CNPS) special status plant species occur in these habitats; as well as three special status invertebrates. During the wet season, cackling geese, wigeon, and coots graze on the depauperate grasses in the alkali meadows, and dabbling ducks and shorebirds feed in the vernal pools. Killdeer, stilts, and avocets nest in these habitats. Alkali meadows and vernal pools are the native, indigenous habitats of the Colusa Plains (Basin), once known as the "hard alkali gooseland." Now, areas on Sacramento NWR, Delevan NWR, and Colusa NWR are virtually all that remain of this habitat type in the region.

3. Describe the strategies used to attain objectives listed above

On an annual basis a review of the previous habitat management plan is conducted, which involves a planning team visiting each habitat unit on each refuge to document the previous year's accomplishments,

establish needs and develop plans for the upcoming year. These findings are compiled to produce the current year's habitat management plan for each refuge.

4. Describe constraints that prevent attainment of objectives and explain the effect on operations
The habitat planning process identifies a far greater workload than can be accomplished in a single year, given present funding, staffing and existing priorities.
5. Describe the strategies used to remedy the constraints listed above
Continue to refine management techniques, to improve efficiency, and develop alternate/additional funding sources to help address present budget and staffing limitations.

Section C - Policies and Procedures

1. Describe the refuge policies/procedures on accepting agricultural drainage water as supply
Colusa Refuge has 2 lift pumps on the Colusa Basin Drain and lifts water from it to supply a portion of the Refuges needs. The water in the Colusa Basin Drain is comprised primarily of agricultural drain water particularly during the dry seasons. GCID has meters on the lift pump stations and claims the rights to all the water in the Colusa basin Drain and thus charges the BOR for the water that the Refuges pumps from the Drain. There is no formal policy or procedure concerning the quality of water that the refuge will accept. No standards have been established and no water quality testing is conducted.

2. Describe the refuge policies/procedures on water pooling, transfers, reallocations or exchanges
The refuge has no Sacramento NWR Complex or US Fish & Wildlife Service policies or procedures on pooling, transfers, reallocations or exchange but follows those established by the CVPIA and in the water supply contracts.

> POOLING OF WATER SUPPLIES
> 6. (a) Whenever the maximum quantities of Level 2 Water Supplies and/or the Incremental Level 4 Water Supplies depicted in Exhibit AB@ are reduced pursuant to Article 9 of this Contract, the remaining Level 2 Water Supplies and/or the Incremental Level 4 Water Supplies may be pooled for use on other Refuge(s); Provided, that no individual Refuge shall receive more Level 2 Water Supplies than would have been made available to it absent a reduction pursuant to Article 9 of this Contract; or be reduced by more than twenty-five (25) percent; Provided further, that the Contracting Officer makes a written determination that pooling of water for use on other Refuge(s) would not have an adverse impact, that cannot be reasonably mitigated, on Project operations, other Project Contractors, or other Project purposes; Provided further, that the Contracting Officer determines that such reallocation is permitted under the terms and conditions of the applicable underlying water right permit and/or license; and Provided still further, that water made available under this contract may not be scheduled for delivery outside the Contractor=s Boundary without prior written approval of the Contracting Officer.
> (b) An Interagency Refuge Water Management Team, to be chaired by the Contracting Officer and to be established upon execution of this Contract, shall be entitled to collaboratively allocate the pooled water supplies and provide a schedule for delivery of the pooled supplies to meet the highest priority needs of the Refuge(s) as depicted in Exhibit AB@; Provided, however, nothing in this Article is intended to require the Contractor to pool the water supply provided for in this Contract. The Interagency Refuge Water Management Team shall be composed of designees of the Bureau of

Reclamation, the United States Fish and Wildlife Service, the California Department of Fish and Game, and the Grassland Water District.

TRANSFERS, REALLOCATIONS OR EXCHANGES OF WATER
7. Subject to the prior written approval of the Contracting Officer, the Project Water made available under this Contract may be transferred, reallocated or exchanged in that Year to other Refuge(s) or Project contractors if such transfer, reallocation or exchange is requested by the Contractor and is authorized by applicable Federal and California State laws, and then-current applicable guidelines or regulations.

3. Describe the refuge water accounting policies/procedures for inflow, internal flow and outflow
Irrigators estimate quantity delivered by month for individual units. Deliveries are measured by the local irrigation district at the point of delivery. A computer spreadsheet of monthly deliveries is updated by the 7th of each month and provided to USBR. The irrigator for each refuge maintains records of the flood-up and draw-down dates for each wetland unit which is recorded in the annual habitat management plan for the refuge. Outflow points have no measurement devices.

4. Attach a copy of the refuge's shortage policies, drought plan, or any similar document.
See attachment B – Colusa National Wildlife Refuge Drought Contingency Plan.

Based on established refuge purposes (see Section B1) and the projected water supply, we determine critical habitat needs and analyze existing water use records by both refuge unit and habitat type, to determine the amount, distribution and timing of each habitat unit to be flooded.

Section D - Inventory of Existing Facilities

1. Mapping

Attach existing facilities map(s) that show points of delivery, turnouts (internal flow), and outflow (spill) points, measurement locations, conveyance system, storage facilities, operational loss recovery system, wells, and water quality monitoring locations. Describe in the body of the plan the information contained in each attached map.

The attached maps (Attachment C – Colusa National Wildlife Refuge Water Delivery and Drainage Map, Colusa National Wildlife Refuge Water Drainage Areas Map, and Colusa National Wildlife Refuge Water System Map) show points of delivery, turnouts (internal flow), and outflow (spill) points, measurement locations, and the conveyance system. Colusa NWR does not have storage facilities, an operational loss recovery system, active wells, or water quality monitoring locations, therefore, these are not shown on the attached facilities maps.

2. Water measurement

a. Inflow/deliveries

Total # of inflow locations/points of delivery 3

Total # of measured points of delivery 3

Percentage of total inflow (volume) measured during report year 100

b. Internal flow at turnouts

Total # of refuge water management units (units) 60
Total # of refuge water management unit turnouts 28
Total # of measured turnouts 0
Estimated % of total internal flow (volume) during report year that was measured at a turnout 0 .
Number of turnouts supplying more than one unit or not directly off delivery system 13

Measurement type	*Number of devices*	*Acres served*	*Accuracy (avg or range)*	*Reading frequency*	*Calibration frequency (months)*	*Maintenance frequency (months/days)*
Orifices						
Propeller						
Weirs						
Flumes						
Venturi						
Alfalfa valves						
Metered gates						
Other, stop-log and screwgates	28	3,209	Unknown	1-3 times/week	Never	weekly

Most water control structures are pre-cast twin-track risers with wooden stop-logs and polyethylene pipe, although a few structures have screwgates attached. During active flood-up of a unit, structures are visually checked and readjusted if needed every 1-2 days to ensure a proper rate of flood-up is maintained to provide optimum habitat. Once a unit is flooded, readjustments are made to the structure to provide a reduced "maintenance" flow (approximately 1-3 cfs depending on the size of the wetland unit) to maintain optimal depth, at which time the structure is visually checked 1-2 times per week.

c. Outflow

Outflow (AF/yr) unknown quantity
Total # of outflow locations/points of spill 7
Total # of measured outflow points 0
Percentage of total outflow (volume) measured during report year 0

Outflow point	*Measuring point*	*Type of measurement*	*Percent of total outflow (estimated)*	*Measuring agency*	*Acres drained*
2047 drain	T1, cell 4	None	9	Colusa NWR	300
2047 drain	Pool 6	None	45	Colusa NWR	1,472

	outlet				
Powell Slough	T9, south outlet	None	1	Colusa NWR	20
2047 drain	T14, cell2	None	2	Colusa NWR	52
2047 drain	T19, cell 4	None	3	Colusa NWR	91
East-West J-Drain	T12A outlet	None	25	Colusa NWR	826
2047 drain	Able Road T17	None	16	Colusa NWR	538

3. Identify the type and length of the refuge internal distribution system

Miles unlined canal			*Miles lined canal*	*Miles piped*	*Miles – other*	
Delivery	Drain	Delivery/Drain		Delivery	Delivery	Drain
9.5	8.5	.75	0			.5

Describe the location and types of identified leaks and areas of higher than average canal seepage, and any relation to soil type.

Refuge staff has not identified any significant leaks or areas of higher than average canal seepage. No areas of high seepage due to soil type (gravel lens, etc.) have been identified.

Refuge operated lift pumps

Pump	*Location*	*Horse Power*
Highway 20 Pump	2047/Colusa basin Drain	40
Main Pump	2047/Colusa Basin Drain	50
Tract 5 lift Pump	West Lateral Canal	25

4. Describe the refuge operational loss recovery system

None

5. Groundwater

Describe groundwater availability, quality and potential for use

USBR drilled four test wells on nearby Sacramento NWR in the early 1990s. Chemical analysis of these groundwater wells at Sacramento NWR and at Colusa NWR detected mercury levels above the EPA chronic criteria (both Sacramento NWR and Colusa NWR) and levels of the hexavalent form of chromium above the EPA chronic and acute criteria (Sacramento NWR). Due to these test results it is believed that the use of this water could have a detrimental effect on the aquatic and wildlife resources that utilize the area. In addition, limited quantity (hundreds of gallons instead of thousands) was found for the test wells at Sacramento NWR. The groundwater basin under the refuge is considered to be of very limited usefulness.

Groundwater plan *No* ___X___ *Yes* _____.

Groundwater basin(s) that underlie the refuge

Name of basin underlying refuge	*Size (sq. mi.)*	*Usable capacity (AF)*	*Safe yield (AF/Y)*	*Management agency*	*Relevant reports*
Colusa Subbasin	1,434	900,000	NA	Colusa County	DWR Bulletin 118

Identify refuge-operated ground water wells

#	*Location*	*Status*	*HP*	*2003 (AFY)*	*Future plans*
None					

Section E Environmental Characteristics

1. Topography - describe and discuss impact on water management

Topography of Colusa NWR is relatively flat with a slope from NW to SE on the northern portions of the Refuge and from the SW to ENE on the southern portions of the refuge. Water for units of the refuge that are located east of the Colusa Basin Drain (CBD) is lifted from the CBD and is discharged either into the CBD or east into Powell Slough. Refuge units west of the CBD primarily receive water from the West Lateral Canal. This canal water flows north from the SW corner of the Refuge and then falls through the units and other canals to the east and south.

2. Soils - describe and discuss impact on water management (see attached map)

The soils of Colusa NWR (Attachment D - Colusa National Wildlife Refuge Soils Map) are fairly tight soils that minimize seepage and are thus beneficial for wetland type habitats. There are no areas of problem soils so water management is very efficient.

3. Climate

National Weather Service – Willows 6 W, California (049699), data period – 10/15/1906 to 7/31/2010

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual*
avg precip	3.72	3.18	2.28	1.13	0.65	0.32	0.04	0.09	0.31	0.98	2.13	3.16	17.99
avg. temp	45.2	49.7	53.5	58.8	66.3	73.5	78.0	76.1	72.5	64.3	53.3	45.9	61.40
avg. max temp	54.5	60.3	65.7	72.9	81.3	89.3	95.2	93.6	89.0	79.2	65.5	55.5	75.2
avg. min temp	35.9	39.0	41.3	44.8	51.3	57.6	60.9	58.7	56.0	49.3	41.1	36.3	47.7
*ETo **	1.22	1.71	2.93	4.72	6.10	7.20	8.54	7.32	5.31	3.60	1.65	1.04	51.34

* ETo data from Appendix B - Reference Crop Evapotranspiration for Willows, Glenn County, California at http://esce.ucr.edu/soilwater/etodata.html.

Discuss the impact of climate, and any microclimates, on water management

Climate can be characterized as mild damp winters and long hot summers. Refuge objectives result in the majority of wetlands being flooded during the fall and winter (to mimic historic hydrologic patterns). Those acres that remain flooded during spring and summer have the greatest amount of water used per habitat acre. The hot summers, and the resulting evaporative losses, require that permanent-water habitat be kept to a minimum. No microclimates exist within the refuge borders.

4. Water quality monitoring (attach water quality test result forms)

If the refuge has a water quality monitoring program complete this table

Analyses performed	*Frequency range*	*Concentration range*	*Average*

pH	Once	7.8 - 8.0	7.8
Dissolved solids	Once	193 - 399	302
Dissolved oxygen	Once	5.8 - 8.2	6.7
Alkalinity as CaCO3	Once	125 - 238	191
Calcium	Once	19 - 31	26
Chloride	Once	10 - 33	21
Magnesium	Once	13 - 26	20
Nitrogen	Once	<0.1 - 0.23	<0.14
Potassium	Once	1.3 - 2.1	1.7
Sodium	Once	28 - 77	55
Sulfate	Once	19 - 60	41
Arsenic	Once	1 - 3	1.8
Boron	Once	110 - 260	188
Cadmium	Once	All <1	<1
Chromium	Once	All <1	<1
Copper	Once	1 - 2	1.3
Lead	Once	<5 - 17	<7
Mercury	Once	All <0.1	<0.1
Molybdenum	Once	<1 - 1	<1
Selenium	Once	<1 - 5	<1.6
Uranium	Once	<0.4 - 1.5	<0.6
Vanadium	Once	3 - 6	4.2
Zinc	Once	<3 - 39	<17.8

Discuss the impact of water quality on water management

The refuge has no water quality monitoring program other than a baseline study (Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Sacramento National Wildlife Refuge Complex) conducted in 1988 which found no water quality problems that would affect water management decisions. Data entered in the table above are based on that baseline study. Water management decisions are based on this baseline study since it is the only source of water quality data specific for the refuge.

Section F Transfers, Exchanges and Trades

Provide information on any transfers, exchanges and/or trades into or out of the refuge

From whom	To whom	Report year (AF)	Use
None			
	TOTAL		

Section G Water Inventory

1. Refuge Water Supplies Quantified

Surface water supplies, imported and originating within the District, by month. Table 1

Ground water extracted by the Refuge, by month. Table 1

Precipitation by Habitat Type Table 3
Upslope Drain Water, by month. Table 1
Other supplies, by month Table 1
Refuge water inventory. Table 4
Ten-year history of Refuge water supplies Table 5

2. Water Used Quantified
3. Conveyance losses, including seepage, evaporation, and operational losses. Table 2
4. Applied Habitat water, evapotranspiration, water used for cultural practices (e.g., disease control, etc.). Table 3
5. Estimated deep percolation (seepage) within Habitat areas. Table 3
6. Habitat spill or drain water leaving the Refuge. Table 4

See Attachment E – Colusa National Wildlife Refuge Water Inventory Tables

Section H Critical Best Management Practices

Describe the 5-year implementation plan and the proposed 3-year funding budget.

1. Management programs
a. Education

Program	*Estimated cost (in $1,000s)*		
	2011	*2012*	*2013*
Irrigator training – 4 staff	$2	$2	$2
Interpretive displays	$1	$1	$1
Environmental Education – 2 staff	$58	$59	$60

Describe the specifics of each program (number of participants, topics, purpose, etc.) and attach program materials, if available.

These programs apply to all the refuges in the Sacramento NWR Complex. The four refuge irrigators are sent to training in distribution system management, flow control, turnout calibration and other aspects of water and wetland management. All refuge staff attend monthly staff/safety meetings during which the status and timing of wetland flood-up and drawdown schedules are discussed, in addition to other applicable water related topics (e.g. status of efforts to secure CVPIA water for Sutter NWR, irrigation district maintenance efforts and the effect on refuge water deliveries, etc.). The Environmental Education program hosts more than 5,000 students visiting each year. Topics covered during the Environmental Education programs include water and wetland habitat management. Interpretive displays on the refuges of the

Complex include information on wetland management. New interpretive displays are purchased periodically and there is an on-going expense to maintain them. The Complex hosts an annual Wetland Management Workshop for landowners attended by 50-60 local landowners and duck club managers. Information concerning water management on the refuges of the Sacramento NWR Complex is being developed for inclusion on the Complex's website.

b. Water quality monitoring

Type of water	*Existing Estimated cost (in $1,000s)*		
	2011	*2012*	*2013*
Surface – USBR and riparian	$5.0	$5.1	$5.2
Upslope drain	NA	NA	NA
Groundwater	NA	NA	NA
Outflow	NA	NA	NA

Short description of existing or planned program – i.e., required by which agency, coordinated with whom, constituents monitored and frequency

The Refuge Complex is a member of the Colusa Sub-basin watershed of the Sacramento Valley Coalition for monitoring water quality. No water quality problems were identified during 2009-2010. Past studies (Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Sacramento National Wildlife Refuge Complex. 1988; etc.) have indicated no surface water (inflow and outflow) quality issues.

c. Cooperative efforts

The Complex is working with GCID to improve water delivery and measurement (partially through the use of SCADA) capabilities to Sacramento, Delevan and Colusa refuges. The Complex is continuing to work with USBR to secure delivery for Sutter NWR.

d. Pump evaluations (mobile labs) NA

Total number of groundwater pumps on refuge 0

Total number of surface water (low-lift) pumps on refuge 0

Groundwater pumps	*Estimated cost (in $1,000s)*		
	2011	*2012*	*2013*
# of groundwater pumps tested	NA	NA	NA
# of pumps to be fixed or replaced	NA	NA	NA
# of low-lift pumps to be tested	NA	NA	NA
# of pumps to be fixed or replaced	NA	NA	NA

e. Policy evaluation

1. The right to move unused allocated water between refuges within our complex, to other CVP refuges, to CDFG, and to other CVP contractors.
2. FWS joins Seven Party Agreement so that outflow (into a canal/drain) from upstream refuges (e.g. Sacramento NWR and Delevan NWR) is available for diversion to downstream refuges at no charge. This would keep the US government (USBR) from having to buy the same water multiple times.

f. (GRCD only) ~~*Provide Customer Services - Facilitate physical/structural improvements for member*~~

~~*units; provide management services and technical advice to raise funds for BMP Implementation and provide customers with water efficiency education programs.*~~

2. (GRCD only) ~~*Pricing structure*~~

3. (GRCD only) ~~*Plan to measure deliveries*~~

4. Water management coordinator

Name: Mike Peters *Title:* Wildlife Refuge Manager

Address: 752 County Road 99W, Willows, CA 95988

Telephone: 530-510-0377 *E-mail:* mike_peters@fws.gov

Section I Exemptible Best Management Practices

Describe the 5-year implementation plan and the proposed 3-year funding budget.

1. Improve management unit configuration

Unit name	*Current acres*	*Reason for change*	*Proposed acres*	*Estimated cost (in $1,000s)*		
				2011	*2012*	*2013*
See comment below						

Changes to unit configuration are determined if needed during the annual habitat management planning cycle.

(GRCD only) ~~*Assist customers to improve management unit configurations.*~~

2. Improve internal distribution system

a. New control structures within distribution system

Proposed location	*Type of structure*	*Reason for new structure*	*Estimated cost (in $1,000s)*		
			2011	*2012*	*2013*
4 yearly – locations TBD	concrete	Replace old CMP control structures	$4	$4.5	$5
See comment below					

Changes to distribution system are determined if needed during the annual habitat management planning cycle. Usually 6-8 existing corrugated metal pipe (CMP) water control structures are replaced annually with the locations determined during the annual habitat management planning cycle or as problems arise with a structure beginning to fail during the course of the year.

b. Line/pipe sections of distribution system

Proposed reach/sect.	*Reason for new structure*	*Estimated cost (in $1,000s)*		
		2011	*2012*	*2013*
See comment below				

Changes to distribution system are determined if needed during the annual habitat management planning cycle. There is limited opportunity for lining or piping sections of the distribution system on the refuge because the existing open distribution system provides some of the most consistently used habitat by giant garter snakes, a federally listed threatened species. This habitat would be lost if the system was lined or piped. However, this BMP is occasionally implemented on limited portions of the distribution system, with the locations identified during the annual habitat management planning cycle.

c. Independent water control for each unit

Proposed control point	*Reason for new control point*	*Estimated cost (in $1,000s)*		
		2011	*2012*	*2013*
Tract 13.3 inlet	Provide opportunity to manage T13.3 and T13A as semi-permanent wetland	3		
See comment below				

Changes to unit configuration and distribution system are determined if needed during the annual habitat management planning cycle.

d. New internal distribution sections (pipe, canal) to provide water to existing and new habitat units

Proposed new section	*Units served*	*Reason for new section*	*Estimated cost (in $1,000s)*		
			2011	*2012*	*2013*
Pool 6 outlet to T27 flume over ditch	T27	Reuse of Pool 6 drainage and supply for T27		5	
Inlet to T27 @NW corner	T27	Reuse of T5/6, T10-13, T15 drainage and supply for Tract 27	3		
See comment below					

Changes to distribution system are determined if needed during the annual habitat management planning cycle.

(GRCD only) ~~Provide assistance to member units to improve internal distribution~~

3. Develop a Water Use Schedule

Plan element	*Completion date*	*Estimated development/update cost (in $1,000s)*		
		2011	*2012*	*2013*
Floodup dates by unit	Completed annually	$1	$1	$1
Drawdown dates by unit	Completed annually	$1	$1	$1
Irrigation dates by unit	Completed annually	$1	$1	$1

Floodup dates, drawdown dates and irrigation dates (where appropriate) are developed for each unit during the annual habitat management planning cycle.

4. Plan to measure outflow

Identify locations, prioritize, determine best measurement method/cost, submit funding proposal

	Estimated cost (in $1,000s)		
	2011	*2012*	*2013*
Identify locations			
Estimate outflow quantity/rank			
Develop plan			

Estimate construction start date			
Estimate construction completion date			

There are a number of ongoing water monitoring planning efforts off the Refuge that may affect our water measurement plan and implementation. Potential outflow measuring sites include Tract 1.3 outlet, Tract 10A outlet, Tract 12A outlet, Tract 17 outlet, and Pool 6 outlet.

5. (GRCD only) ~~Incentive pricing~~

6. Construct and operate operational loss recovery systems

Proposed location	*Reason for improvement*	*Estimated cost (in $1,000s)*		
		2011	*2012*	*2013*
Pool 6 outlet to T27 flume over ditch	Reuse Pool 6 outflow as supply for Tract 27		5	
Inlet to T27 @NW corner	Reuse outflow from multiple upstream units as supply for Tract 27	3		
See comment below				

FWS is exploring the possibility of joining the Seven Party Agreement so that outflow/spill from upstream refuges can be credited to downstream diversions. Outflow credits could be used to fund outflow/spill measurement programs.

7. Optimize conjunctive use of surface and groundwater

Proposed production/injection well	*Anticipated yield*	*Estimated cost (in $1,000s)*		
		2011	*2012*	*2013*
NA – no useable groundwater				
See comment below				

Chemical analysis of groundwater wells at Sacramento NWR and Colusa NWR conducted in the early 1990s detected mercury levels above the EPA chronic criteria (both Sacramento NWR and Colusa NWR) and levels of the hexavalent form of chromium above the EPA chronic and acute criteria (Sacramento NWR). Due to these test results it is believed that the use of this water could have a detrimental effect on the aquatic and wildlife resources that utilize the area. In addition, limited quantity (hundreds of gallons instead of thousands) was found for the test wells at Sacramento NWR. The groundwater basin under the refuges is considered to be of very limited usefulness.

8. Facilitate use of available recycled urban wastewater that otherwise would not be used beneficially, meets all health and safety criteria, and does not cause harm to wildlife management goals.

NA - no recycled urban wastewater is available

9. Mapping – COMPLETE

See Attachment C – Colusa National Wildlife Refuge Water Delivery and Drainage Map, and Colusa National Wildlife Refuge Water Drainage Areas Map.

GIS map layers	*Estimated cost (in $1,000s)*		
	2011	*2012*	*2013*
Map 1 – Water Delivery and Drainage Map	$0	$0	$0
Map 2 – Water Drainage Areas Map	$0	$0	$0

10. CALFED Quantifiable Objectives

Describe any past, present, or future plans that address the goals identified for this refuge

If reducing nonproductive ET involves removing invasive plants, complete the following:

Invasive unwanted species name	Estimated acres			*Estimated cost (in $1,000s)*		
	2011	*2012*	*2013*	*2011*	*2012*	*2013*
Arundo	1	1	1	$.5	$.5	$.5
	2	2	2	$1	$1	$1
Water primrose	10	10	10	$3.5	$3.5	$3.5

Colusa National Wildlife Refuges (NWRs)

1. Describe actions that reduce the salinity of surface return water. (Targeted Benefit (TB) 24)

None - no salinity or conductivity problems have been documented on any of the refuge's wetlands.

2. Describe actions that reduce nonproductive ET. (TB 25)

The refuge has a continuous program to minimize or eradicate invasive aquatic plants (primrose, and Arundo).

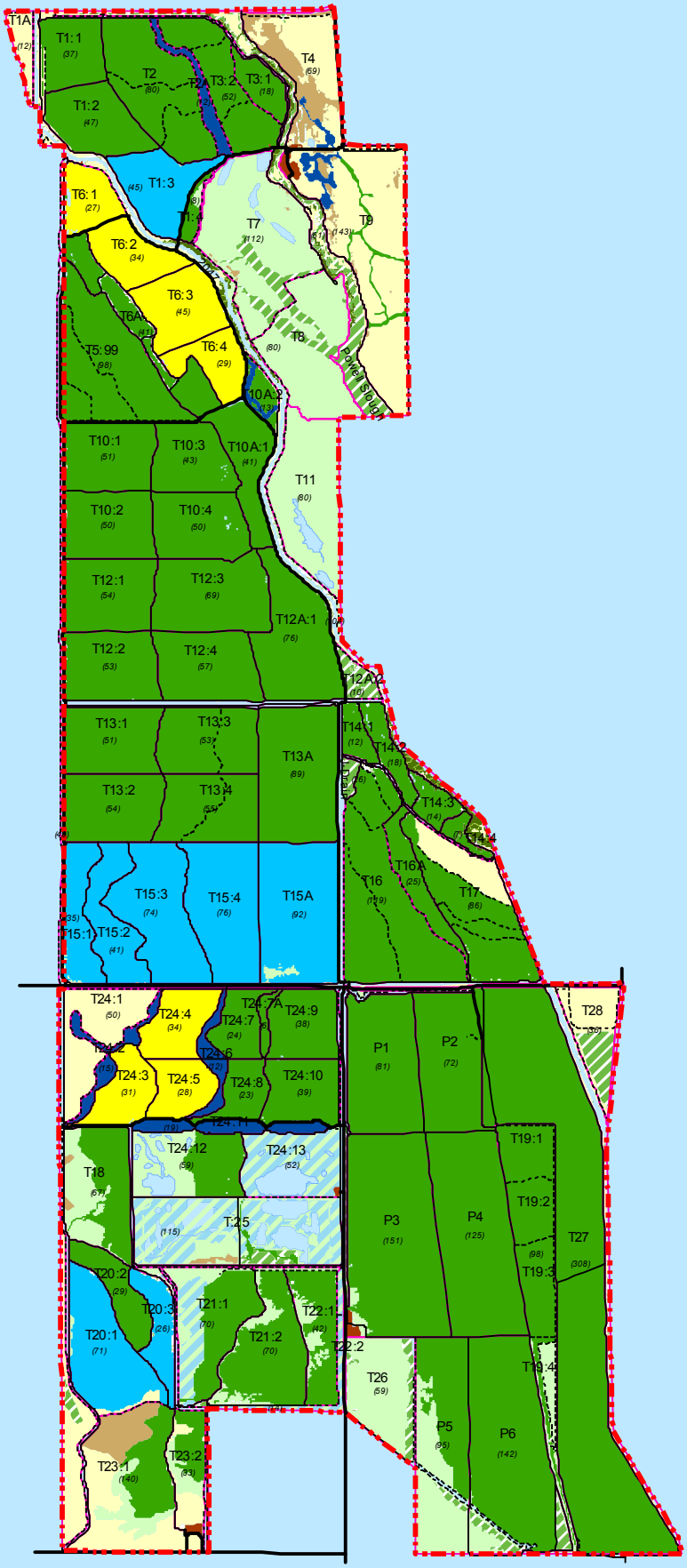
Attachment A

Colusa National Wildlife Refuge

Habitat Map

February 28, 2011

Colusa NWR
Habitat Management 2010-11



Refuge Boundary

Roads

- All Weather
- Standard Dirt
- Non-Drivable
- Cell Boundaries (no roads)

Habitat Management 2010-11

- Seasonal Flooded Marsh
- Unmanaged Freshwater Wetland
- Watergrass
- Summer Water
- Permanent Pond
- Vernal Pool
- Alkali Meadow
- Vernal Pool/Alkali Meadow Complex
- Riparian Willow Scrub
- Cottonwood Willow
- Mixed Riparian Forest
- Annual Grassland
- Perennial Grassland
- Facilities

0 0.25 0.5 1 1.5 2 Miles

Attachment B

Colusa National Wildlife Refuge

Drought Contingency Plan

February 28, 2011

Sacramento National Wildlife Refuge Complex – Colusa NWR
Drought Contingency Plan
February 2011

In the event of reduced water allocations, the refuges of the Sacramento National Wildlife Refuge Complex wetland management practices will be adjusted according to the severity of the water reduction as well as the timing within the water year when the cutback is finalized. Dry year and critically dry year water allocations are based upon the Shasta Lake Index and approximate allocations can be found in Tables 1-4.

Adjustments to wetland management practices and their potential impacts to the wetlands of the refuges are identified below for four anticipated water availability scenarios (See Tables 1-4 and Figures 1-4).

A. 100% Level 2 at Sacramento, Delevan, Colusa NWR's & Level 4 (Delevan NWR)

1. Normal spring draw-downs would provide habitat suitable for shorebird habitat/use and plant germination objectives being met.
2. Standard acres of permanent ponds and summer water (approximately 5-15% of total managed wetlands on each refuge) would be managed for use by giant garter snakes, tricolored blackbirds, western pond turtles, and duck broods.
3. Standard number of irrigated acres for annual food plant production (approximately 12-15% of total managed wetlands on each refuge) and control of invasive species (e.g. cocklebur).
4. Flood-ups start in late July and total wetland acres would be flooded by early November.
5. Standard wetland habitat maintenance water supply would be available.
6. Visitor Services programs (i.e. hunting, wildlife observation, wildlife photography, interpretation, and environmental education) that support 100,000 to 125,000 visitors would be fully operational.

B. 75% Level 2 at Sacramento, Delevan, Colusa NWR's & Level 4 (Delevan NWR)

1. Earlier spring draw-downs than normal due to less maintenance water available, resulting in less shorebird habitat and poorer plant germinations.
2. Permanent pond acres decreased by 50% and summer water acres by 25% potentially negatively impacting garter snakes, tricolored blackbirds, and western pond turtles.
3. 10% decrease in acres irrigated for annual food plants and to control invasive species such as cocklebur. There would be an increase in acres mowed, resulting in more diesel consumption, to mitigate for the decreased control of invasive species by irrigating.
4. Flood-ups would be delayed on a number of wetlands resulting in less habitat available for early migrants, and increased potential for crop depredation (Lea Act consideration at Colusa NWR). Water would be shifted from Sacramento and Colusa refuges to Delevan NWR. Wetland flood-ups would not be completed until late November.

5. Total wetland acres would be reduced by at least 10% with potential longer term impacts to future wetland quality.

6. Concentration of waterfowl on reduced habitat acres would increase disease risk, particularly with other public/private wetland acres anticipated to be reduced as well.

7. Standard habitat maintenance water supplies planned for use on the reduced wetland acres.

8. Reduced visitor use due to lower hunter quotas early in the hunting season before wetland units are flooded, a few auto tour units being dry, etc.

C. 50 % Level 2 at Sacramento, Delevan, Colusa NWR's & Level 4 (Delevan NWR)

1. Early spring draw-downs resulting in much less shorebird habitat available and poor plant germinations due to reduced maintenance supplies,

2. Permanent pond acres decreased by 75% and summer water decreased by 50% with associated significant impacts to giant garter snakes, tricolored blackbirds, western pond turtles, and duck broods.

3. 50% decrease in acres irrigated for annual food plants and control of invasive species such as cocklebur, with increased mowing/diesel use to mitigate.

4. Flood-ups delayed on an increased number of wetlands with significantly increased potential for crop depredation, problems likely near refuges (Lea Act consideration at Colusa NWR). Wetland flood-ups would not be completed until early December.

5. Total wetland acres reduced 30-50% with longer-term impacts to future wetland quality on more acres.

6. Significantly increased waterfowl crowding and associated disease risk due to the reduced habitat available. Other public/private wetland acres would be reduced significantly.

7. Standard habitat maintenance water supplies planned for use on vastly reduced number of wetland acres.

8. The hunting program on all three refuges would be eliminated, the auto tour at Colusa NWR would be closed, and visitor use on the Sacramento NWR auto tour would be reduced by 50% due to poorer viewing opportunities. Overall visitor use would drastically decrease.

D. 25% Level 2 at Sacramento, Delevan, Colusa NWR's & Level 4 (Delevan NWR)

1. Very early spring draw-downs would result in severely limited shorebird habitat and poor plant germinations due to reduced maintenance water supplies,

2. Permanent pond acreage decreased by 80% and summer water decreased by 80% with even more dramatic impact of giant garter snakes, tricolored blackbirds, western pond turtles, and duck broods.

3. Complete elimination of irrigations for annual food plants and control of invasive species resulting in vastly increased mowing/diesel fuel consumption to mitigate.

4. Flood-ups delayed even later on what few acres that could be flooded. Significant widespread crop depredation would be almost a certainty (Lea Act considerations at Colusa NWR). Water would be shifted from Colusa NWR to Sacramento NWR. Wetland flood-ups would be completed by mid-December.

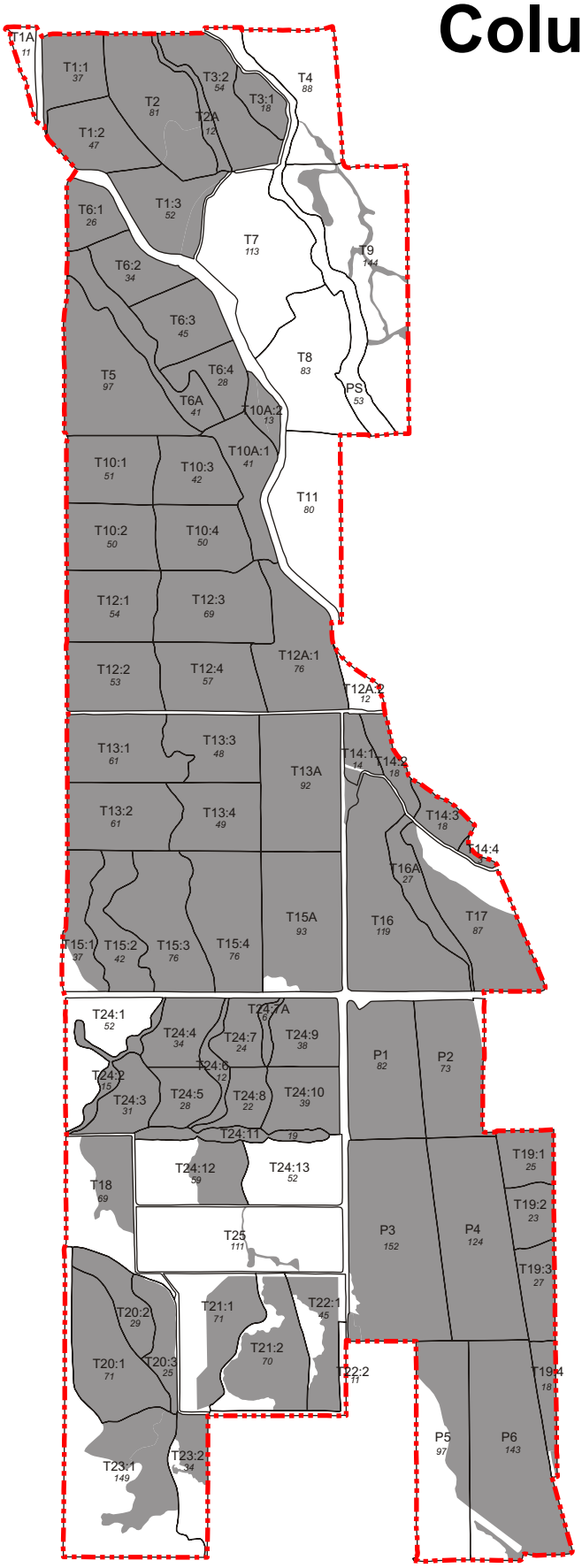
5. Total wetland acres reduced 60-70% with longer-term impacts to future wetland quality on a vast majority of refuge wetlands.

6. Extreme waterfowl crowding and disease risk, particularly since there would be minimal other public/private wetlands available.

7. Uncertain habitat maintenance water supply on what few acres we are able to flood-up.

8. Public use on all refuge habitats would be eliminated, other than having the Sacramento NWR visitor center open. Visitor use would decrease to a fraction of normal.

Colusa NWR



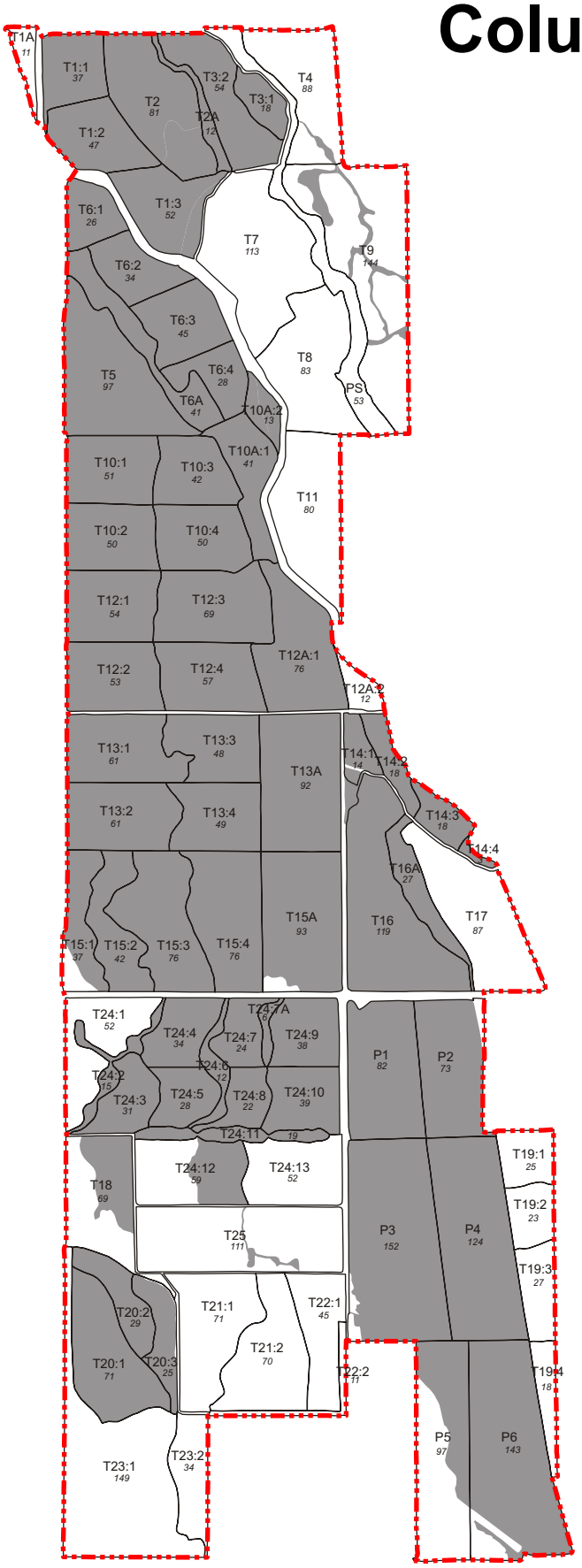
100% Water Available

Refuge Boundary

Managed wetlands flooded

0 0.25 0.5 1 1.5 2 Miles

Colusa NWR



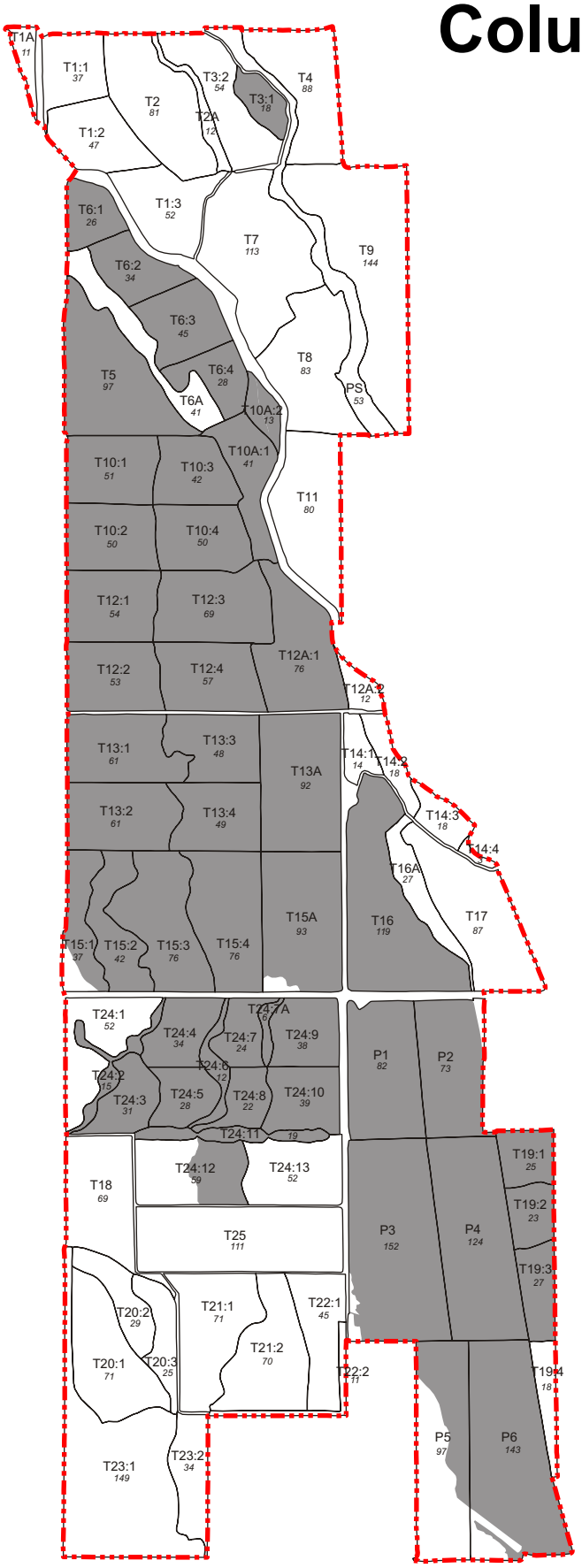
75% Water Available

Refuge Boundary

Managed wetlands flooded

0 0.25 0.5 1 1.5 2 Miles

Colusa NWR



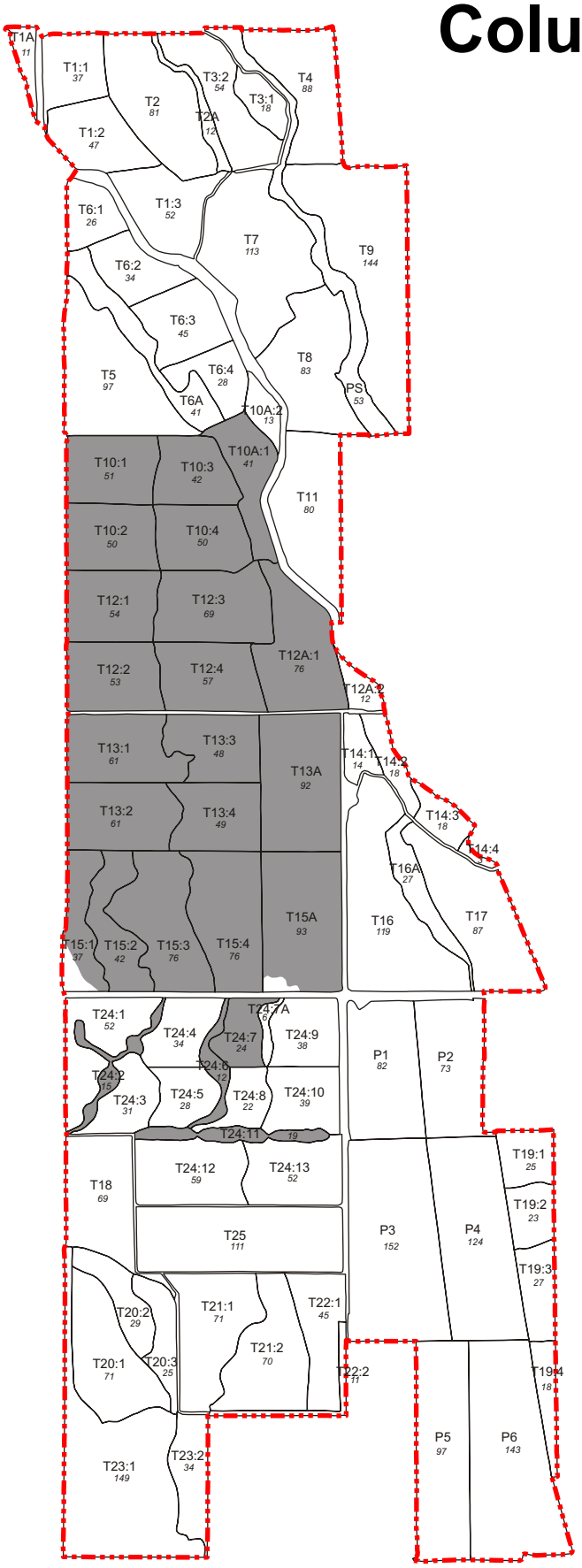
50% Water Available

Refuge Boundary

Managed wetlands flooded

0 0.25 0.5 1 1.5 2 Miles

Colusa NWR



25% Water Available

Refuge Boundary

Managed wetlands flooded

0 0.25 0.5 1 1.5 2 Miles

Attachment C

Colusa National Wildlife Refuge

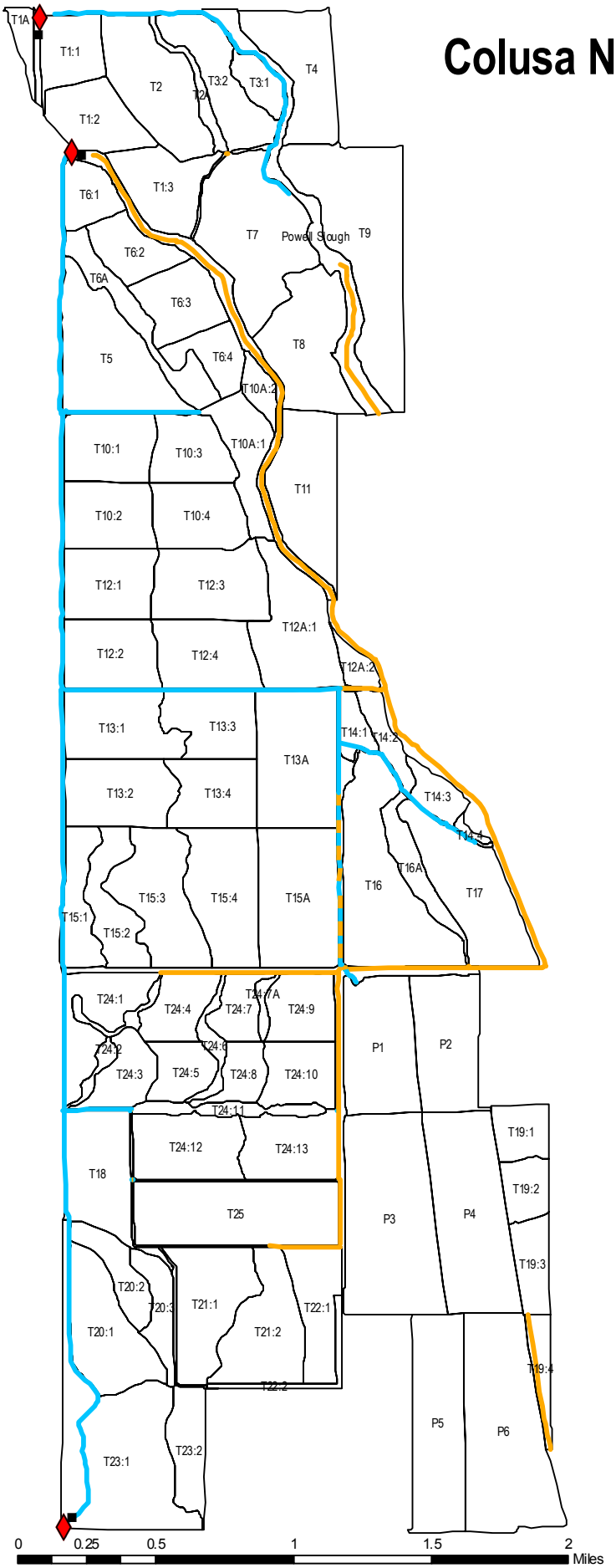
Water Delivery and Drainage Map

Water Drainage Areas Map

Water System Map

February 28, 2011

Colusa National Wildlife Refuge

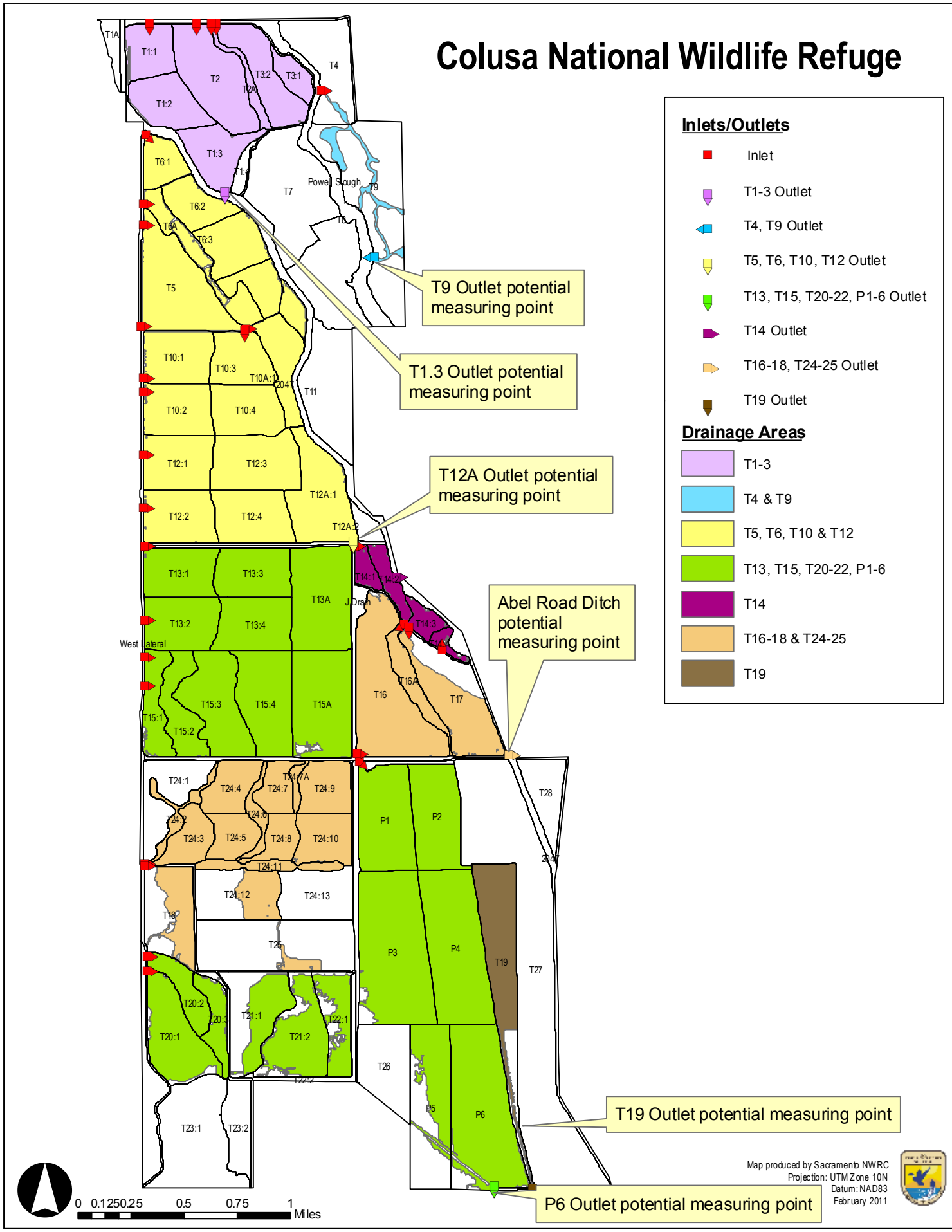


Water Delivery

- Delivery
- Delivery and Drain
- Drain
- Point of Delivery
- Meter Locations

Map produced by Sacramento NWRC
Projection: UTM Zone 10N
Datum: NAD83
February 2011

Colusa National Wildlife Refuge

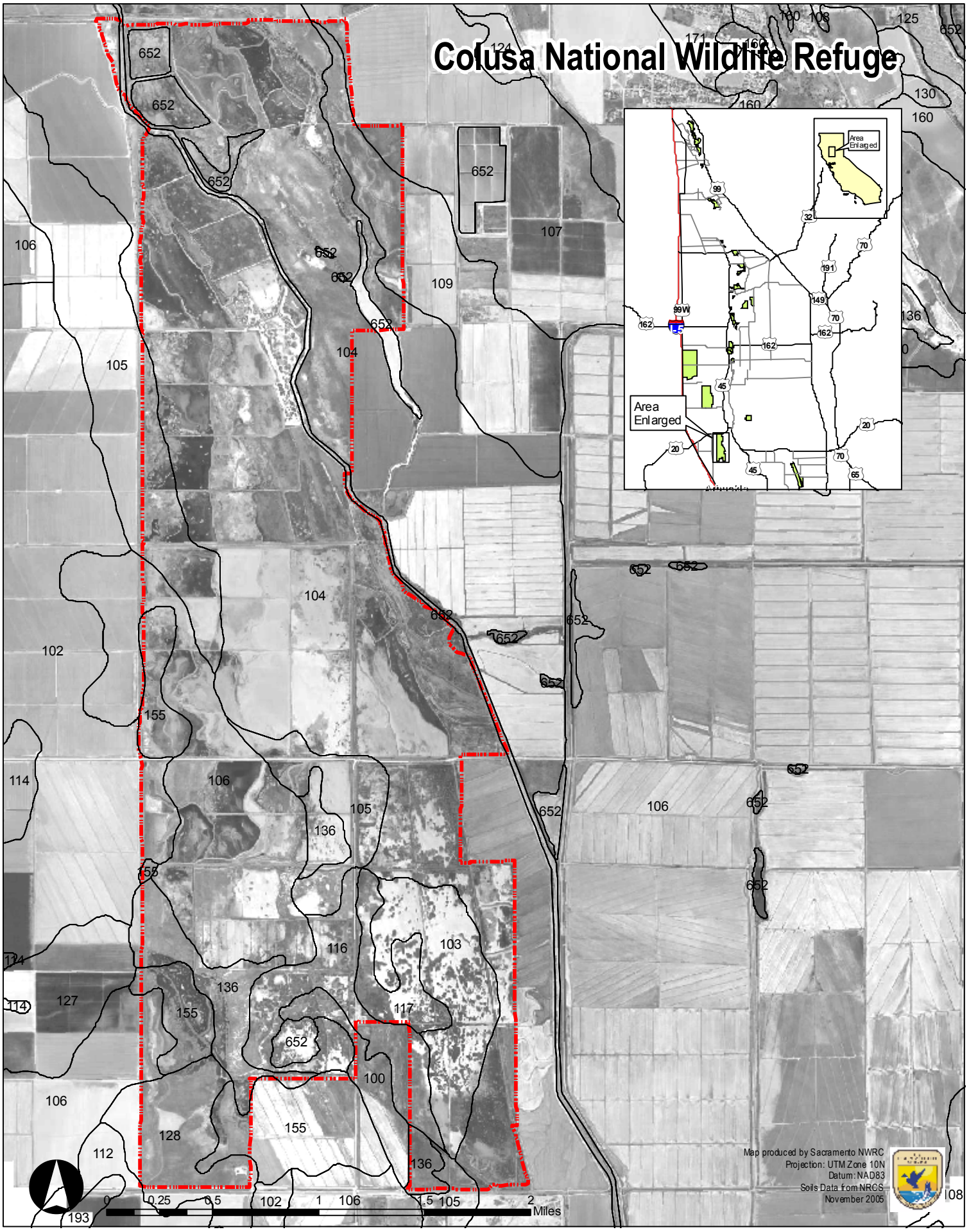


Attachment D

Colusa National Wildlife Refuge

Soils Map

February 28, 2011


Colusa National Wildlife Refuge
Area Enlarged
Area Enlarged
Map produced by Sacramento NWRC
Projection: UTM Zone 10N
Datum: NAD83
Soils Data from NRCS
November 2005
0 0.25 0.5 1 1.5 2
Miles

Colusa National Wildlife Refuge
Soil Series/Types*

Colusa County

#	Description
100	Capay clayloam, 0-1% slopes, occasionally flooded
103	Capay clayloam, 0-1% slopes, frequently flooded
105	Willows silty clay, 0-1% slopes, occasionally flooded
106	Willows silty clay, 0-1% slopes
107	Scribner silt loam, 0-1% slopes, occasionally flooded
109	Scribner silt loam, 0-1% slopes, frequently flooded
116	Clear Lake clay, calcareous, 0-2% slopes, occasionally flooded
117	Clear Lake clay, calcareous, 0-1% slopes, frequently flooded
128	Mallard loam, 0-1% slopes
136	Colusa loam, 0-2% slopes
155	Alcapay clay, 0-1% slopes
652	Water

* from USDA Map Unit Legend Summary for Colusa County, California on NRCS Web Soil Survey.

Attachment E

Colusa National Wildlife Refuge

Water Inventory Tables

February 28, 2011

Table 1

Water Supply

2010	Federal Wtr Level 2 (acre-feet)	Federal Wtr Level 4 (acre-feet)	Local Water Supply (acre-feet)	Refuge Groundwtr (acre-feet)	Up Slope Drain Wtr (acre-feet)	other (define) (acre-feet)	Total (acre-feet)
Method							
Jan-2010	1,147	0	0	0	0	0	**1,147**
February	944	0	0	0	0	0	**944**
Mar-2009	54	0	0	0	0	0	**54**
April	145	0	0	0	0	0	**145**
May	397	0	0	0	0	0	**397**
June	798	0	0	0	0	0	**798**
July	676	0	0	0	0	0	**676**
August	520	0	0	0	0	0	**520**
September	2,651	0	0	0	0	0	**2,651**
October	4,833	0	0	0	0	0	**4,833**
November	3,134	0	0	0	0	0	**3,134**
December	2,197	0	0	0	0	0	**2,197**
TOTAL	**17,496**	**0**	**0**	**0**	**0**	**0**	**17,496**

***March 1, 2009 - February 28, 2010**

Measurement Method Definitio	
M1	Measured summ
M2	Measured summ
M3	Measured summ
C1	Calculated (mo
C2	Calculated usin
C3	Calculated usin
E1	Estimated usin
E2	Estimated usin
E3	Estimated usin
O1	Other (attach a

Table 2

Internal Distribution System

Year	2010								
Canal, lateral	Length (feet)	Width (feet)	Surface Area (square feet)	Precip. (acre-feet)	Evaporation (acre-feet)	Seepage (acre-feet)	Operational losses (acre-feet)	Measure method (see Cell K5	Total (acre-feet)
West Canal	26,400	20	528,000	20.69	51.86	500	0	M1	**(531)**
HWY 20 Canal	6,864	15	102,960	4.03	10.11	150		M1	**(156)**
Tract 5 Canal	2,640	10	26,400	1.03	2.59	50			**(52)**
Tract 13 Canal	5,280	15	79,200	3.10	7.78	100			**(105)**
Tract 14 Canal	2,640	15	39,600	1.55	3.89	50			**(52)**
N/S J-Drain	5,280	30	158,400	6.21	15.56	100			**(109)**
Tract 18 Canal	1,320	15	19,800	0.78	1.94	50			**(51)**
			0	0.00	0.00				**0**
			0	0.00	0.00				**0**
			0	0.00	0.00				**0**
			0	0.00	0.00				**0**
			0	0.00	0.00				**0**
			0	0.00	0.00				**0**
TOTAL	**50,424**		**954,360**	**37**	**94**	**1,000**	**0**		**(1,056)**
			22	**acres**					

Table 3

Managed Lands Water Needs

Habitat Type	Area habitat acres	Habitat Water (AF/ac)	AF/ac water (AF/ac)	Delivered Water (Total AF)	Precip (AF/Ac)	Shallow Groundwtr (AF/Ac)	Evap (AF/Ac)	Cultural Practices (AF/Ac)	Seepage (AF/Ac)
Seasonal wetlands: timothy	2,700	5.00	3.60	9,720	1.60	0.00	1.46	0.00	0.00
Seasonal wetlands: smartweed	173	5.00	3.50	606	1.60	0.00	1.46	0.00	0.00
Seasonal wetlands: watergrass	224	8.00	7.00	1,568	1.60	0.00	1.46	0.00	0.00
Permanent wetlands	71	12.00	10.00	710	1.71	0.00	4.28	0.00	0.00
Semi-perm wetlands/brood pond	449	10.00	8.50	3,817	1.71	0.00	1.46	0.00	0.00
Riparian	62	12.00	0.00	0	1.71	0.00	4.28	0.00	0.00
Irrigated pasture				0	0.42	0.00	3.57	0.00	0.00
Upland	1,155		0.00	0	0.42	0.00	3.57	0.00	0.00
(define)				0	0.00	0.00	0.00	0.00	0.00
(define)				0	0.00	0.00	0.00	0.00	0.00
Total Habitat Acres	**4,834**	**4.60**	**3.40**	**16,420**					

Table 4

Refuge Water Inventory

Year	2010	Reference		
Total Water Supply		**Table 1**		17,496
Precipitation		**Table 2**	**plus**	37
Evaporation		**Table 2**	**minus**	94
Seepage		**Table 2**	**minus**	1,000
Operational Losses		**Table 2**	**minus**	0
		Deliveries to Managed Lands		16,440
Managed Land needs		**Table 3**	**minus**	22,243
Difference		**(calculated)**		(5,803)
		Balance (outflow?) (Table 3)		13,003
		Water Inventory Balance		7,200

Table 5

Annual Water Quantities Delivered Under Each Right or Contract

Year	Federal Wtr Level 2 (acre-feet)	Federal Wtr Level 4 (acre-feet)	Local Water Supply (acre-feet)	Refuge Groundwtr (acre-feet)	Up Slope Drain Wtr (acre-feet)	other (define) (acre-feet)	Total (acre-feet)
2001	14,652	0	0	0	0	0	**14,652**
2002	14,952	0	0	0	0	0	**14,952**
2003	18,604	0	0	0	0	0	**18,604**
2004	20,171	0	0	0	0	0	**20,171**
2005	21,418	0	0	0	0	0	**21,418**
2006	19,562	0	0	0	0	0	**19,562**
2007	20,140	0	0	0	0	0	**20,140**
2008	20,500	0	0	0	0	0	**20,500**
2009	16,551	0	0	0	0	0	**16,551**
2010	17,496	0	0	0	0	0	**17,496**
Total	**184,046**	**0**	**0**	**0**	**0**	**0**	**184,046**
Average	**18,405**	**0**	**0**	**0**	**0**	**0**	**18,405**

CHEMICAL QUALITY OF GROUND WATER IN THE CENTRAL SACRAMENTO VALLEY, CALIFORNIA

By Ronald P. Fogelman

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 77-133

Prepared in cooperation with the
California Department of Water Resources

6200-02

February 1978

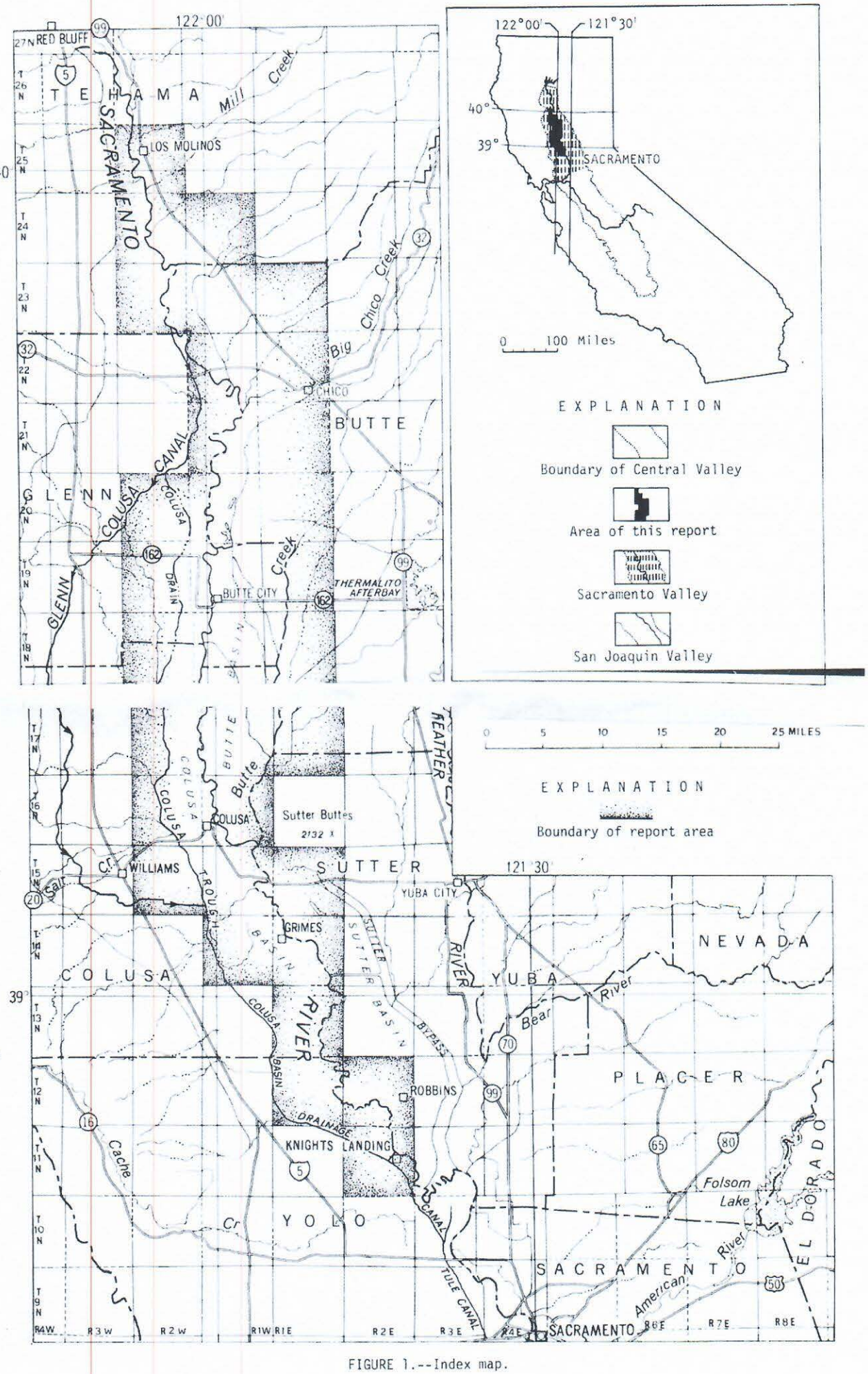


FIGURE 1.--Index map.

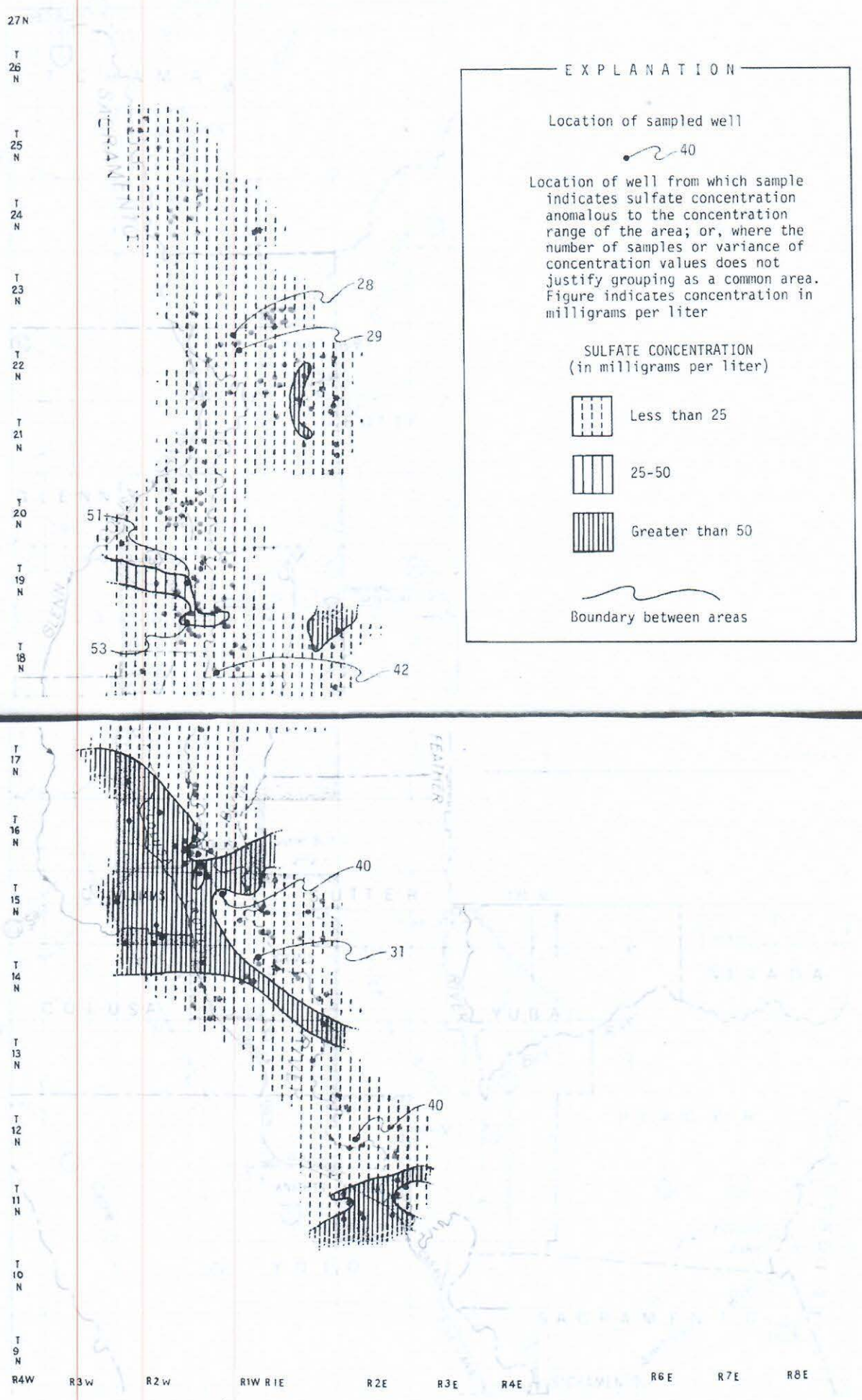


FIGURE 9.--Areal distribution of sulfate concentrations in ground water.