Table 2-19. Chowchilla Subbasin Surface Water Inflows by Water Source Type (AF) (23 CCR §354.18(b)(1)).

Water year (Type)	Local Supplies			CVP Supplies						Surface Water Inflows Total
	Chowchilla Bypass	Received LeGrand	Water Rights Deliveries*	Irrigation Releases from Buchanan Dam	Flood Releases from Buchanan Dam	Irrigation Releases from Madera Canal	Flood Releases from Madera Canal	Fresno River	Deliveries to CWD Growers from MID	
1989 (C)	0	0	0	7,890	0	54,730	0	0	0	62,620
1990 (C)	0	0	0	3,480	0	38,790	0	0	0	42,270
1991 (C)	0	0	1,240	17,040	0	55,060	0	0	0	73,350
1992 (C)	0	0	790	16,970	0	46,470	0	0	0	64,220
1993 (W)	571,210	0	2,830	18,210	0	166,480	0	66,920	0	825,650
1994 (C)	0	0	1,660	62,630	0	65,320	0	170	0	129,780
1995 (W)	572,200	0	3,460	47,580	24,860	84,660	81,530	120,760	0	935,040
1996 (W)	587,640	0	1,560	53,420	29,450	135,210	3,410	71,330	0	882,010
1997 (W)	541,010	0	930	37,660	186,330	136,550	26,850	188,130	0	1,117,450
1998 (W)	517,240	0	1,840	83,240	108,760	42,800	82,930	192,100	0	1,028,910
1999 (AN)	108,790	910	1,490	48,320	0	131,550	17,620	30,300	0	338,980
2000 (AN)	4,240	1,020	310	57,980	6,840	113,230	0	22,010	0	205,630
2001 (D)	0	880	890	81,760	0	64,750	0	330	0	148,610
2002 (D)	0	1,120	760	22,160	0	69,850	0	0	0	93,880
2003 (BN)	0	320	2,140	10,730	0	99,040	0	0	0	112,230
2004 (D)	0	690	860	19,620	0	70,290	0	0	0	91,460
2005 (W)	244,630	70	1,930	46,330	0	112,740	16,870	27,130	0	449,700
2006 (W)	831,930	540	3,480	54,850	76,550	98,770	44,750	126,760	0	1,237,640
2007 (C)	0	190	760	80,450	0	39,110	0	4,640	0	125,160
2008 (C)	0	0	570	24,090	0	64,860	0	0	0	89,530
2009 (BN)	0	0	840	15,070	0	94,850	0	0	0	110,760
2010 (AN)	0	530	1,990	17,620	0	159,480	0	13,940	0	193,560
2011 (W)	771,100	390	3,190	26,050	64,340	156,740	10,860	106,810	150	1,139,640
2012 (D)	0	0	810	97,830	0	55,340	0	8,140	140	162,260
2013 (C)	0	0	80	36,620	0	36,290	0	1,700	80	74,770
2014 (C)	0	0	0	0	0	440	0	0	0	440
2015 (C)	0	0	0	0	0	530	0	0	0	530
Average (1989-2014)	182,690	260	1,320	37,980	19,120	84,360	10,950	37,740	10	374,440
Average (1989-2014) W	579,620	130	2,400	45,920	61,290	116,740	33,400	112,490	20	952,000
Average (1989-2014) AN	37,680	820	1,260	41,310	2,280	134,750	5,870	22,080	0	246,050
Average (1989-2014) BN	0	160	1,490	12,900	0	96,940	0	0	0	111,490
Average (1989-2014) D	0	670	830	55,340	0	65,060	0	2,120	30	124,050
Average (1989-2014) C	0	20	510	24,920	0	40,160	0	650	10	66,270

*Includes water diverted under pre-1914, riparian, and prescriptive water rights along Chowchilla River.

2.2.3.4.2 Surface Water Outflows

Surface water outflows are summarized in **Figure 2-87** and **Table 2-20**. These include natural flows along waterways, runoff of precipitation, and flood releases or spillage of CVP deliveries. As surface outflows serve as the water budget closure term, the monthly proportion of outflows of each water source type is estimated as equal to the proportion of inflows of each water source type by waterway. Overall, total surface outflows are significantly higher in wet years, averaging over 700 taf during wet years.

2.2.3.4.3 Groundwater System Inflows

Estimates of groundwater system inflows are provided in **Figure 2-88** and **Table 2-21**. These inflows include calculated inflows from the SWS and subsurface groundwater inflows from adjacent subbasins[56]. Infiltration of precipitation to the groundwater system is highly variable from year to year due to variation in the timing and amount of precipitation, while infiltration of applied water has remained comparatively steady over time. Infiltration of surface water (seepage) also exhibits substantial variability, particularly from the Rivers and Streams system, matching the annual variability of surface water inflows. Although the San Joaquin River passes along the Subbasin boundary, it provides significant infiltration to the groundwater system.

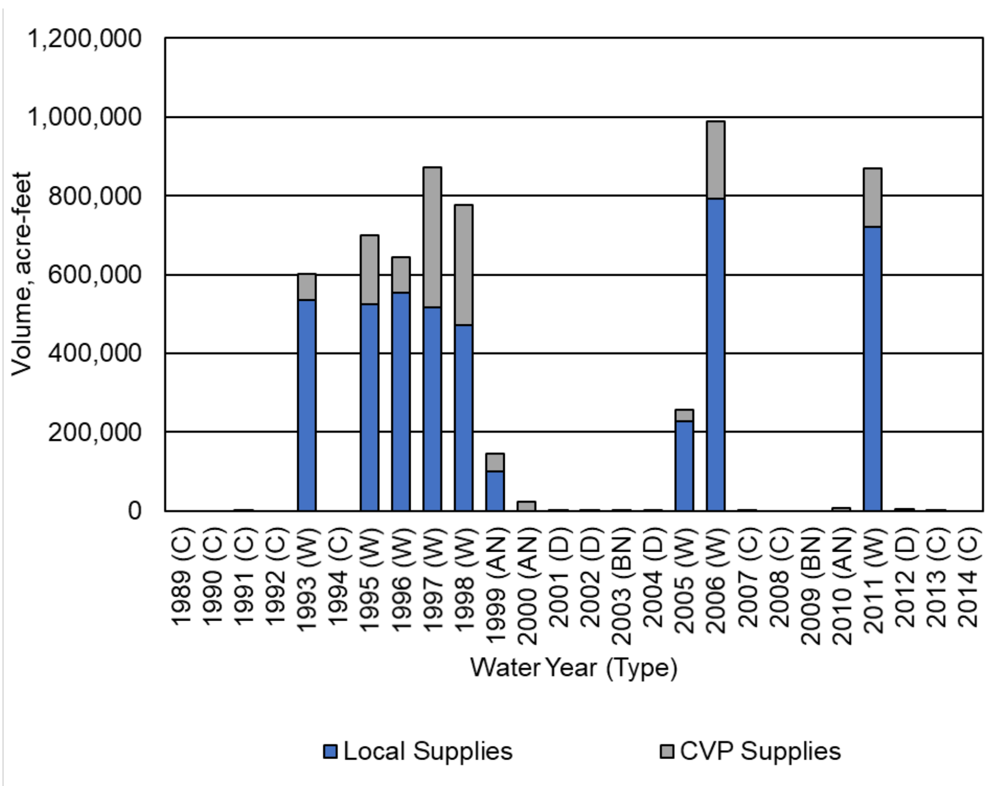

Figure 2-87. Chowchilla Subbasin Surface Outflows by Water Source Type.

[56] Subsurface groundwater inflows to Chowchilla Subbasin include simulated inflows from the Delta-Mendota, Madera, and Merced subbasins.

Table 2-20. Chowchilla Subbasin Surface Outflows by Water Source Type (AF) (23 CCR §354.18(b)(1)).

Water Year	Local Supplies	CVP Supplies	Total
1989 (C)	0	0	0
1990 (C)	0	0	0
1991 (C)	240	0	240
1992 (C)	0	0	0
1993 (W)	535,240	66,690	601,930
1994 (C)	0	0	0
1995 (W)	524,170	176,640	700,810
1996 (W)	554,090	89,210	643,300
1997 (W)	516,760	356,340	873,100
1998 (W)	471,770	306,340	778,110
1999 (AN)	99,710	45,300	145,010
2000 (AN)	440	24,460	24,900
2001 (D)	300	560	860
2002 (D)	860	140	1,000
2003 (BN)	50	170	220
2004 (D)	0	320	320
2005 (W)	228,820	27,640	256,460
2006 (W)	792,690	195,090	987,780
2007 (C)	90	1,930	2,020
2008 (C)	0	0	0
2009 (BN)	0	0	0
2010 (AN)	430	7,470	7,900
2011 (W)	721,820	148,630	870,450
2012 (D)	170	4,330	4,500
2013 (C)	130	220	350
2014 (C)	0	0	0
2015 (C)	0	0	0
Average (1989-2014)	171,070	55,830	226,890
Average (1989-2014) W	543,170	170,820	713,990
Average (1989-2014) AN	33,530	25,740	59,270
Average (1989-2014) BN	30	90	110
Average (1989-2014) D	330	1,340	1,670
Average (1989-2014) C	50	240	290

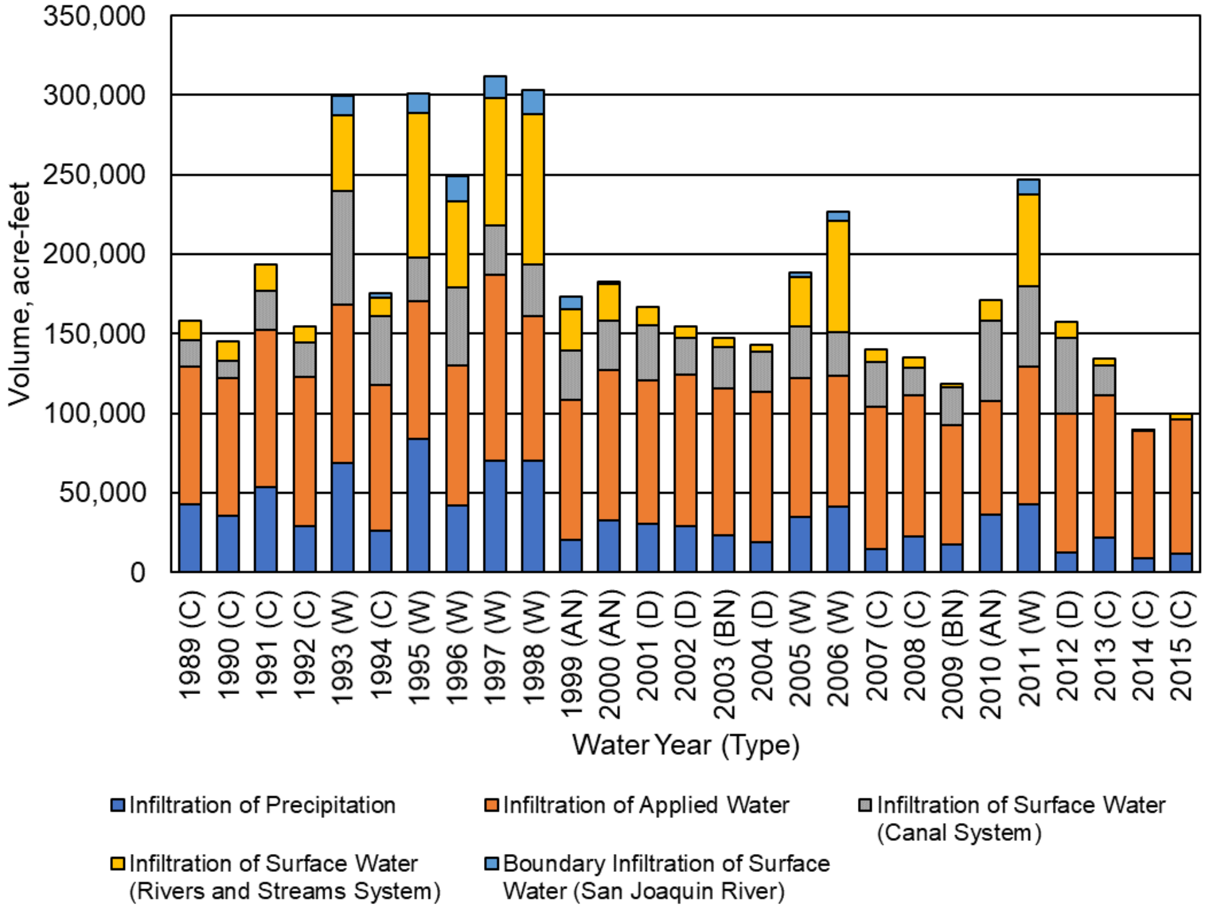

Figure 2-88. Chowchilla Subbasin Groundwater System Inflows.

Table 2-21. Chowchilla Subbasin Groundwater System Inflows (AF) (23 CCR §354.18(b)(2)).

Water Year (Type)	Net Subsurface Groundwater Inflow*	Infiltration of Precip	Infiltration of Applied Water	Infiltration of Surface Water (Canal System)	Infiltration of Surface Water (Rivers and Streams System)[1]
1989 (C)	*	42,470	87,050	16,410	11,930
1990 (C)	*	35,580	86,210	11,330	12,030
1991 (C)	*	53,200	99,140	25,590	16,740
1992 (C)	*	29,150	93,670	22,290	10,390
1993 (W)	*	68,910	99,510	74,020	59,820
1994 (C)	*	26,450	91,210	44,720	14,610
1995 (W)	*	83,880	86,780	30,630	103,330
1996 (W)	*	42,280	87,980	49,960	70,030
1997 (W)	*	70,440	116,280	32,210	94,033
1998 (W)	*	70,160	91,040	33,990	109,978
1999 (AN)	*	20,630	87,680	32,670	33,613
2000 (AN)	*	32,960	94,410	31,180	24,203

Water Year (Type)	Net Subsurface Groundwater Inflow*	Infiltration of Precip	Infiltration of Applied Water	Infiltration of Surface Water (Canal System)	Infiltration of Surface Water (Rivers and Streams System)[1]
2001 (D)	*	30,220	90,370	35,540	11,210
2002 (D)	*	28,890	95,360	24,450	6,950
2003 (BN)	*	23,120	92,400	28,280	5,820
2004 (D)	*	18,640	94,860	26,480	3,950
2005 (W)	*	34,490	87,680	34,660	33,930
2006 (W)	*	41,170	82,150	31,420	75,850
2007 (C)	*	14,710	89,190	28,890	7,900
2008 (C)	*	22,610	88,330	18,680	6,150
2009 (BN)	*	17,160	75,160	24,790	2,620
2010 (AN)	*	36,210	71,730	52,700	13,000
2011 (W)	*	42,450	86,770	54,170	66,610
2012 (D)	*	12,590	87,410	47,810	10,060
2013 (C)	*	22,000	89,080	18,840	4,330
2014 (C)	*	9,070	79,630	30	390
2015 (C)	*	11,500	84,610	10	3,770
Average (1989-2014)	47,280	35,750	89,660	31,990	31,130
Average (1989-2014) W	*	56,720	92,270	42,630	76,700
Average (1989-2014) AN	*	29,930	84,610	38,850	23,610
Average (1989-2014) BN	*	20,140	83,780	26,540	4,220
Average (1989-2014) D	*	22,590	92,000	33,570	8,040
Average (1989-2014) C[2]	*	28,360	89,280	20,750	9,390

*Year type values and averages are not reported because of the variable quality and timing of available groundwater level data and the resulting potential for biasing subsurface lateral flow calculations based on discrete snapshots of groundwater level conditions.
[1] Includes combined infiltration of surface water from the Subbasin Rivers and Streams System and boundary infiltration of surface water from the San Joaquin River.
[2]Average infiltration of precipitation higher in critical years due to relatively higher amounts of precipitation in 1989-1992.

2.2.3.4.4 Groundwater Extraction by Water Use Sector

Estimates of groundwater extraction by water use sector are provided in **Figure 2-89** and **Table 2-22**. For agricultural and urban (urban, semi-agricultural and industrial) lands, groundwater extraction represents pumping, while for native vegetation lands, groundwater extraction by riparian vegetation was considered to be minimal[57] because of the depth to groundwater in the Subbasin. Groundwater extraction is dominated by irrigated agriculture, varying substantially from year to year based on variability in surface water supplies and crop water demands.

[57] Groundwater extraction of native vegetation estimated by ET_{aw} from the Chowchilla IDC application is less than 5 AF/yr.

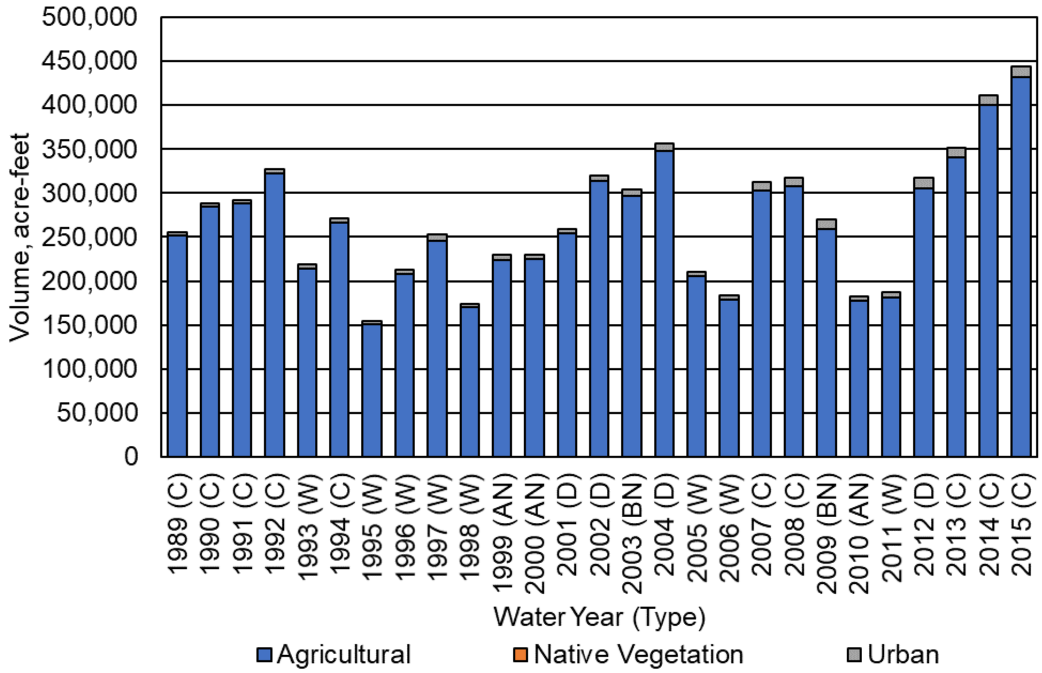

Figure 2-89. Chowchilla Subbasin Groundwater Extraction by Water Use Sector.

Table 2-22. Chowchilla Subbasin Groundwater Extraction by Water Use Sector (AF) (23 CCR §354.18(b)(3)).

Water Year	Agricultural	Native Vegetation	Urban	Total
1989 (C)	251,340	0	3,440	254,780
1990 (C)	283,970	0	3,760	287,730
1991 (C)	288,060	0	3,810	291,870
1992 (C)	321,910	0	4,930	326,840
1993 (W)	214,460	0	3,930	218,390
1994 (C)	266,480	0	4,880	271,360
1995 (W)	151,330	0	2,640	153,970
1996 (W)	208,230	0	4,030	212,260
1997 (W)	245,760	0	6,650	252,410
1998 (W)	170,840	0	3,470	174,310
1999 (AN)	224,000	0	5,620	229,620
2000 (AN)	224,830	0	4,950	229,780
2001 (D)	254,620	0	4,820	259,440
2002 (D)	313,640	0	6,580	320,220
2003 (BN)	296,800	0	6,670	303,470
2004 (D)	347,970	0	8,830	356,800
2005 (W)	205,020	0	5,790	210,810
2006 (W)	178,220	0	5,820	184,040
2007 (C)	303,090	-10	9,640	312,720
2008 (C)	307,660	0	9,920	317,580
2009 (BN)	259,520	0	10,010	269,530
2010 (AN)	177,000	0	5,920	182,920
2011 (W)	181,040	0	6,570	187,610
2012 (D)	305,780	0	11,110	316,890
2013 (C)	340,050	0	11,150	351,200

Water Year	Agricultural	Native Vegetation	Urban	Total
2014 (C)	399,610	0	10,960	410,570
2015 (C)	432,110	0	12,080	444,190
Average (1989-2014)	258,510	0	6,380	264,890
Average (1989-2014) W	194,360	0	4,860	199,230
Average (1989-2014) AN	208,610	0	5,500	214,100
Average (1989-2014) BN	278,160	0	8,340	286,490
Average (1989-2014) D	305,500	0	7,840	313,340
Average (1989-2014) C	306,910	0	6,940	313,850

2.2.3.4.5 Groundwater Discharge to Surface Water Sources

The depth to groundwater is greater than 100-200 ft across much of the Chowchilla Subbasin. Given the substantial depth to the water table, groundwater discharge to surface water sources is negligible.

2.2.3.4.6 Evapotranspiration by Water Use Sector

Total evapotranspiration (ET) by water use sector is reported in **Figure 2-90** and **Table 2-23**. Total ET varies between years but has gradually increased over time due to changes in crops, with the lowest observed in 1989, at approximately 300 taf, and the greatest in 2015, at over 400 taf. Agricultural ET tends to increase in drier years, while native vegetation ET decreases.

In addition to total ET from land surfaces, estimates of evaporation from rivers and streams are reported in **Figure 2-91** and **Table 2-24**. Evaporation is highest in wet years when surface water inflows are typically higher, averaging approximately 2.5 taf overall.

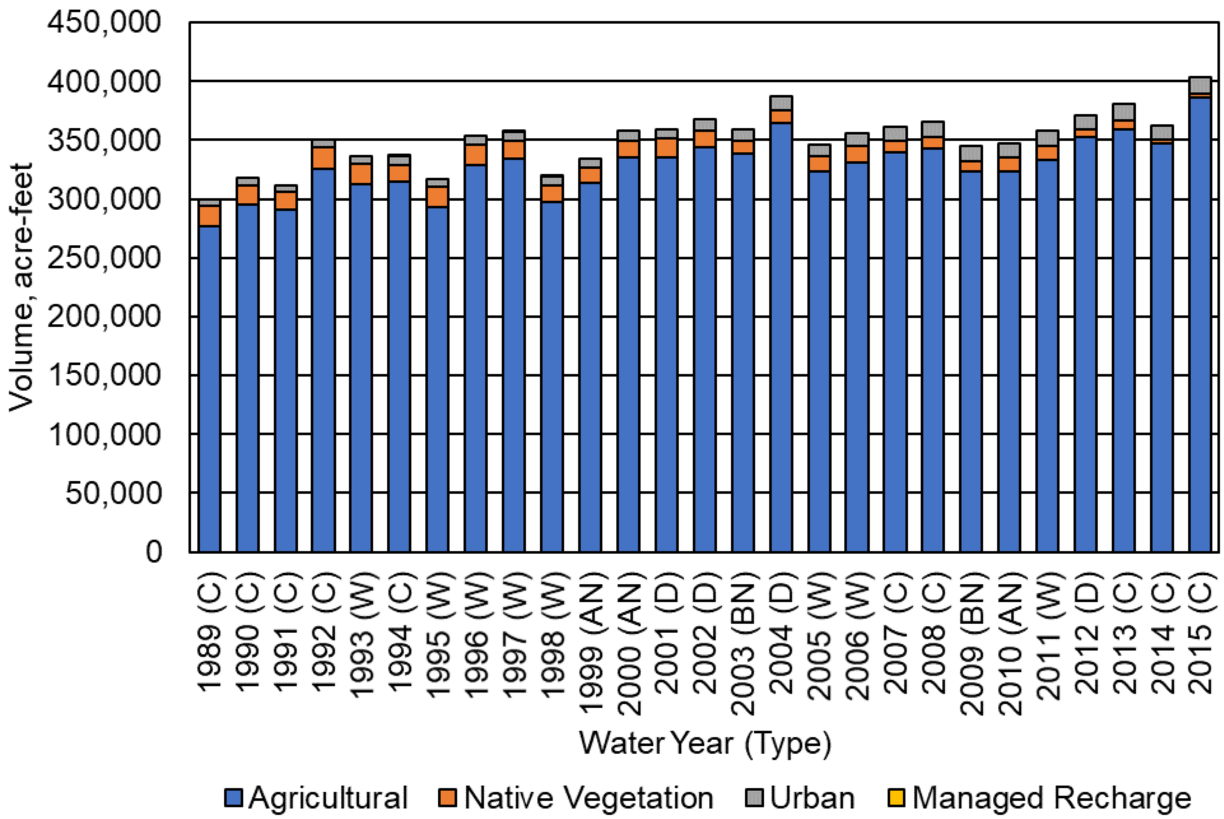

Figure 2-90. Chowchilla Subbasin Total Evapotranspiration by Water Use Sector.

Table 2-23. Chowchilla Subbasin Total Evapotranspiration by Water Use Sector (AF) (23 CCR §354.18(b)(3)).

Water Year	Agricultural	Native Vegetation	Urban	Managed Recharge	Total
1989 (C)	277,050	16,730	5,960	0	299,740
1990 (C)	295,140	16,670	6,360	0	318,170
1991 (C)	290,960	14,820	5,780	0	311,560
1992 (C)	325,520	18,030	7,230	0	350,780
1993 (W)	312,470	17,220	7,080	0	336,770
1994 (C)	314,570	14,280	7,190	10	336,050
1995 (W)	293,420	16,550	6,750	0	316,720
1996 (W)	328,400	17,490	7,450	0	353,340
1997 (W)	333,910	15,470	8,070	20	357,470
1998 (W)	297,250	14,180	7,230	30	318,690
1999 (AN)	313,390	12,940	7,480	0	333,810
2000 (AN)	335,290	14,130	8,160	0	357,580
2001 (D)	335,770	15,330	8,260	0	359,360
2002 (D)	343,980	14,250	9,370	0	367,600
2003 (BN)	338,240	11,140	9,630	0	359,010
2004 (D)	364,120	11,820	11,320	0	387,260
2005 (W)	323,270	12,920	10,430	0	346,620
2006 (W)	331,270	13,790	11,180	0	356,240
2007 (C)	339,570	10,030	11,680	0	361,280
2008 (C)	342,680	10,050	13,240	0	365,970

Water Year	Agricultural	Native Vegetation	Urban	Managed Recharge	Total
2009 (BN)	323,520	8,170	13,500	0	345,190
2010 (AN)	323,730	11,330	12,590	0	347,650
2011 (W)	333,570	11,790	13,220	0	358,580
2012 (D)	353,050	6,230	12,310	0	371,590
2013 (C)	359,330	7,040	14,320	0	380,690
2014 (C)	347,440	3,400	11,990	0	362,830
2015 (C)	386,190	3,610	13,350	0	403,150
Average (1989-2014)	326,040	12,920	9,530	0	348,480
Average (1989-2014) W	319,200	14,930	8,930	10	343,050
Average (1989-2014) AN	324,140	12,800	9,410	0	346,350
Average (1989-2014) BN	330,880	9,660	11,570	0	352,100
Average (1989-2014) D	349,230	11,910	10,320	0	371,450
Average (1989-2014) C	321,360	12,340	9,310	0	343,010

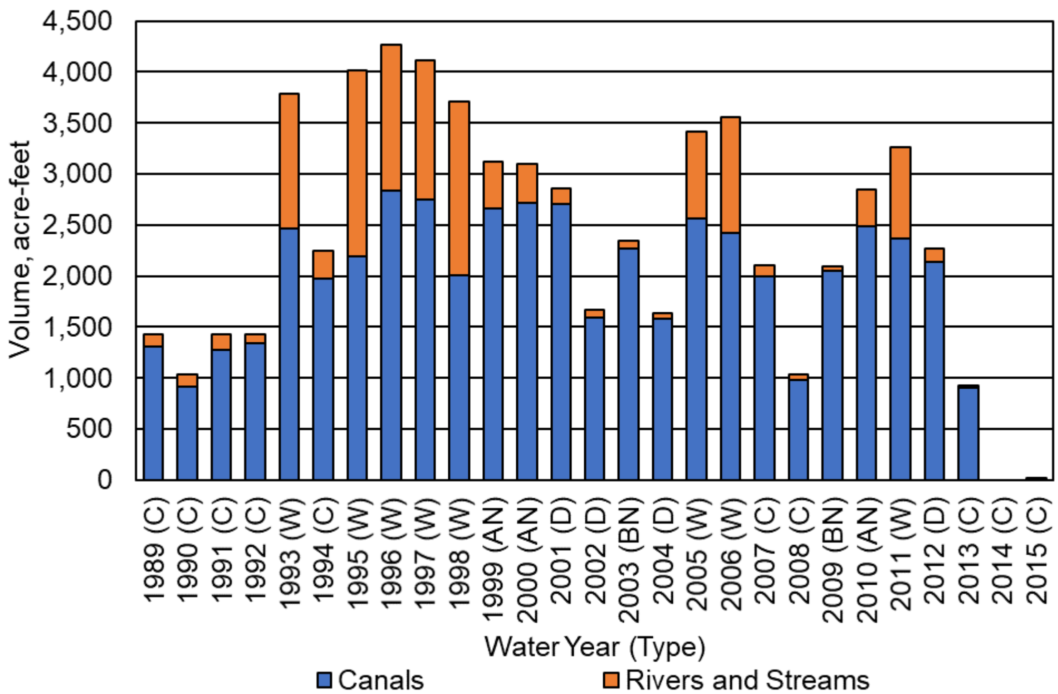

Figure 2-91. Chowchilla Subbasin Evaporation from the Surface Water System.

Table 2-24. Chowchilla Subbasin Evaporation from the Surface Water System (AF) (23 CCR §354.18(b)(3)).

Water Year	Canals	Rivers and Streams	Total
1989 (C)	1,310	120	1,430
1990 (C)	910	130	1,040
1991 (C)	1,270	160	1,430
1992 (C)	1,340	90	1,430
1993 (W)	2,460	1,330	3,790
1994 (C)	1,970	270	2,240
1995 (W)	2,190	1,820	4,010
1996 (W)	2,840	1,430	4,270
1997 (W)	2,750	1,360	4,110
1998 (W)	2,010	1,700	3,710
1999 (AN)	2,660	460	3,120
2000 (AN)	2,720	380	3,100
2001 (D)	2,710	150	2,860
2002 (D)	1,590	80	1,670
2003 (BN)	2,270	80	2,350
2004 (D)	1,580	50	1,630
2005 (W)	2,560	860	3,420
2006 (W)	2,420	1,140	3,560
2007 (C)	2,000	100	2,100
2008 (C)	980	50	1,030
2009 (BN)	2,050	40	2,090
2010 (AN)	2,490	360	2,850
2011 (W)	2,370	890	3,260
2012 (D)	2,140	130	2,270
2013 (C)	900	30	930
2014 (C)	0	0	0
2015 (C)	0	20	20
Average (1989-2014)	1,940	510	2,450
Average (1989-2014) W	2,450	1,320	3,770
Average (1989-2014) AN	2,620	400	3,020
Average (1989-2014) BN	2,160	60	2,220
Average (1989-2014) D	2,010	100	2,110
Average (1989-2014) C	1,190	110	1,290

2.2.3.4.7 Change in Storage

Estimates of average annual change in storage within the GWS are summarized for each water budget scenario in **Table 2-27**.

2.2.3.4.8 Historical Water Budget Summary

Annual inflows, outflows, and change in SWS storage under historical conditions in the Chowchilla Subbasin SWS are summarized in **Figure 2-92**. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. Review of the variability in component volumes across years provides insight into the impacts of hydrology on the surface water system water budget and opportunities for projects to increase groundwater recharge and the sustainable yield.

Detailed historical water budget components in each subregion are summarized in detail in **Appendices 2.F.a.** through **2.F.e.**

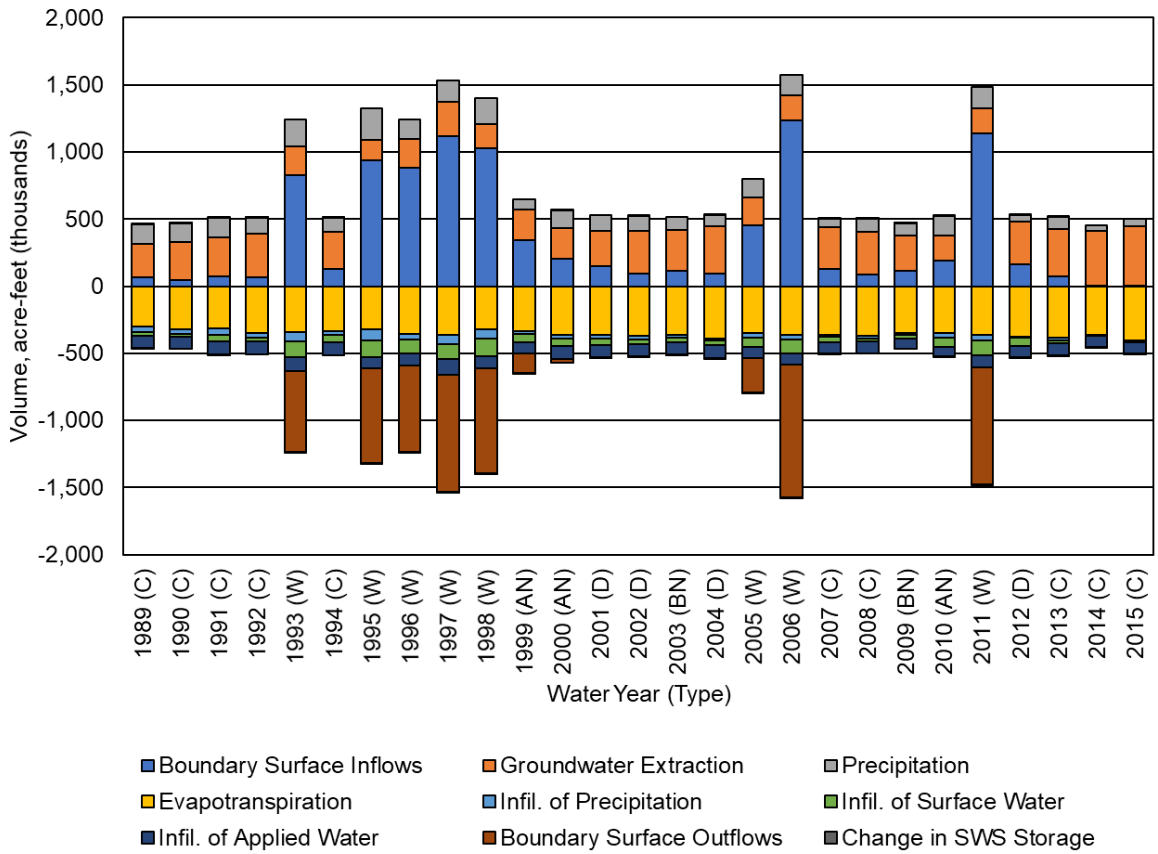

Figure 2-92. Chowchilla Subbasin Surface Water System Historical Water Budget.

2.2.3.4.9 Current Water Budget Summary

Annual inflows, outflows, and change in SWS storage under current land use conditions in the Chowchilla Subbasin SWS are summarized in **Figure 2-93**. Inflows are shown as positive values, while outflows and change in SWS storage are shown as negative values. Review of the variability in component volumes across years provides insight into the impacts of current land use on SWS inflows and outflows over time.

Detailed current water budget components in each subregion are summarized in detail in **Appendices 2.F.a.** through **2.F.e.**

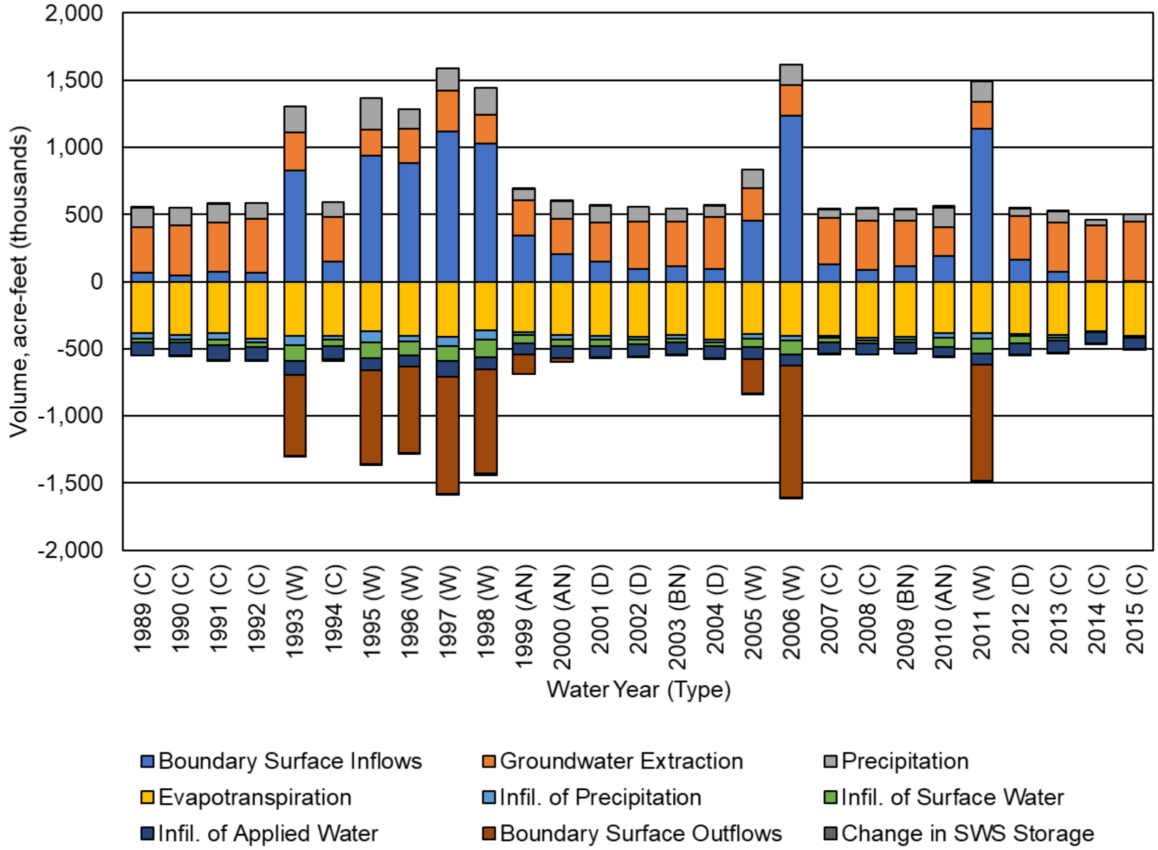

Figure 2-93. Chowchilla Subbasin Surface Water System Current Water Budget.

2.2.3.4.10 Projected Water Budget Development

Water budgets were projected into the future to estimate future water demands under different future scenarios and to evaluate the potential effects of different management actions and implementation of different projects.

Two primary projected water budget scenarios were considered: a projected without projects (no action) scenario, and a projected with projects scenario. Both these projected scenarios were also considered in the context of potential climate change effects on surface water supply and weather parameters.

Two major time periods exist in the future projected model: the implementation period (2020-2039), during which PMAs are implemented to bring the basin into sustainability, and the sustainability period (2040-2090), after which PMAs have been fully implemented.

The development of the projected future scenarios is described in detail in **Appendix 6.D.**, Groundwater Model Documentation. The development of projected time series for precipitation, evapotranspiration, and surface water flows are briefly summarized in **Tables 2-25** and **2-26** below.

Table 2-25. Development of Projected Future Precipitation and Evapotranspiration Time Series.

Water Budget Component	Without Climate Change Adjustments		With Climate Change Adjustments	
	Implementation Period	Sustainability Period	Implementation Period	Sustainability Period
	(2020-2039)	(2040-2090)	(2020-2039)	(2040-2090)
Precipitation	2001-2010 historical data (2020-2029 and 2030-2039)	1965-2015 historical data (2040-2090)	2001-2010 historical data (2020-2029 and 2030-2039) adjusted by CalSim II 2030 monthly change factors by water year type	1965-2015 historical data (2040-2090) adjusted by CalSim II 2030 monthly change factors by water year type
Evapotranspiration	2001-2010 historical data (2020-2029 and 2030-2039), assuming 2017 land use adjusted for projected urban area growth from 2017-2039	1965-2015 historical data, assuming 2017 land use adjusted for projected urban area growth from 2017-2070 (urban area constant from 2071-2090)	2001-2010 historical data (2020-2029 and 2030-2039) adjusted by CalSim II 2030 monthly change factors by water year type, assuming 2017 land use adjusted for projected urban area growth from 2017-2039	1965-2015 historical data (2040-2090) adjusted by CalSim II 2030 monthly change factors by water year type, assuming 2017 land use adjusted for projected urban area growth from 2017-2070 (urban area constant from 2071-2090)

Table 2-26. Development of Projected Future Surface Water Supply Time Series.

Water Budget Component	Without Climate Change Adjustments		With Climate Change Adjustments	
	Implementation Period	Sustainability Period	Implementation Period	Sustainability Period
	(2020-2039)	(2040-2090)	(2020-2039)	(2040-2090)
Surface Water Inflow – Unimpaired Streams	2001-2010 historical data (2020-2029 and 2030-2039)	1965-2015 historical data (2040-2090)	2001-2010 historical data (2020-2029 and 2030-2039) adjusted by CalSim II 2030 monthly streamflow change factors by water year type	1965-2015 historical data (2040-2090) adjusted by CalSim II 2030 monthly streamflow change factors by water year type
Surface Water Inflow – Chowchilla River (Buchanan Dam Releases)	2001-2010 historical data (2020-2029 and 2030-2039)	1965-2015 historical data (2040-2090)	2001-2010 data (2020-2029 and 2030-2039): 2001-2003 historical data adjusted by CalSim II 2030 climate change projections for Eastman Lake; 2004-2010 data estimated as the historical volume adjusted by the average monthly climate-adjusted volume by water year type	1965-2003 historical data (2040-2078) adjusted by CalSim II 2030 climate change projections for Eastman Lake; 2004-2015 data (2079-2090) estimated as the historical volume adjusted by the average monthly climate-adjusted volume by water year type

Water Budget Component	Without Climate Change Adjustments		With Climate Change Adjustments	
	Implementation Period	Sustainability Period	Implementation Period	Sustainability Period
	(2020-2039)	(2040-2090)	(2020-2039)	(2040-2090)
Surface Water Inflow – Fresno River (Hidden Dam Releases)	2001-2010 historical data (2020-2029 and 2030-2039)	1965-2015 historical data (2040-2090)	2001-2010 data (2020-2029 and 2030-2039): 2001-2003 historical data adjusted by CalSim II 2030 climate change projections for Hensley Lake; 2004-2010 data estimated as the historical volume adjusted by the average monthly climate-adjusted volume by water year type	1965-2003 historical data (2040-2078) adjusted by CalSim II 2030 climate change projections for Hensley Lake; 2004-2015 data (2079-2090) estimated as the historical volume adjusted by the average monthly climate-adjusted volume by water year type
Surface Water Inflow – San Joaquin River (Friant Dam Releases)	Estimated based on the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	Estimated based on the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	2001-2010 data (2020-2029 and 2030-2039): 2001-2003 data provided by Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2010 data estimated as the historical volume adjusted by the average Friant Report volume by month and water year type	1965-2003 data (2040-2078) provided by Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2015 data (2079-2090) estimated as the historical volume adjusted by the average Friant Report volume by month and water year type
Surface Water Inflow – Chowchilla Bypass	Estimated based on the historical monthly ratio of Chowchilla Bypass (CBP) and San Joaquin River (SJR) flows, with projected SJR inflow data provided by the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	Estimated based on the historical monthly ratio of CBP and SJR flows, with projected SJR inflow data provided by the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	2001-2010 data (2020-2029 and 2030-2039): 2001-2003: estimated based on the historical monthly ratio of CBP and SJR flows by water year type, with projected SJR inflow data provided by the Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2010: estimated based on the historical monthly ratio of CBP to SJR flows by water year type, with average projected SJR inflows calculated from 1921-2003 by month and water year type	1965-2003 (2040-2078): estimated based on the historical monthly ratio of CBP to SJR flows by water year type, with projected SJR inflow data provided by the Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2015 (2079-2090): estimated based on the historical monthly ratio of CBP to SJR flows by water year type, with average projected SJR inflows calculated by month and water year type

Water Budget Component	Without Climate Change Adjustments		With Climate Change Adjustments	
	Implementation Period	Sustainability Period	Implementation Period	Sustainability Period
	(2020-2039)	(2040-2090)	(2020-2039)	(2040-2090)
Diversions from Madera Canal	Estimated based on the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	Estimated based on the Friant Water Authority Report* (same as the implementation period with climate change adjustments**, see right)	2001-2010 data (2020-2029 and 2030-2039): 2001-2003 data provided by Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2010 data estimated as the historical volume adjusted by the average Friant Report climate change volume by month and water year type	1965-2003 data (2040-2078) provided by Friant Water Authority Report*, considering the CalSim II 2030 climate change projections and implementation of the SJRRP; 2004-2015 data (2079-2090) estimated as the historical volume adjusted by the average Friant Report climate change volume by month and water year type
Other Diversions/ Bypasses	2001-2010 historical data (2020-2029 and 2030-2039)	1965-2015 historical data (2040-2090)	2001-2010 historical data (2020-2029 and 2030-2039)***	1965-2015 historical data (2040-2090)***

* "Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California," Friant Water Authority, 2018.

** Although the Friant Water Authority Report (or Friant Report) accounts for climate change, it is considered the best available estimate of projected Madera Canal deliveries under SJRRP. For comparison, projected Madera Canal deliveries under SJRRP were also estimated without account for climate change from the Steiner Report Kondolf Hydrograph (Steiner, 2005). These estimates were approximately equal to the Friant Report 2030 climate change adjusted deliveries. Thus, the Friant Report projections were used instead to maintain consistent assumptions in estimating Madera Canal deliveries across all projected simulations.

*** Historical volumes specified in the model to ensure that GSAs can use as much surface water as is available in a given time step up to the maximum historical surface water used.

2.2.3.4.11 Comparison of Water Budget Scenarios

Table 2-27 provides a summary of the average annual inflows, outflows, change in groundwater storage, and overdraft estimated at the Subbasin-level in the historical, current, projected without projects, and projected with projects water budgets. This table also provides an estimate of Subbasin sustainable yield from the projected with projects water budget.

Table 2-27. Comparative Summary of all Water Budget Scenarios, Annual Average Volumes by Flow Path (AF).

23 CCR Section	Flow Path Direction (Relative to GWS)	Flow Path	Water Budget Period: Historical 1989-2014	Current 2017 land use, 1989-2014 average hydrology/supply	Projected, No Action 2040-2090	Projected, With Projects 2040-2090	Reason for Difference from Historical
354.18(b)(1)	N/A (SWS flow path)	Surface Water Inflows	374,400	374,400	329,200	309,600	Decrease due to SJRRP (Projected), upstream (Madera Subbasin) GSP project diversions (With Projects)
		Local Supplies	*182,900*	*182,900*	*143,600*	*123,100*	Decrease in Chowchilla Bypass flows with SJRRP (Projected), upstream (Madera Subbasin) GSP project diversions (With Projects)
		CVP Supplies	*191,500*	*191,500*	*185,600*	*186,500*	Decrease in CVP deliveries with SJRRP (Projected)
354.18(b)(1)	N/A (SWS flow path)	Surface Water Outflows	226,900	226,900	206,100	129,200	Decrease due to decreased surface water inflows described above (Projected), upstream (Madera Subbasin) GSP project diversions (With Projects)
		Local Supplies	*171,100*	*171,100*	*187,000*	*117,200*	
		CVP Supplies	*55,800*	*55,800*	*19,100*	*12,000*	
Implied	N/A (SWS flow path)	Precipitation	124,200	124,300	144,100	144,100	Increase due to higher proportion of W water years anticipated in projected period (35% of years, versus 31% in historical period)
354.18(b)(2)	Inflow	Infiltration of Surface Water	63,100	62,100	67,200	120,500	Increase due to infiltration of GSP projects (With Projects)
354.18(b)(2)	Inflow	Infiltration of Applied Water	89,700	89,300	83,000	82,300	Decrease due to urban growth (Projected), demand management (with Projects)
354.18(b)(2)	Inflow	Infiltration of Precipitation	35,700	33,700	34,500	38,400	N/A

23 CCR Section	Flow Path Direction (Relative to GWS)	Flow Path	Water Budget Period: Historical, 1989-2014	Current, 2017 land use, 1989-2014 average hydrology/supply	Projected, No Action, 2040-2090	Projected, With Projects, 2040-2090	Reason for Difference from Historical
354.18(b)(3)	N/A (SWS flow path)	Evapotranspiration	350,900	398,000	394,300	369,500	Increase due to cropping (Current; Projected, No Action); Decrease due to demand management (Projected, With Projects)
354.18(b)(3)	Outflow	GW Pumping	264,900	307,600	297,800	248,500	Increase due to cropping (Current; Projected, No Action); Decrease due to demand management (Projected, With Projects)
354.18(b)(3)	Outflow	GW Discharge to Surface Water Sources	0	0	0	0	Low groundwater levels
354.18(b)(2),(3)	Inflow (Net)	Net Subsurface Inflow	47,300	N/A[1]	71,400	9,700	Increase due to low groundwater levels (Projected, No Action); Decrease due to GSP projects and management actions used to achieve sustainability (Projected, With Projects)
354.18(b)(4)	Inflows – Outflows	Average Annual Change in Groundwater Storage	-29,100	N/A[1]	-41,700	2,400	Decrease due to cropping and related groundwater extraction (Current; Projected, No Action); Increase due to GSP projects and management actions used to achieve sustainability (Projected, With Projects)
354.18(b)(5)	Inflows – Outflows	Average Overdraft	-29,100	N/A[1]	-41,700	2,400	Changes due to reasons above.

[1]Net subsurface inflow not estimated for current water budget due to uncertainties in adjacent basin groundwater conditions.

2.2.3.4.12 Overdraft Conditions

Overdraft is defined in DWR Bulletin 118 as "the condition of a groundwater basin or subbasin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years, during which the water supply conditions approximate average conditions" (DWR, 2003). The Chowchilla Subbasin water budget indicates that overdraft conditions occurred during the 1989-2014 historical base period. Per 23 CCR § 354.18(b)(5), the Subbasin overdraft has been quantified for this period. Overdraft is calculated as the sum of all outflows from the groundwater system, including groundwater extraction and subsurface outflow, minus the sum of all inflows to the groundwater system, including infiltration from all sources and subsurface inflow.

The average Subbasin overdraft is presented below for 1989-2014 based on the historical water budget (**Table 2-28**) and current land use water budget (**Table 2-29**).

2.2.3.4.13 Net Recharge from SWS

For estimates of the SWS contribution to overdraft, the term net recharge from the SWS is defined as groundwater recharge minus groundwater extraction. Net recharge from the SWS is useful for understanding and analyzing the combined effects of land surface processes on the underlying GWS.

When calculated from the historical water budget, average net recharge from the SWS represents the average recharge (when positive) or shortage (when negative) of recharge from the SWS based on historical cropping, land use practices, and average hydrologic conditions. When calculated from the current land use water budget, average net recharge represents the average recharge or shortage based on current cropping, land use practices, and average hydrologic conditions.

Table 2-28. Historical Water Budget: Average Overdraft by Water Year Type, 1989-2014 (AF) (23 CCR §354.18(b)(5)).

Year Type	Number of Years	Net Subsurface Groundwater Inflow (a)	Infiltration of Applied Water (b)	Infiltration of Precipitation (c)	Infiltration of Surface Water[1] (d)	Groundwater Extraction (e)	Overdraft (a+b+c+d-e)
W	8	*	92,270	56,720	119,330	199,230	*
AN	3	*	84,610	29,930	62,460	214,100	*
BN	2	*	83,780	20,140	30,760	286,490	*
D	4	*	92,000	22,580	41,610	313,340	*
C	9	*	89,280	28,360	30,140	313,850	*
Annual Average (1989-2014)	26	47,280[2]	89,660	35,750	63,120	264,890	-29,080

* Year type values and averages are not reported because of the variable quality and timing of available groundwater level data and the resulting potential for biasing subsurface lateral flow calculations based on discrete snapshots of groundwater level conditions.

[1] Includes infiltration of surface water from the Canal System and Rivers and Streams System, and boundary infiltration of surface water from San Joaquin River.

[2]Significant uncertainty in net groundwater inflow arises from the use of different methods/tools and boundary assumptions in groundwater system analysis. As a result, net subsurface inflow has been revised since initial presentation based on additional groundwater modeling resulting in a lower overdraft than was originally presented.

Table 2-29. Current Land Use Water Budget: Average Overdraft by Water Year Type, 1989-2014 (AF) (23 CCR §354.18(b)(5)).

Year Type	Number of Years	Subsurface Groundwater Inflow (a)	Infiltration of Applied Water (b)	Infiltration of Precipitation (c)	Infiltration of Surface Water[1] (d)	Groundwater Extraction (e)	Overdraft (a+b+c+d-e)
W	8	*	92,140	53,830	118,190	239,510	*
AN	3	*	82,150	28,240	62,000	245,370	*
BN	2	*	84,180	18,710	30,140	336,830	*
D	4	*	86,190	20,940	41,120	340,770	*
C	9	*	91,730	26,550	28,700	367,580	*
Annual Average (1989-2014)	26	N/A[2]	89,320	33,670	62,100	307,580	N/A[2]

* Year type values and averages are not reported because of the variable quality and timing of available groundwater level data and the resulting potential for biasing subsurface lateral flow calculations based on discrete snapshots of groundwater level conditions.
[1] Includes infiltration of surface water from the Canal System and Rivers and Streams System, and boundary infiltration of surface water from San Joaquin River.
[2] Net subsurface inflow not estimated for current water budget due to uncertainties in adjacent basin groundwater conditions.

Average net recharge from the SWS is presented below for 1989-2014 based on the historical water budget (**Table 2-30**) and current land use water budget (**Table 2-31**). Historically, average annual net recharge from the SWS in the Chowchilla Subbasin was approximately -76 taf between 1989 and 2014. Under current land use conditions, average net recharge from the SWS in the Chowchilla Subbasin has decreased to approximately -122 taf.

Table 2-30. Historical Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (AF).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	92,270	56,720	119,330	199,230	69,090
AN	3	84,610	29,930	62,460	214,100	-37,100
BN	2	83,780	20,140	30,760	286,490	-151,810
D	4	92,000	22,580	41,610	313,340	-157,150
C	9	89,280	28,360	30,140	313,850	-166,070
Annual Average (1989-2014)	26	89,660	35,750	63,120	264,890	-76,360

[1] Includes infiltration of surface water from the Canal System and Rivers and Streams System, and boundary infiltration of surface water from San Joaquin River.

Table 2-31. Current Land Use Water Budget: Average Net Recharge from SWS by Water Year Type, 1989-2014 (AF).

Year Type	Number of Years	Infiltration of Applied Water (a)	Infiltration of Precipitation (b)	Infiltration of Surface Water[1] (c)	Groundwater Extraction (d)	Net Recharge from SWS (a+b+c-d)
W	8	92,140	53,830	118,190	239,510	24,650
AN	3	82,150	28,240	62,000	245,370	-72,980
BN	2	84,180	18,710	30,140	336,830	-203,800
D	4	86,190	20,940	41,120	340,770	-192,520
C	9	91,730	26,550	28,700	367,580	-220,600
Annual Average (1989-2014)	26	89,320	33,670	62,100	307,580	-122,490

[1] Includes infiltration of surface water from the Canal System and Rivers and Streams System, and boundary infiltration of surface water from San Joaquin River.

2.2.3.4.14 Annual Supply, Demand, and Change in Groundwater Stored by Water Year Type

Annual supply, demand, and change in groundwater stored is summarized by water year type in **Table 2-32** for historical, current, projected without projects (no action), and projected with projects conditions.

Table 2-32. Comparative Summary of Annual Supply, Demand, and Change in Storage by Water Year Type (AFY) (23 CCR §354.18(b)(6)).

Water Year Type	Water Budget Element	Water Budget Flow Paths	Water Budget Period			
			Historical	Current	Projected, No Action	Projected, With Projects
			1989-2014	2017 land use, 1989-2014 average hydrology/supply	2040-2090	2040-2090
W	Supply	Surface Water Inflows	952,000	952,000	702,000	638,900
	Supply	Precipitation	173,400	173,400	201,900	201,900
	Demand	Evapotranspiration	346,800	393,200	392,300	366,300
	Change in Storage	Change in Groundwater Storage	106,900	N/A[1]	92,300	289,900
AN	Supply	Surface Water Inflows	246,100	246,100	243,900	260,800
	Supply	Precipitation	119,600	119,600	145,500	145,500
	Demand	Evapotranspiration	349,400	387,900	398,700	372,300
	Change in Storage	Change in Groundwater Storage	-4,200	N/A[1]	-8,900	-54,200
BN	Supply	Surface Water Inflows	111,500	111,500	119,800	118,600
	Supply	Precipitation	91,600	91,600	115,500	115,500
	Demand	Evapotranspiration	354,300	407,100	400,100	375,200
	Change in Storage	Change in Groundwater Storage	-93,800	N/A[1]	-106,900	-138,900

Water Year Type	Water Budget Element	Water Budget Flow Paths	Water Budget Period			
			Historical	Current	Projected, No Action	Projected, With Projects
			1989-2014	2017 land use, 1989-2014 average hydrology/supply	2040-2090	2040-2090
D	Supply	Surface Water Inflows	124,100	124,100	124,900	127,800
	Supply	Precipitation	91,800	91,800	105,700	105,700
	Demand	Evapotranspiration	373,600	408,900	407,200	380,100
	Change in Storage	Change in Groundwater Storage	-109,500	N/A[1]	-121,900	-182,400
C	Supply	Surface Water Inflows	66,300	66,300	69,000	69,200
	Supply	Precipitation	99,200	99,200	99,200	99,200
	Demand	Evapotranspiration	350,200	399,300	385,600	364,500
	Change in Storage	Change in Groundwater Storage	-121,100	N/A[1]	-165,800	-192,900

[1]Net subsurface inflow not estimated for current water budget due to uncertainties in adjacent basin groundwater conditions.

2.2.3.4.15 Subbasin Sustainable Yield Estimate.

The GSP regulations require the water budget to quantify the sustainable yield for the Subbasin. Sustainable yield is defined as “the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result” (CWC Section 10721(w)).

Sustainable yield is dependent upon conditions in existence at the time, and therefore changes during the implementation period as projects are completed, increasing recharge or leading to reductions in demand. As such, sustainable yield was only calculated for the sustainability period during which all identified projects would be fully operational (2040-2090).

For the 2040-2090 period, model results demonstrate that sustainability indicator MTs and associated undesirable results are avoided by the combined effects of the project implementation schedule and the mitigation program for domestic wells described in this GSP. Thus, the sustainable yield for this 2040-2090 projected period is the quantity of groundwater “…that can be withdrawn annually from a groundwater supply without causing an undesirable result” (CWC Section 10721(w)). In alignment with the GSP regulations and DWR’s Sustainable Management Criteria BMP (DWR, 2017), sustainable yield has been calculated for the 2040-2090 projected period (**Table 2-33**) with a single value of sustainable yield for the Subbasin as a whole (DWR, 2017).

The sustainable yield is estimated as the average annual groundwater extraction during the projected 2040-2090 period. This projected groundwater extraction equals the sum of the average annual recharge without projects and the average annual net project infiltration during the projected period. Since average groundwater inflows approximately equal outflows during the 2040-2090 period, the average annual change in the groundwater storage was assumed to be zero over this 50-year period. By this method, sustainable yield is estimated to be 245,700 AFY. Accounting for all uncertainties in GWS inflows and outflows, the sustainable yield is estimated to range between 184,300 AF and 307,100 AFY.

Table 2-33. Summary of Sustainable Yield Estimates from Projected with Projects Water Budget (23 CCR §354.18(b)(7)).

Quantification Method	Average Volume, 2040-2090 (AF)	Estimated Confidence Interval[1] (percent)	Average minus CI (AF)	Average plus CI (AF)
Groundwater Extraction	245,700	25%	184,300	307,100

[1] Confidence interval source: Professional judgment based on historical calculations.

2.2.3.4.16 Surface Water Available for Groundwater Recharge

Implementation of the GSP will require the Chowchilla Subbasin to be operated within its sustainable yield by 2040. To achieve this, GSAs may implement projects to restrict groundwater pumping or to increase groundwater recharge.

There are five potential sources of water available for groundwater recharge projects: Buchanan flood releases, Madera Canal flood releases, Eastside Bypass flows, additional CVP diversions, and water purchased from outside the Subbasin.

Buchanan flood releases include designated flood releases from Buchanan Dam along the Chowchilla River and exclude irrigation releases to CWD. During the historical base period (1989-2014), Buchanan flood releases occurred during six of eight years classified as wet and one year classified as above normal by DWR's San Joaquin River Water Year Index. The average annual inflow volume during the historical base period was 61 taf during wet years and 2 taf during above normal years. Across the 1965-2015 projected dataset used to develop the 2019-2090 projected water budgets (historical hydrologic and water supply data, as described in Section 2.2.3.2), Buchanan flood releases are expected during 11 out of 18 wet years (averaging 46 taf per wet year) and during 2 out of 7 above normal years (averaging 2 taf per above normal year).

Madera Canal flood releases are comprised of flood releases to the Chowchilla Subbasin along Madera Canal (including Section 215 water[58], 16(b) water[59], or other sources of CVP yield determined by Reclamation to be available to its contractors). During the historical base period, Madera Canal flood releases occurred in 8 of 26 years. Seven of these years were classified as wet years (33 taf per year on average), while the remaining year was classified as above normal (6 taf per year). Madera Canal flood releases are projected to occur in an estimated 21 years out of 51 years of the 1965-2015 projected dataset used to develop the 2019-2090 projected water budgets.

Eastside Bypass flows include all water entering the Subbasin along Fresno River and Chowchilla Bypass downstream of Madera Subbasin. During the historical base period, combined flood inflows from the

[58] Reclamation Reform Act of 1982, Section 215 allows delivery of large, temporary, and non-storable water supplies to land that is otherwise ineligible to receive federal water.

[59] San Joaquin River Restoration Settlement, Paragraph 16(b): Recovered Water Account.

Chowchilla Bypass and Fresno River[60] are available in eight wet years and three above normal years, averaging approximately 680 taf and 54 taf across all wet and above normal years, respectively. Eastside Bypass flows are projected to occur during wet and above normal years, which include 25 out of 51 total years of the 1965-2015 projected dataset used to develop the 2019-2090 projected water budgets. It is important to note that when water historically flows in the Chowchilla Bypass, the major contributor to Eastside Bypass flow, the duration of flow averages approximately 40 days.

The remaining potential sources of water available for groundwater recharge – additional CVP diversions and purchased water – are new sources of water that would be brought into the Subbasin to supply GSP projects.

2.2.4 Management Areas (23 CCR § 354.20)

SGMA regulations allow for a GSA or group of GSAs in a subbasin to decide if designation of Management Areas will help facilitate implementation of the GSP. Options for use of Management Areas and potential areas to be covered by potential Management Areas were discussed among GSA representatives and the GSP consultant team and in public meetings. The Chowchilla Subbasin GSAs decided to designate two Management Areas: A Western Management Area (WMA) comprised of Triangle T Water District GSA and Madera County GSA – West, and an Eastern Management Area (EMA) comprised of Chowchilla Water District, Madera County GSA – East, and Sierra Vista Mutual Water Company (Merced County GSA and portion of Madera County GSA – East) (**Figure 2-94**).

The primary reason for creation of these two Management Areas was differences in historical and recent subsidence impacts. The amount of subsidence occurring in the Western Management Area has resulted in significant impacts to infrastructure. While some amount of subsidence has also occurred in the Eastern Management Area, the magnitude of subsidence in the Eastern Management Area has not yet (as of 2019) resulted in significant impacts to infrastructure. It should also be noted that the Western Management Area includes a GDE Unit, whereas no GDE Units were identified in the Eastern Management Area. Delineation of two Management Areas allows for subsidence (and other SMC, as necessary) to be set differently to more reliably manage the Subbasin to reach sustainability.

The hydrogeologic conceptual model, groundwater conditions, and water balance information for the areas encompassing both Management Areas are included in Sections 2.2.1, 2.2.2. and 2.2.3, respectively, in this GSP. A distinguishing hydrogeologic feature is that the Western Management Area is comprised of two distinct and viable aquifers in terms of an Upper Aquifer and the Lower Aquifer (above and below the regionally continuous Corcoran Clay), whereas the Upper Aquifer in the East Management Area is largely unsaturated or only contains a thin perched aquifer and/or the Corcoran Clay layer is not present. The sustainable management criteria (SMC) and projects/management actions for each management area are described in Sections 3 and 4, respectively. The primary differences in SMC among the two Management Areas relate to subsidence and are described in more detail in Section 3.

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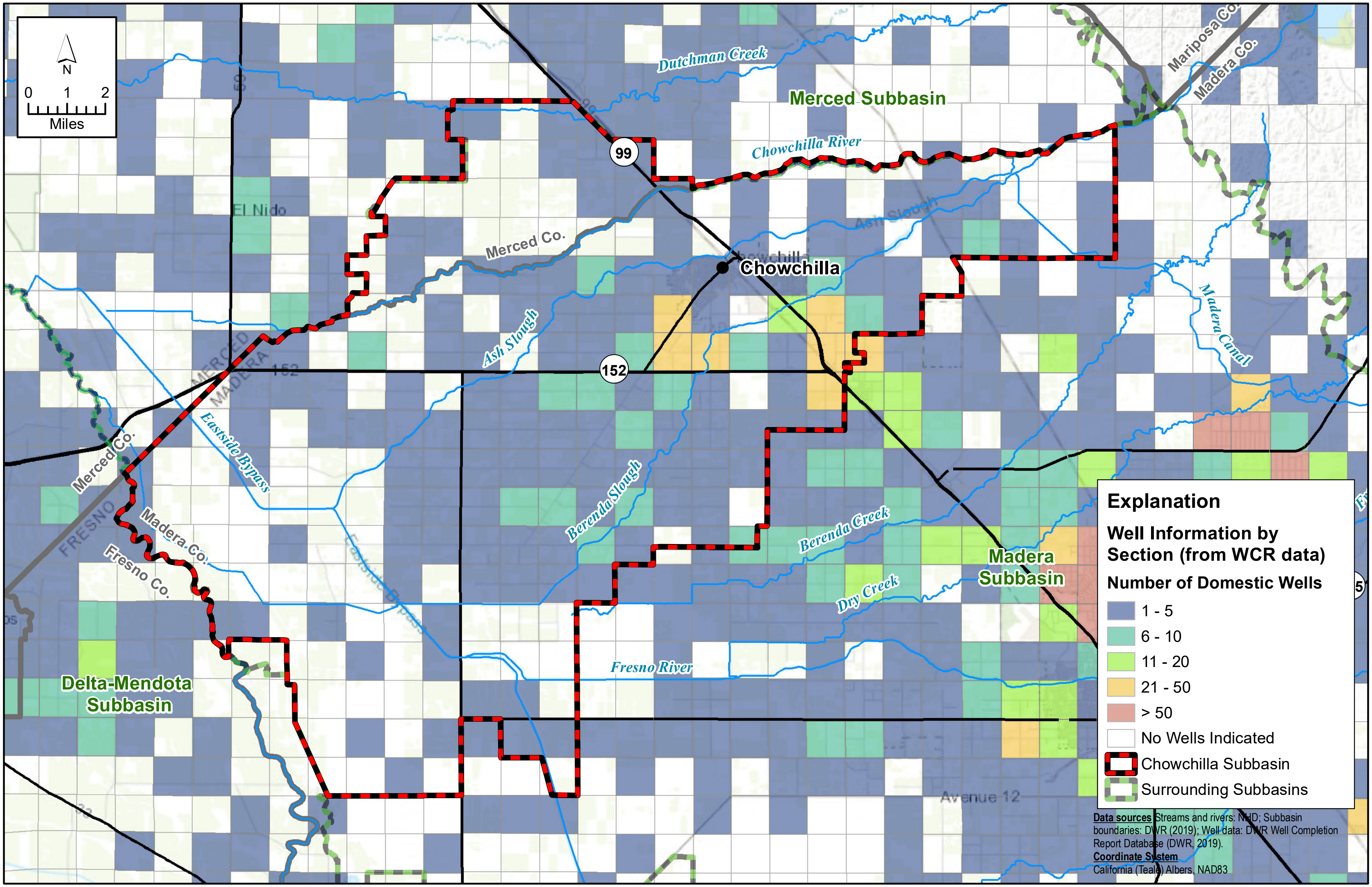
[60] The total historical available Fresno River flood inflows exclude appropriative water rights diversions and riparian diversions along Fresno River in Chowchilla Subbasin, which are considered unavailable to groundwater recharge projects.

CHAPTER 2 PLAN AREA AND BASIN SETTING

2.3 Selected Figures

The following figures can be found after this page: Figures 2-4 to 2-6, Figures 2-9 to 2-76 and 2-94.



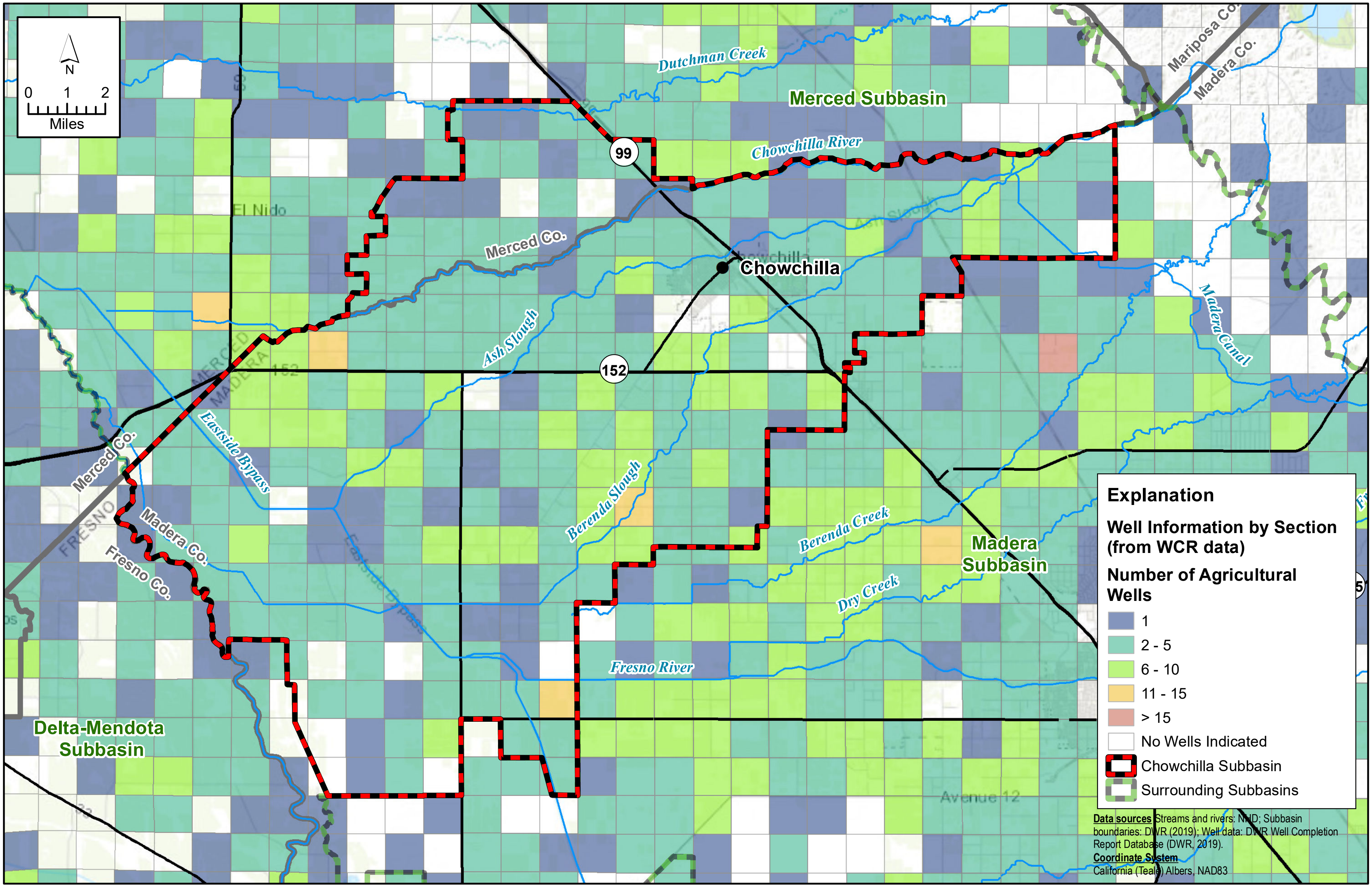
X:\2021\21-166 Davids Engineering - Chowchilla Subbasin GSP DWR Consultation Letter\REPORT\RevisedGSP\Sections from Bernadette\Water Levels\MAPS\Figure 2-4 Chowchilla Subbasin Wells By Section Dom Well Count.mxd

DAVIDS ENGINEERING, INC

Luhdorff & Scalmanini Consulting Engineers

FIGURE 2-4A
Map of Well Information by Section: Number of Domestic Wells (from WCR data)

Chowchilla Subbasin Groundwater Sustainability Plan



X:\2021\21-166 Davids Engineering - Chowchilla Subbasin GSP DWR Consultation Letter\REPORT\RevisedGSP\Sections from Bernadette\Water Levels\MAPS\Figure 2-5 Chowchilla Subbasin Wells By Section Ag Well Count.mxd

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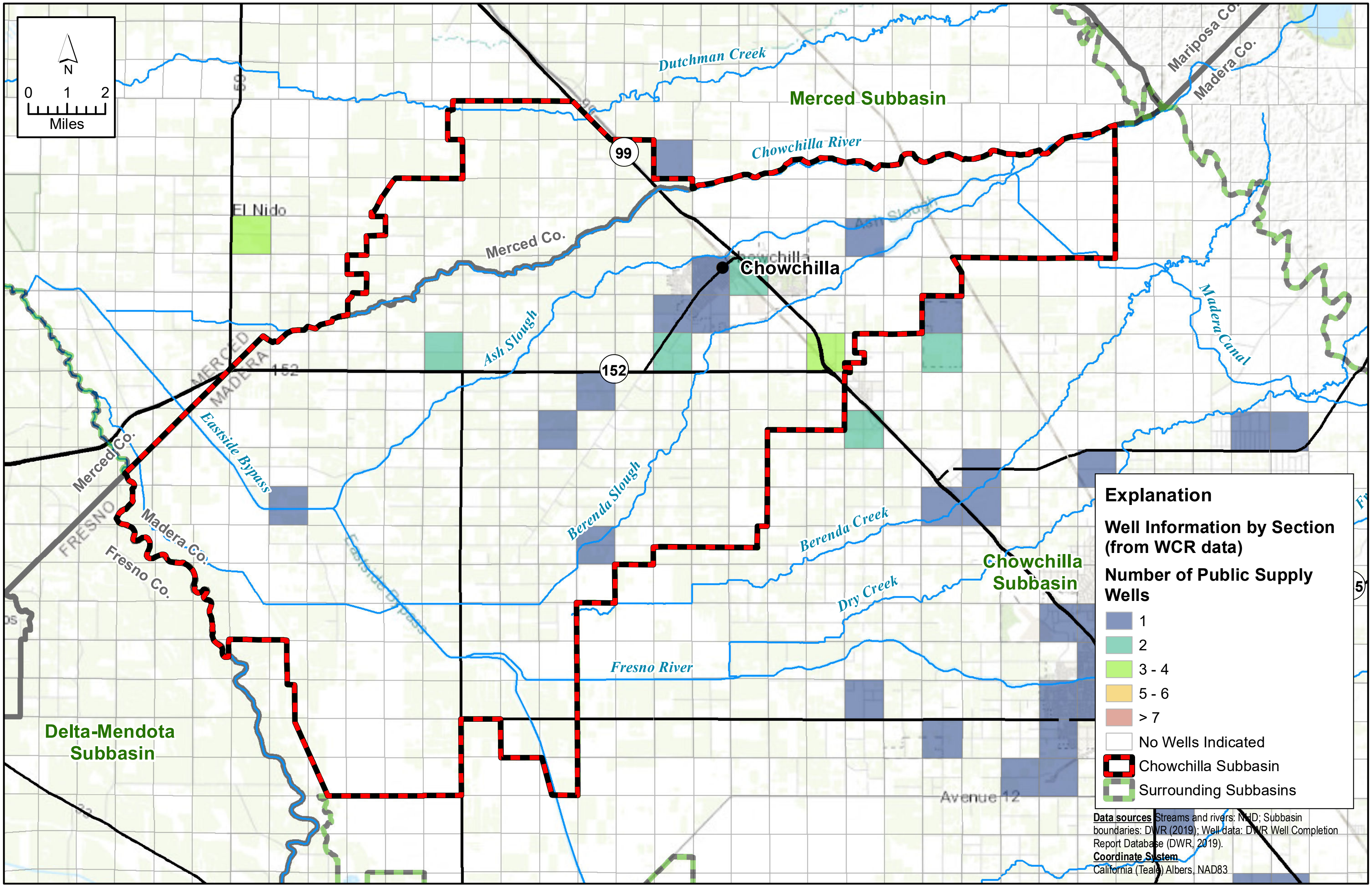
FIGURE 2-4B
Map of Well Information by Section: Number of Agricultural Wells (from WCR data)

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2021\21-166 Davids Engineering - Chowchilla Subbasin GSP DWR Consultation Letter\REPORT\RevisedGSP\Sections from Bernadette\Water Levels\MAPS\Figure 2-6 Chowchilla Subbasin Wells By Section PWS Well Count.mxd

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FIGURE 2-5A
Map of Well Information by Section: Number of Public Supply Wells (from WCR data)

Chowchilla Subbasin Groundwater Sustainability Plan

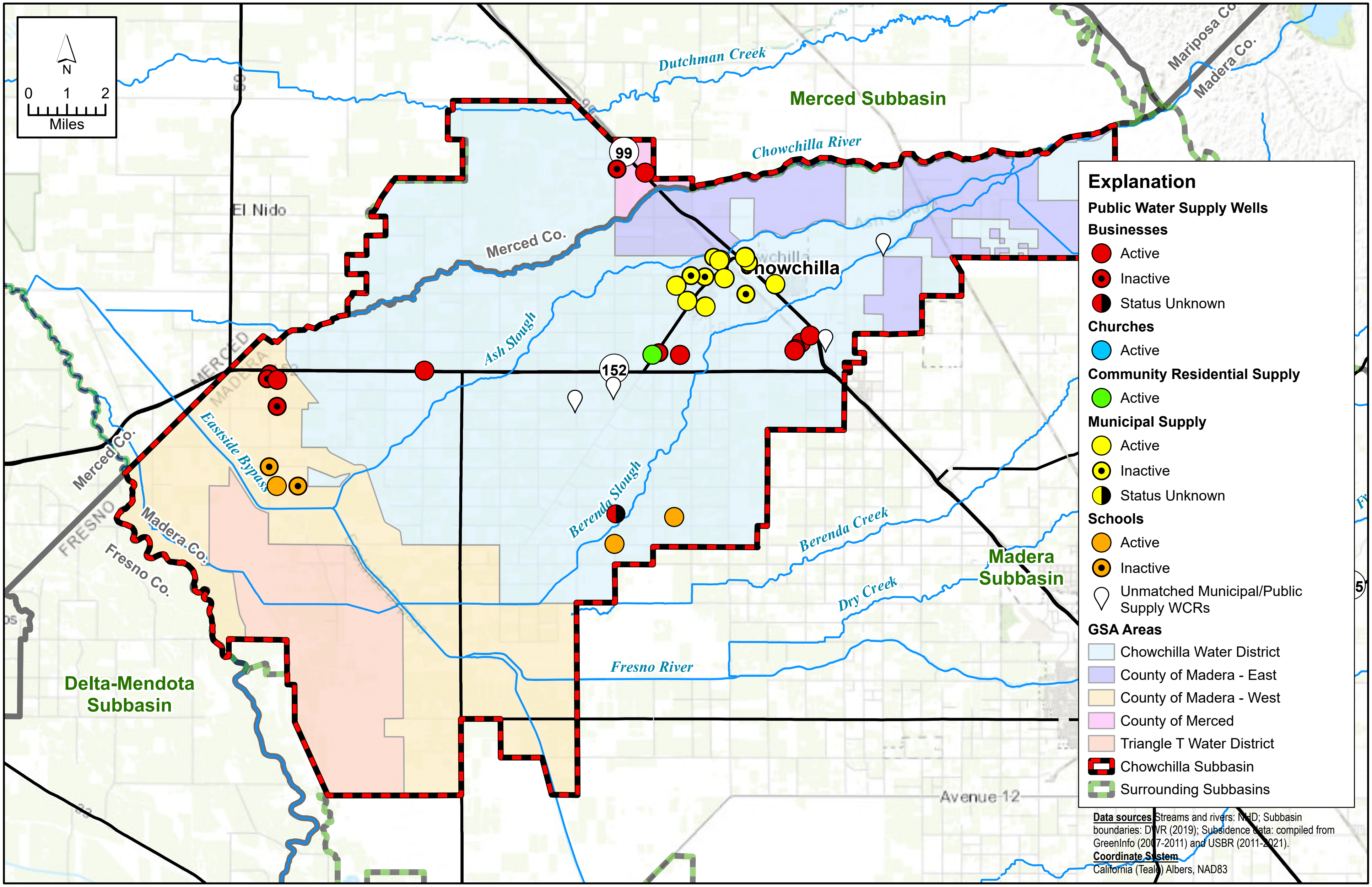

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FIGURE 2-5B

Map of Public Supply Wells in Chowchilla Subbasin

Chowchilla Subbasin
Groundwater Sustainability Plan

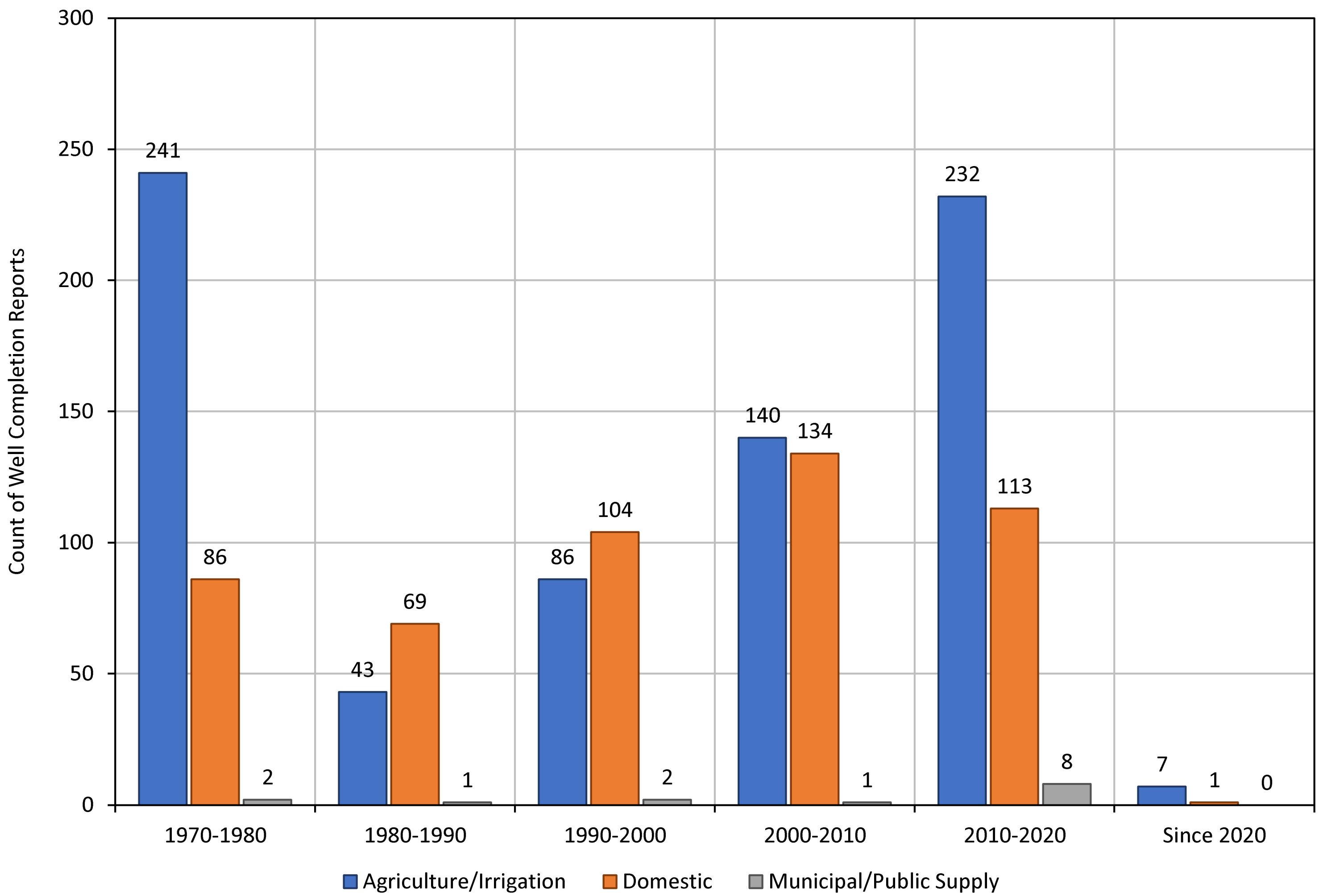

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FIGURE 2-6A

Number of Wells Constructed by Decade

Chowchilla Subbasin
Groundwater Sustainability Plan

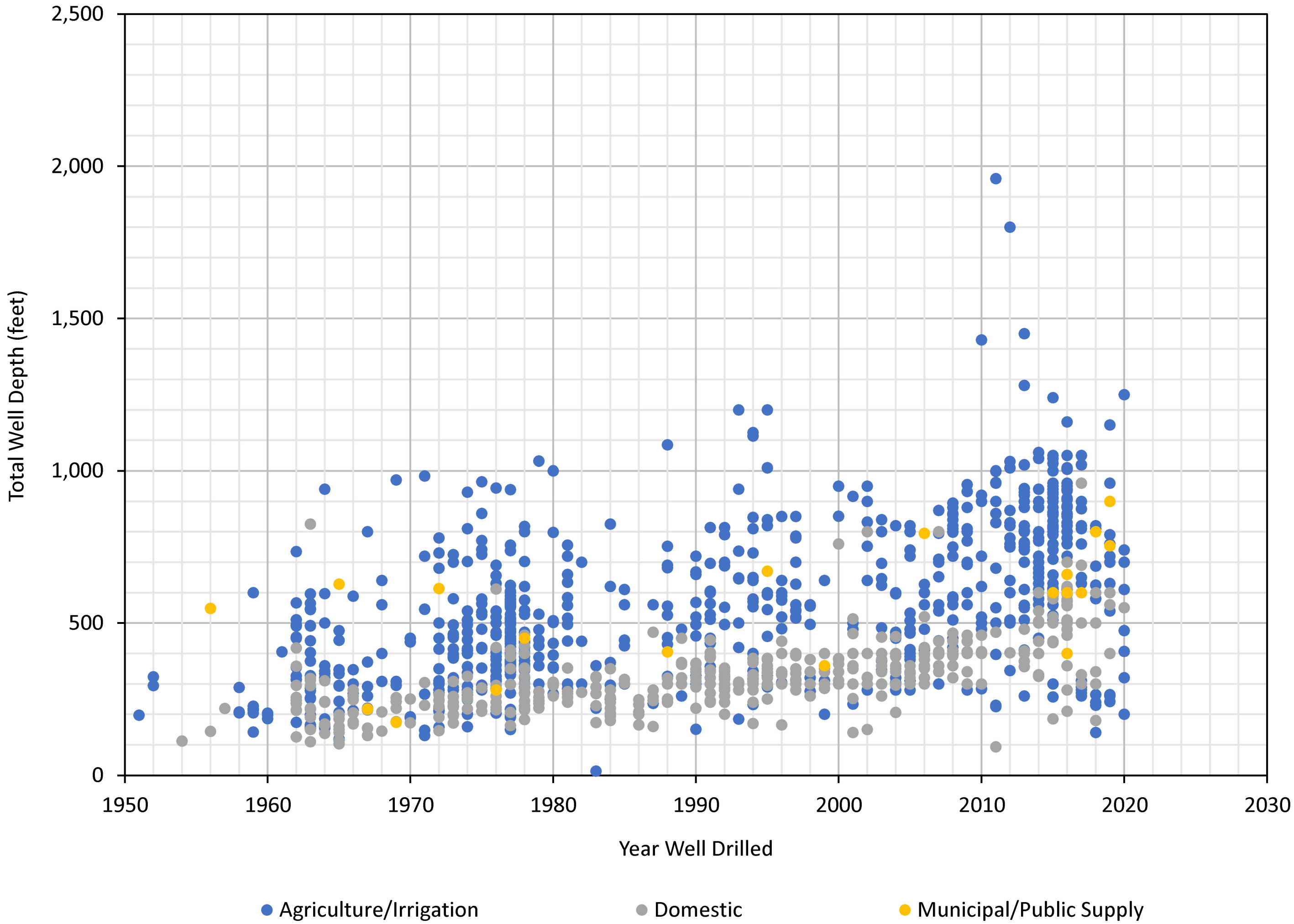

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FIGURE 2-6B

Typical Well Depths by Well Type through Time

Chowchilla Subbasin
Groundwater Sustainability Plan

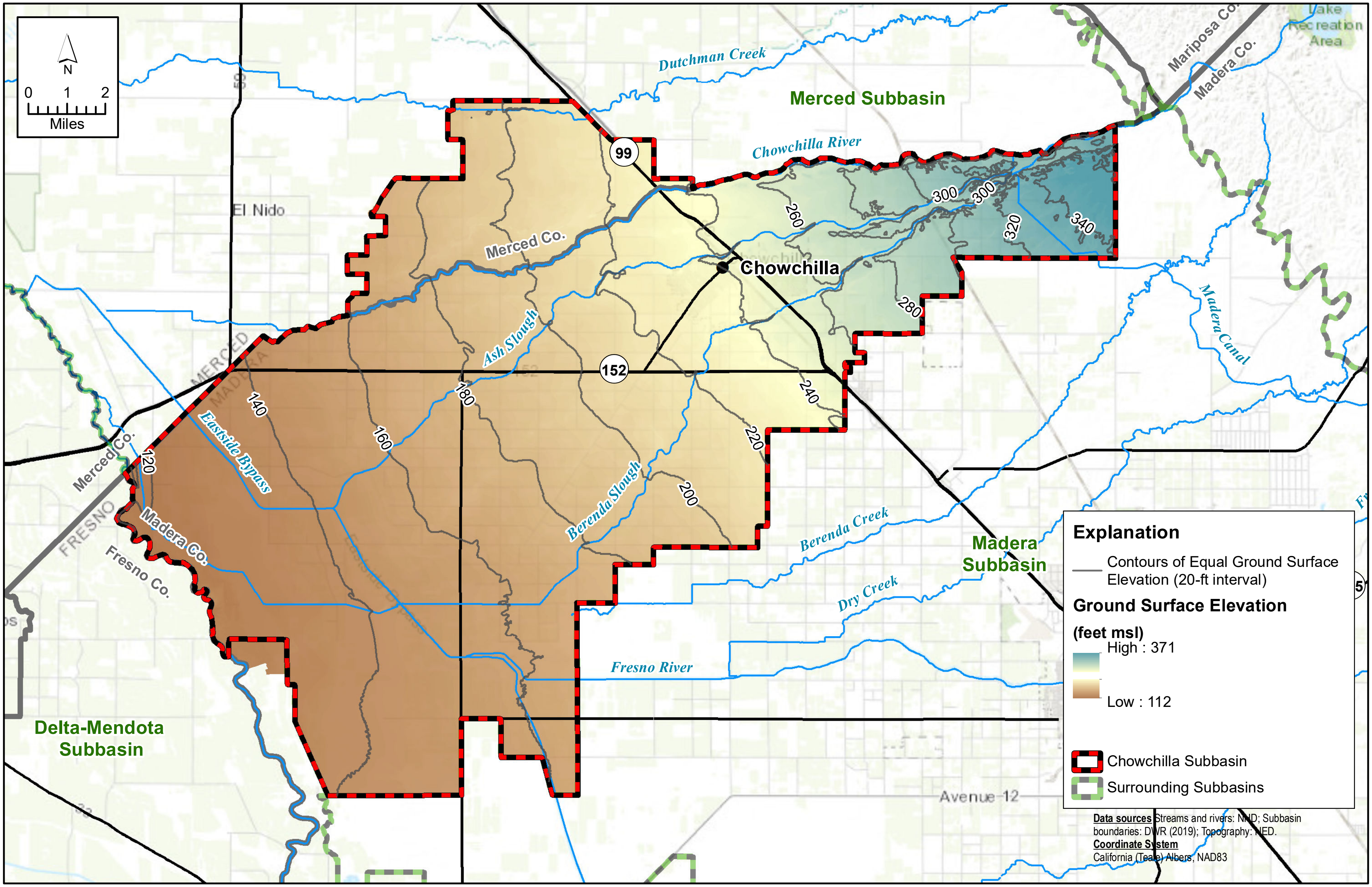

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FIGURE 2-9

Topographic Map

Chowchilla Subbasin
Groundwater Sustainability Plan

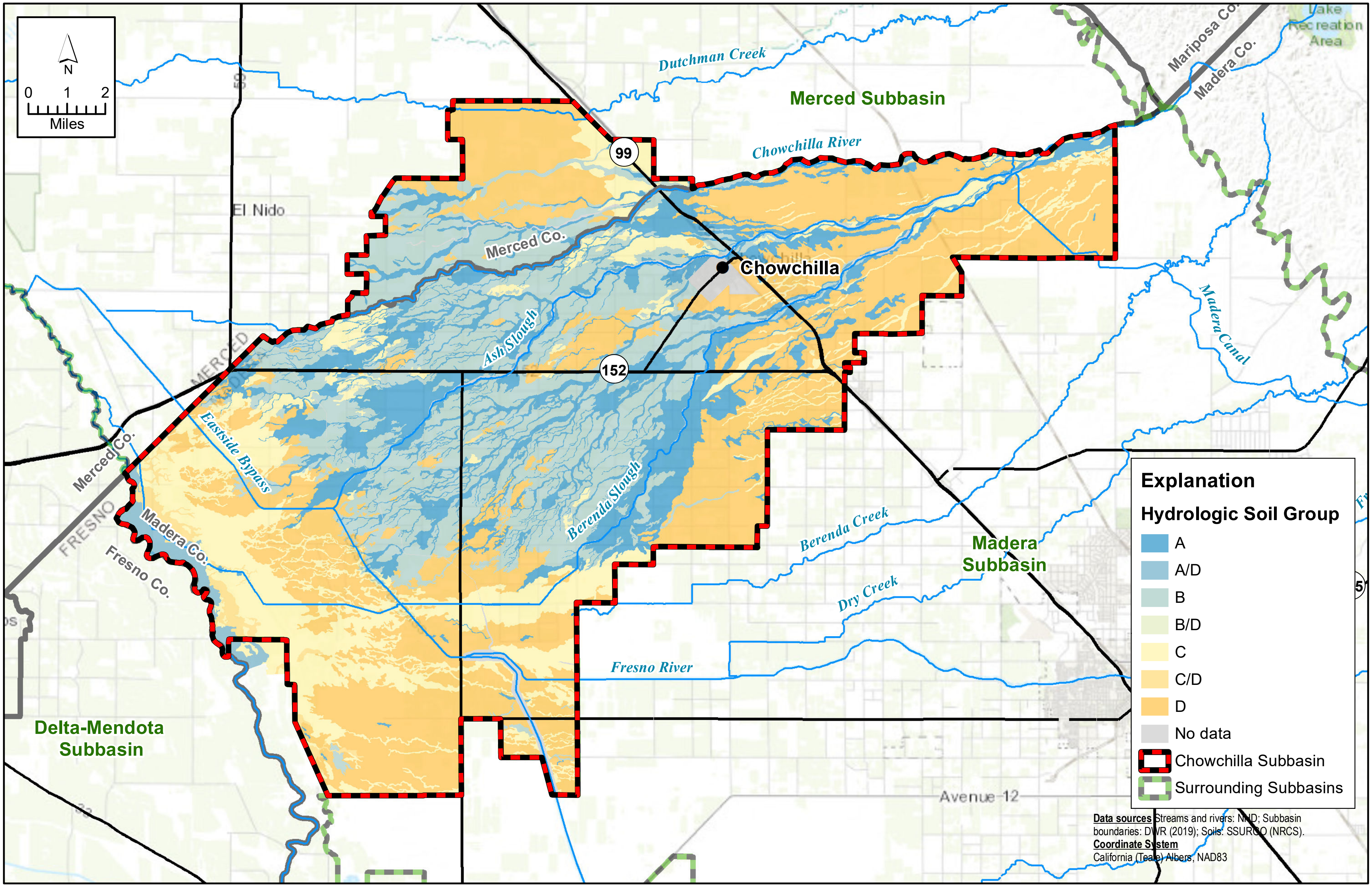

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FIGURE 2-10

Soil Unit Map

Chowchilla Subbasin
Groundwater Sustainability Plan

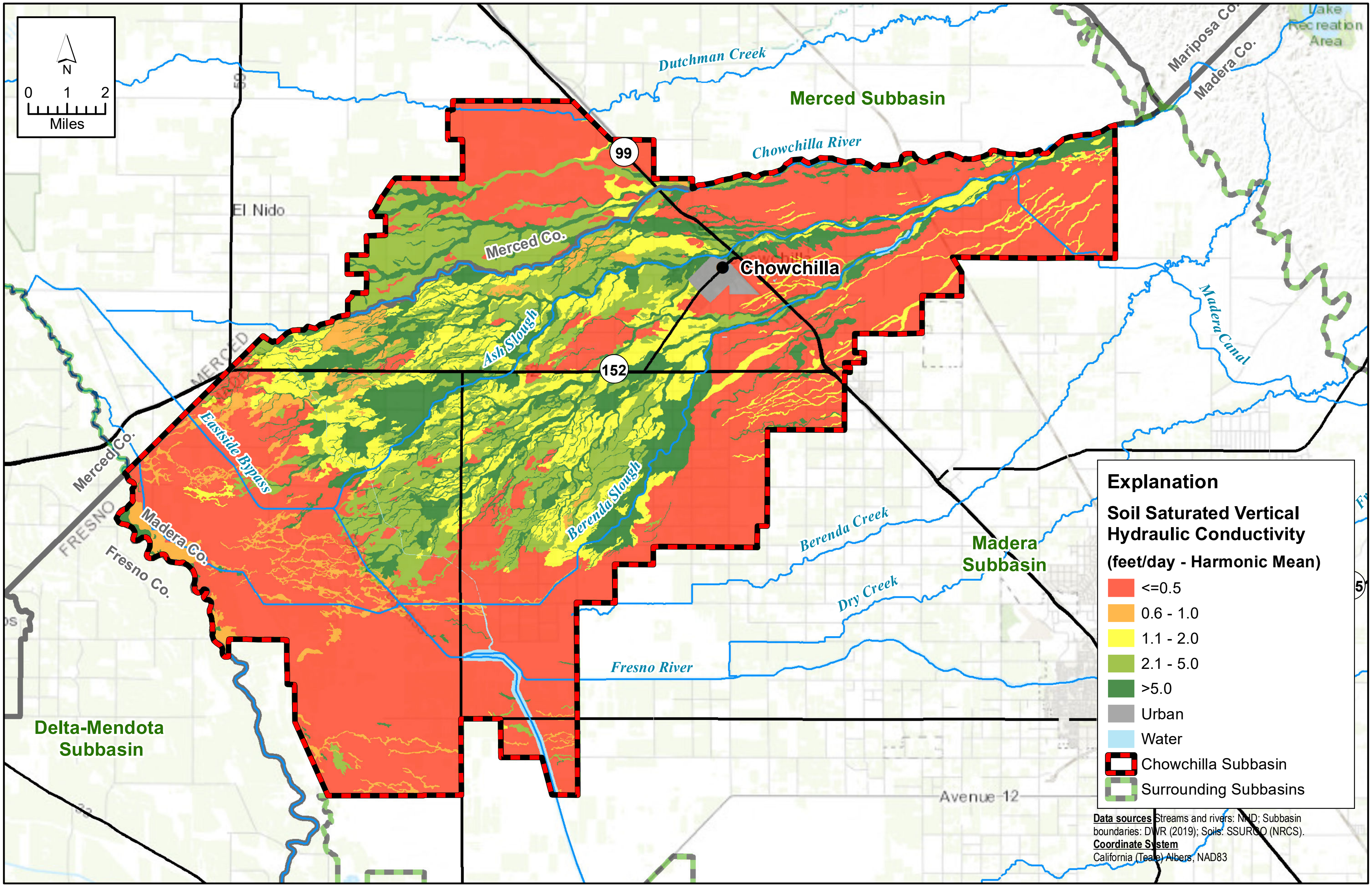

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FIGURE 2-11

Soil Hydraulic Conductivity Map

Chowchilla Subbasin
Groundwater Sustainability Plan

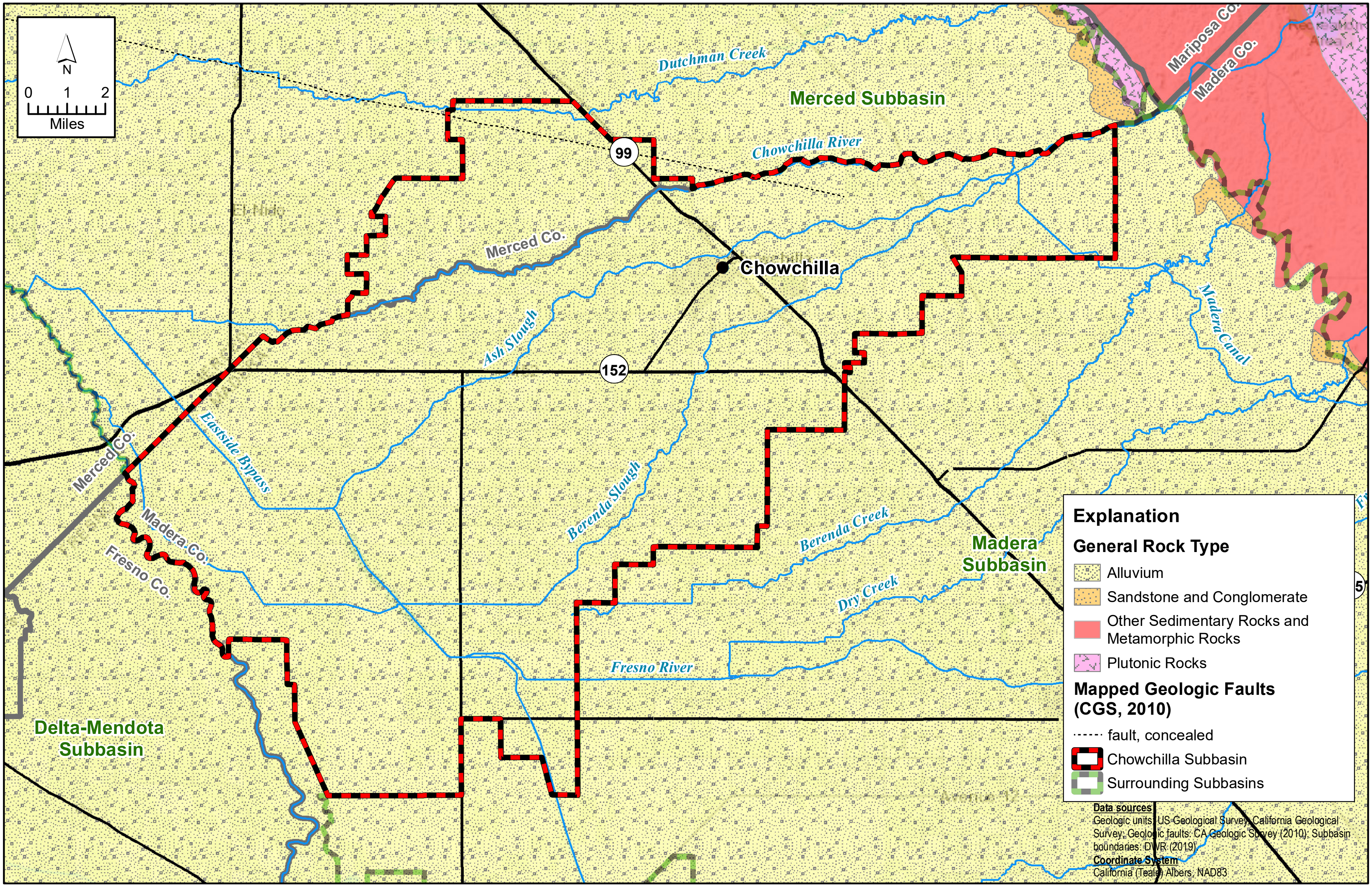

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FIGURE 2-12

General Geologic Map

Chowchilla Subbasin
Groundwater Sustainability Plan

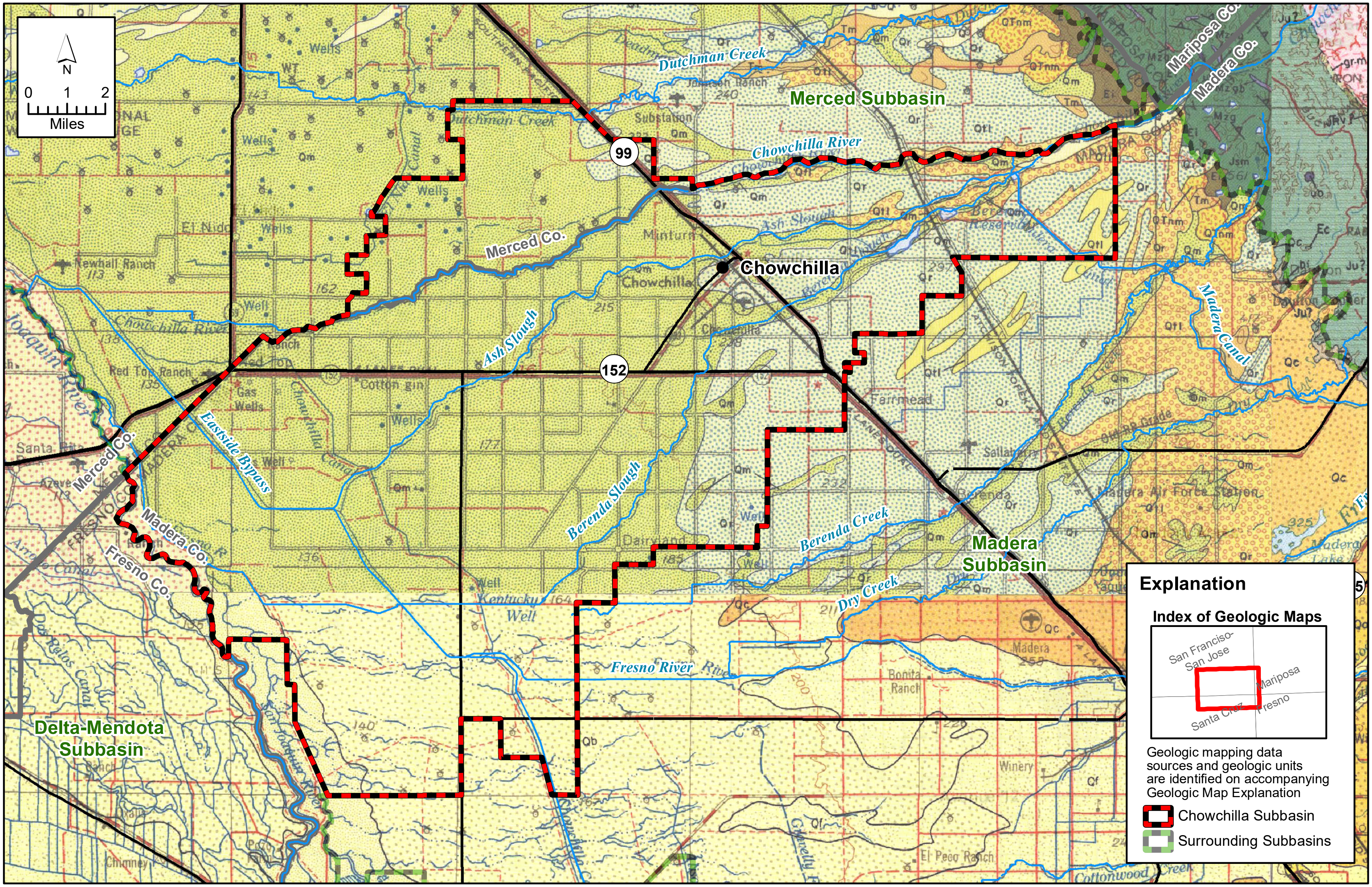

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FIGURE 2-13

Surficial Geologic Map

Chowchilla Subbasin
Groundwater Sustainability Plan

Compiled Geologic Map Explanation

San Francisco - San Jose Quadrangle

Q	Alluvium
Qdp	Dos Palos Alluvium
Qf	Alluvial fan deposits
Qsl	San Luis Ranch Alluvium
Qp	Patterson Alluvium
Qtl	Turlock Lake Formation *(Nonmarine sand, silt, and gravel)*
Pl	Laguna Formation *(Consolidated alluvium)*
Qm	Modesto Formation
Qr	Riverbank Formation
Qlb	Los Banos Alluvium
QTnm	North Merced Gravel *(Thin pediment veneer)*
Jjp	Jasper Point Formation *(Chert, tuff, pillow basalt; marine)*
ms	Metasedimentary rocks*
ls	Crystalline limestone and dolomite*
Pzcc	Calaveras Complex *(Metasedimentary rocks)*
mv	Metavolcanic rocks*
Mtm	Table Mountain Latite
Tm	Mehrten Formation *(Andesitic conglomerate)*
Tvs	Valley Springs Formation *(Rhyolitic tuff and sedimentary rocks)*
Ei	Ione Formation *(Quartzose sandstone and kaolinitic clay; mostly nonmarine)*
Tg	"Auriferous" Gravels
Pl	Locatelli Formation *(Marine sandstone and conglomerate)*
Kl	Lower Cretaceous marine sandstone and shale
Mzg	Granitic rocks
Mzgb	Gabbroic rocks
um	Ultramafic rocks
Jm	Mariposa Formation *(Slate, graywacke, and conglomerate; marine)*
Jsm	Salt Springs and Merced Falls Slates
Jms	Jurassic(?) metasedimentary rocks
Jch	Copper Hill Volcanics
Jlr	Logtown Ridge Volcanics
Jgo	Gopher Ridge Volcanics
Jpb	Penon Blanco Volcanics
Jmv	Jurassic metavolcanic rocks

Santa Cruz, Mariposa, and Fresno Quadrangles

Qal	Alluvium
Qsc	Stream channel deposits (GREAT VALLEY)
Qf	Fan deposits (GREAT VALLEY)
Qb	Basin deposits (GREAT VALLEY)
Qc	Pleistocene nonmarine
QP	Plio-Pleistocene nonmarine
Qpv	Pleistocene volcanic: Qpv^r —rhyolite; Qpv^a—andesite; Qpv^b —basalt; Qpv^p —pyroclastic rocks
Tc	Tertiary nonmarine
Pmv	Permian metavolcanic rocks
Ec	Eocene nonmarine
E	Eocene marine
Tv	Tertiary volcanic: Tv^r —rhyolite; Tv^a —andesite; Tv^b —basalt; Tv^p —pyroclastic rocks
Ju	Upper Jurassic marine
m / ls	Pre-Cretaceous metamorphic rocks (ls = limestone or dolomite)
ms	Pre-Cretaceous metasedimentary rocks
gr-m	Pre-Cenozoic granitic and metamorphic rocks
Pv	Paleozoic metavolcanic rocks
Cv	Carboniferous metavolcanic rocks

Geologic Map compiled from:

1. Wagner, D.L., Bortugno, E.J., and Mc Junkin, R.D., 1991, Geologic Map of the San Francisco - San Jose Quadrangle, California Geological Survey, Regional Geologic Map No. 5A, 1:250,000 scale.
2. Jennings, C.W. and Strand, R.G., 1958, Geologic Atlas of California - Santa Cruz Quadrangle, California Geological Survey, Geologic Atlas of California Map No. 020, 1:250,000 scale.
3. Strand, R.G., 1967, Geologic Atlas of California - Mariposa Quadrangle, California Geological Survey, Geologic Atlas of California Map No. 009, 1:250,000 scale.
4. Matthews, R.A. and Burnett, J.L., 1965, Geologic Atlas of California - Fresno Quadrangle, California Geological Survey, Geologic Atlas of California Map No. 005, 1:250,000 scale.

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FIGURE 2-13 EXPLANATION

Surficial Geology Map Explanation

Chowchilla Subbasin
Groundwater Sustainability Plan

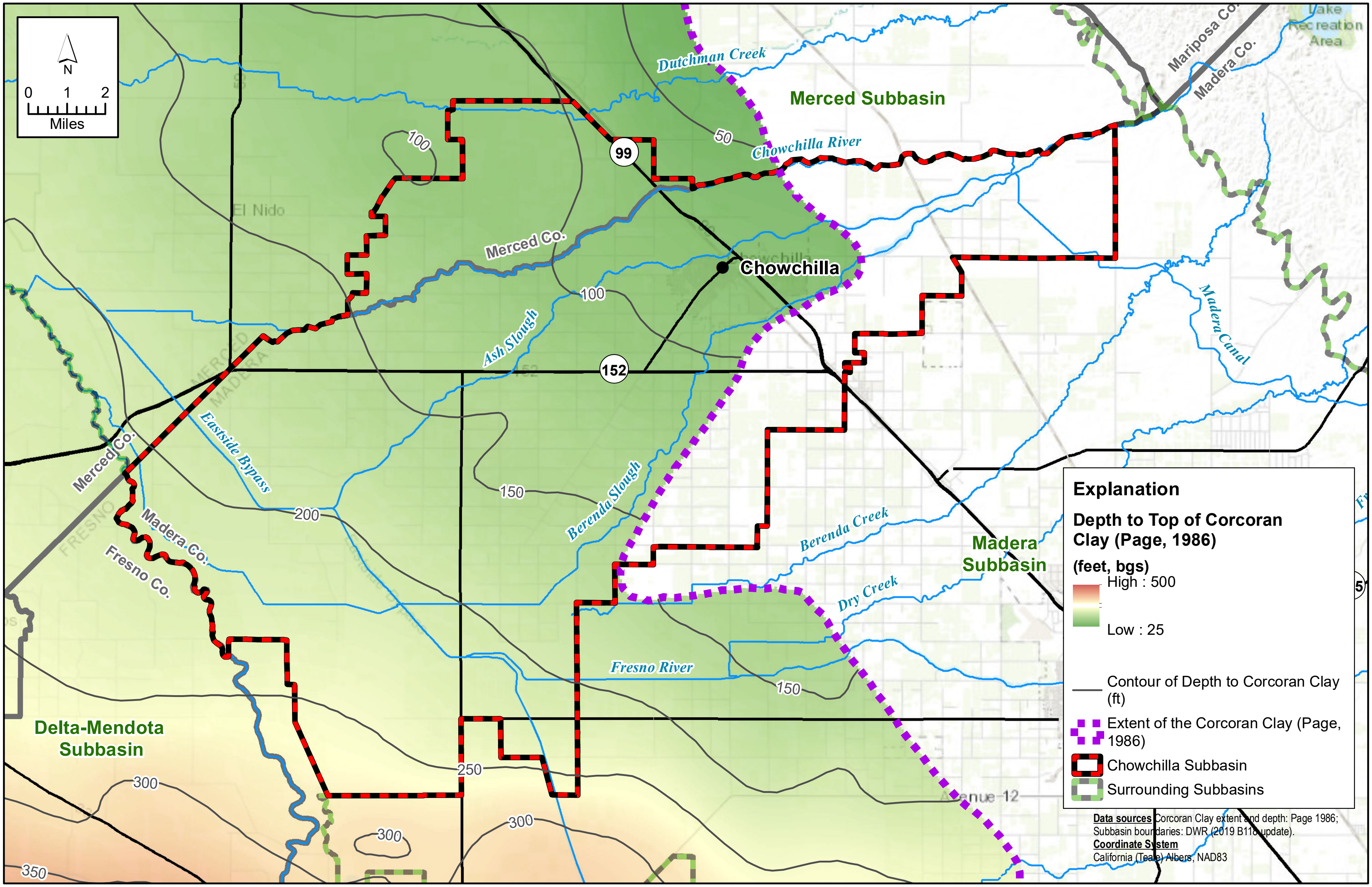

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FIGURE 2-14
Extent and Depth of the Corcoran Clay: After Page (1986)

Chowchilla Subbasin
Groundwater Sustainability Plan

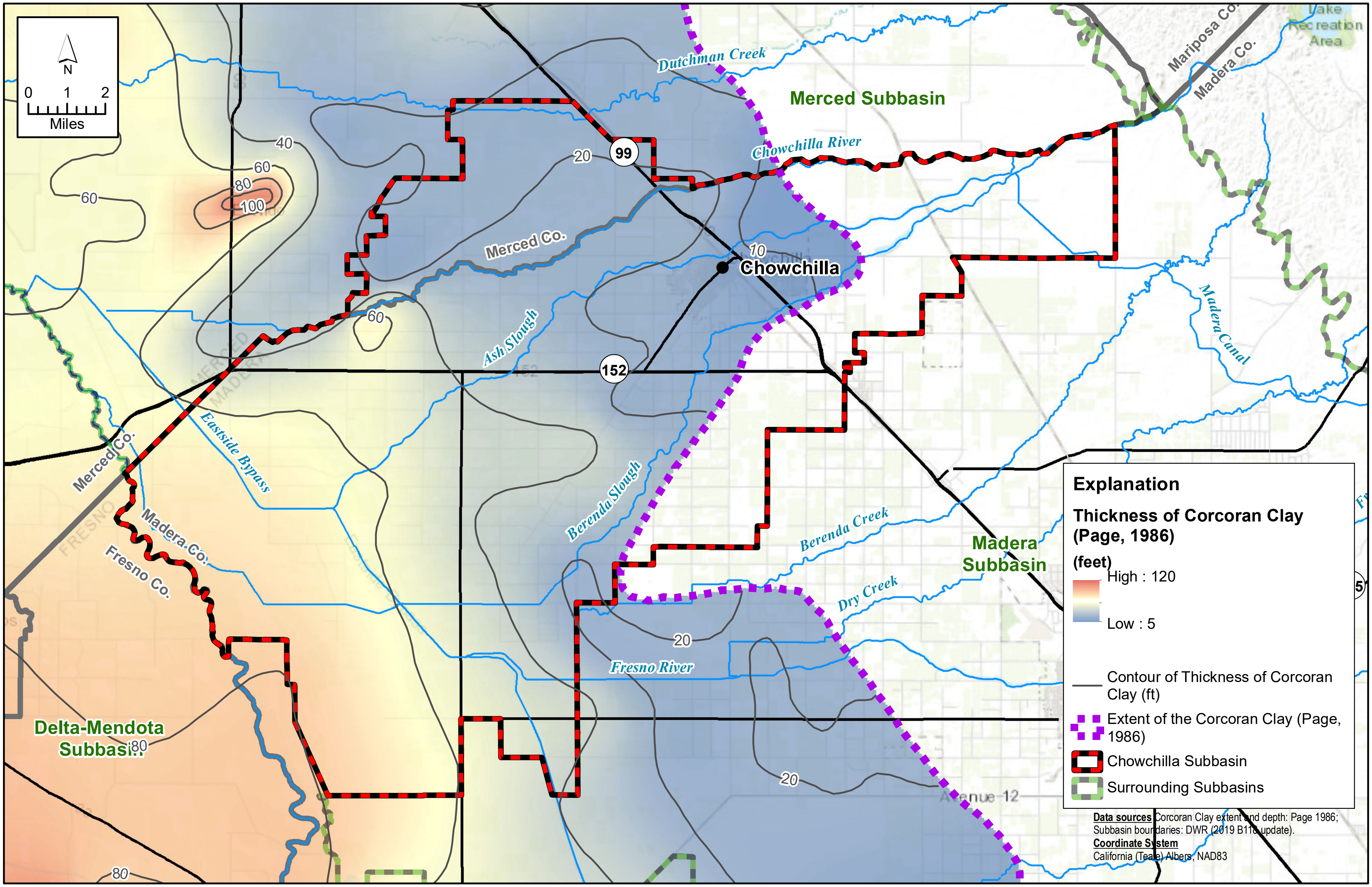

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FIGURE 2-15
Thickness of the Corcoran Clay: After Page (1986)

Chowchilla Subbasin Groundwater Sustainability Plan

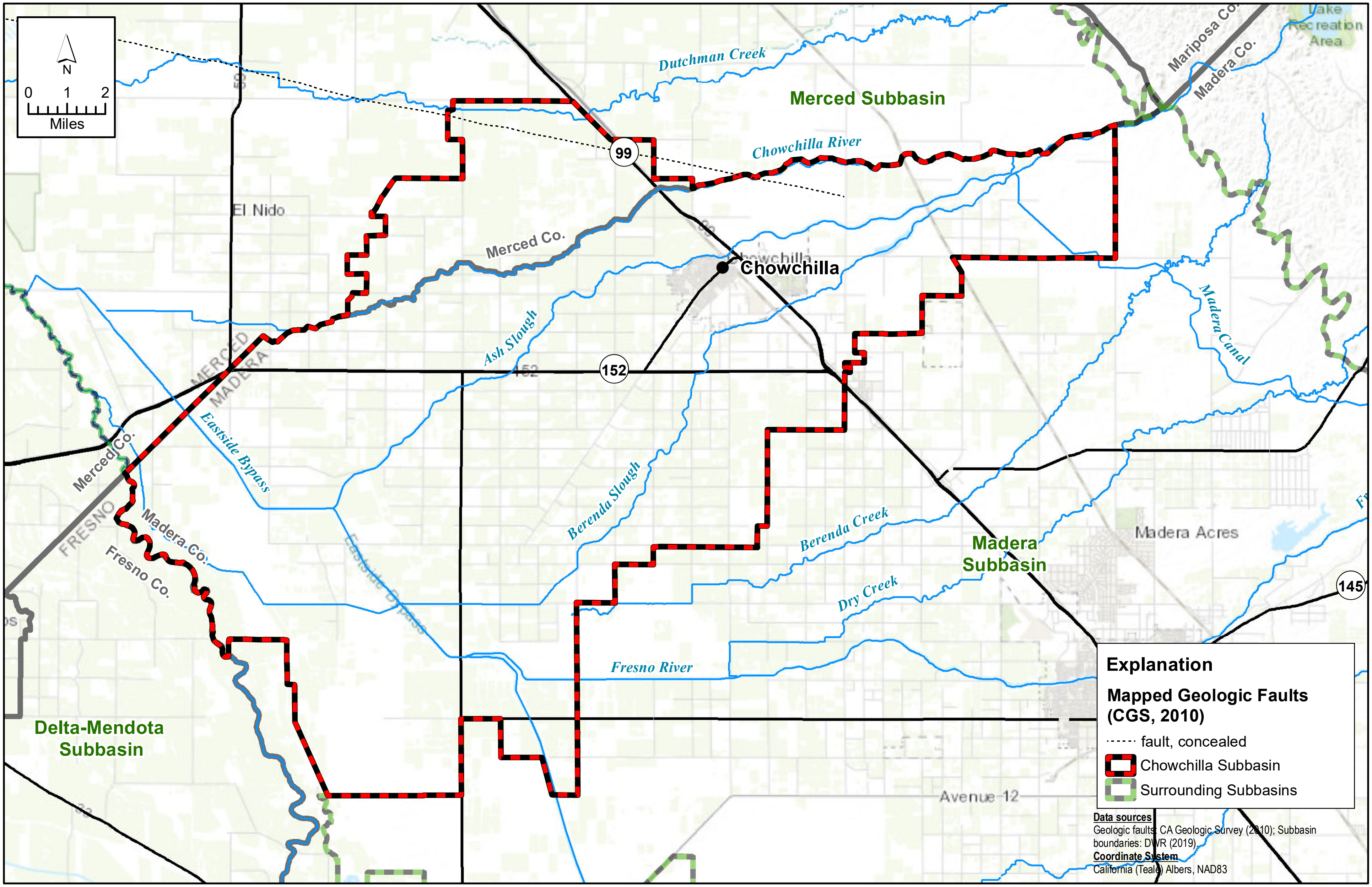

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FIGURE 2-16

Geologic Fault Map

Chowchilla Subbasin
Groundwater Sustainability Plan

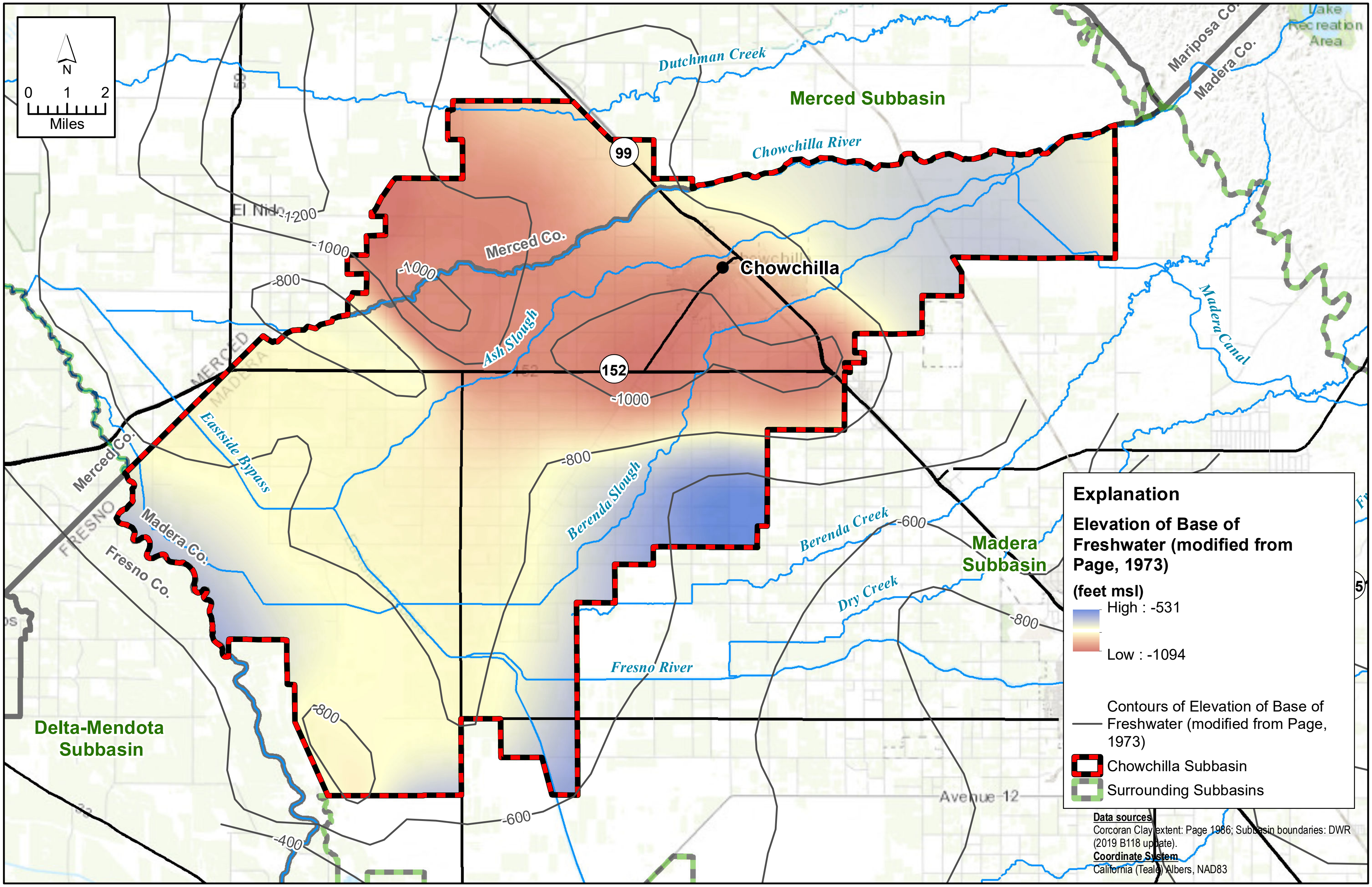

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FIGURE 2-17
Elevation of Base of Freshwater: Modified from Page (1973)

Chowchilla Subbasin
Groundwater Sustainability Plan

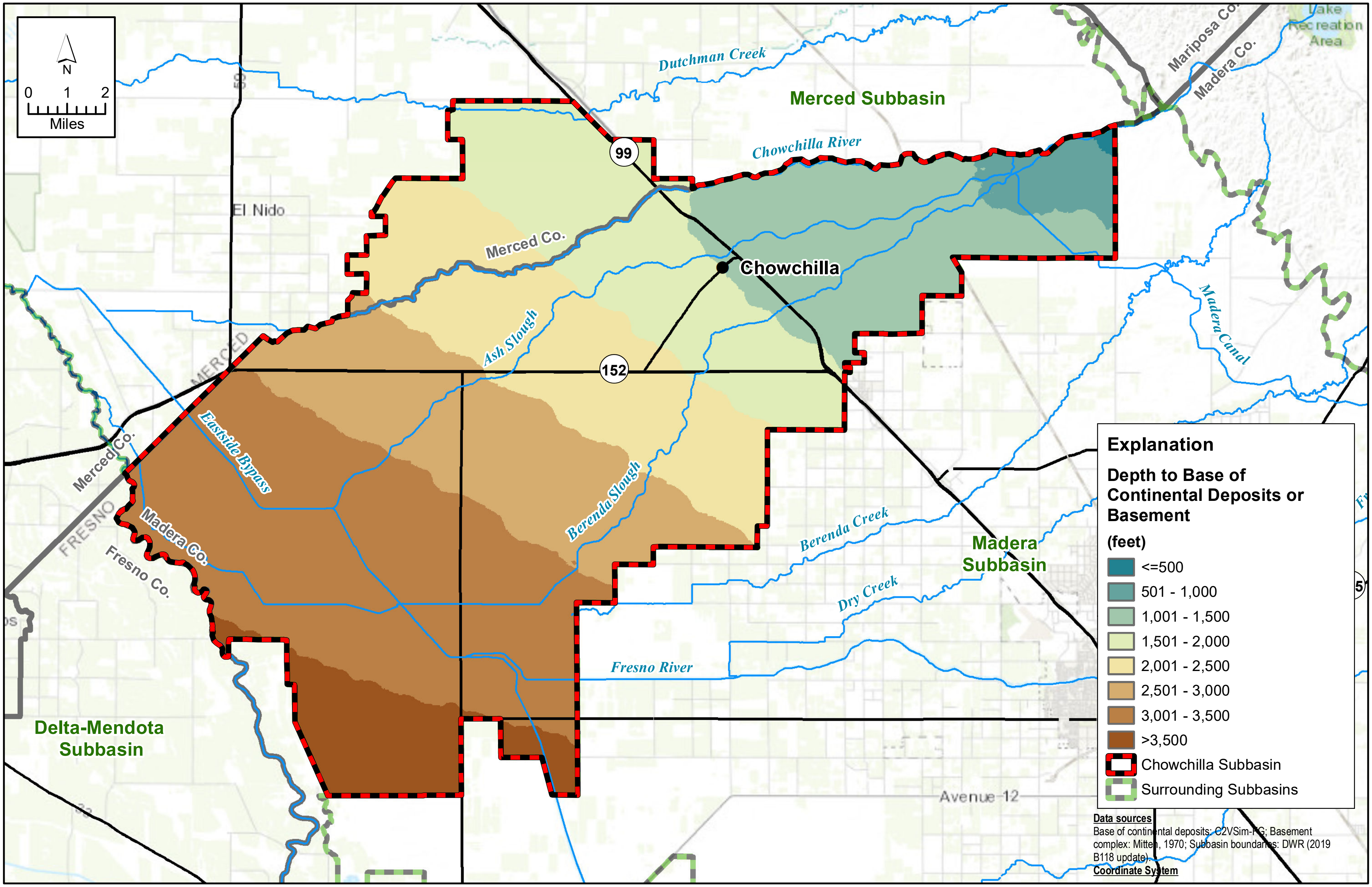

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FIGURE 2-18
Depth to Base of Continental Deposits or Basement Complex

Chowchilla Subbasin
Groundwater Sustainability Plan

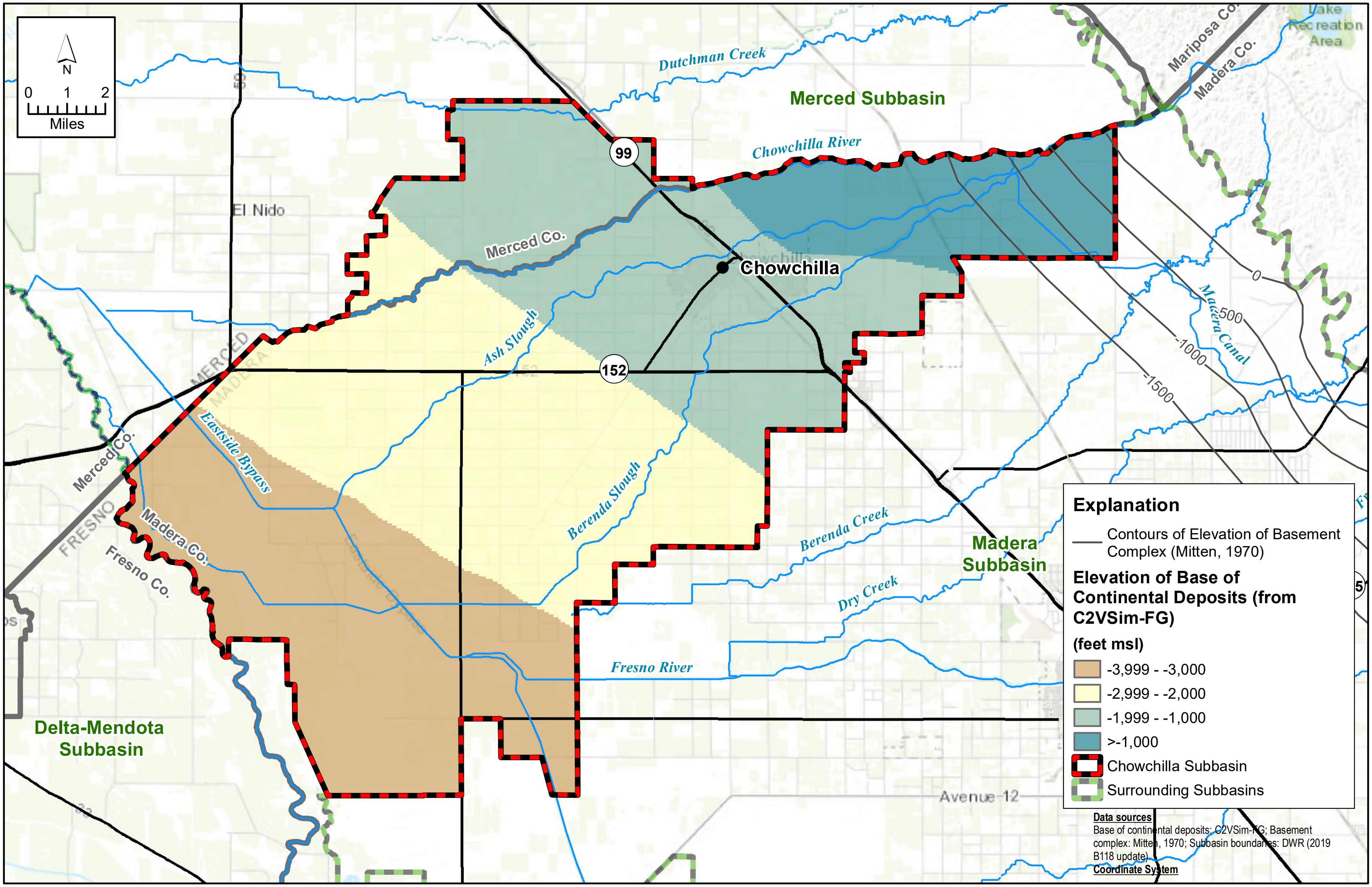

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FIGURE 2-19
Elevation of Top of Basement Complex (from Mitten, 1970) and Bottom of Continental Deposits (from C2VSim-FG, 2018)

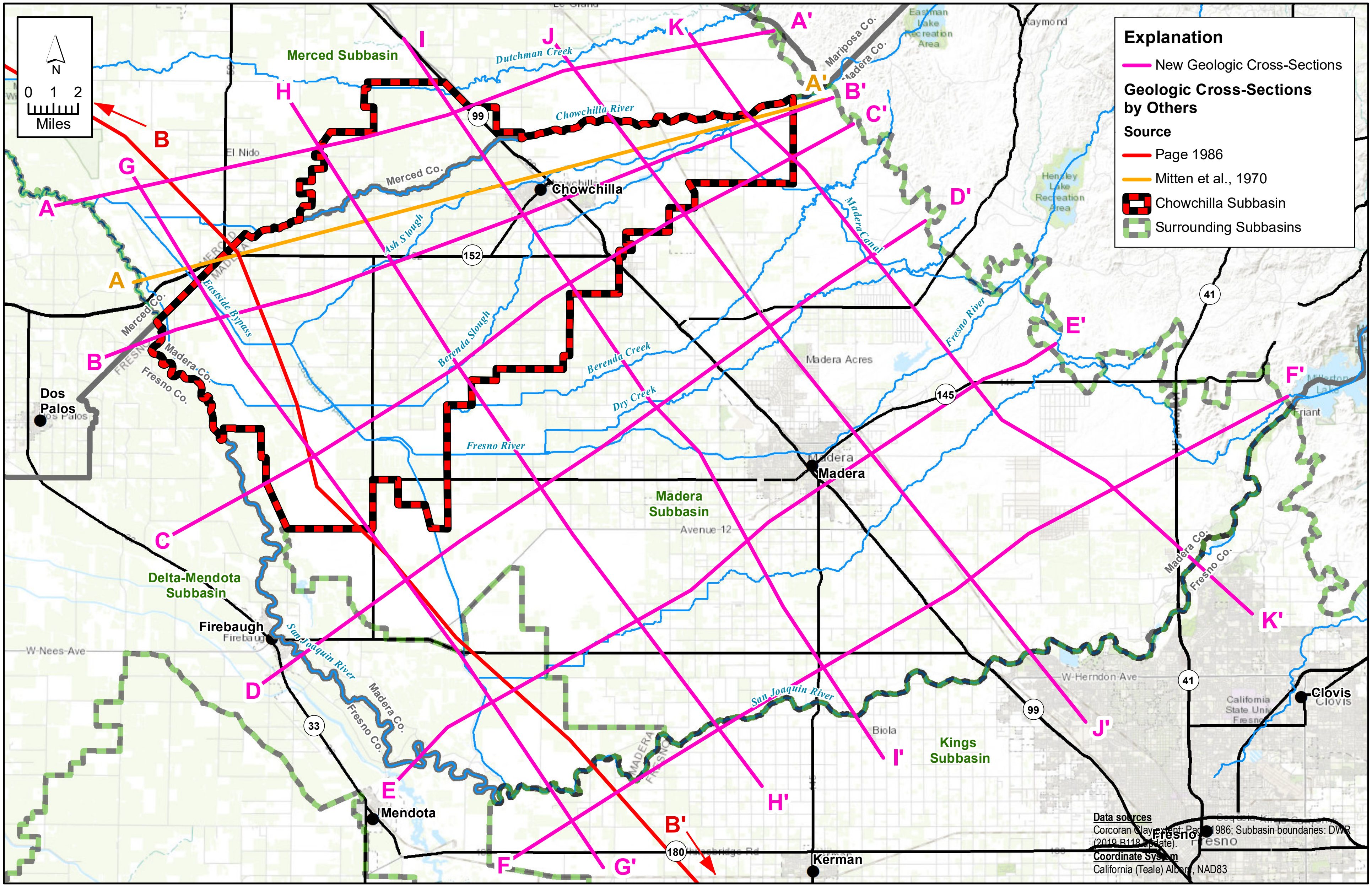

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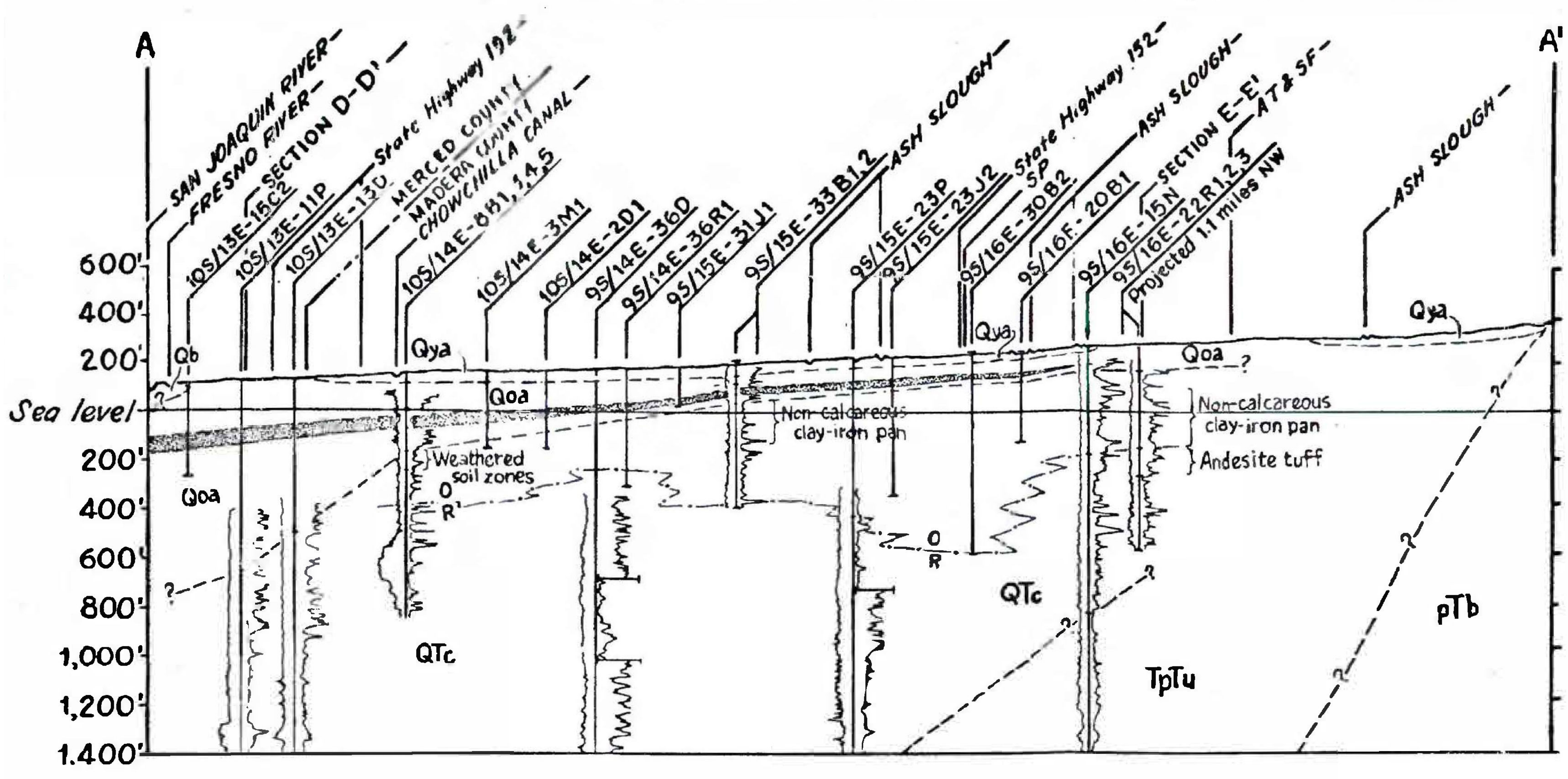
FIGURE 2-20

Geologic Cross-Section Location Map

Chowchilla Subbasin
Groundwater Sustainability Plan



EXPLANATION

UNCONSOLIDATED DEPOSITS

Holocene — QUATERNARY
- Qb — Flood-basin deposits
- Qya — Younger alluvium

Holocene (?) — QUATERNARY
- Ql — Lacustrine and marsh deposits
- Qoa — Older alluvium

Pleistocene (?) — TERTIARY AND QUATERNARY
- QTc — Continental deposit of Tertiary and Quaternary (?) age

UNCONFORMITY

CONSOLIDATED ROCKS

PRE-TERTIARY AND TERTIARY
- TpTu — Marine and continental sedimentary rocks, undifferentiated

UNCONFORMITY

PRE-TERTIARY
- pTb — Basement complex

Contact
Queried where evidence is inconclusive

Contact between oxidized (O) and reduced (R) deposits

E-clay (Ql)

TOP OF WELL
BOTTOM OF WELL
Well symbol

CHANGE IN RESISTIVITY SCALE
Well with electric log

Horizontal scale same as scale of maps; vertical scale X 26.4. Datum is mean sea level

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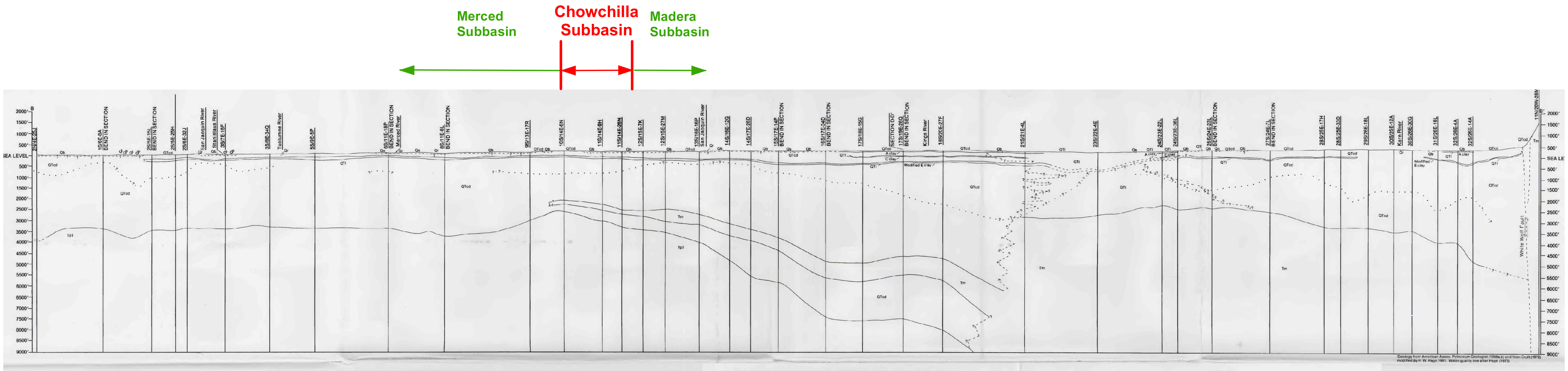
FIGURE 2-21
Geologic Cross-Section: Mitten et al. (1970) Section A-A'

Chowchilla Subbasin Groundwater Sustainability Plan



SAN JOAQUIN VALLEY SECTION B - B' and D - D'

	SAN JOAQUIN VALLEY SECTION B - B' and D - D'	B - B'
Qs	**Sand dunes (Holocene)** Windblown sand and dune sand	Description at left
Qb	**Flood-basin deposits (Holocene)** Clay, silt, and some sand;	Near northern end of section consist of muck, peat, and other organic soils
Qr	**River deposits (Holocene)** Gravel, sand, silt, and minor amounts of clay; deposited along channels, flood plains, and natural levees of main streams.	Description at left
QTl	**Lacustrine and marsh deposits (Pliocene to Holocene)** Clay, silt, and some sand; in subsurface include three widespread clays: A clay (Pleistocene and Holocene?), C clay (Pleistocene); and modified E clay (Pleistocene), includes Corcoran Clay Member of Tulare Formation	Description at left
QTcd	**Continental rocks and deposits (Oligocene to Holocene)** Heterogeneous mix of generally poorly sorted clay, silt, sand, and gravel, some beds of claystone, siltstone, sandstone, and conglomerate...	On this section, principal unit, continental rocks and deposits (Miocene to Holocene): in northern part of section may include continental rocks and deposits (Miocene and Pliocene)--mostly Mehrten Formation or an equivalent, and continental rocks and deposits (Oligocene and Miocene) -mostly Valley Springs Formation or an equivalent. Include continental rocks and deposits (Miocene and Pliocene)--chiefly the Chanac Formation (Miocene) at extreme southern end of section, and the Zilch Formation of informal subsurface usage, which is considered to be the continental equivalent of the Marine Temblor Formation (Oligocene and Miocene)
Tm	**Marine rocks and deposits (Eocene, Oligocene, Miocene, and Pliocene)** Sand, clay, silt, sandstone, shale, mudstone, and siltstone. On these section include marine rocks and deposits of Miocene and Pliocene age only	Description at left
TpT	**Continental and marine rocks and deposits (Pre-Tertiary to Oligocene)** Continental rocks and deposits of clay, shale, sand, sandstone and conglomerate; marine rocks and deposits of clay, shale, sandstone, and conglomerate...	On this section include marine rocks and deposits of Eocene and Oligocene age, also include some Paleocene marine rocks. Include continental rocks and deposits (Eocene to Miocene)-- chiefly Walker Formation (Eocene to Miocene) at depths off the section - greater than 13,000ft, where the Walker Formation underlies Eocene, marine sediments. Include marine rocks (Pre-Tertiary)
pTgm	**Granitic and metamorphic rocks (Pre-Tertiary)** Granitic rocks with some mafic intrusive rocks, and metasedimentary and metavolcanic rocks. Include granitic rocks (Pre-Tertiary) and metamorphic rocks (Pre-Tertiary)	Not present

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FIGURE 2-22
Geologic Cross-Section: Page (1986) Section B-B'

Chowchilla Subbasin Groundwater Sustainability Plan

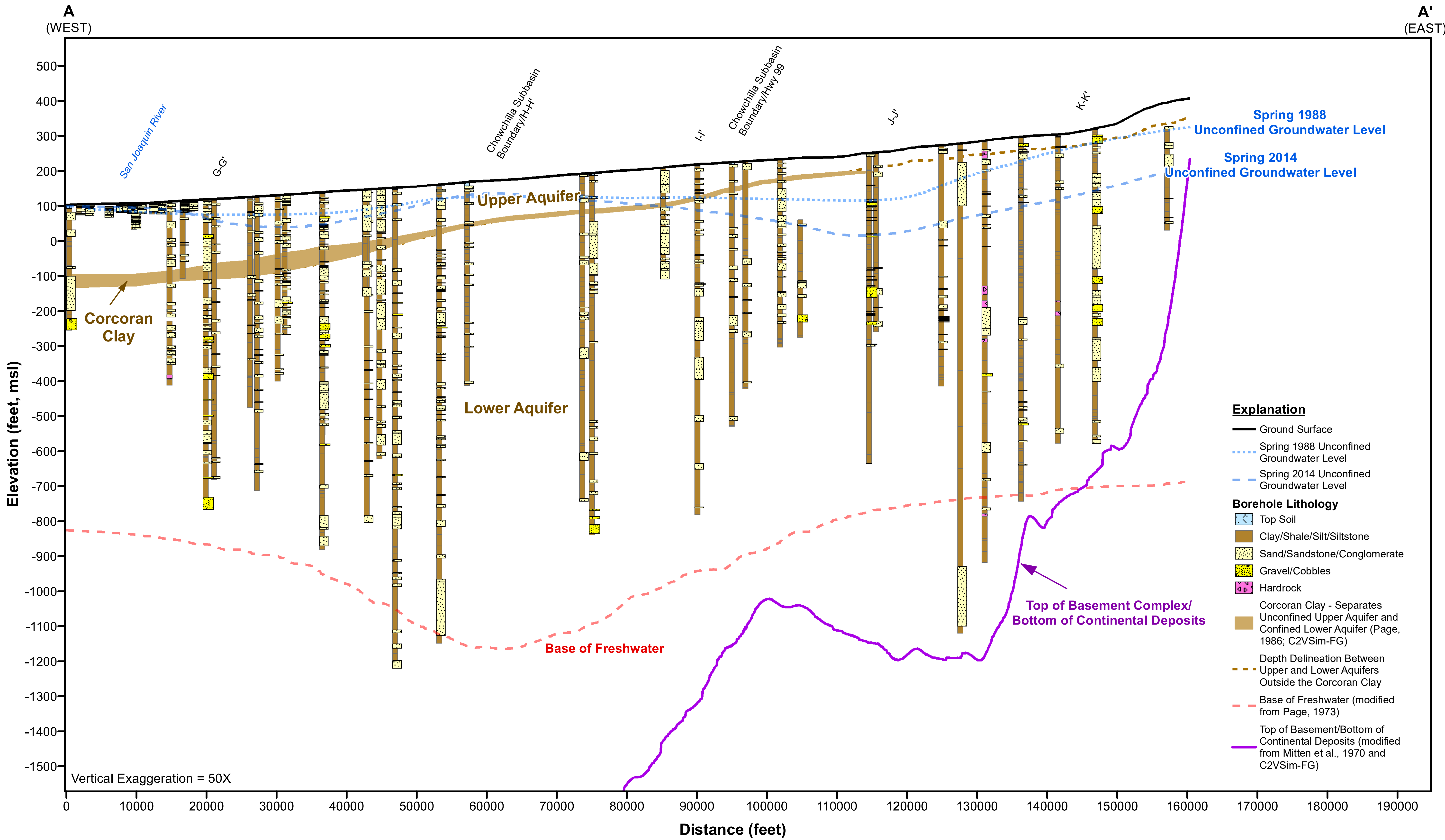

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FIGURE 2-23

Madera County Geologic Cross-Section A

Chowchilla Subbasin Groundwater Sustainability Plan

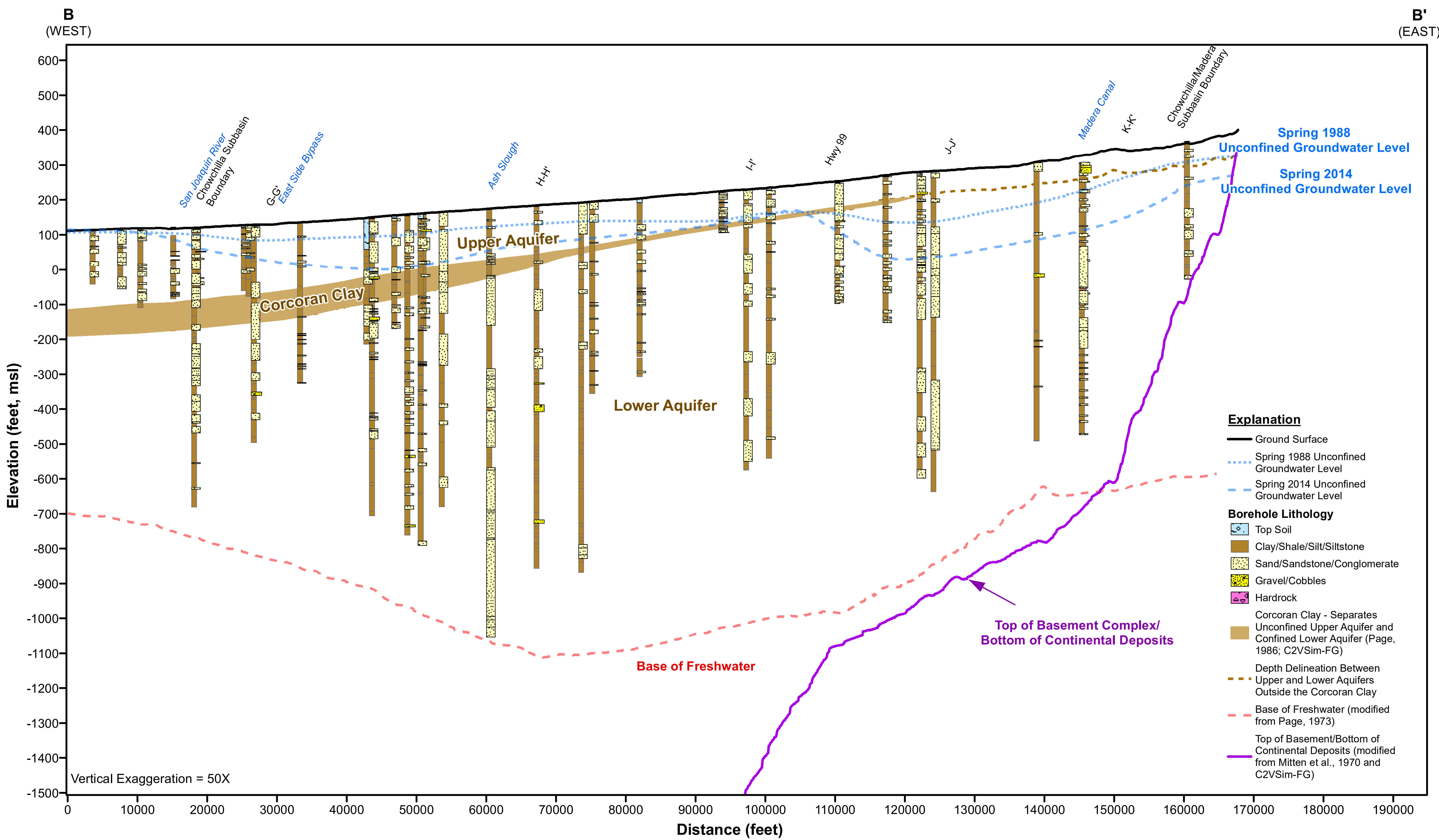

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FIGURE 2-24

Madera County Geologic Cross-Section B

Chowchilla Subbasin
Groundwater Sustainability Plan

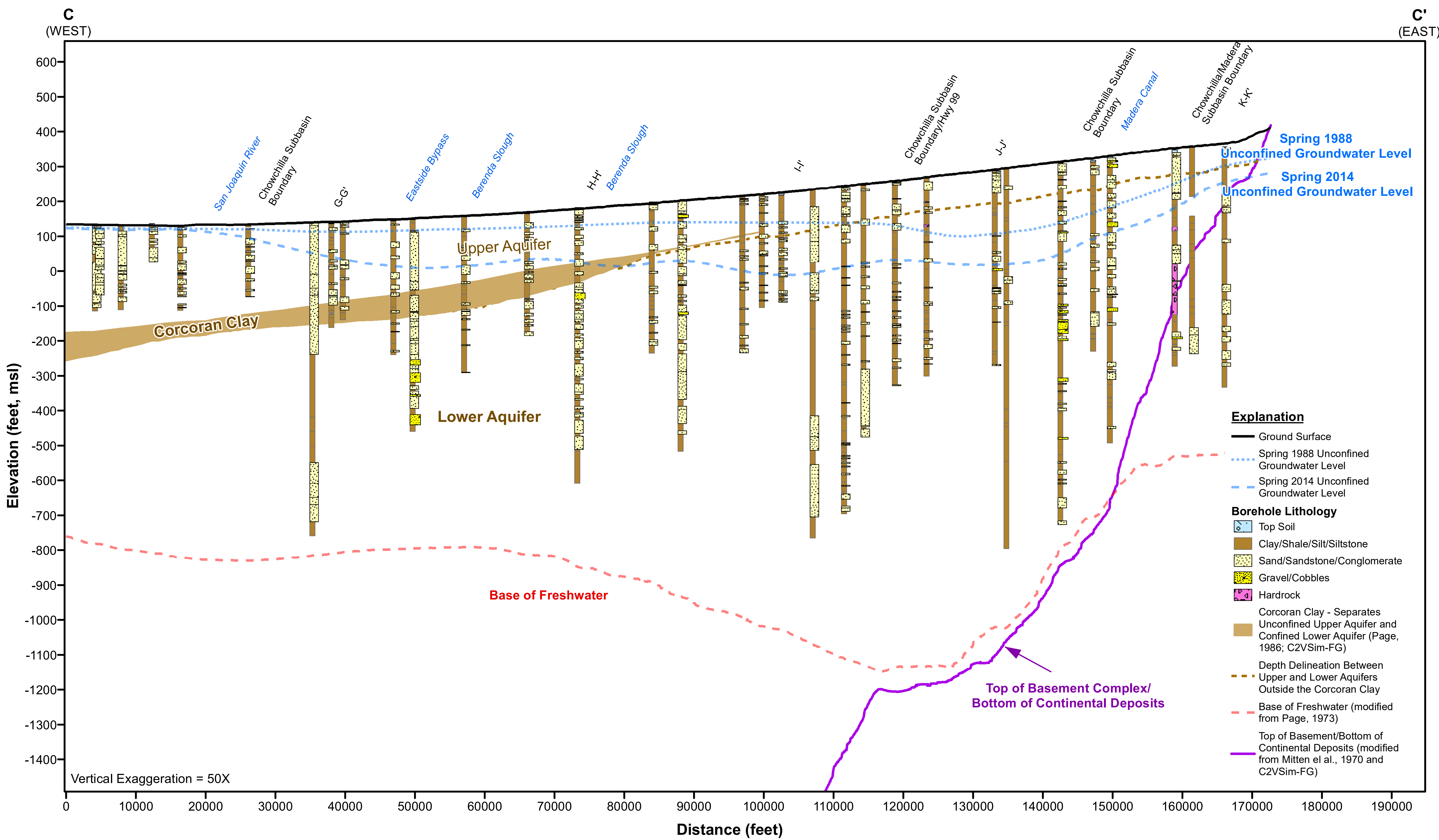

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FIGURE 2-25

Madera County Geologic Cross-Section C

Chowchilla Subbasin
Groundwater Sustainability Plan

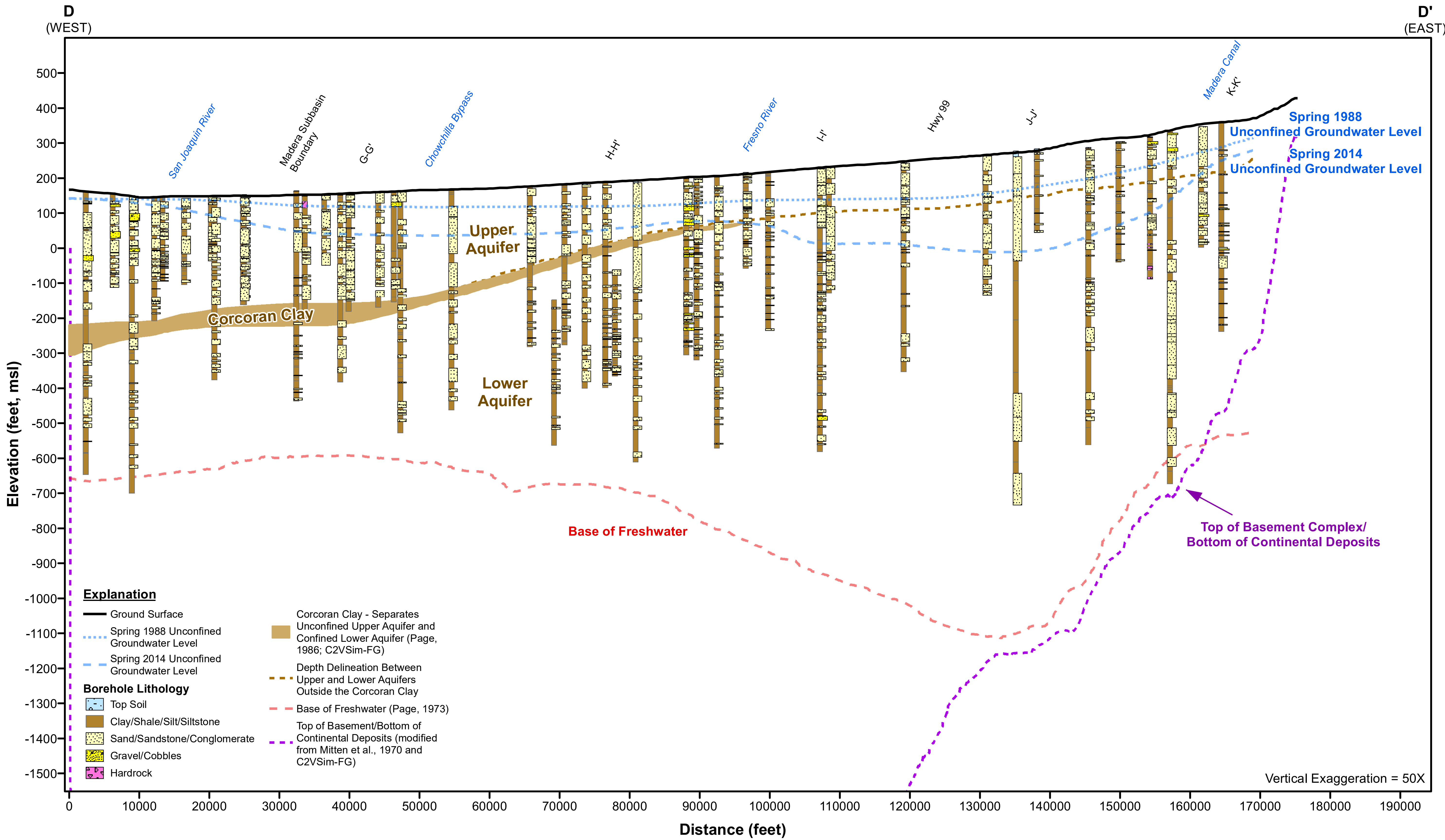

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FIGURE 2-26

Madera County Geologic Cross-Section D

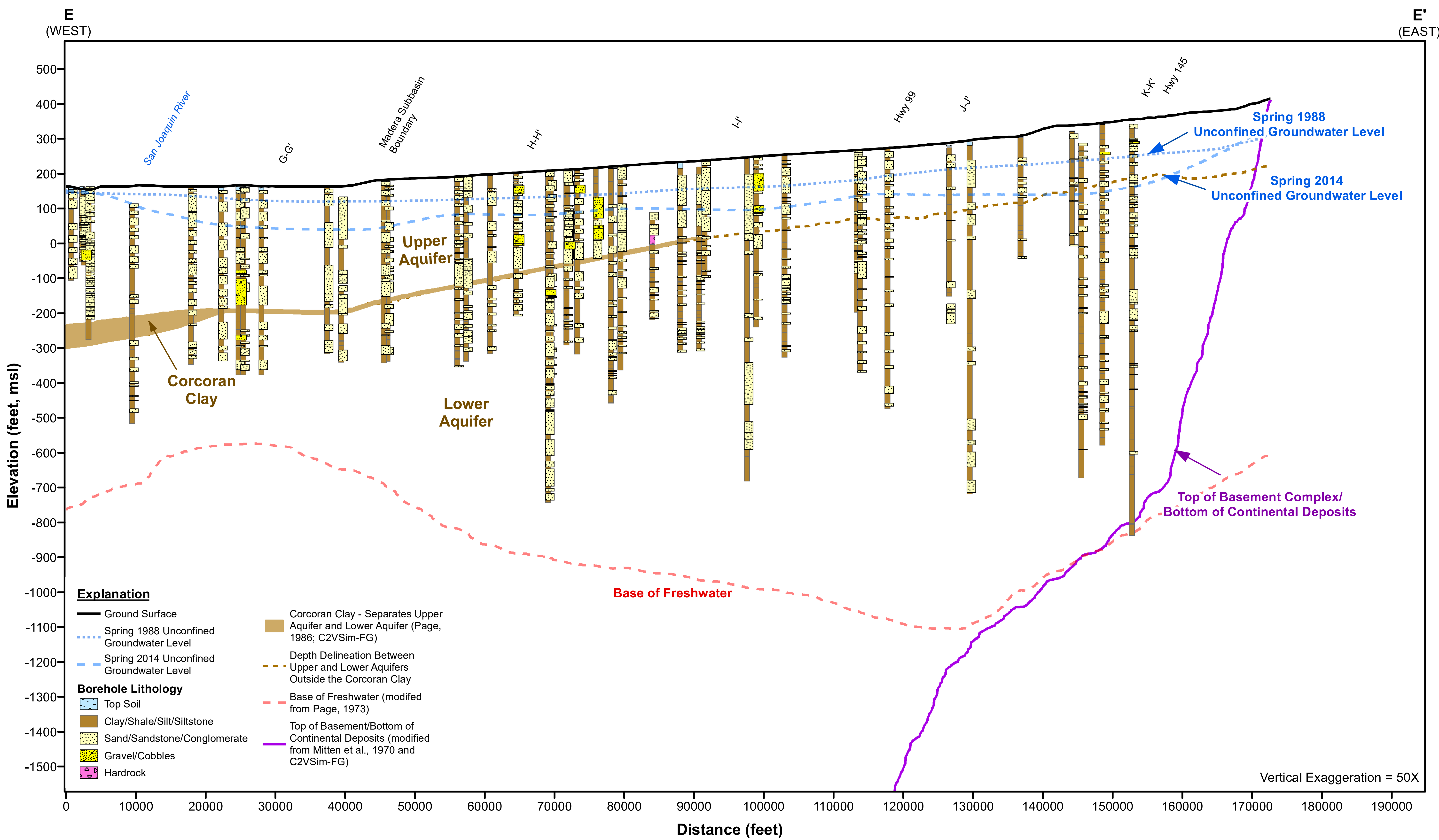

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FIGURE 2-27

Madera County Geologic Cross-Section E

Chowchilla Subbasin
Groundwater Sustainability Plan

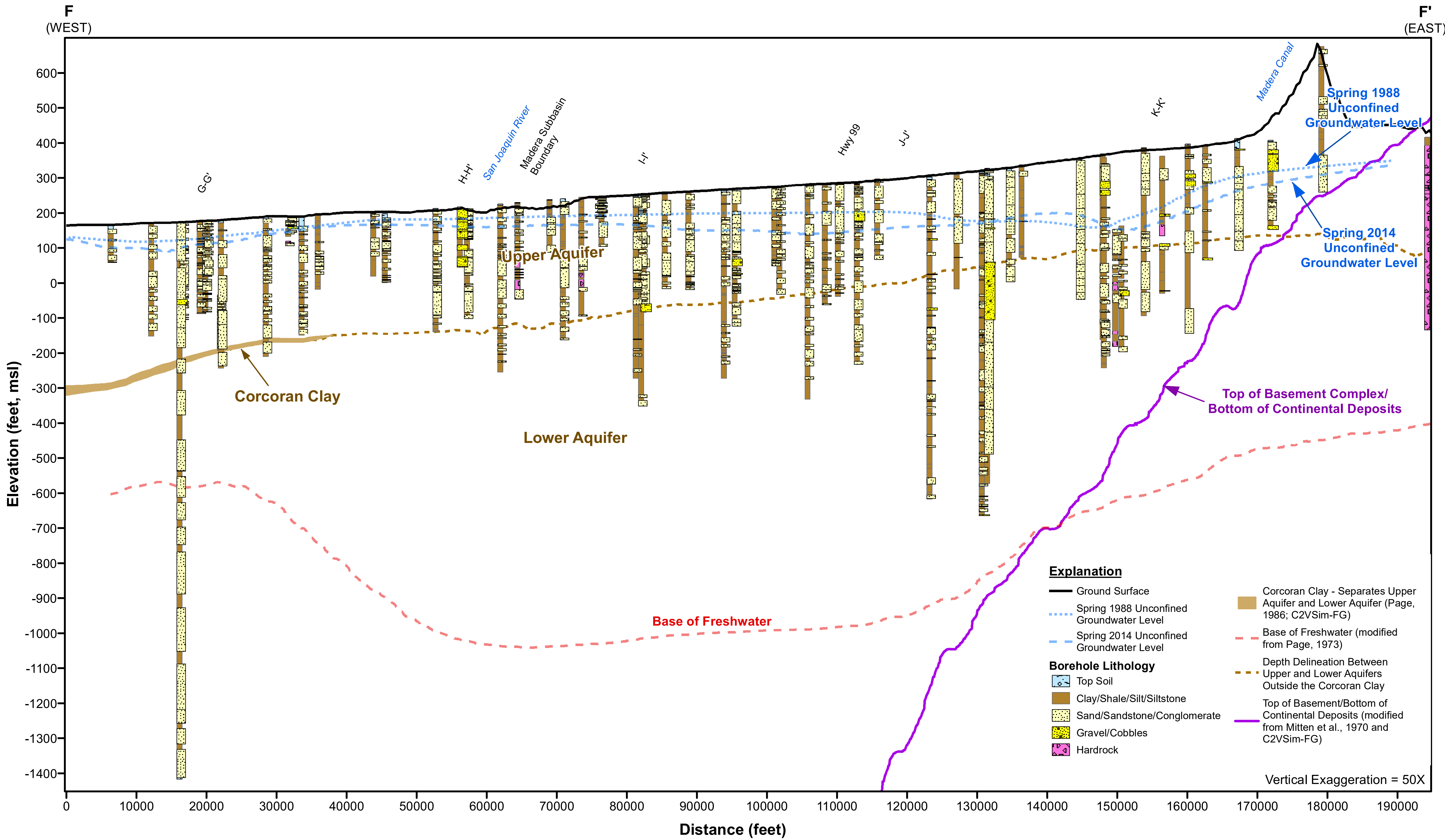

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FIGURE 2-28

Madera County Geologic Cross-Section F

Chowchilla Subbasin
Groundwater Sustainability Plan

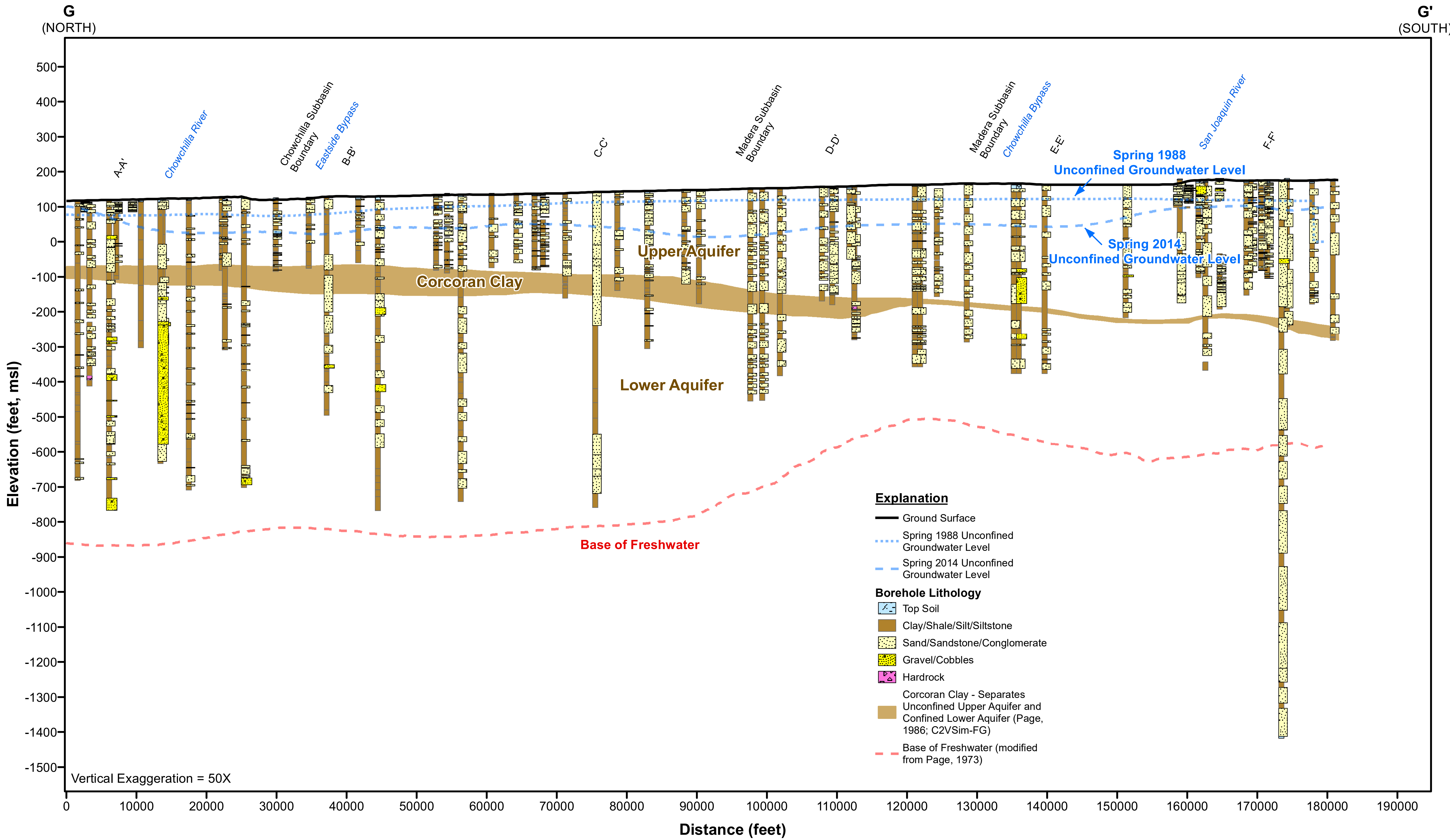

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FIGURE 2-29

Madera County Geologic Cross-Section G

Chowchilla Subbasin
Groundwater Sustainability Plan

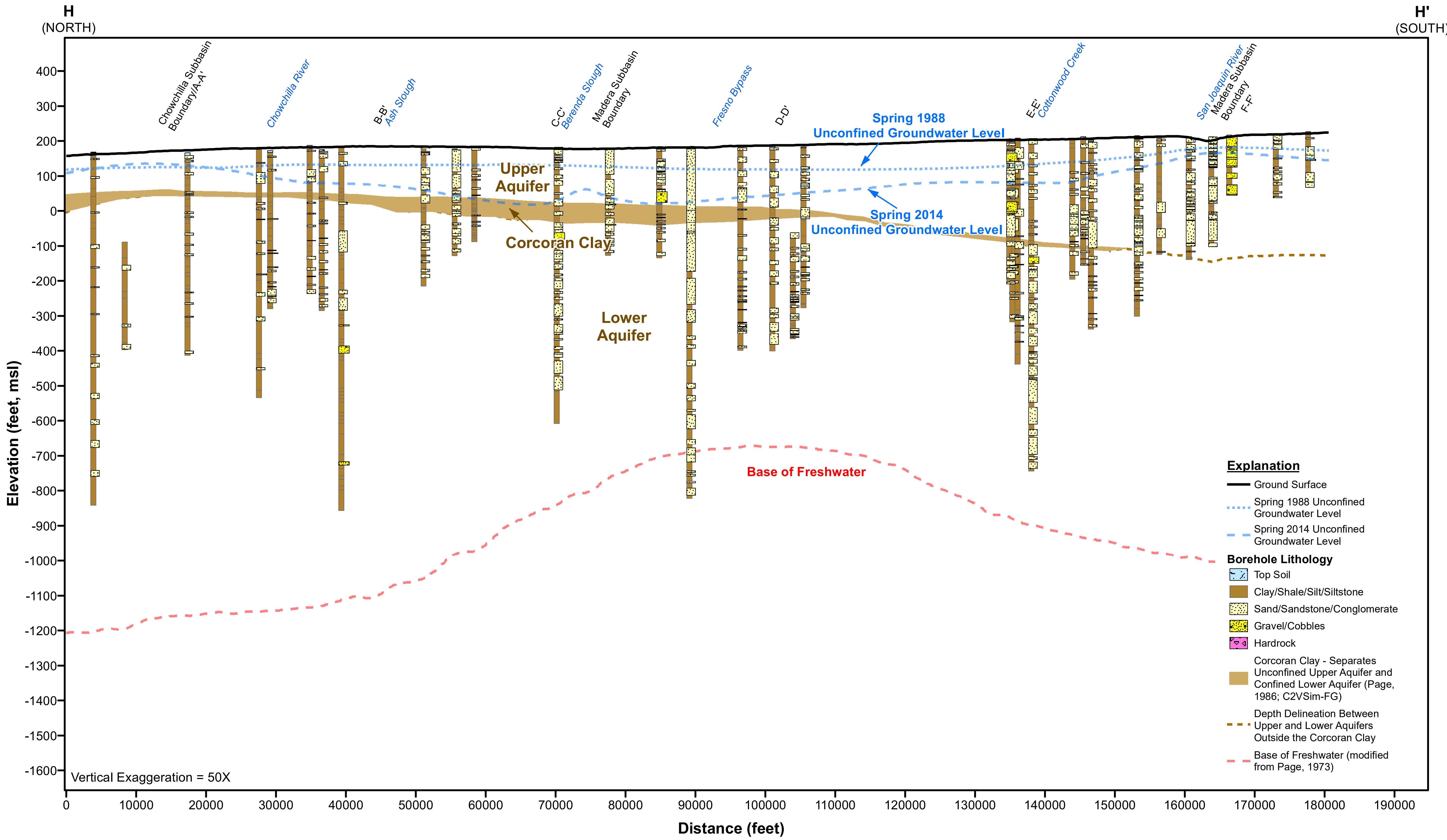

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FIGURE 2-30

Madera County Geologic Cross-Section H

Chowchilla Subbasin
Groundwater Sustainability Plan

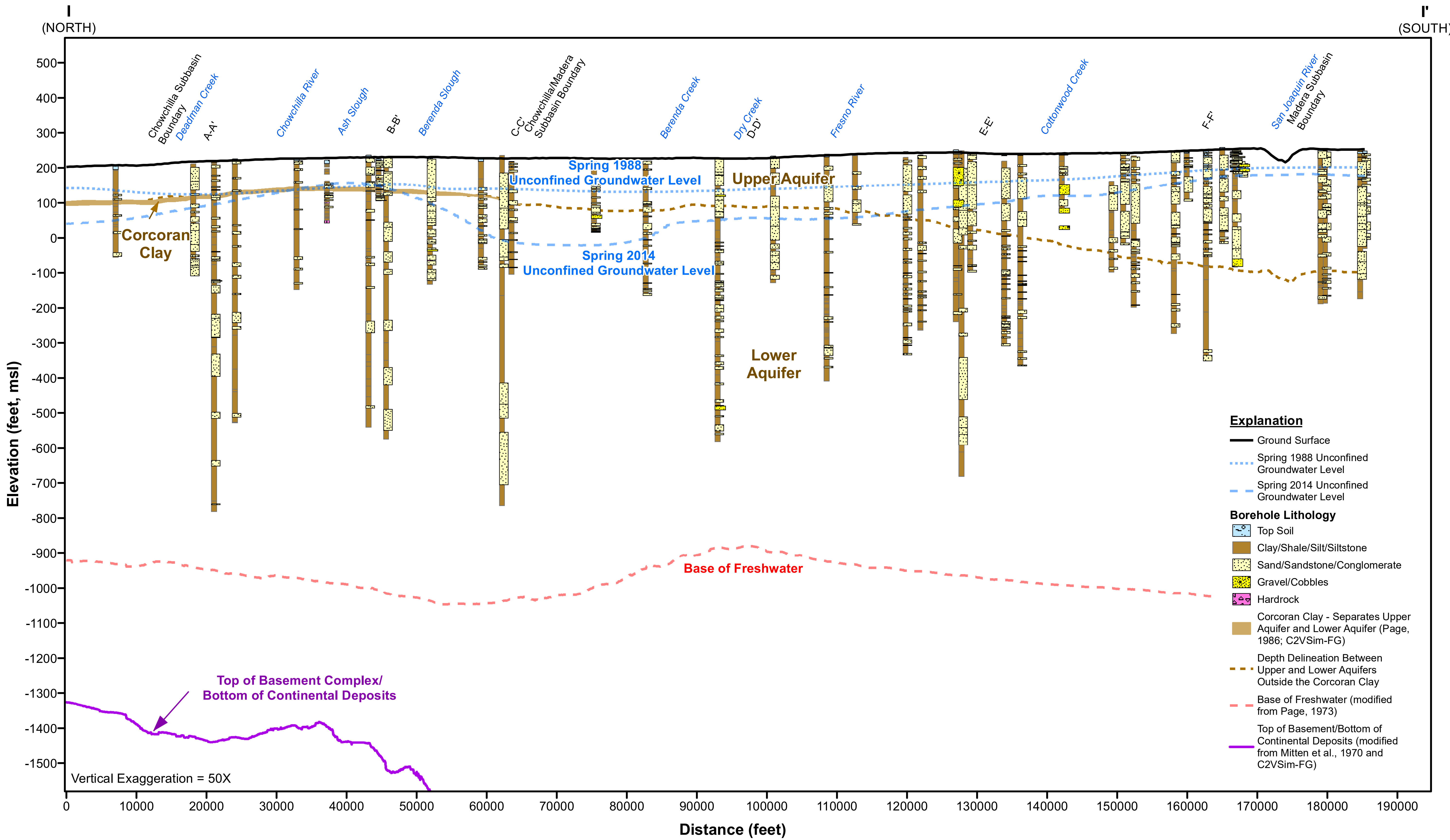

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FIGURE 2-31

Madera County Geologic Cross-Section I

Chowchilla Subbasin
Groundwater Sustainability Plan

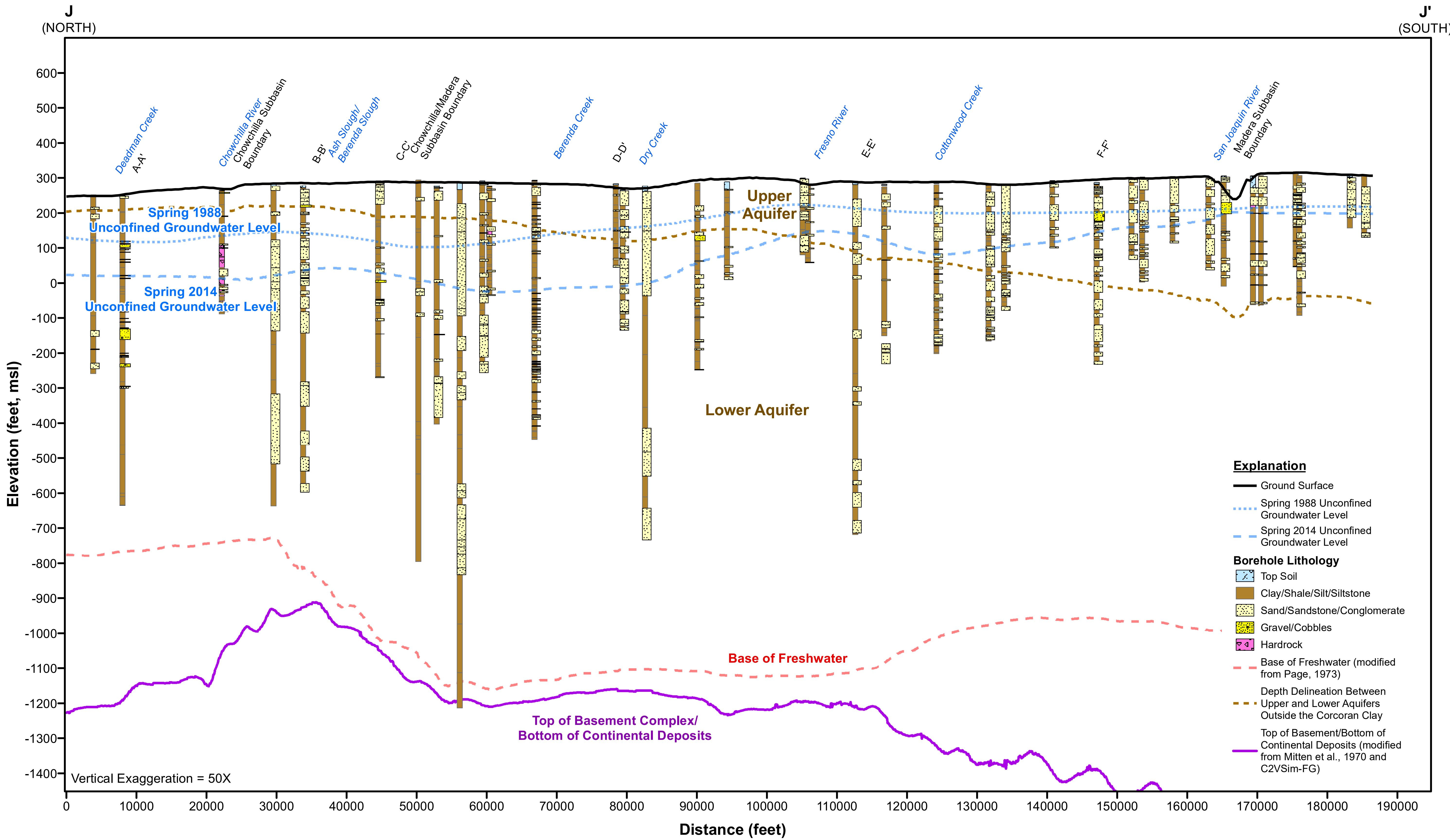

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FIGURE 2-32

Madera County Geologic Cross-Section J

Chowchilla Subbasin
Groundwater Sustainability Plan

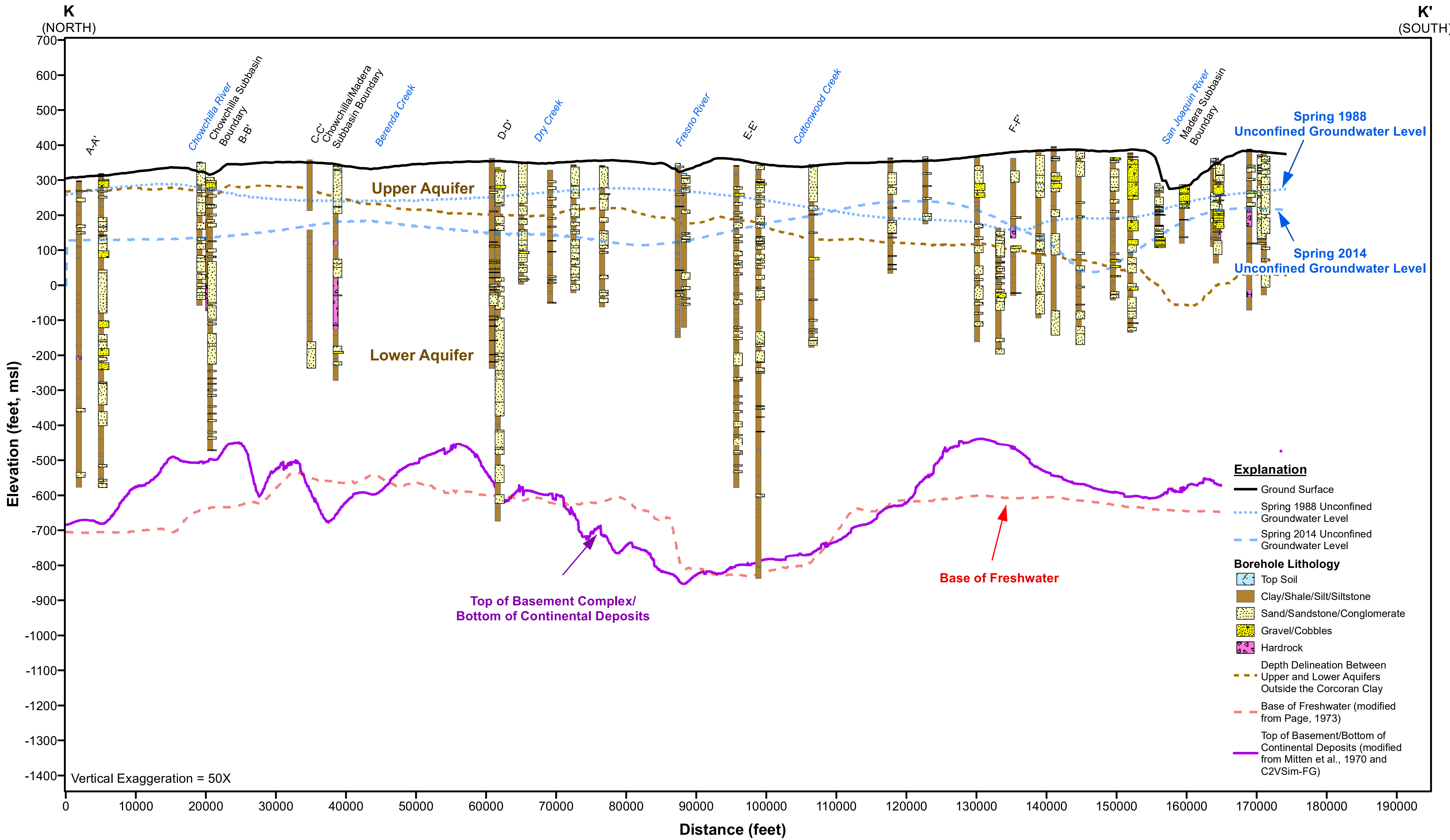

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FIGURE 2-33

Madera County Geologic Cross-Section K

Chowchilla Subbasin
Groundwater Sustainability Plan

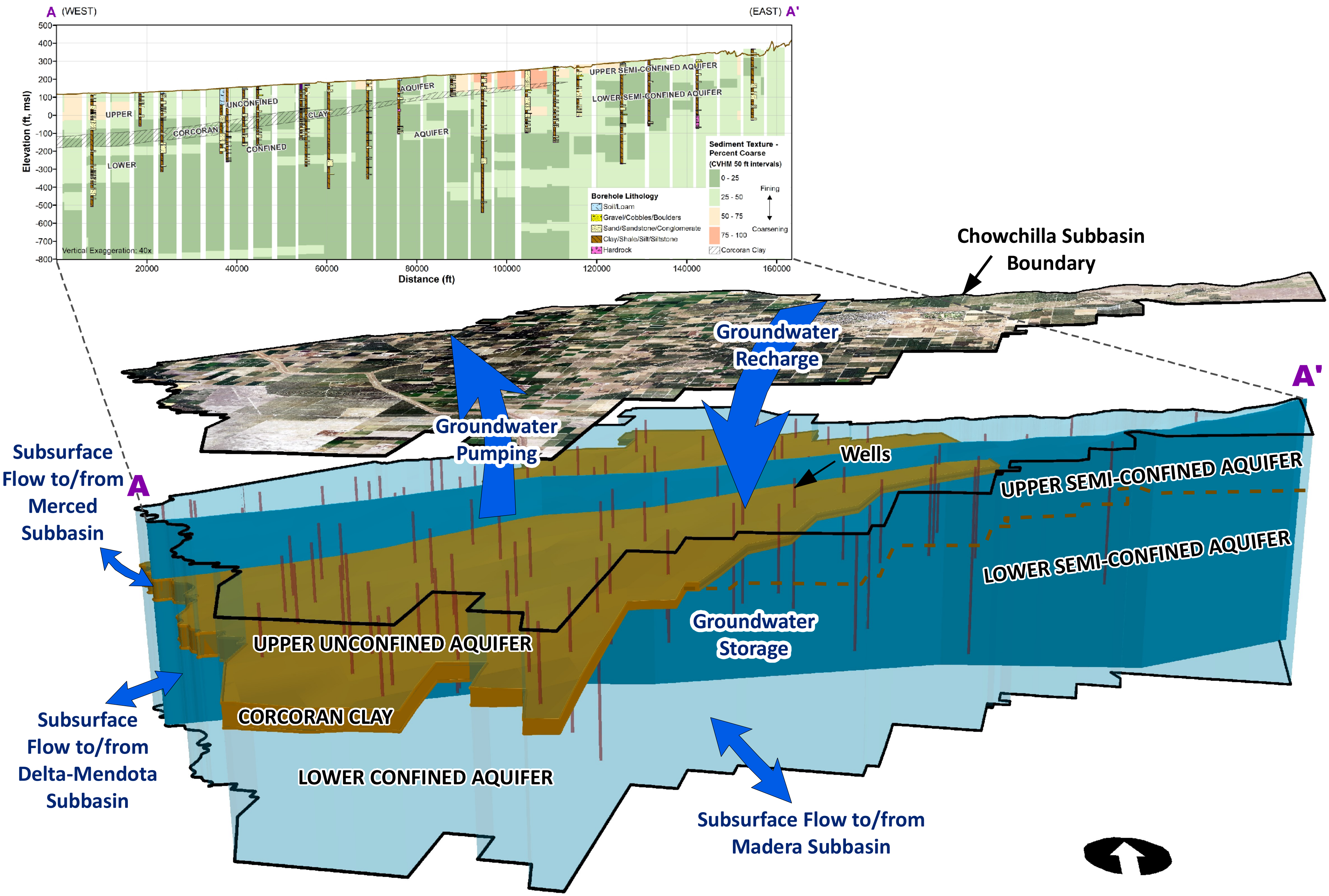

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FIGURE 2-34

Chowchilla Subbasin Conceptual Hydrogeologic System

Chowchilla Subbasin
Groundwater Sustainability Plan

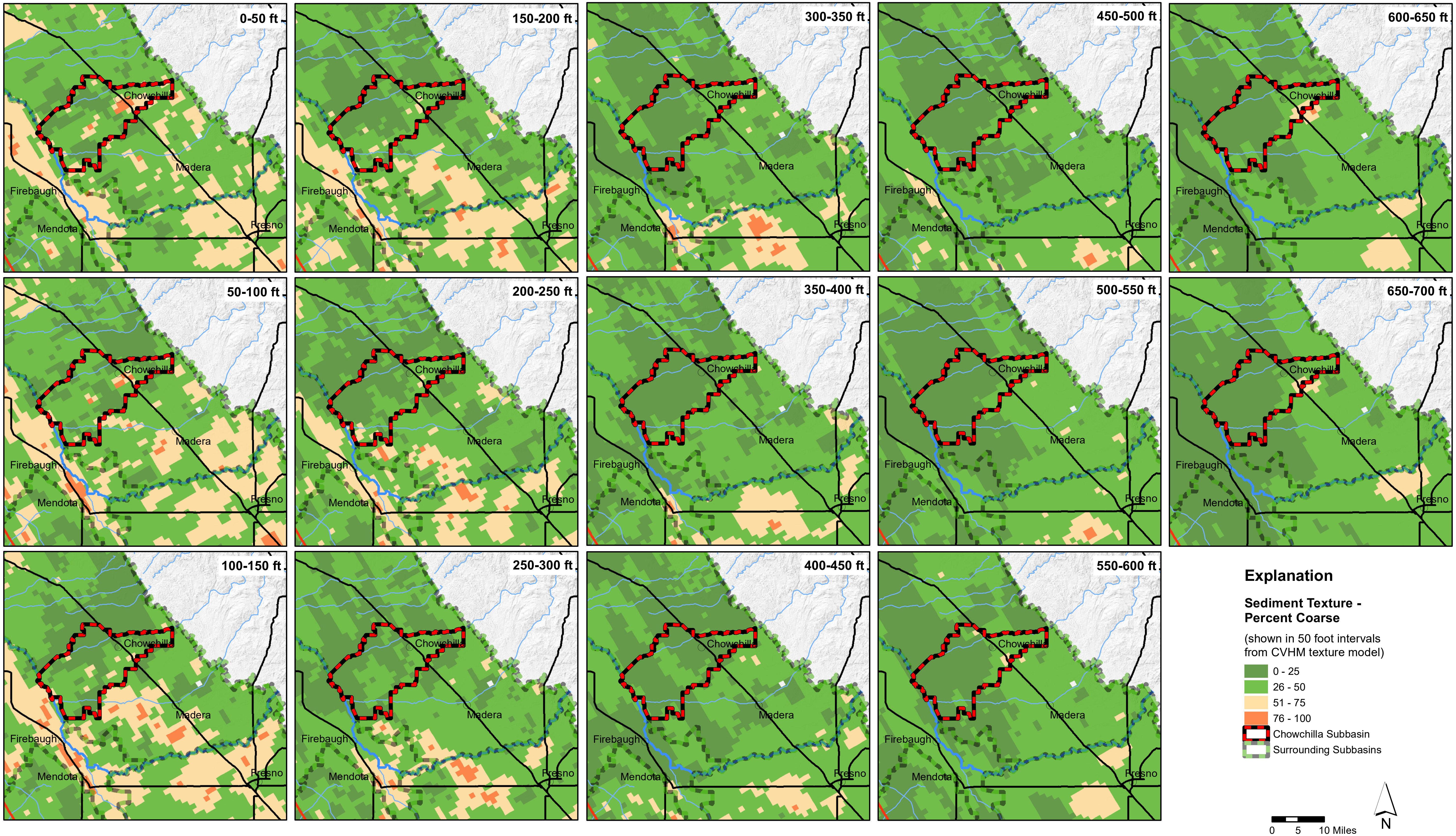

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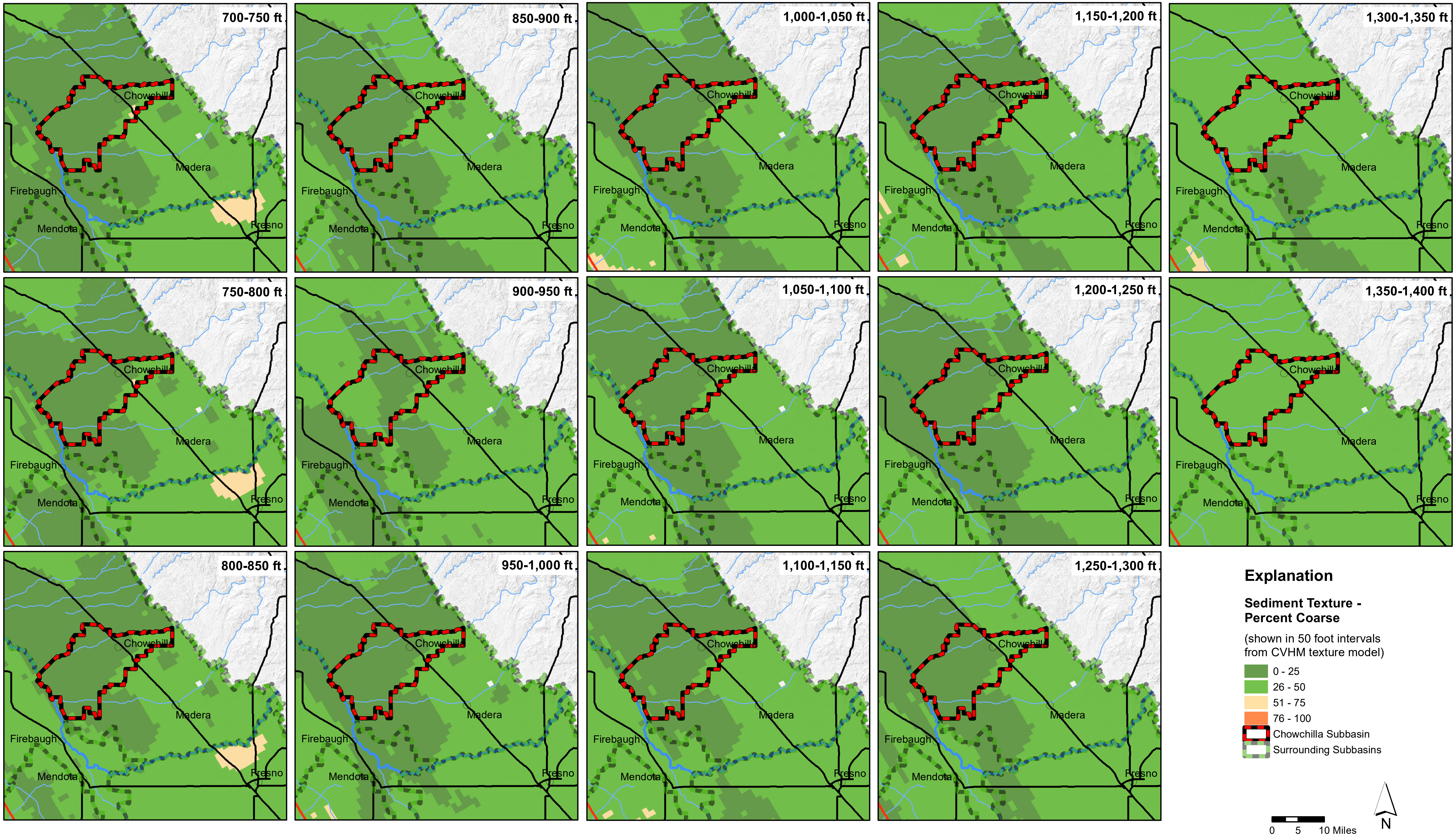
FIGURE 2-35

CVHM Sediment Texture Model: 0 to 700 feet

Chowchilla Subbasin
Groundwater Sustainability Plan

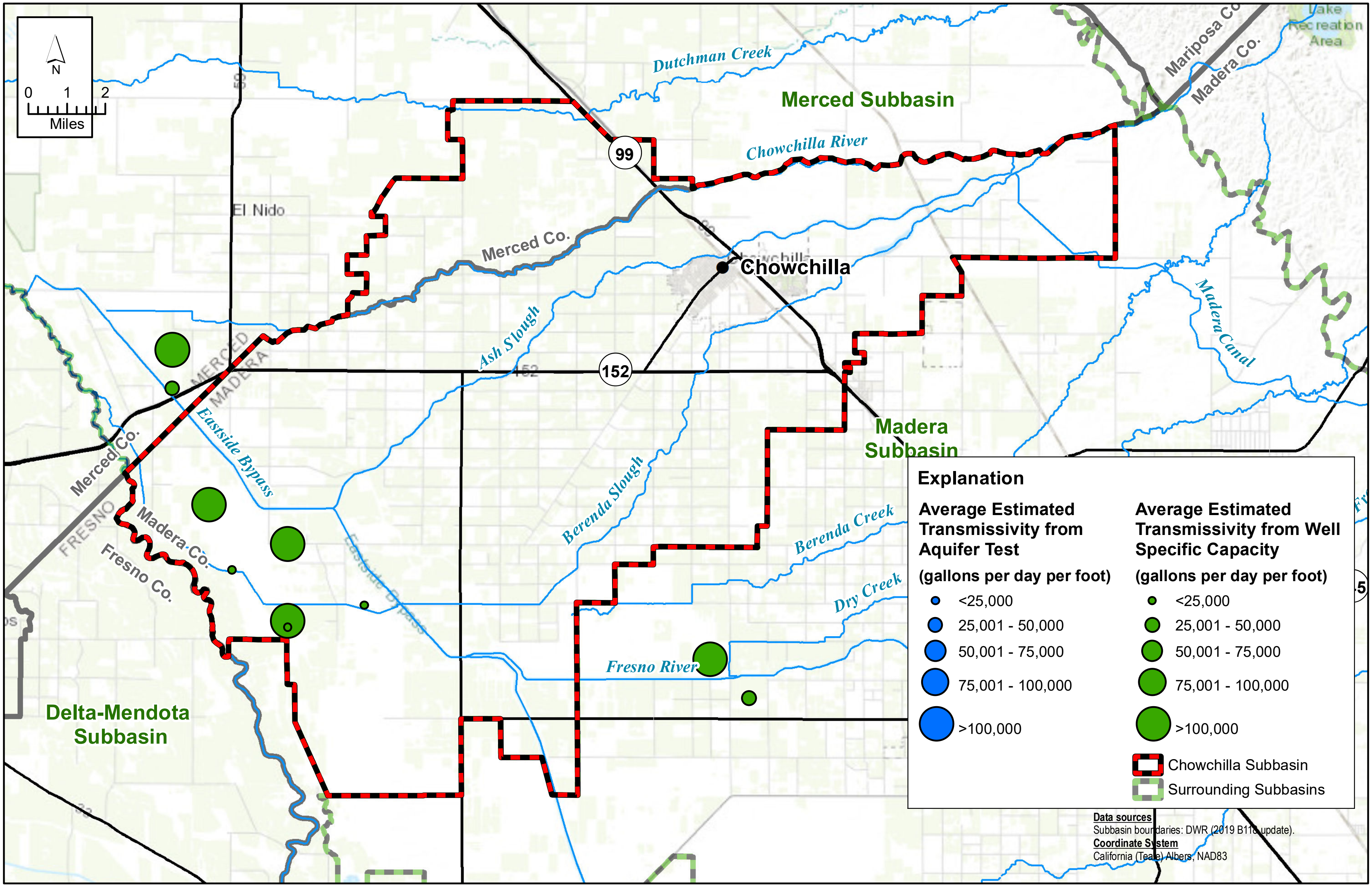


X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-36 CVHM Sediment Texture Model 700 to 1400.mxd

FIGURE 2-36

CVHM Sediment Texture Model: 700 to 1,400 feet

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-37 Chowchilla Subbasin Aquifer Property Data_Upper.mxd

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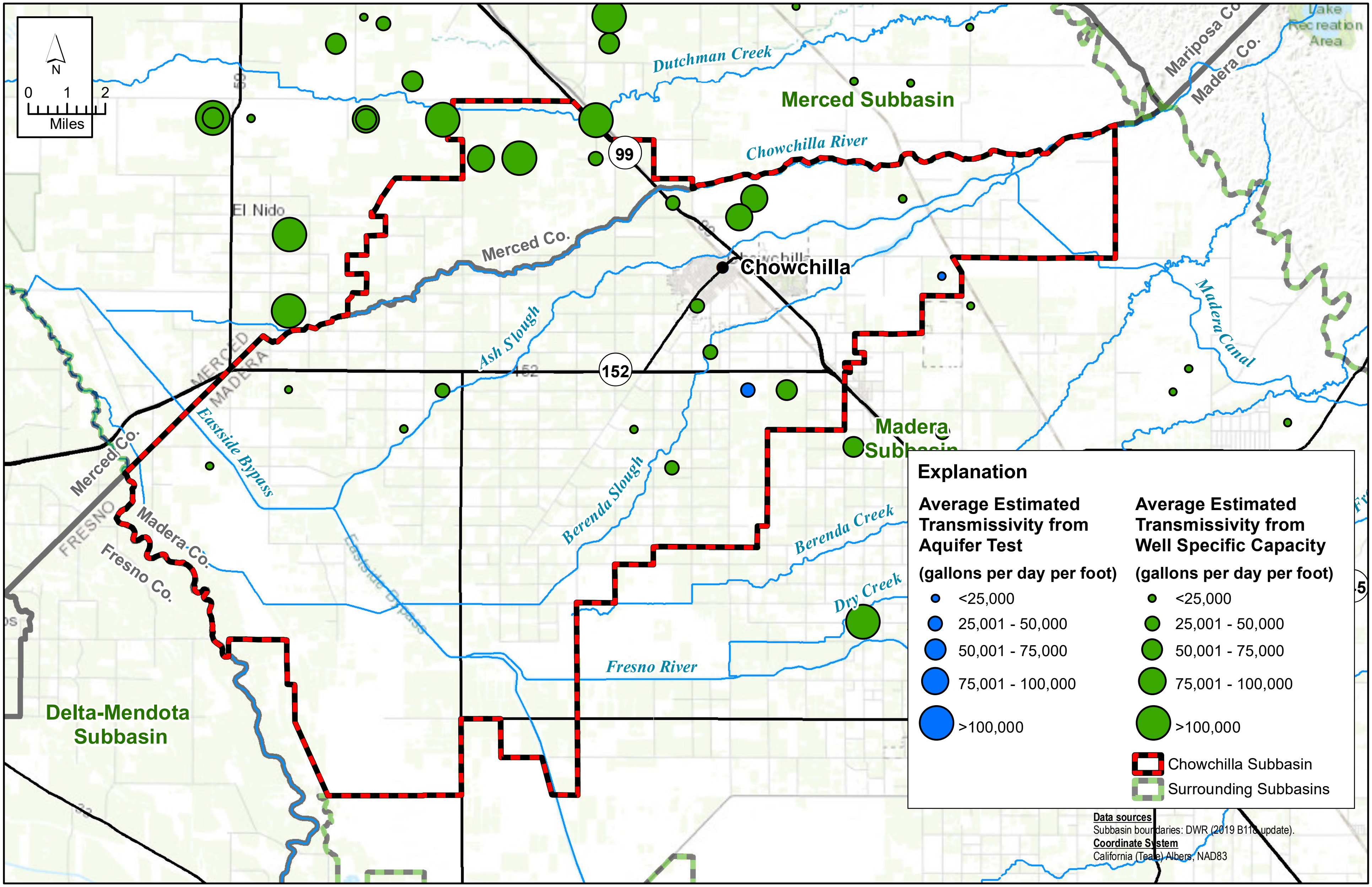
FIGURE 2-37
Map of Well Test Aquifer Property Data: Upper Aquifer

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-38 Chowchilla Subbasin Aquifer Property Data_Lower.mxd

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FIGURE 2-38
Map of Well Test Aquifer Property Data: Lower Aquifer

Chowchilla Subbasin
Groundwater Sustainability Plan

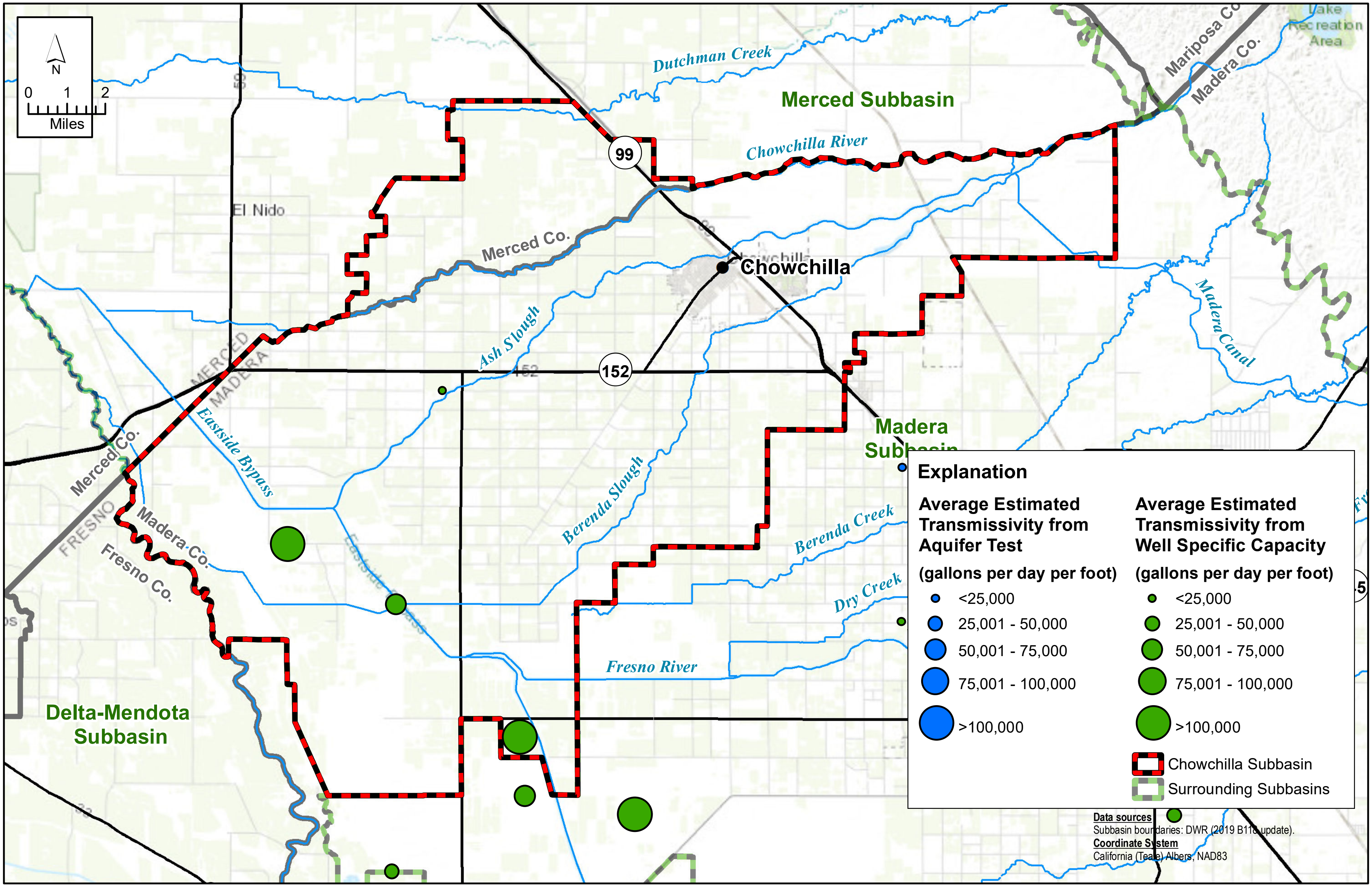

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FIGURE 2-39
Map of Well Test Aquifer Property Data: Composite Wells or Unknown Depth

Chowchilla Subbasin
Groundwater Sustainability Plan

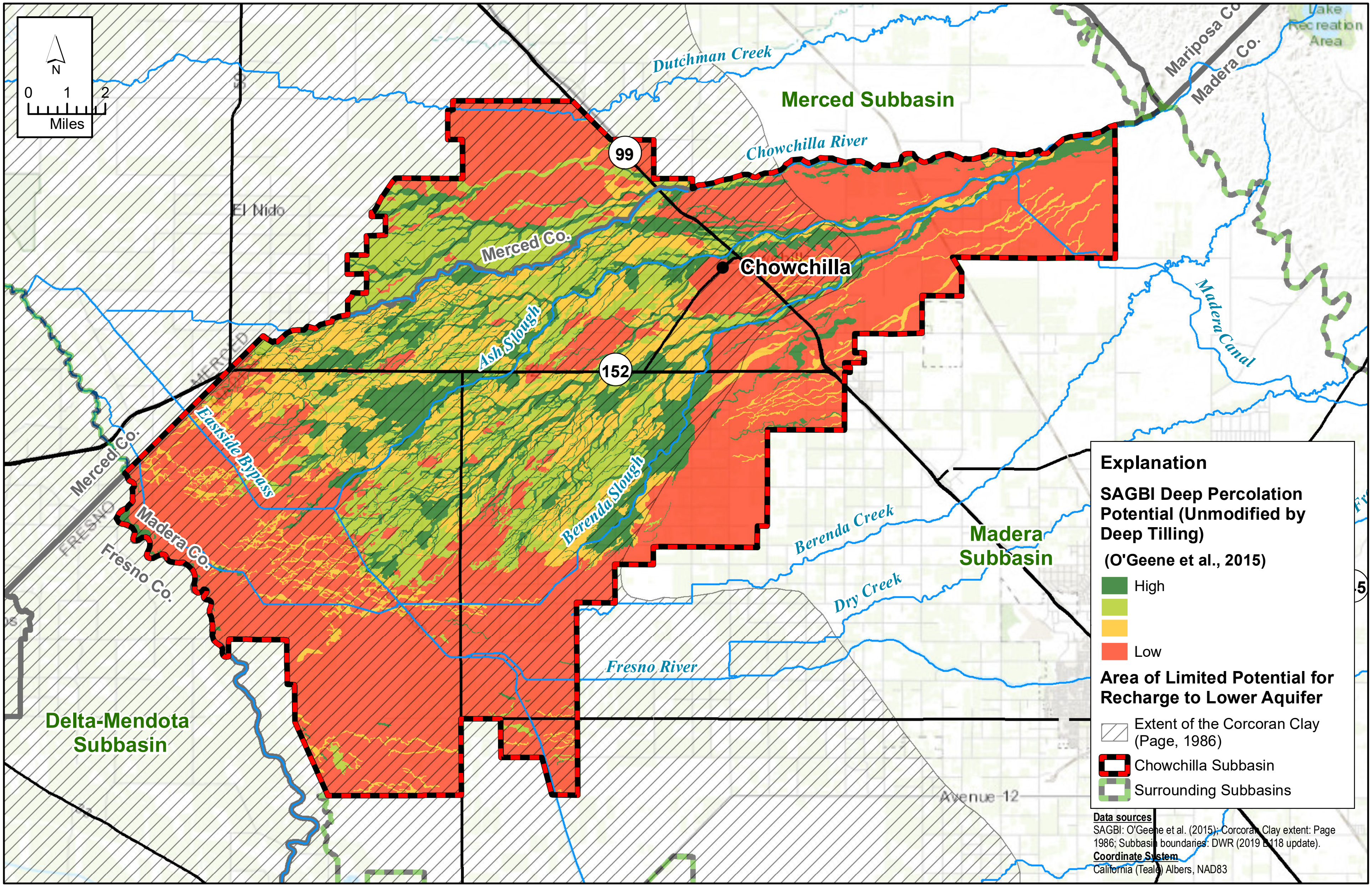

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FIGURE 2-40
SAGBI Deep Percolation Potential: Unmodified by Tilling

Chowchilla Subbasin
Groundwater Sustainability Plan

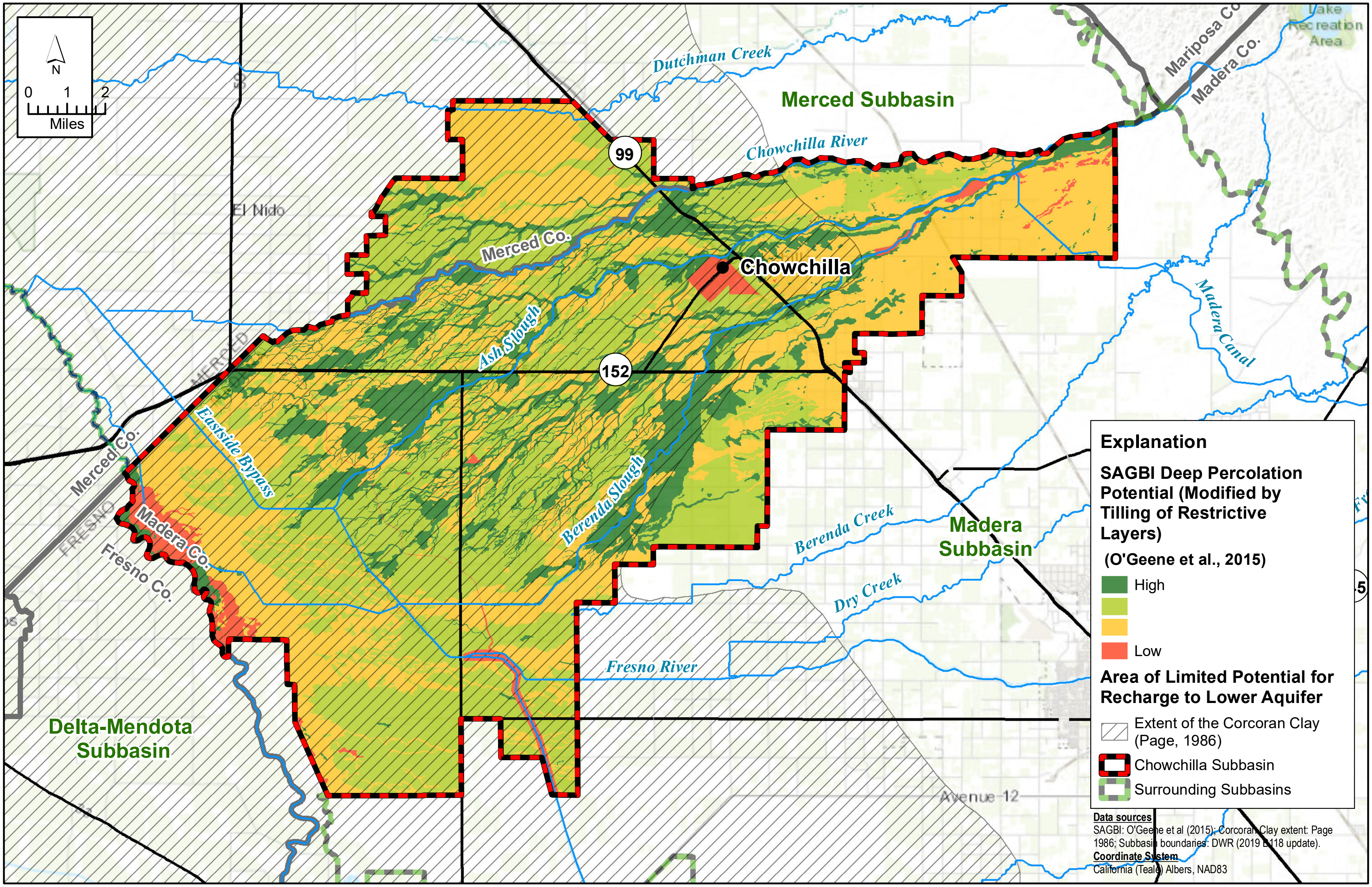

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FIGURE 2-41

SAGBI Deep Percolation Potential: Modified by Tilling of All Restrictive Layers

Chowchilla Subbasin

Groundwater Sustainability Plan

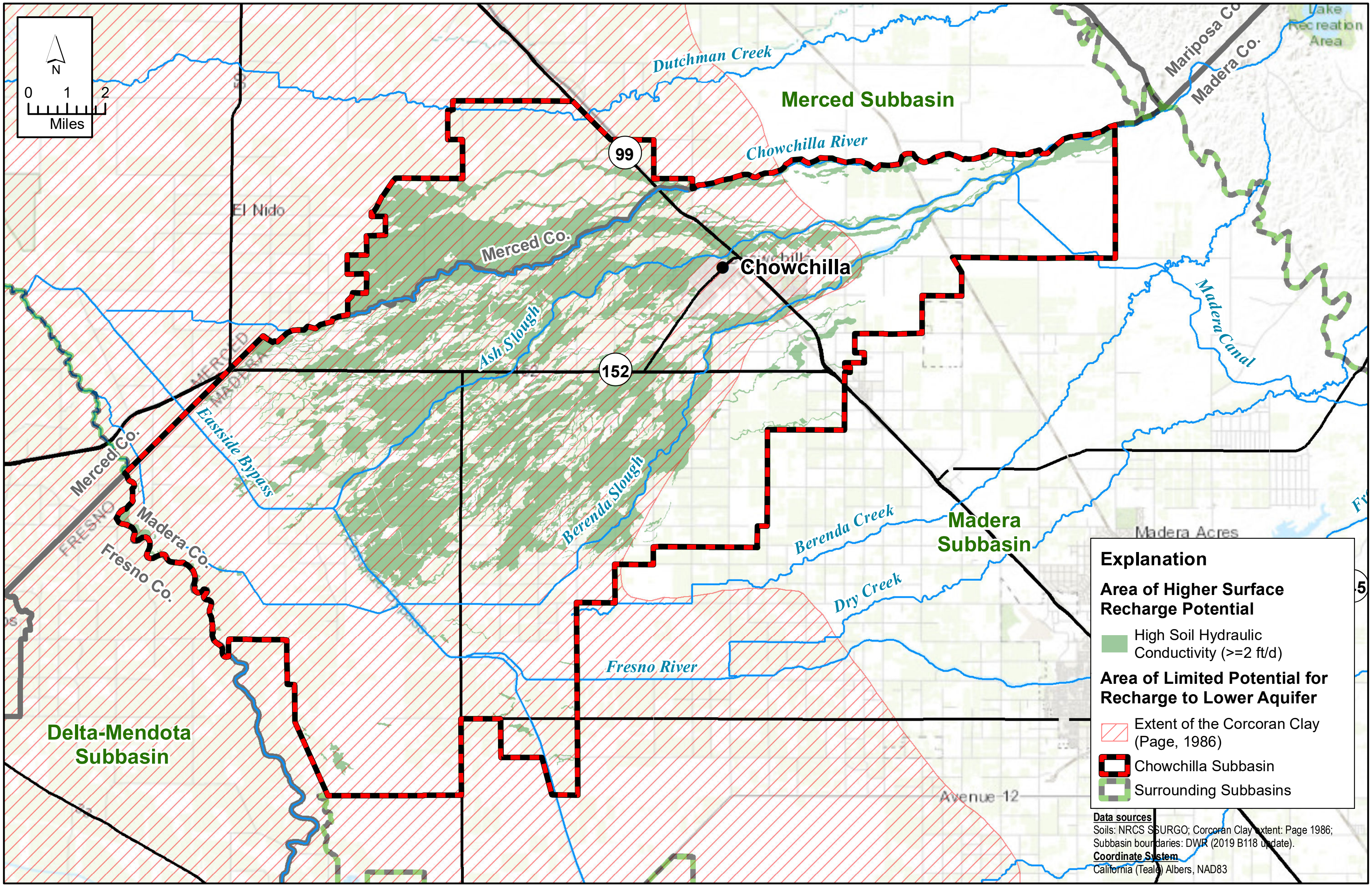

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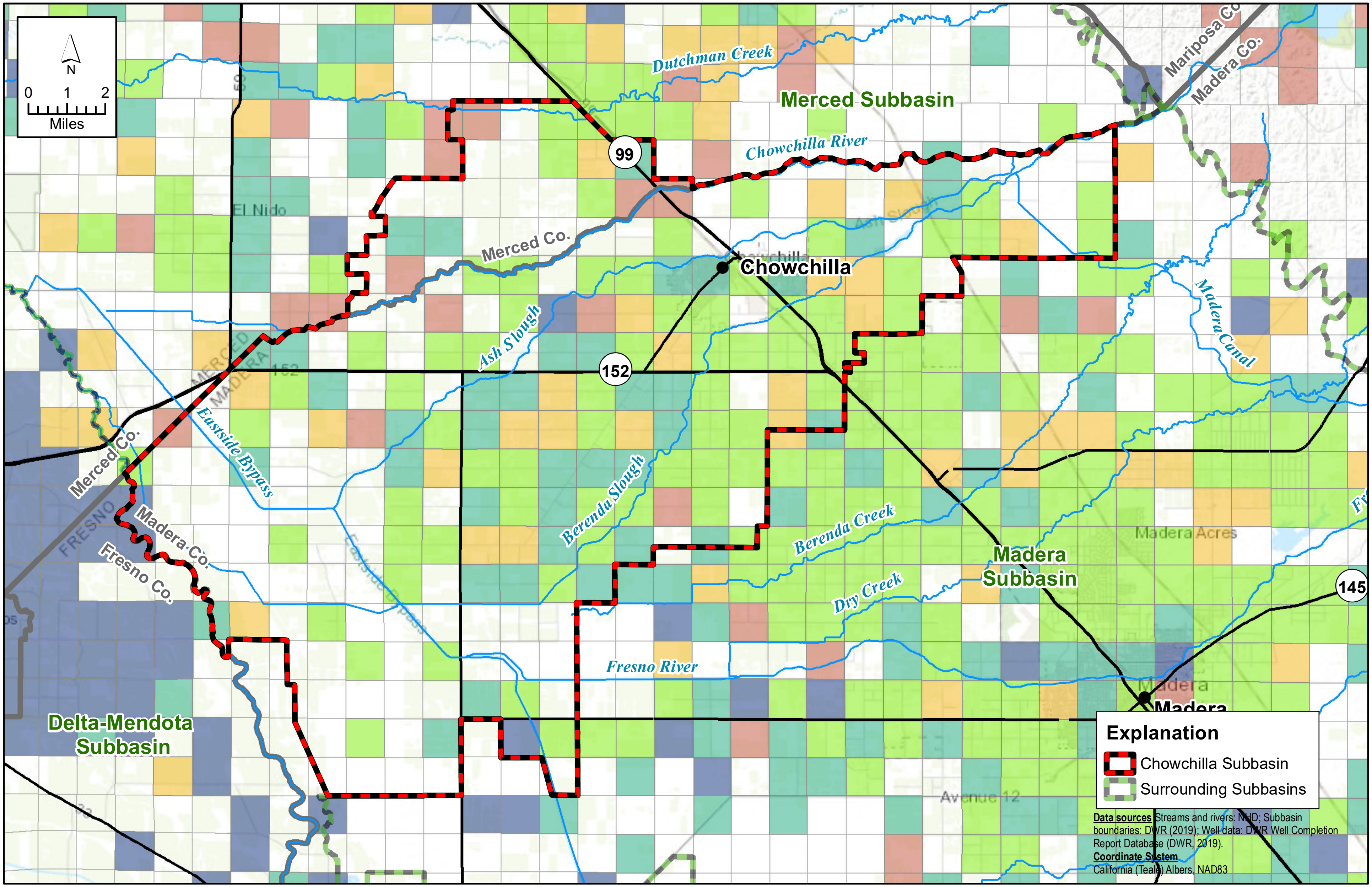
FIGURE 2-42

Areas of Higher Recharge Potential

Chowchilla Subbasin
Groundwater Sustainability Plan



\\SERVER-01\Clerical\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-43 Chowchilla Subbasin Wells By Section Dom Well Depth.mxd

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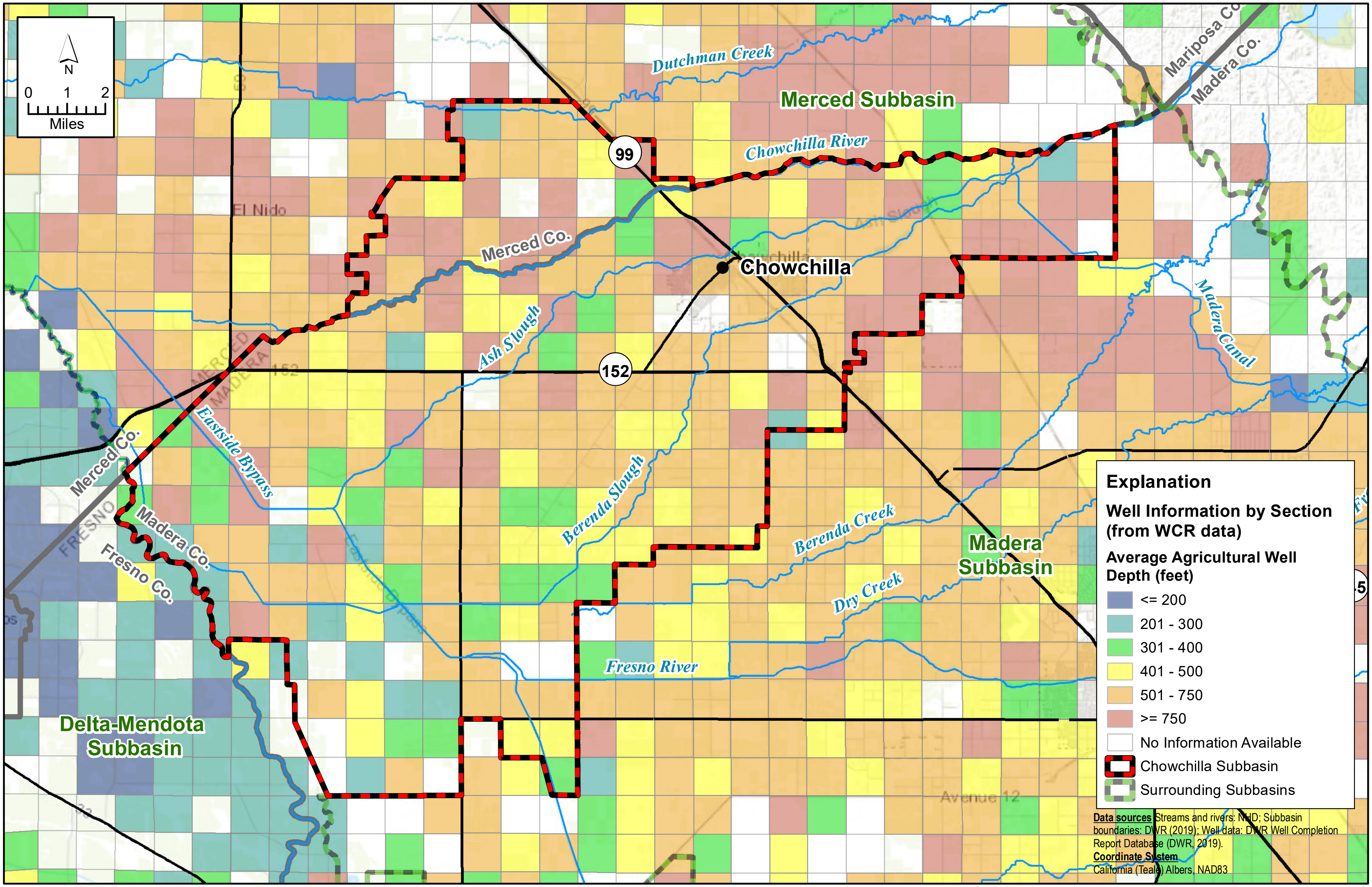
FIGURE 2-43
Map of Well Information by Section: Average Domestic Well Depth (from WCR data)

Chowchilla Subbasin Groundwater Sustainability Plan



\\SERVER-01\Clerical\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-44 Chowchilla Subbasin Wells By Section Ag Well Depth.mxd

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FIGURE 2-44
Map of Well Information by Section: Average Agricultural Well Depth (from WCR data)

Chowchilla Subbasin Groundwater Sustainability Plan

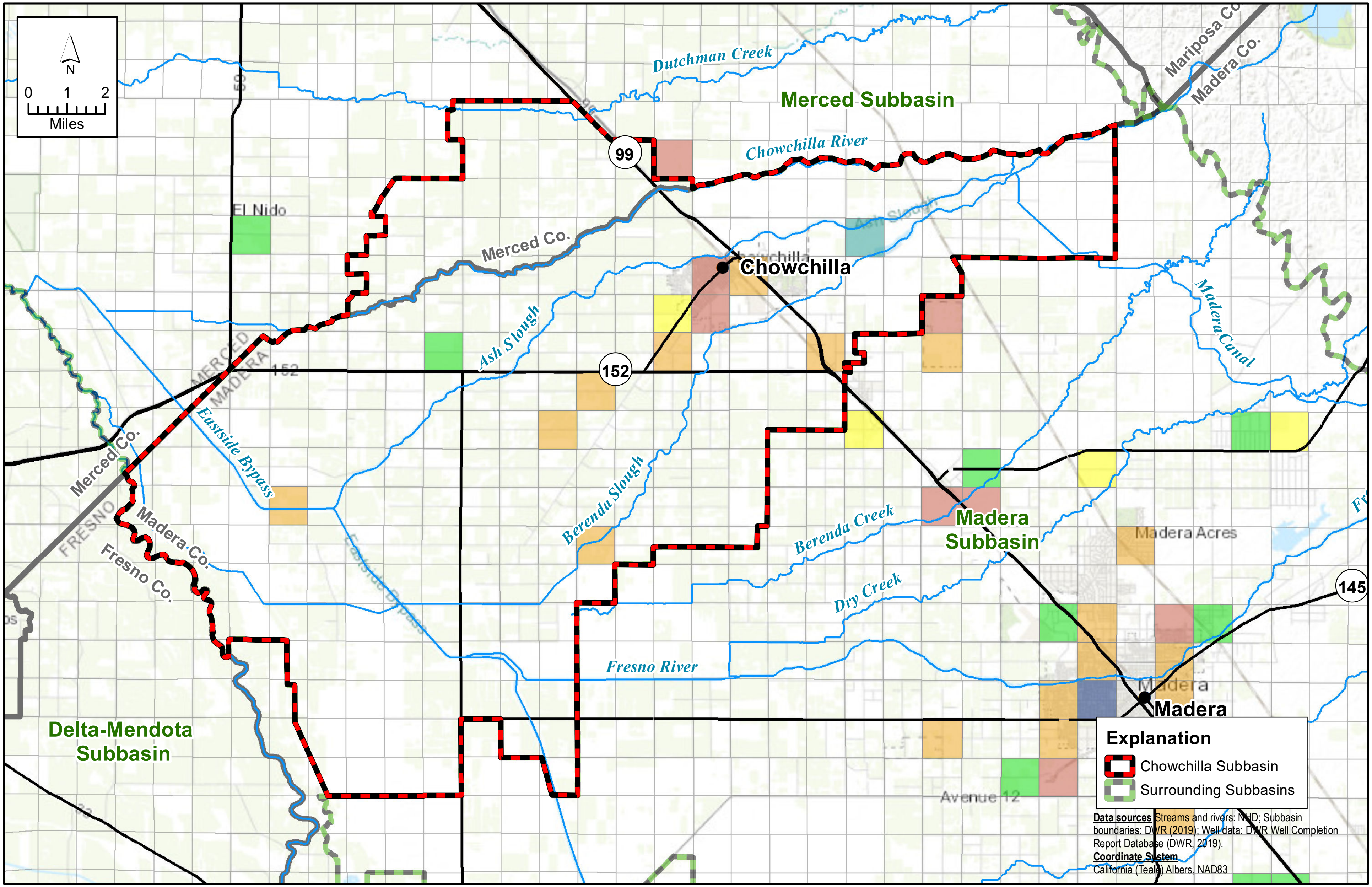

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FIGURE 2-45
Map of Well Information by Section:
Average Public Supply Well Depth (from WCR data)

Chowchilla Subbasin
Groundwater Sustainability Plan

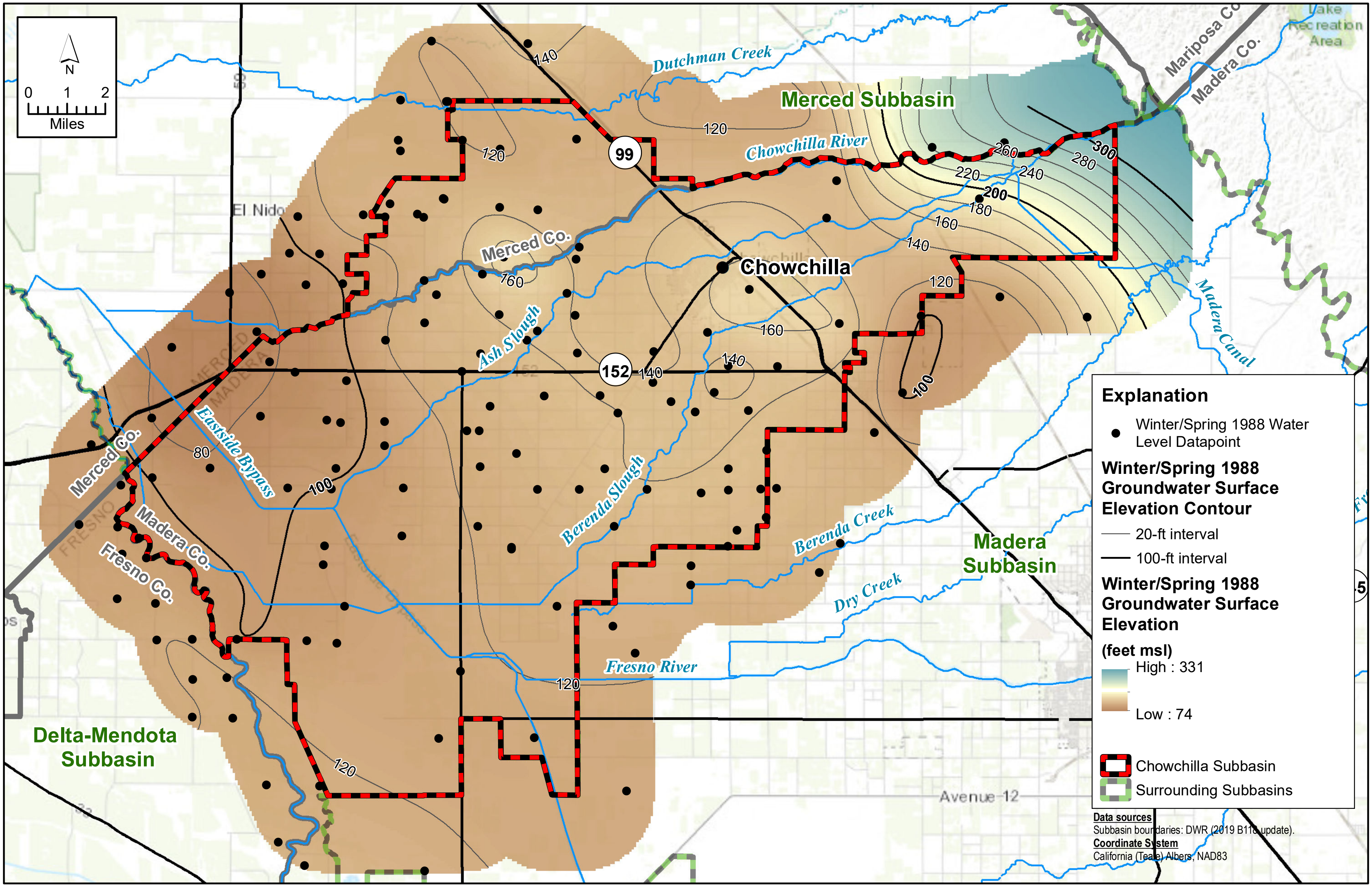

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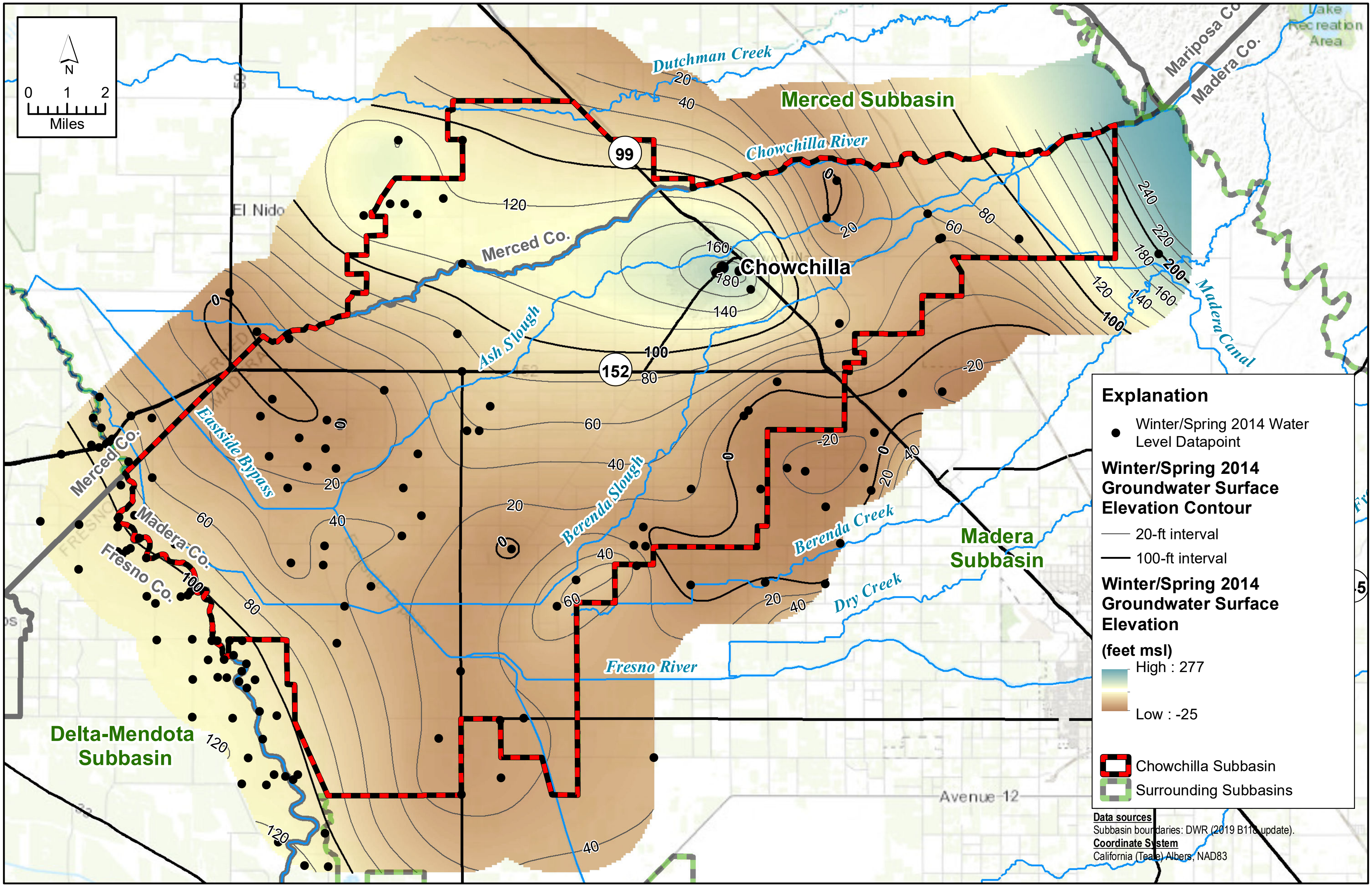
FIGURE 2-46
Groundwater Surface Elevation Map: Winter/Spring 1988 - Unconfined Groundwater

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-47 Chowchilla Subbasin SpW2014 GWEL Contours_Unconfined.mxd

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FIGURE 2-47
Groundwater Surface Elevation Map: Winter/Spring 2014 - Unconfined Groundwater

Chowchilla Subbasin
Groundwater Sustainability Plan

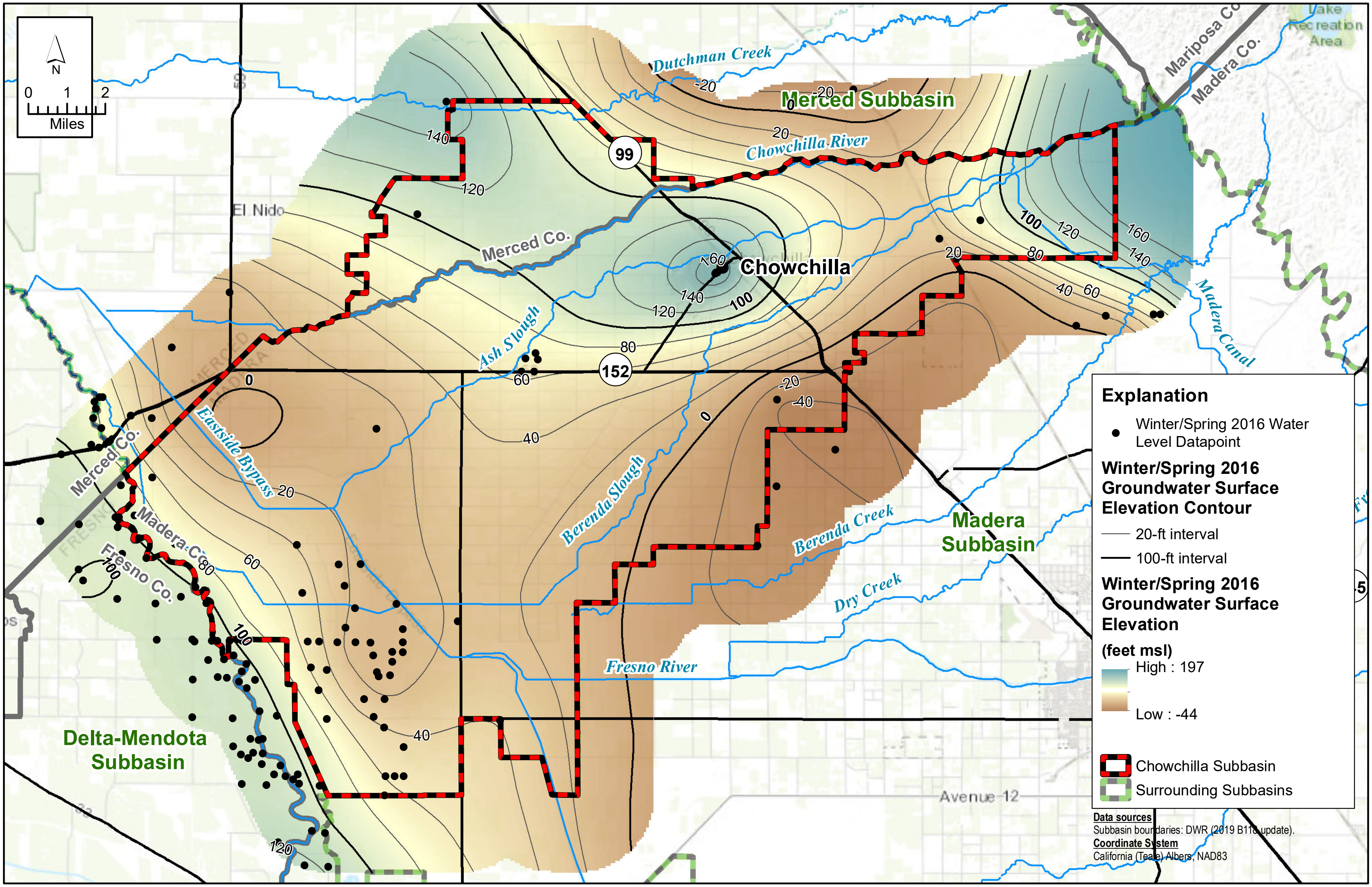

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FIGURE 2-48
Groundwater Surface Elevation Map: Winter/Spring 2016 - Unconfined Groundwater

Chowchilla Subbasin
Groundwater Sustainability Plan

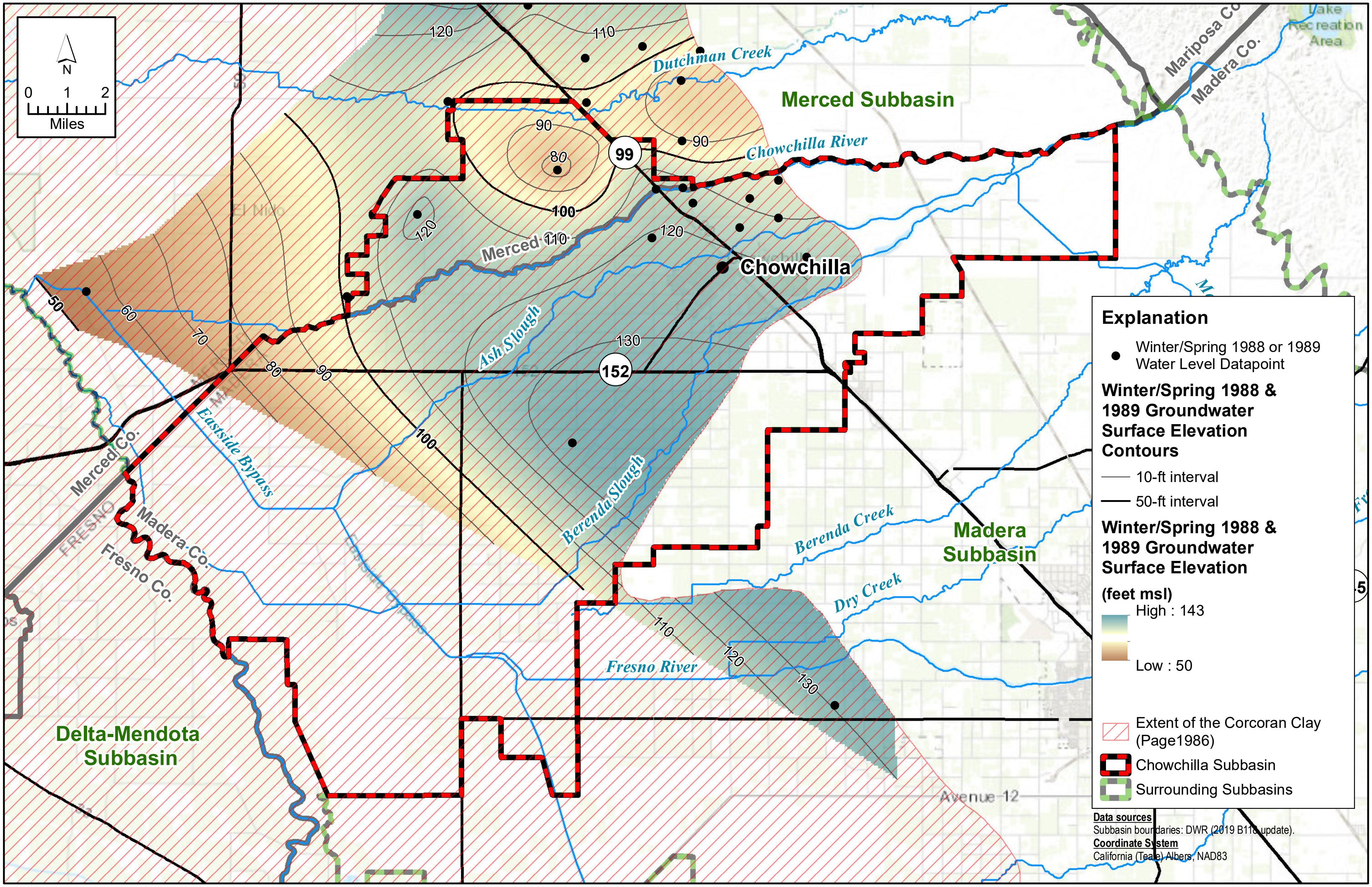

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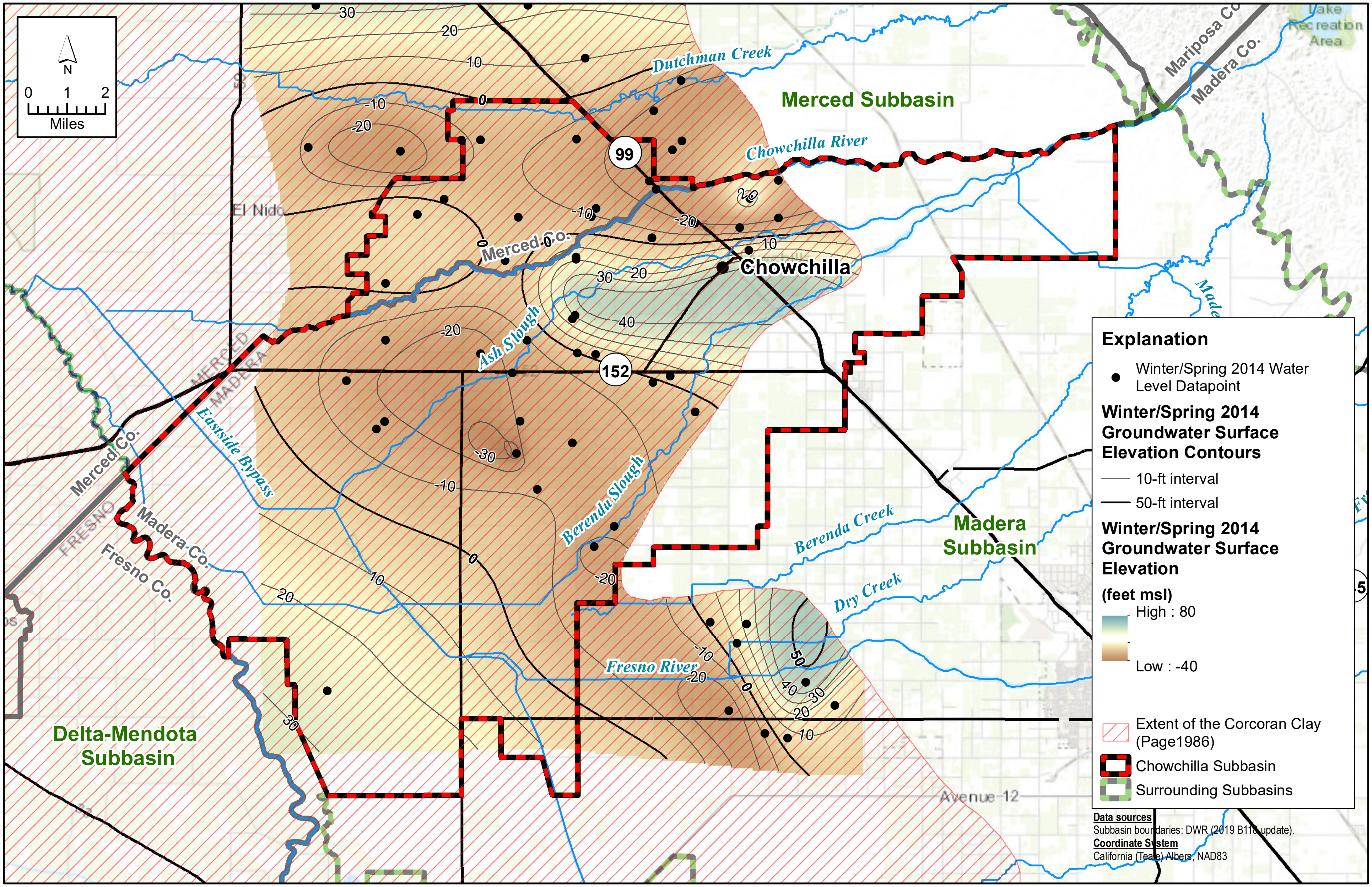
FIGURE 2-49
Groundwater Surface Elevation Map: Winter/Spring 1988 and 1989 - Lower Aquifer within Corcoran Clay

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-50 Chowchilla Subbasin SpW2014 GWEL Contours_Lower.mxd

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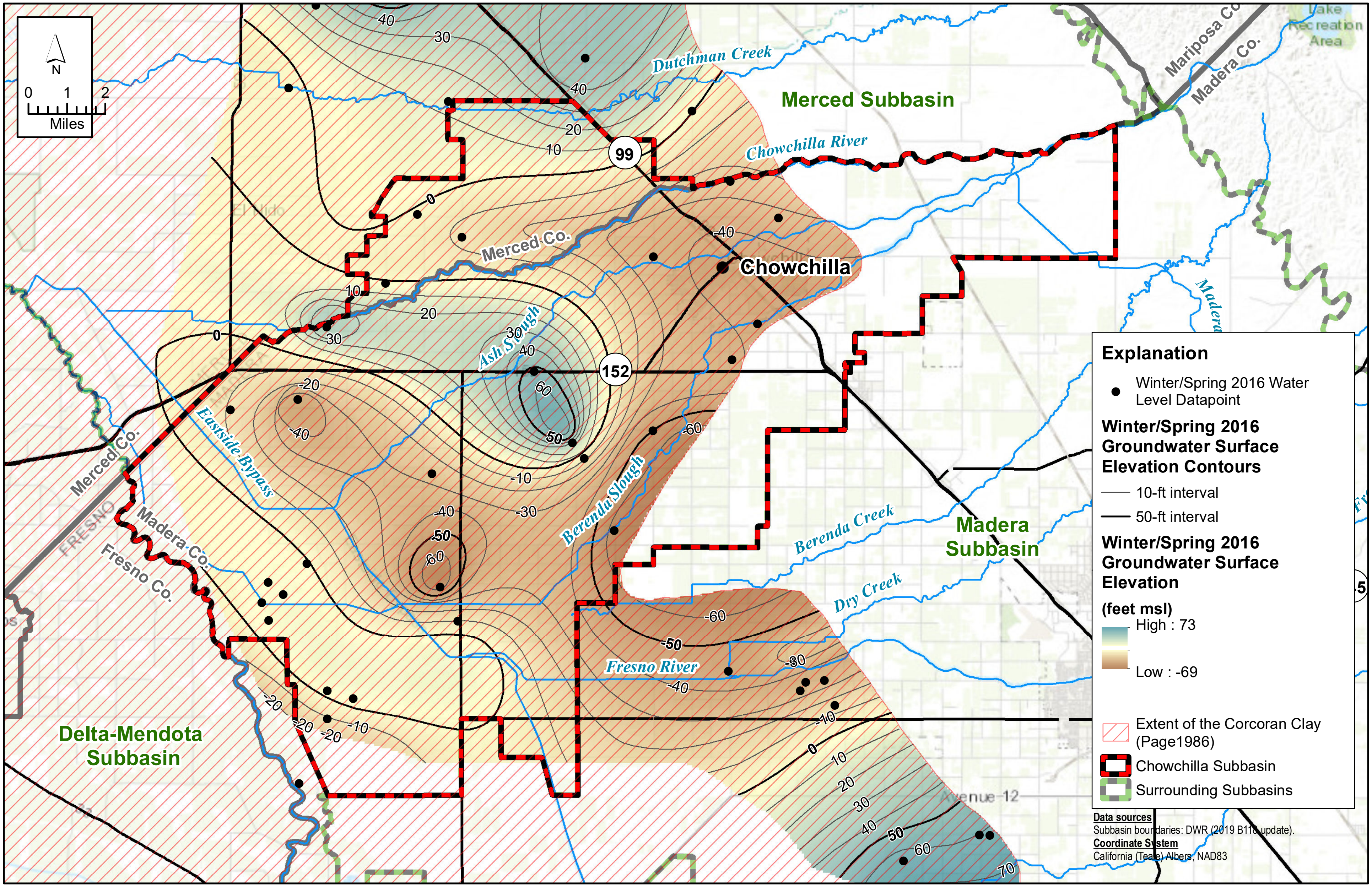
FIGURE 2-50
Groundwater Surface Elevation Map: Winter/Spring 2014 - Lower Aquifer within Corcoran Clay

Chowchilla Subbasin Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-51 Chowchilla Subbasin SpW2016 GWEL Contours_Lower.mxd

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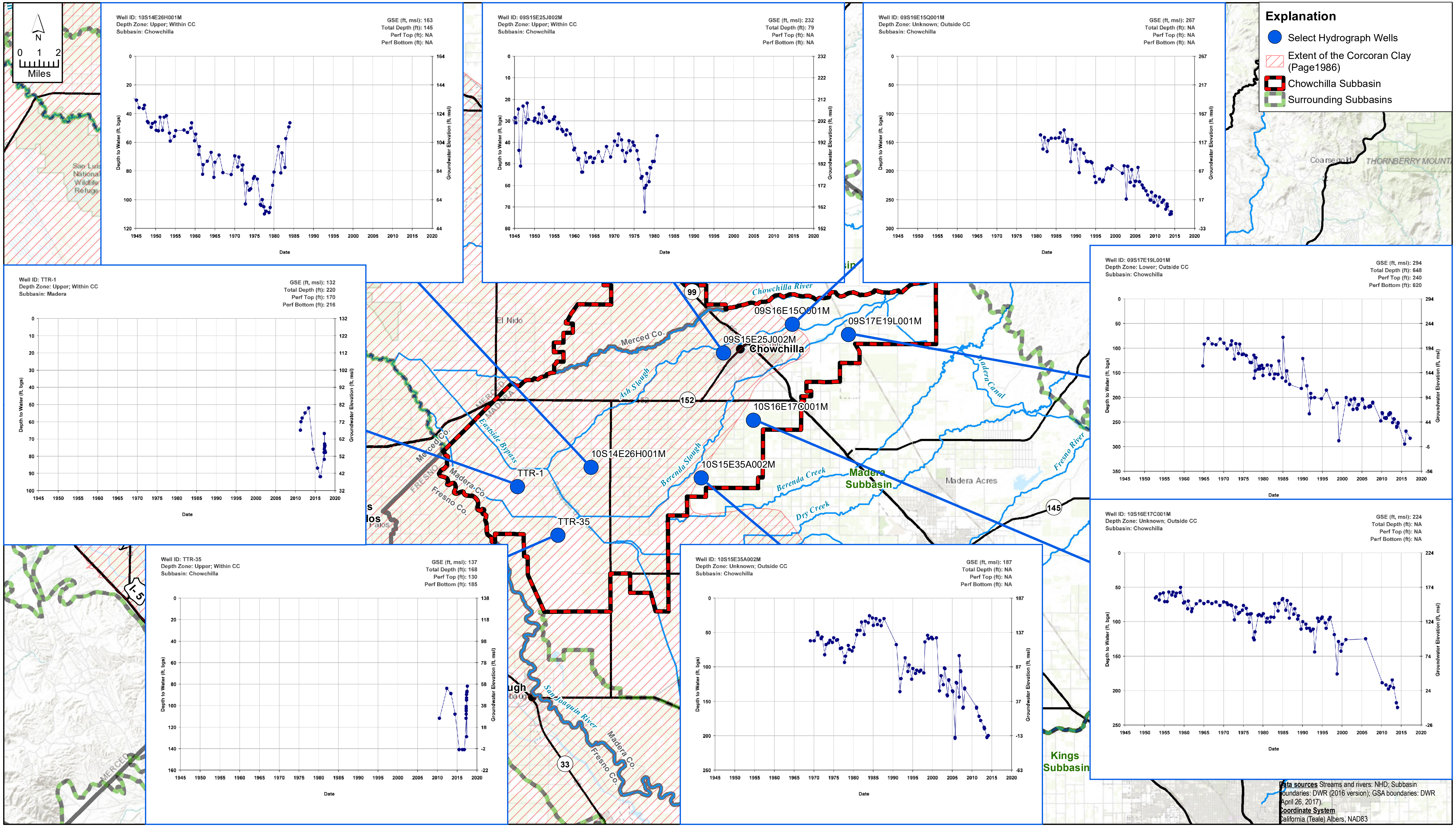
FIGURE 2-51
Groundwater Surface Elevation Map: Winter/Spring 2016 - Lower Aquifer within Corcoran Clay

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-52 Chowchilla Subbasin GW Level Hydrographs_Upper.mxd

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FIGURE 2-52
Select Groundwater Level Hydrographs:
Outside the Corcoran Clay or Upper Aquifer within the Corcoran Clay

Chowchilla Subbasin
Groundwater Sustainability Plan

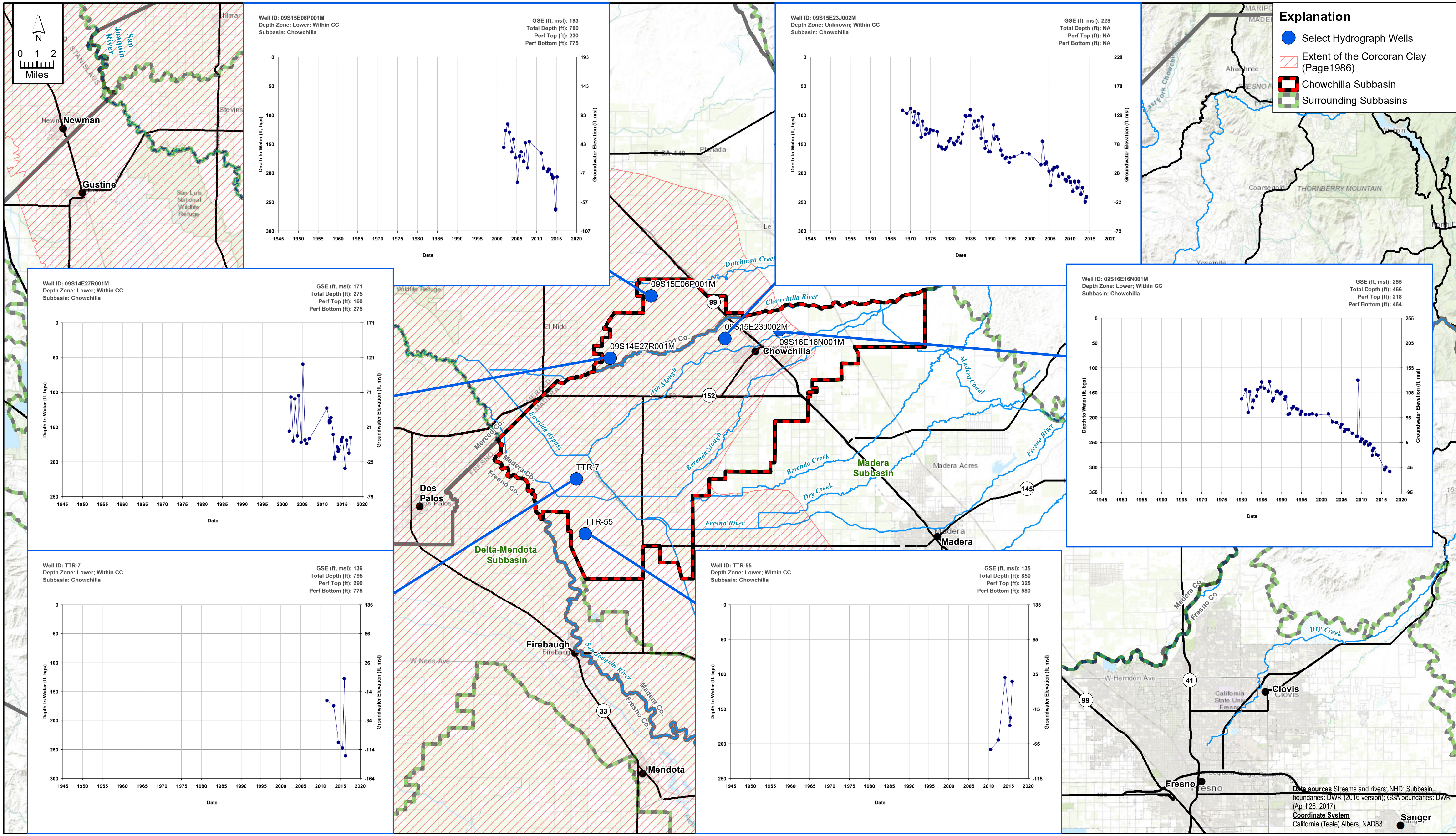

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FIGURE 2-53
Select Groundwater Level Hydrographs: Lower Aquifer within the Corcoran Clay

Chowchilla Subbasin
Groundwater Sustainability Plan

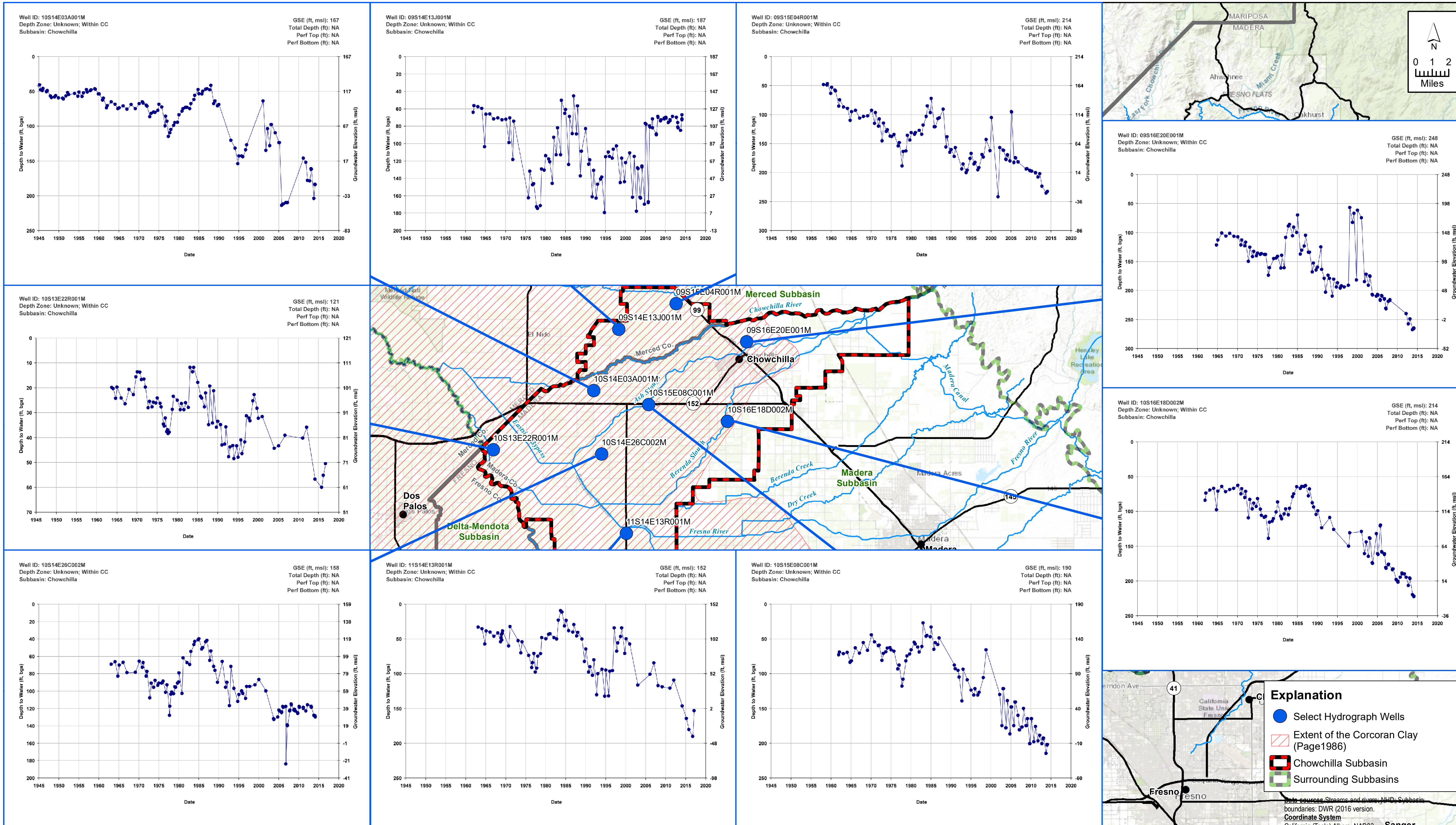

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FIGURE 2-54
Select Groundwater Level Hydrographs: Wells of Unknown Construction

Chowchilla Subbasin
Groundwater Sustainability Plan

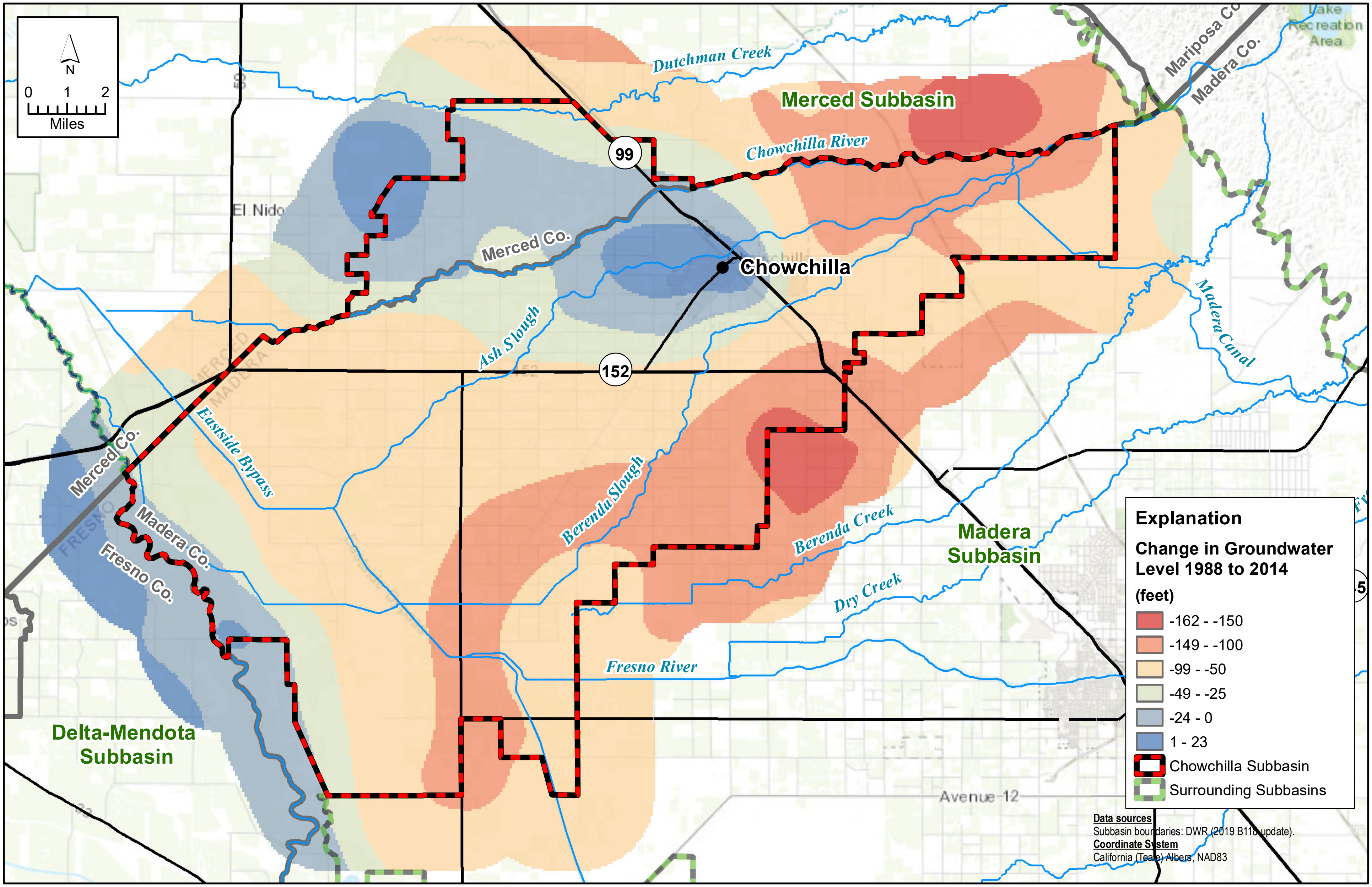

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FIGURE 2-55
Groundwater Level Change Map: Winter/Spring 1988 to 2014 - Unconfined Groundwater

Chowchilla Subbasin Groundwater Sustainability Plan

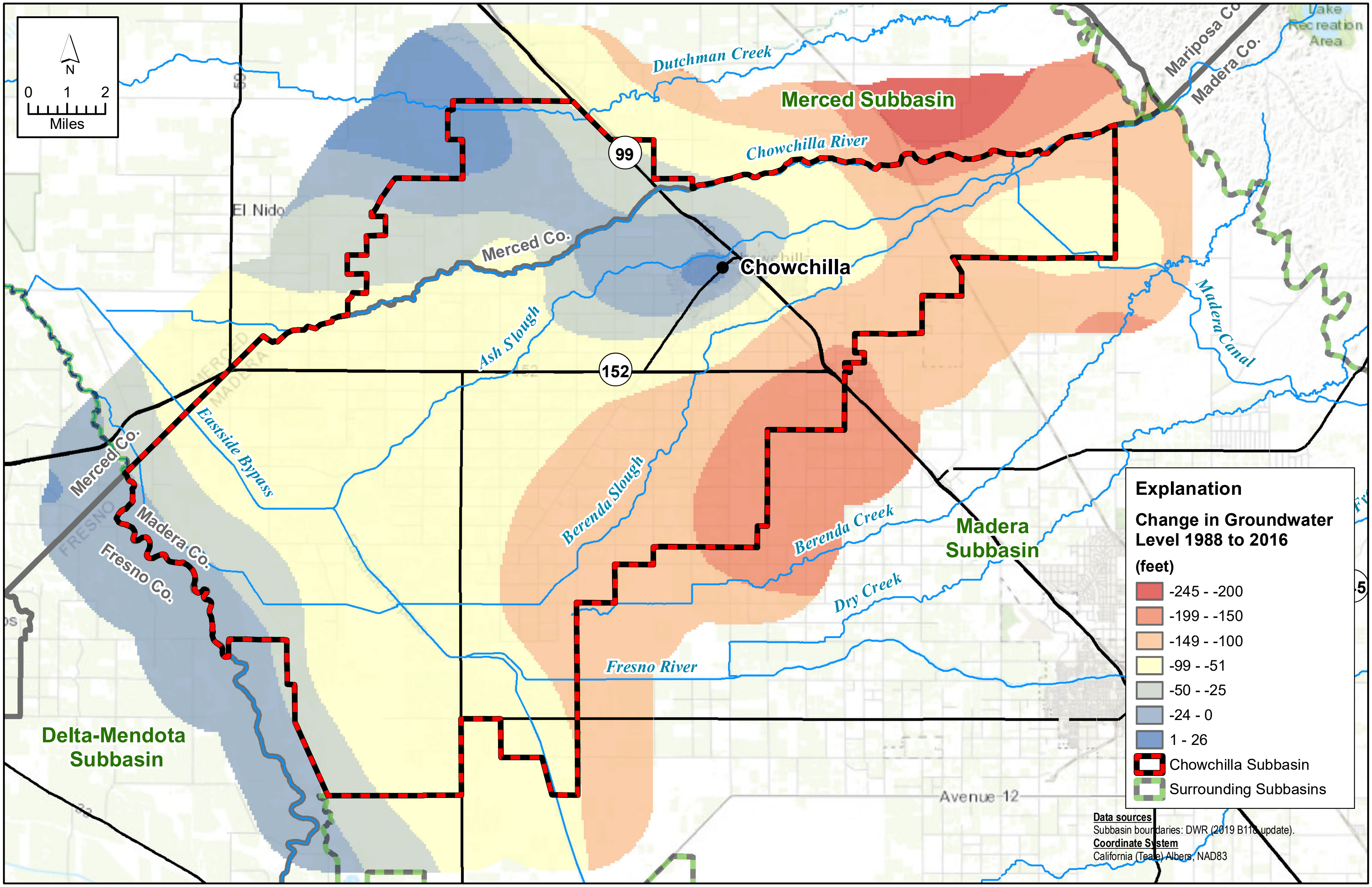

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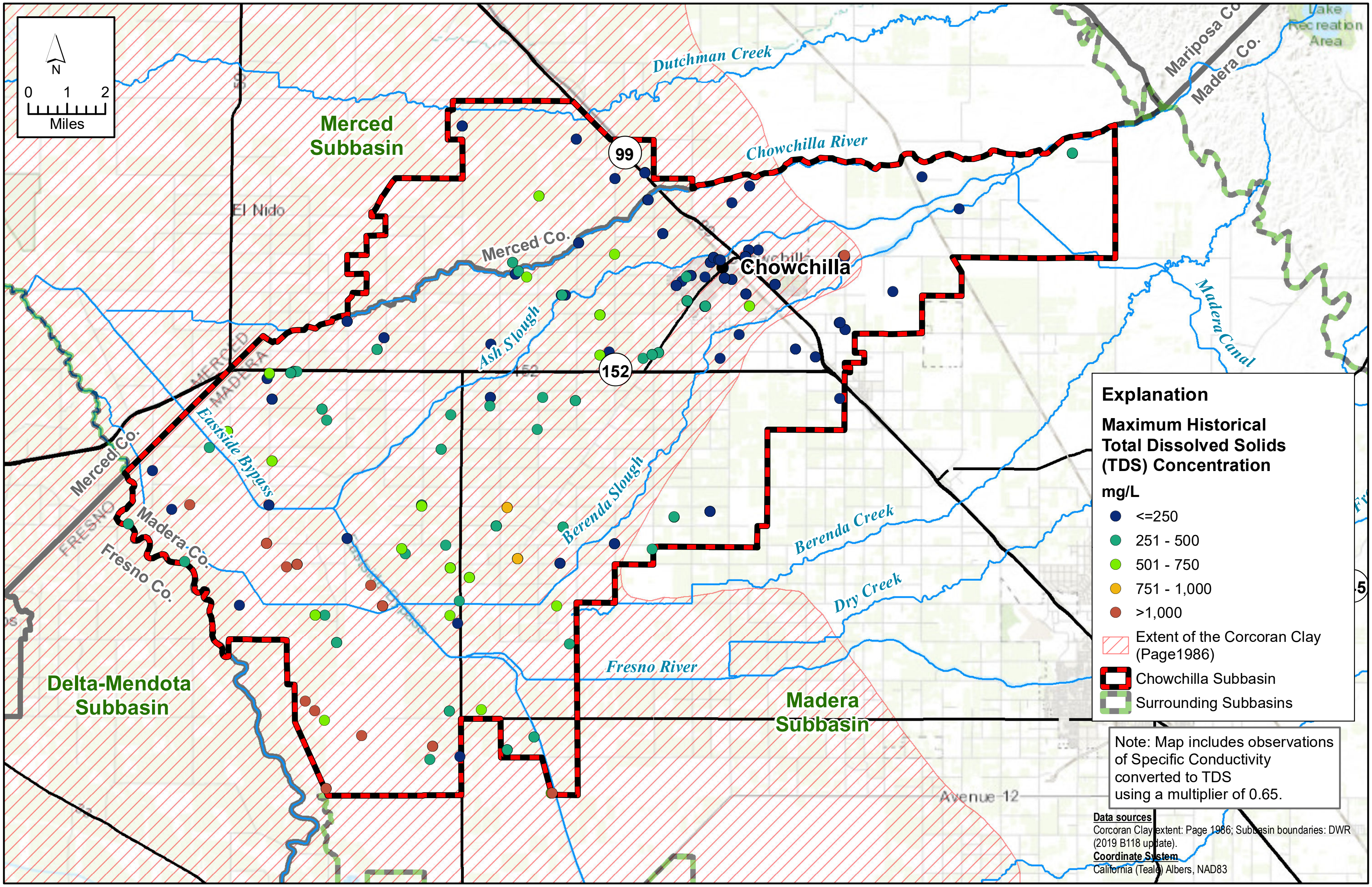
FIGURE 2-56
Groundwater Level Change Map: Winter/Spring 1988 to 2016 - Unconfined Groundwater

Chowchilla Subbasin Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-57 Chowchilla Subbasin GW Quality Map TDS All Wells_20190710.mxd

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FIGURE 2-57
Groundwater Quality Map: Total Dissolved Solids Concentrations in All Wells

Chowchilla Subbasin
Groundwater Sustainability Plan

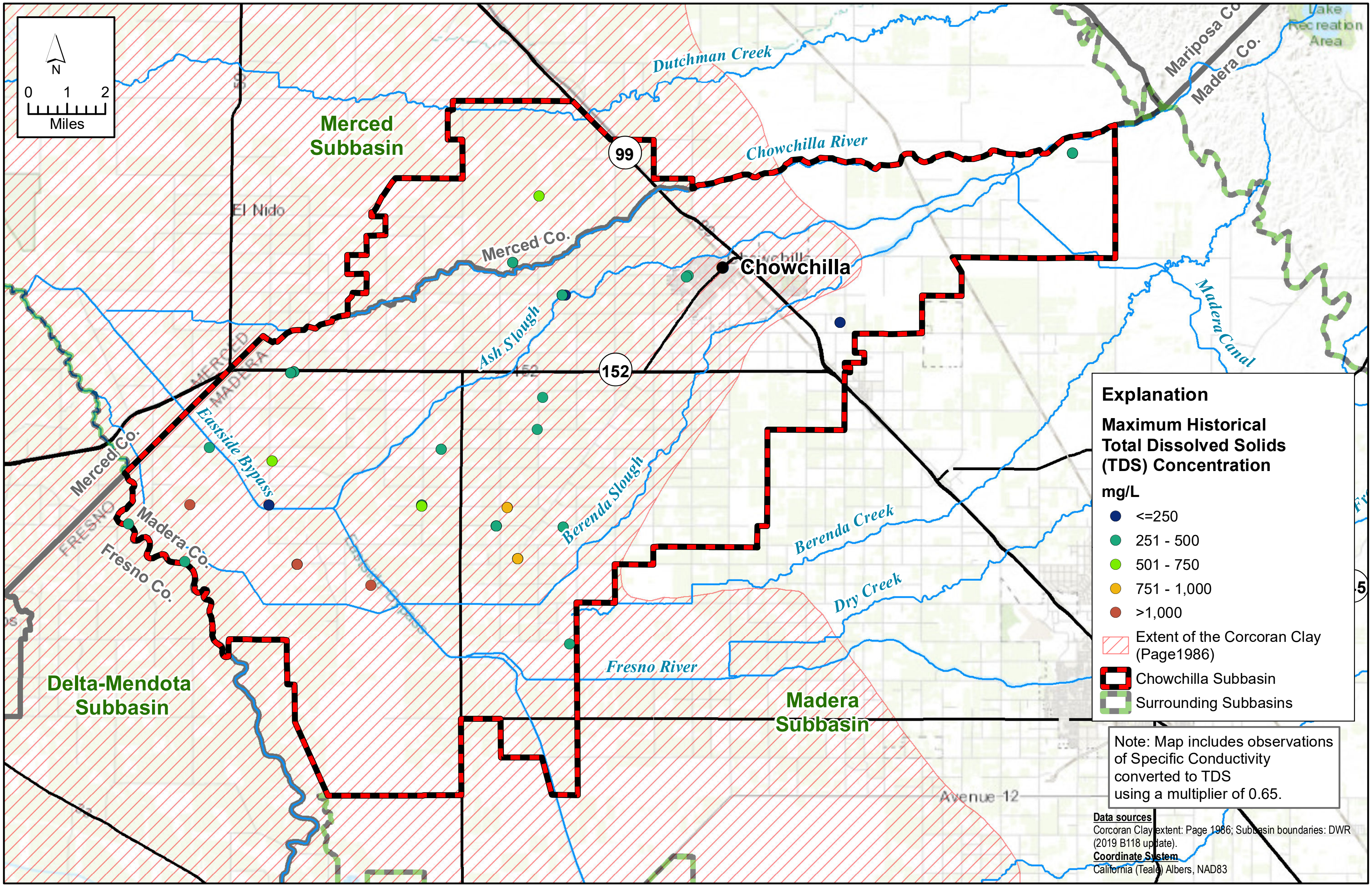

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FIGURE 2-58
Groundwater Quality Map: Total Dissolved Solids Concentrations in Upper Aquifer Wells

Chowchilla Subbasin
Groundwater Sustainability Plan

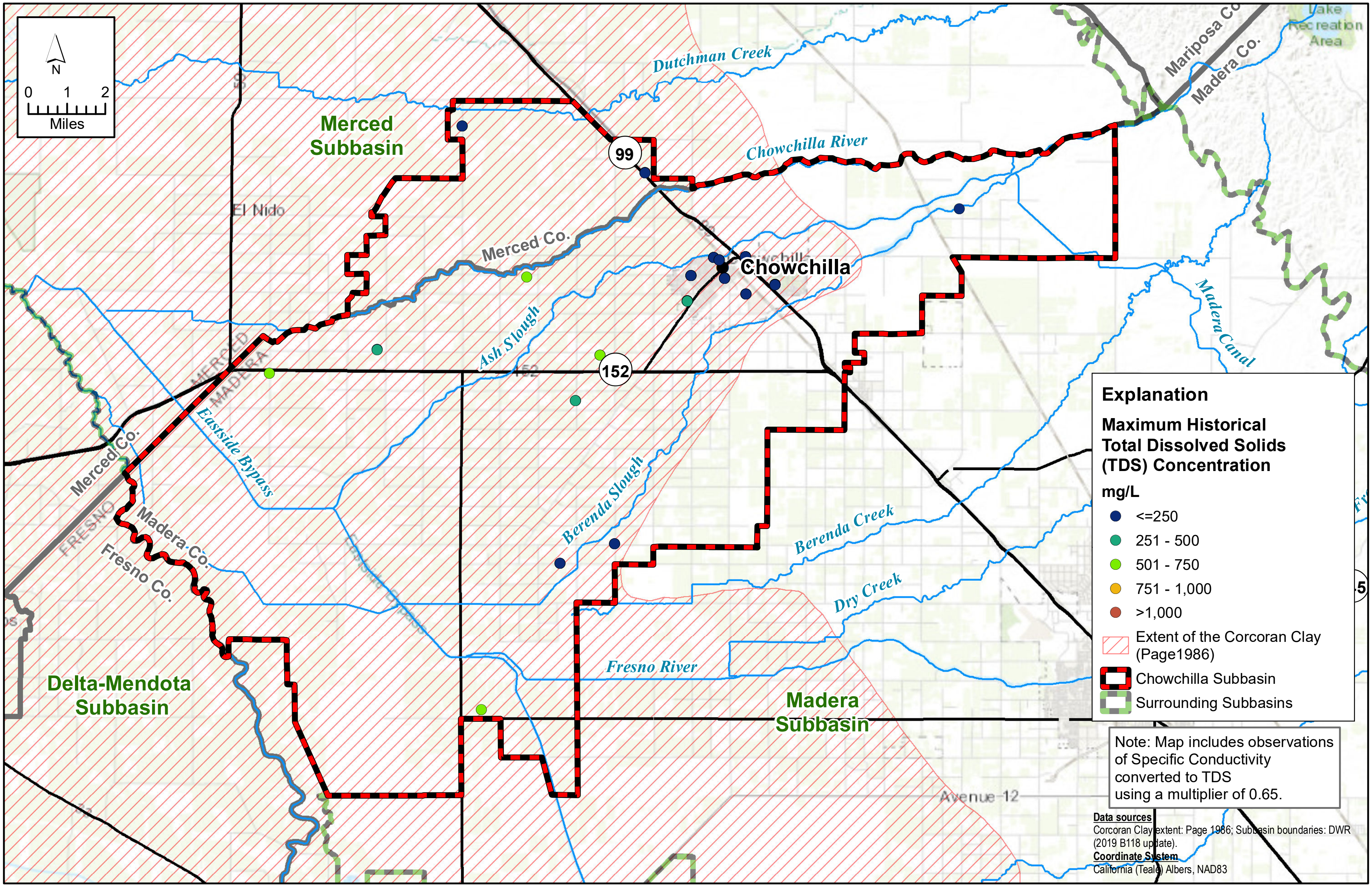

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FIGURE 2-59
Groundwater Quality Map: Total Dissolved Solids Concentrations in Lower Aquifer Wells

Chowchilla Subbasin
Groundwater Sustainability Plan

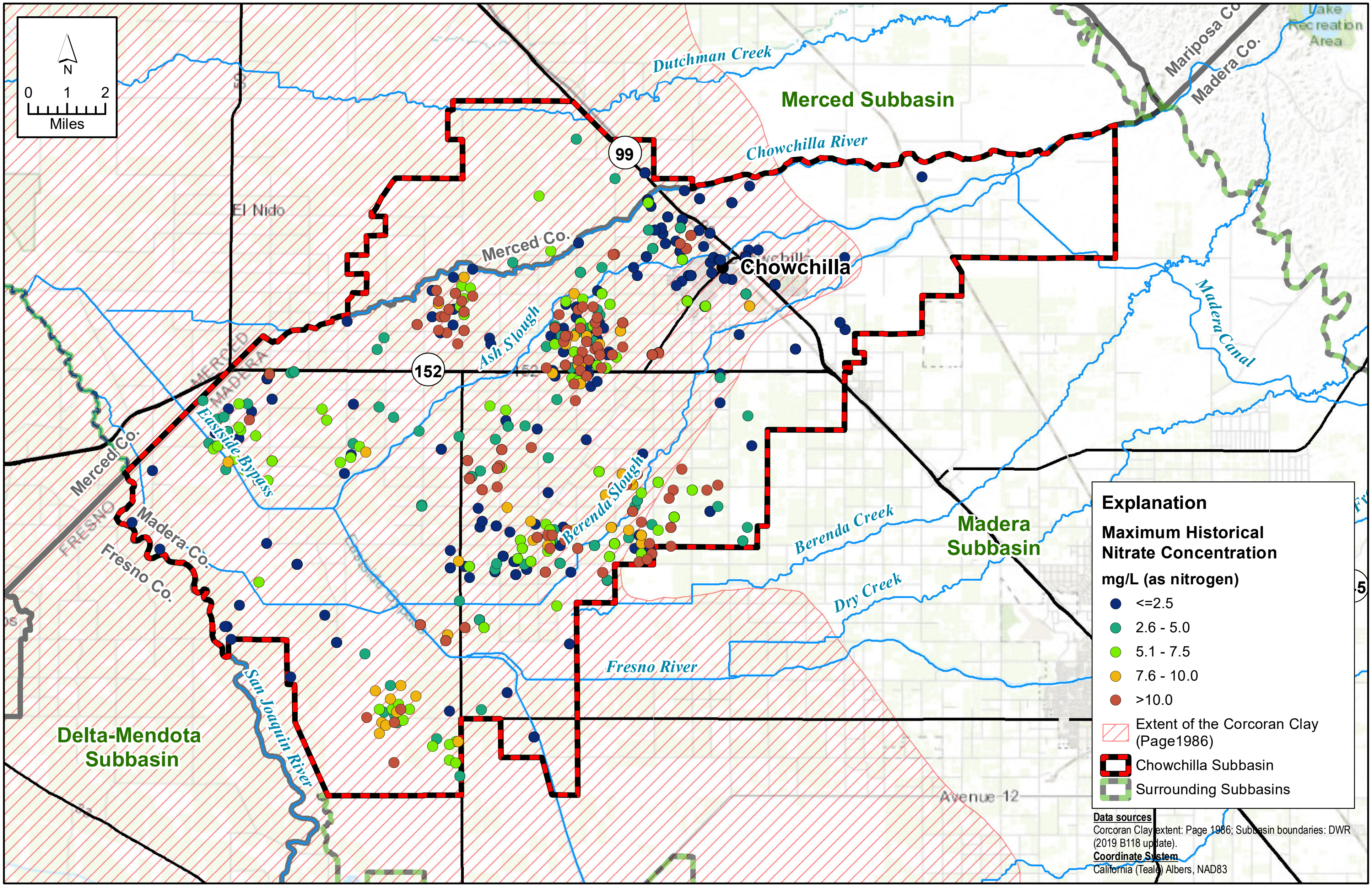

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FIGURE 2-60
Map of Groundwater Quality: Nitrate Concentrations in All Wells

Chowchilla Subbasin
Groundwater Sustainability Plan

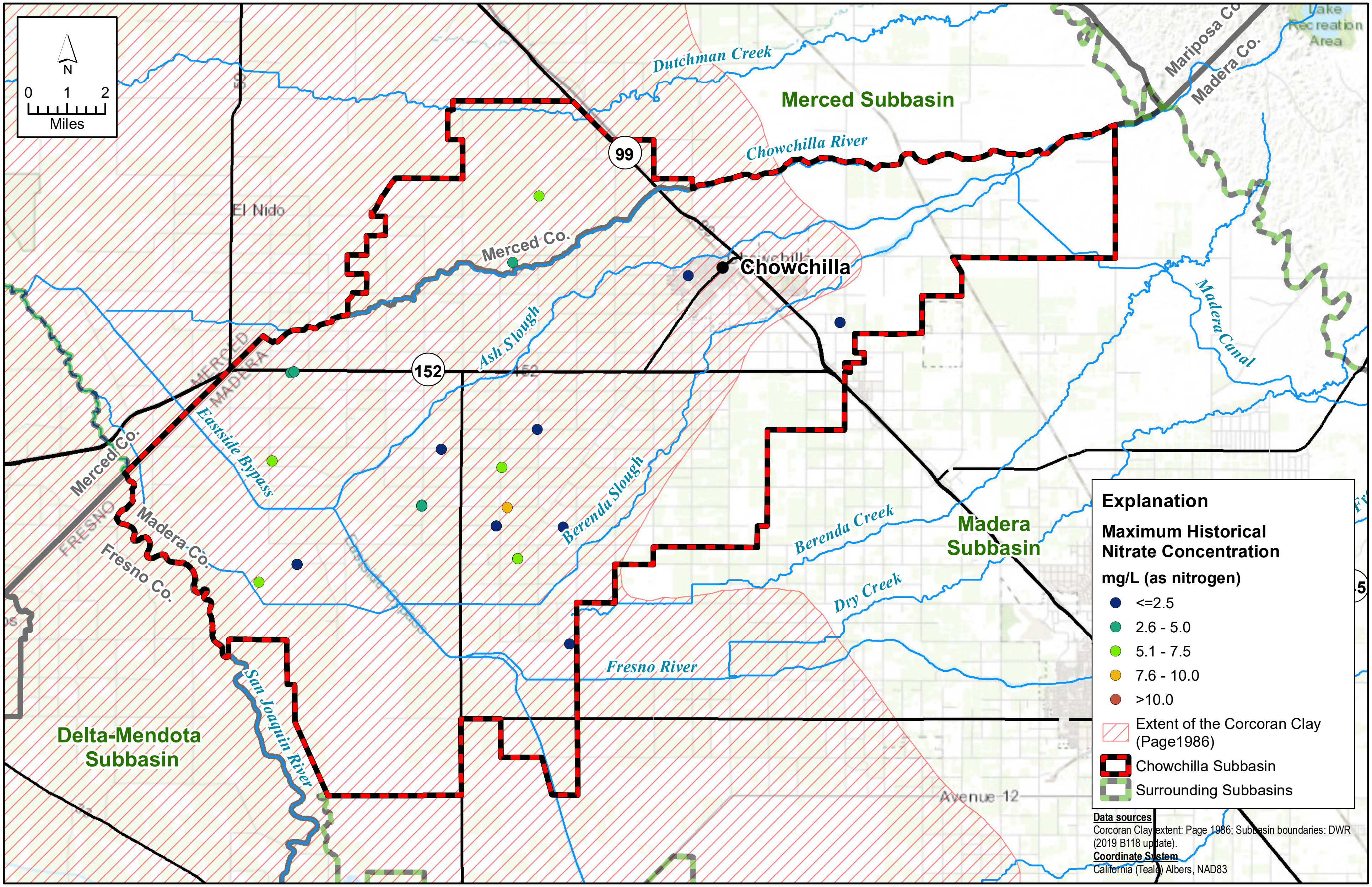

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FIGURE 2-61
Map of Groundwater Quality: Nitrate Concentrations in Upper Aquifer Wells

Chowchilla Subbasin
Groundwater Sustainability Plan

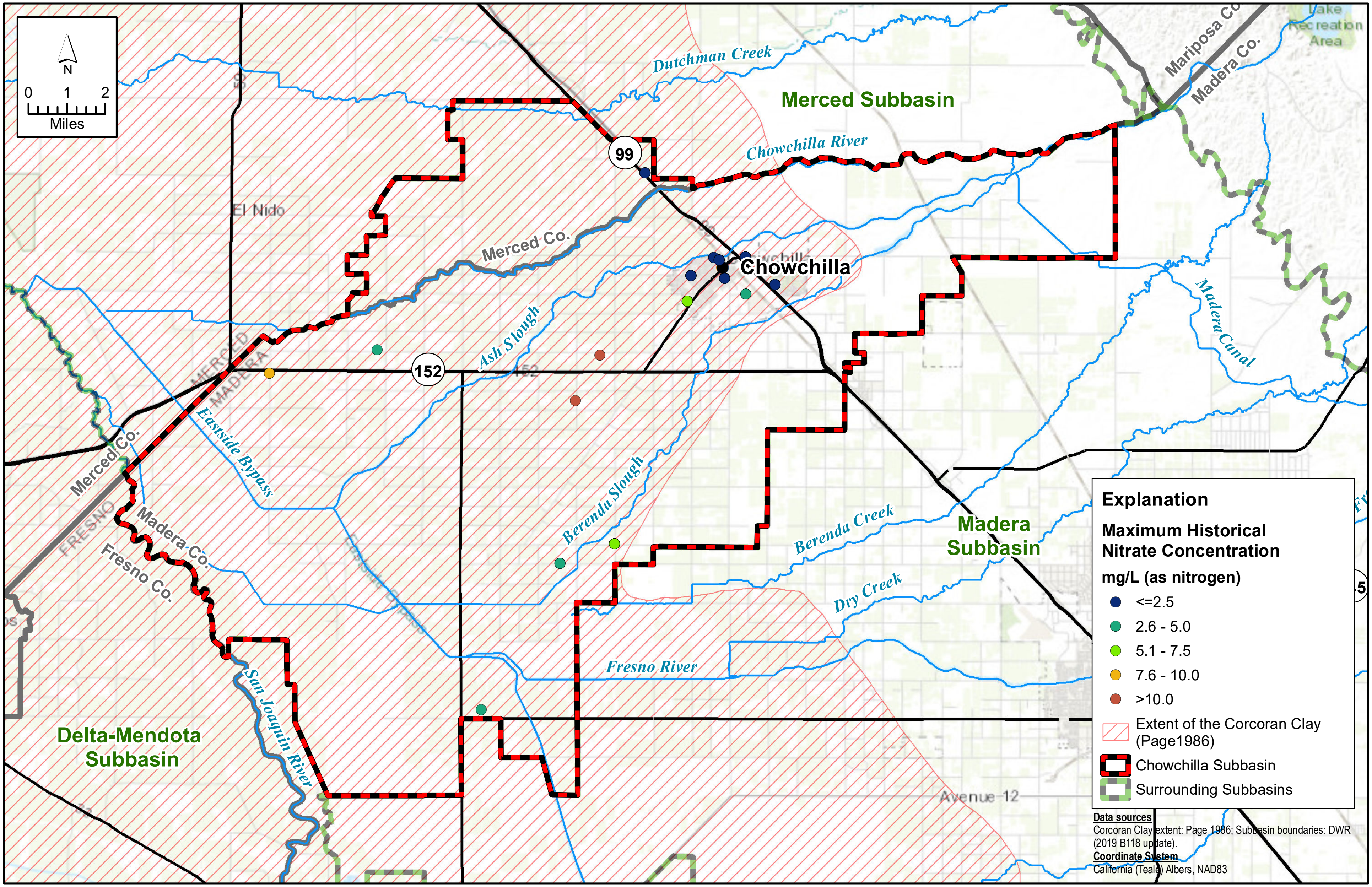

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FIGURE 2-62
Map of Groundwater Quality: Nitrate Concentrations in Lower Aquifer Wells

Chowchilla Subbasin
Groundwater Sustainability Plan

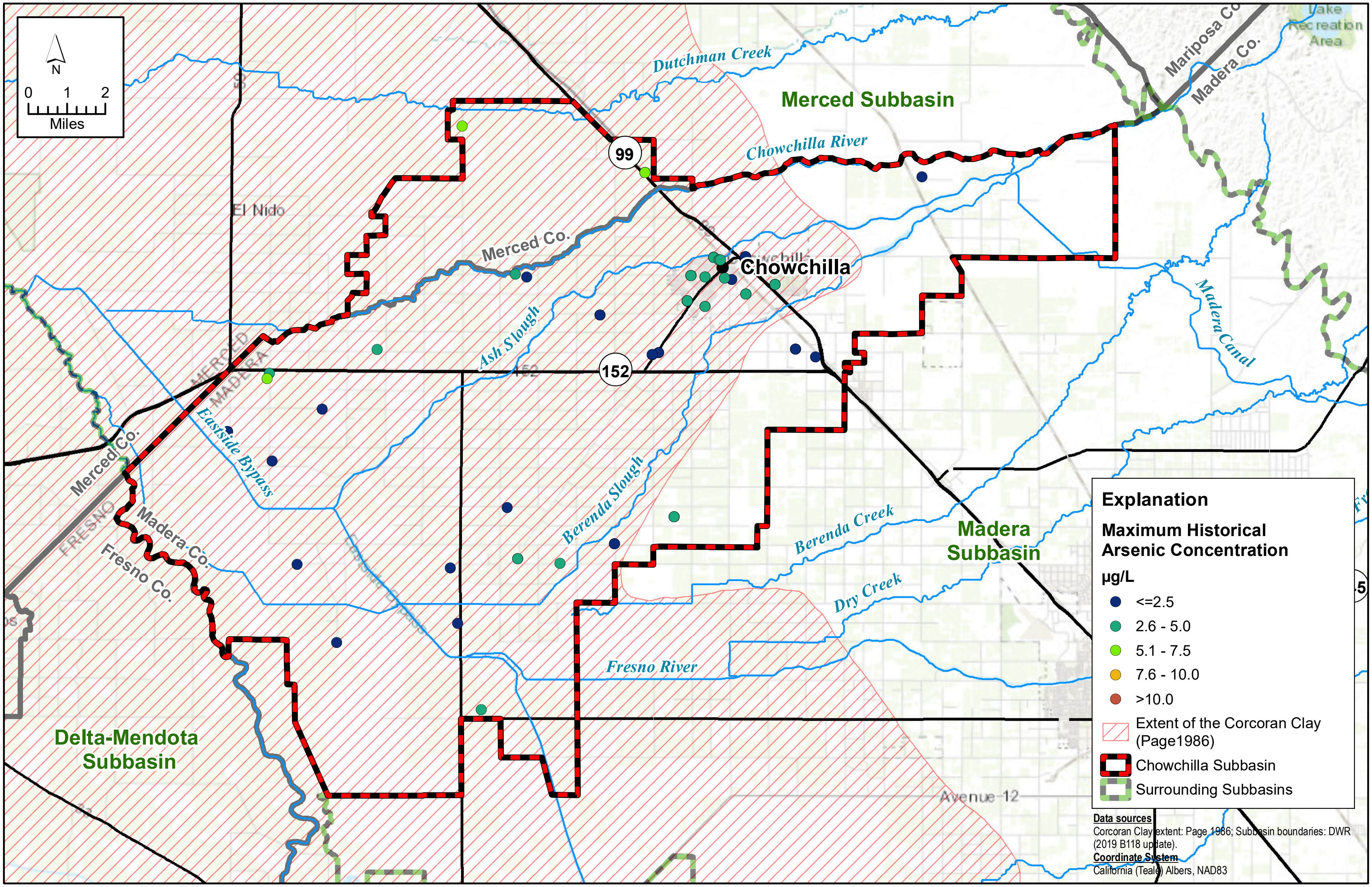

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FIGURE 2-63
Map of Groundwater Quality: Arsenic Concentrations in All Wells

Chowchilla Subbasin
Groundwater Sustainability Plan

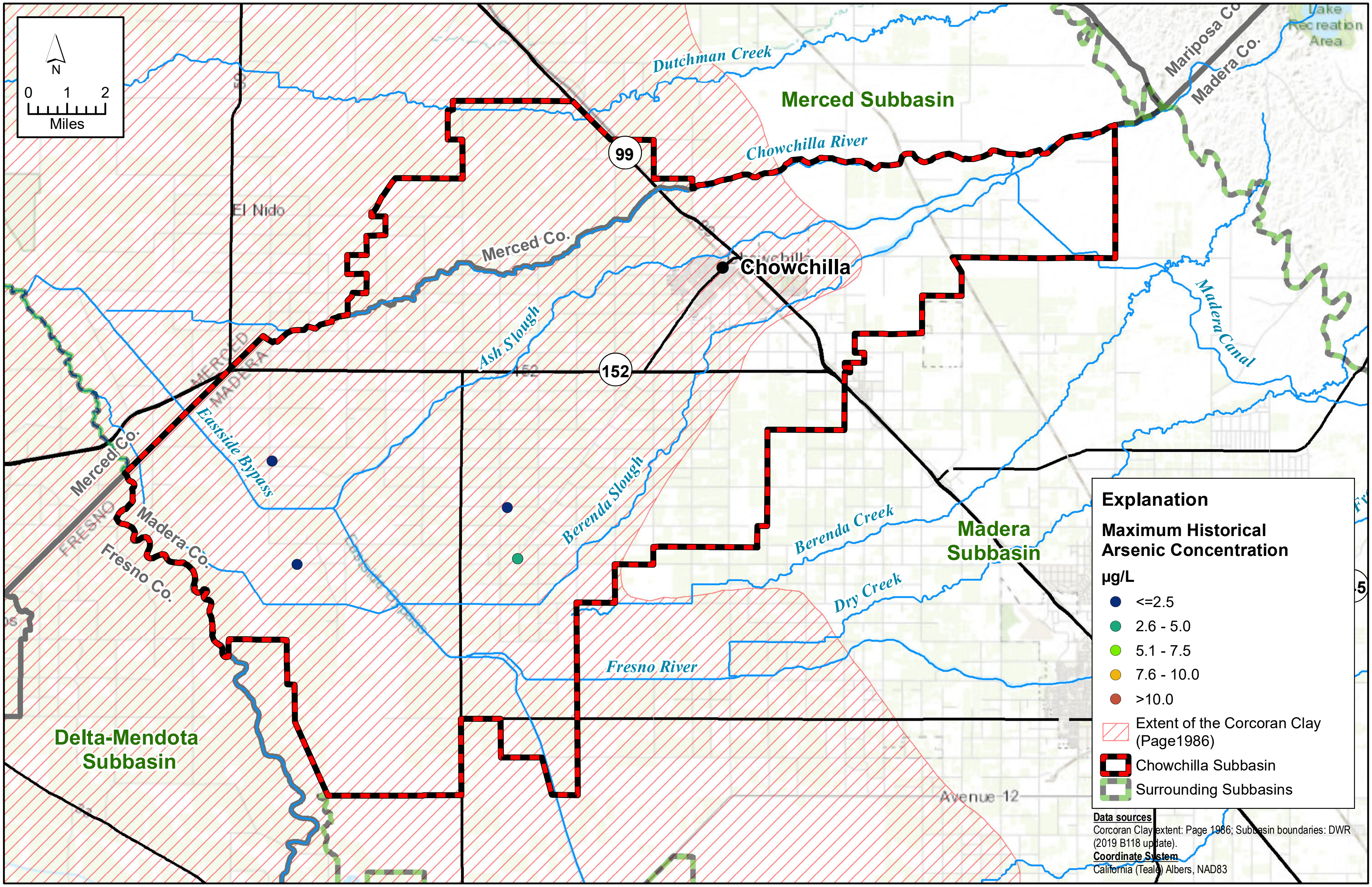

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FIGURE 2-64
Map of Groundwater Quality: Arsenic Concentrations in Upper Aquifer Wells

Chowchilla Subbasin
Groundwater Sustainability Plan

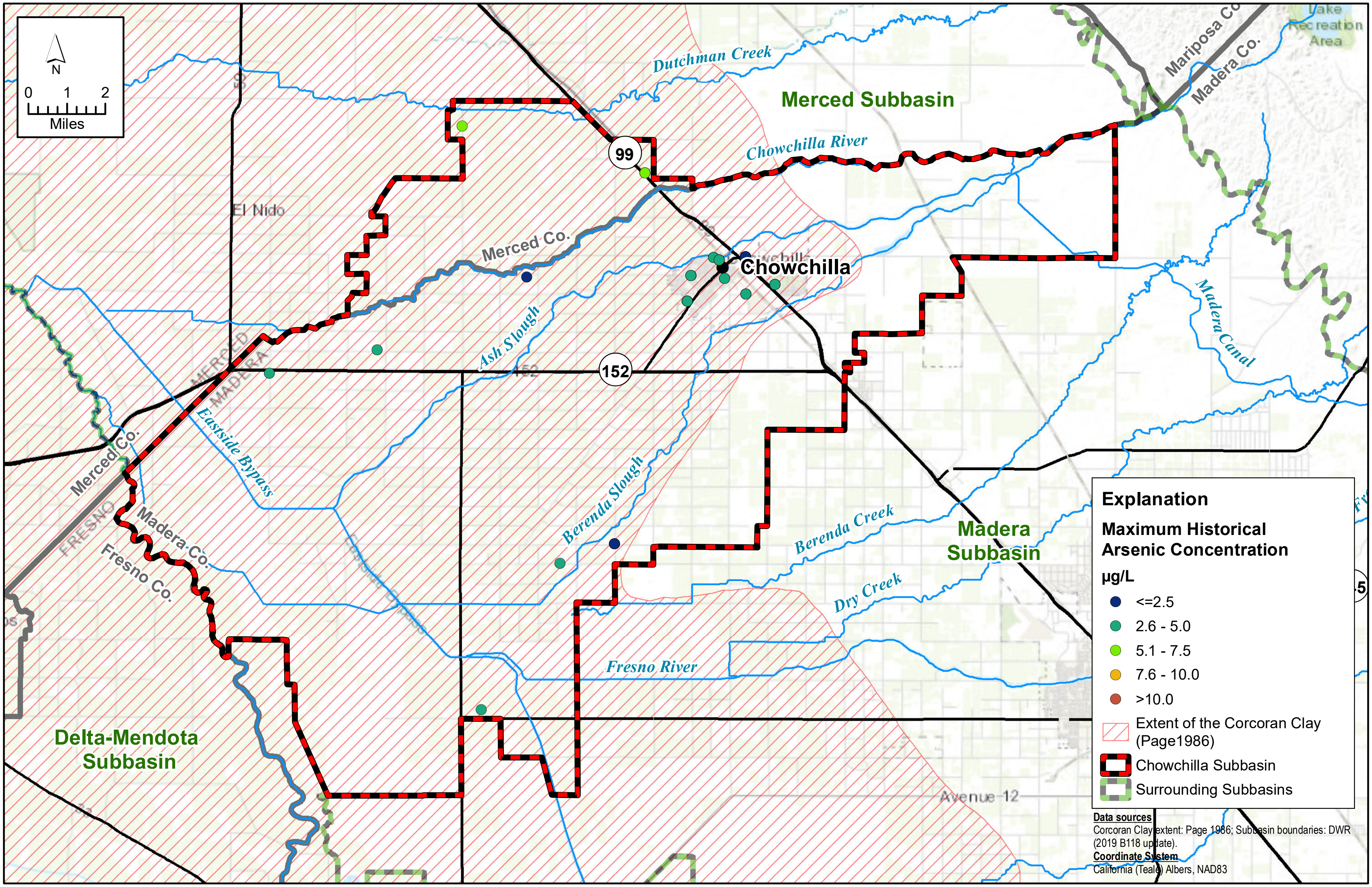

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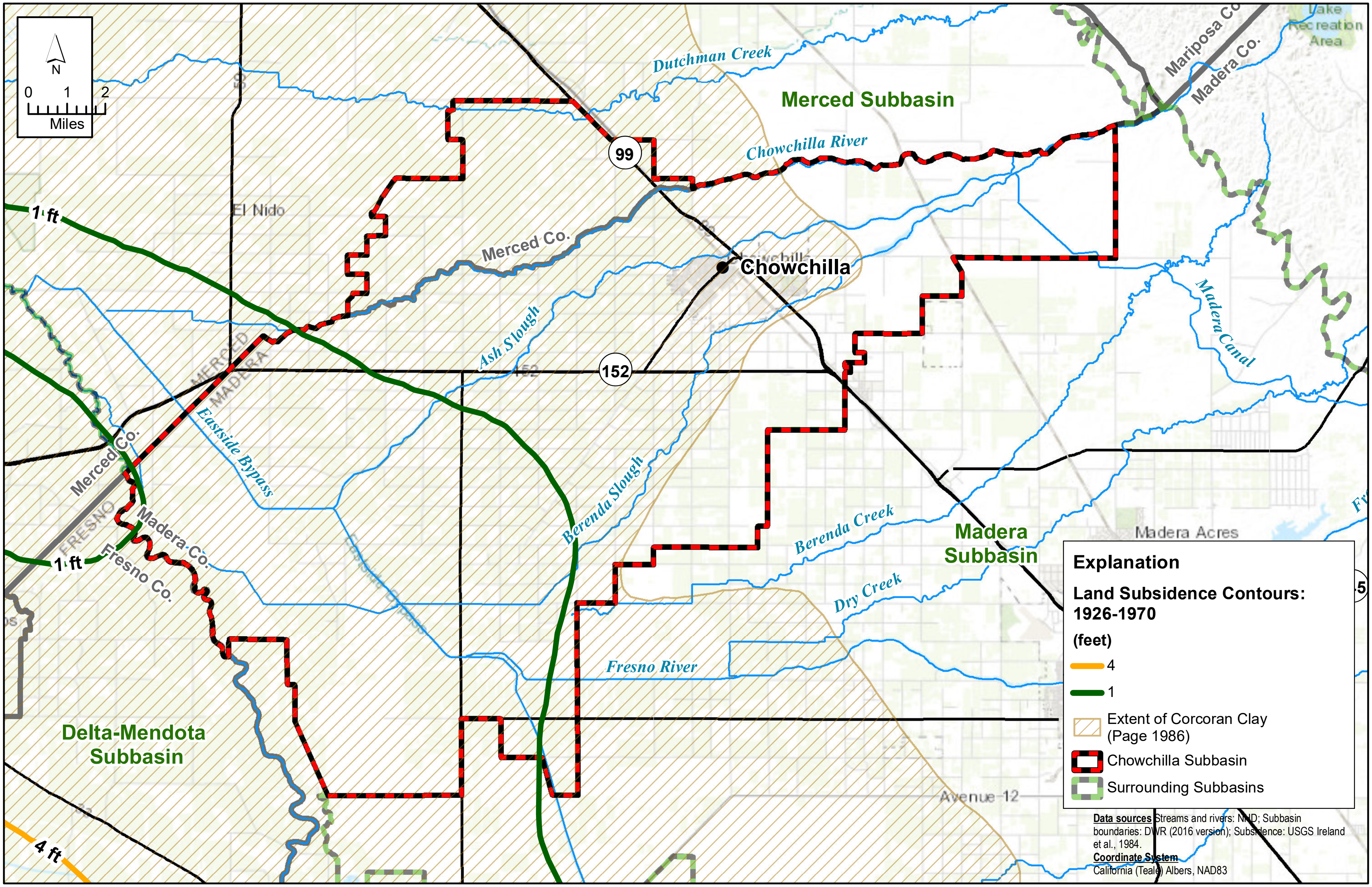
FIGURE 2-65
Map of Groundwater Quality: Arsenic Concentrations in Lower Aquifer Wells

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-66 Chowchilla Subbasin Land Subsidence 1926-1970.mxd

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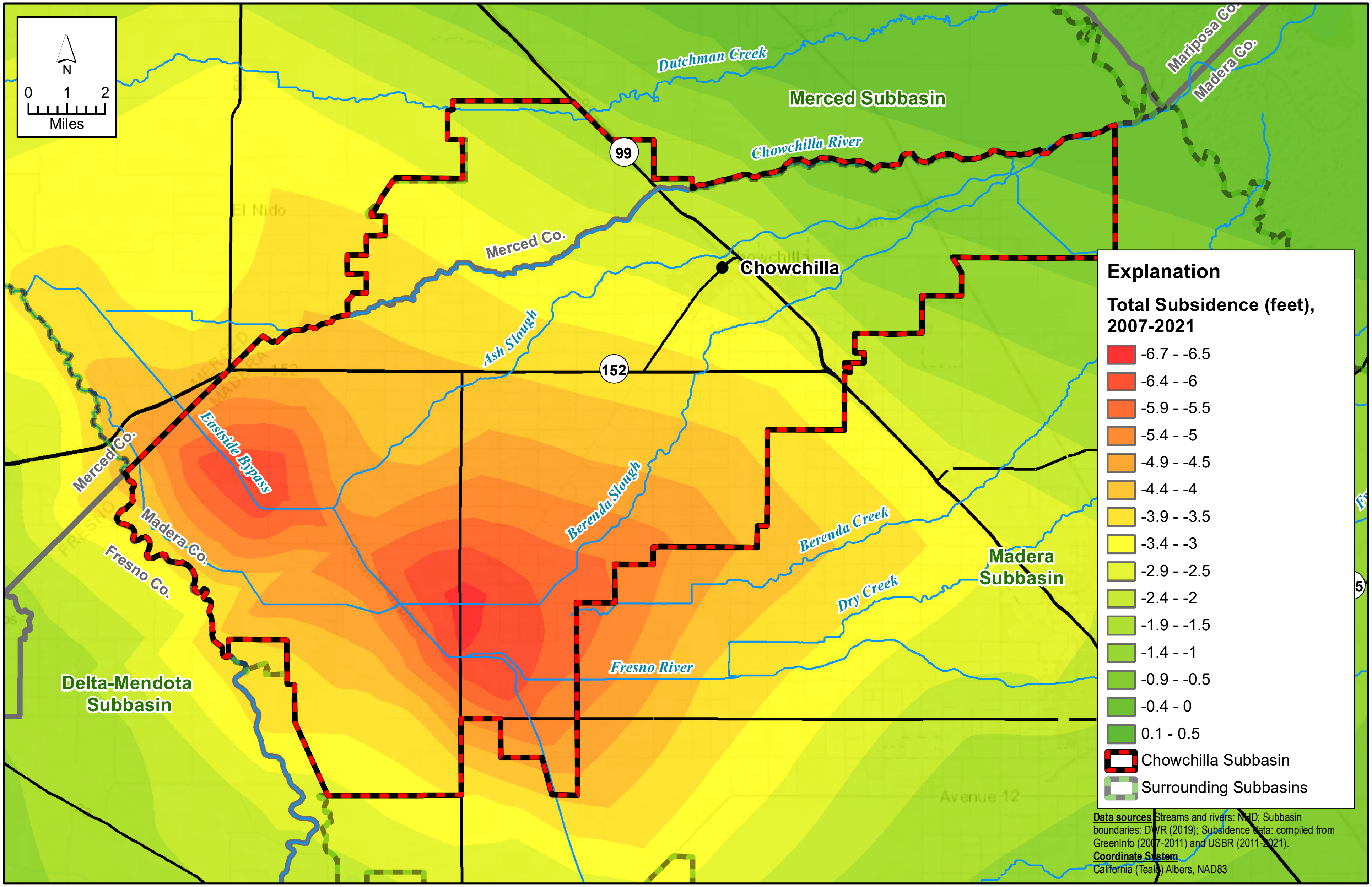
FIGURE 2-66

Map of Historical Land Subsidence Contours: 1926-1970

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2021\21-166 Davids Engineering - Chowchilla Subbasin GSP DWR Consultation Letter\REPORT\RevisedGSP\Sections from Bernadette\Subsidence\MAPS\Figure X-X Chowchilla Subbasin Total Subsidence 2007-2021.mxd

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FIGURE 2-67
Map of Total Subsidence 2007-2021
[combined from GreenInfo (2007-2011) and USBR (2011-2021)]

Chowchilla Subbasin
Groundwater Sustainability Plan

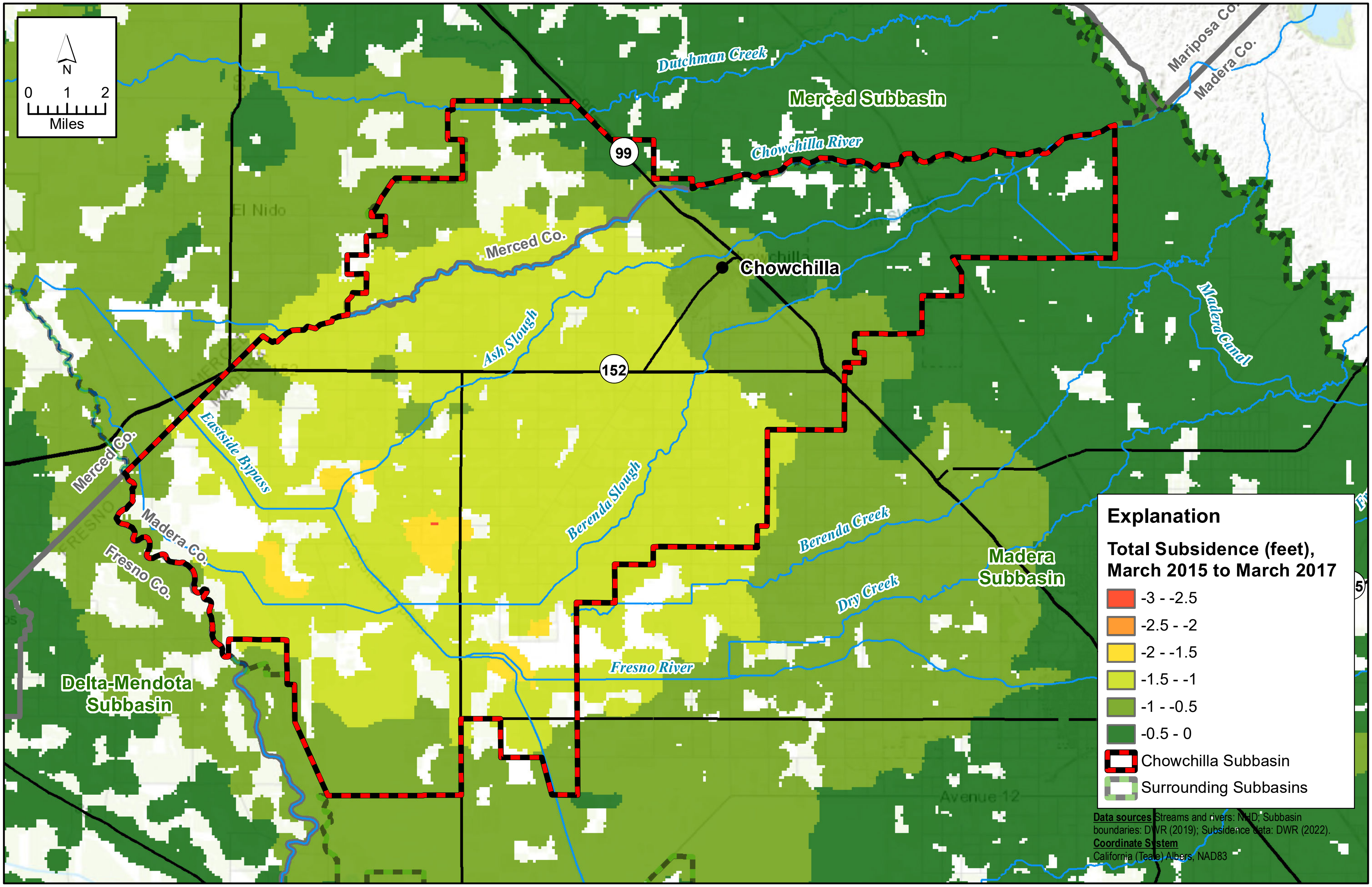

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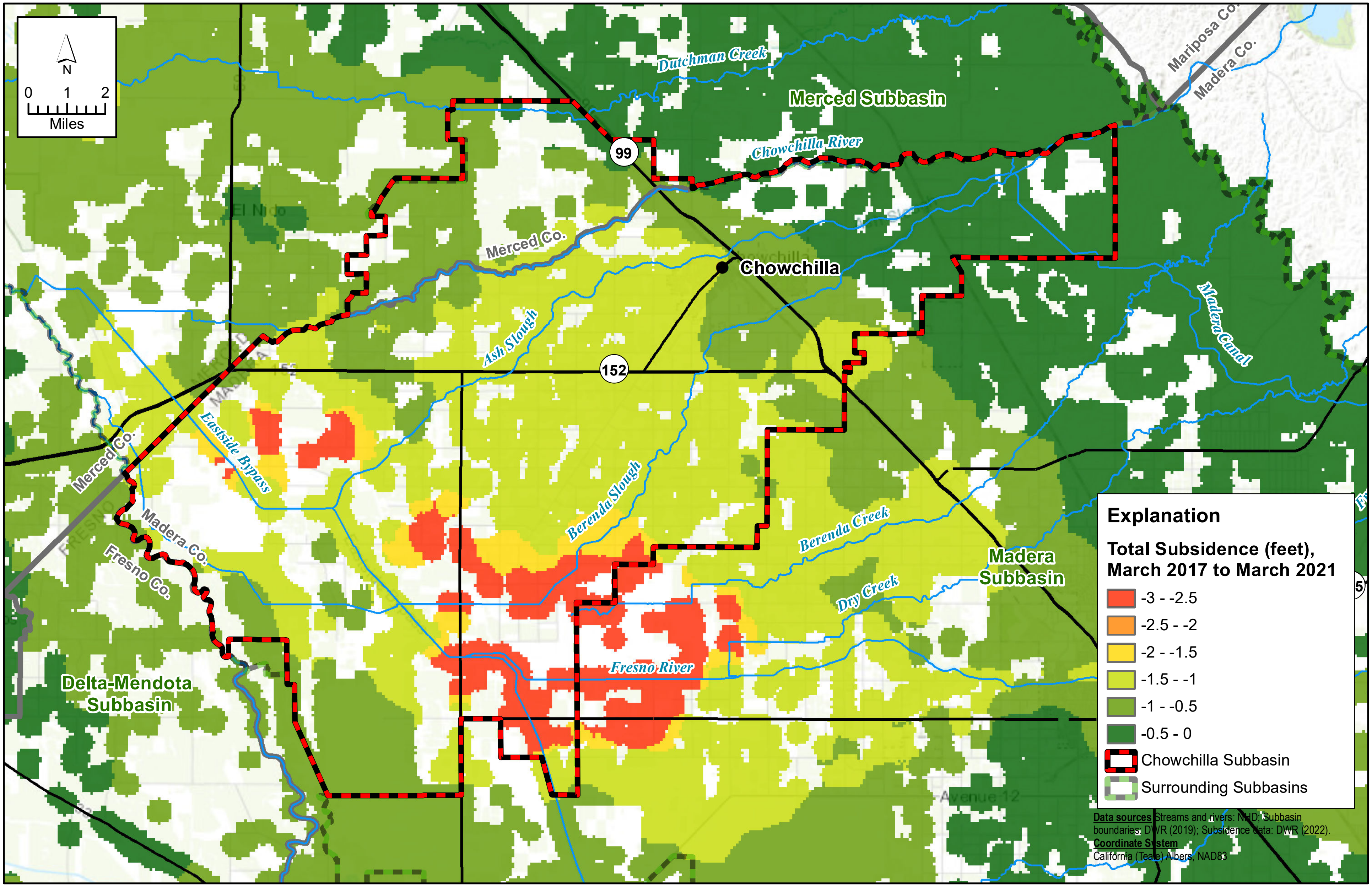
FIGURE 2-68A

Map of Total Subsidence 2015-2017 from DWR InSAR data

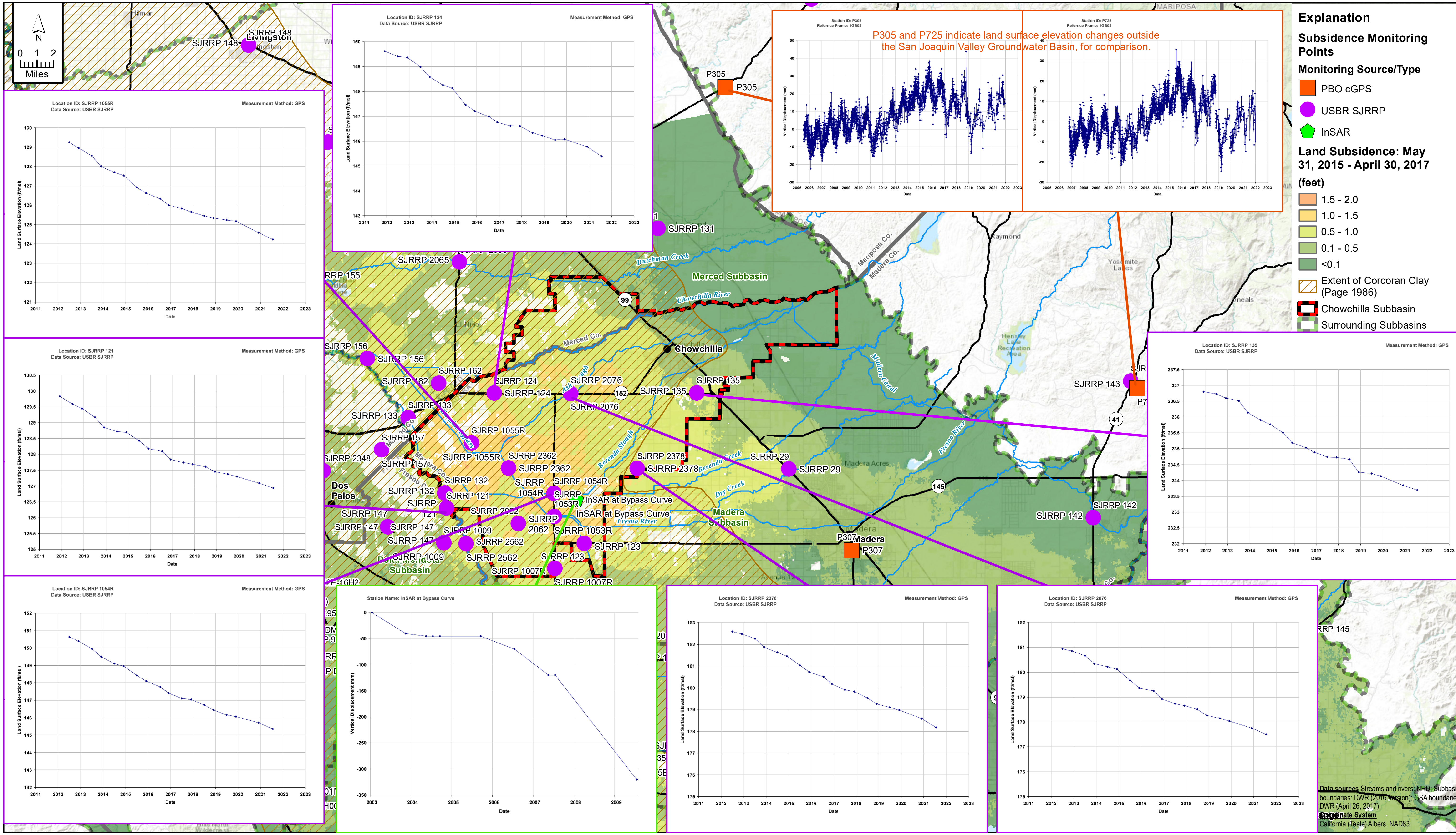
Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2021\21-166 Davids Engineering - Chowchilla Subbasin GSP DWR Consultation Letter\REPORT\RevisedGSP\Sections from Bernadette\Subsidence\MAPS\Figure X-X Chowchilla Subbasin Total Subsidence 2017-2021.mxd

FIGURE 2-68B

Map of Total Subsidence 2017-2021 from DWR InSAR data



X:\2021\21-166 Davids Engineering - Chowchilla Subbasin GSP DWR Consultation Letter\GIS\CHOW_GSP_UPDATE\Figure 2-69 Chowchilla Subbasin Land Subsidence Monitoring Point Trends_UPDATE_20220418.mxd

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FIGURE 2-69

Map of Subsidence Monitoring Locations

Chowchilla Subbasin
Groundwater Sustainability Plan

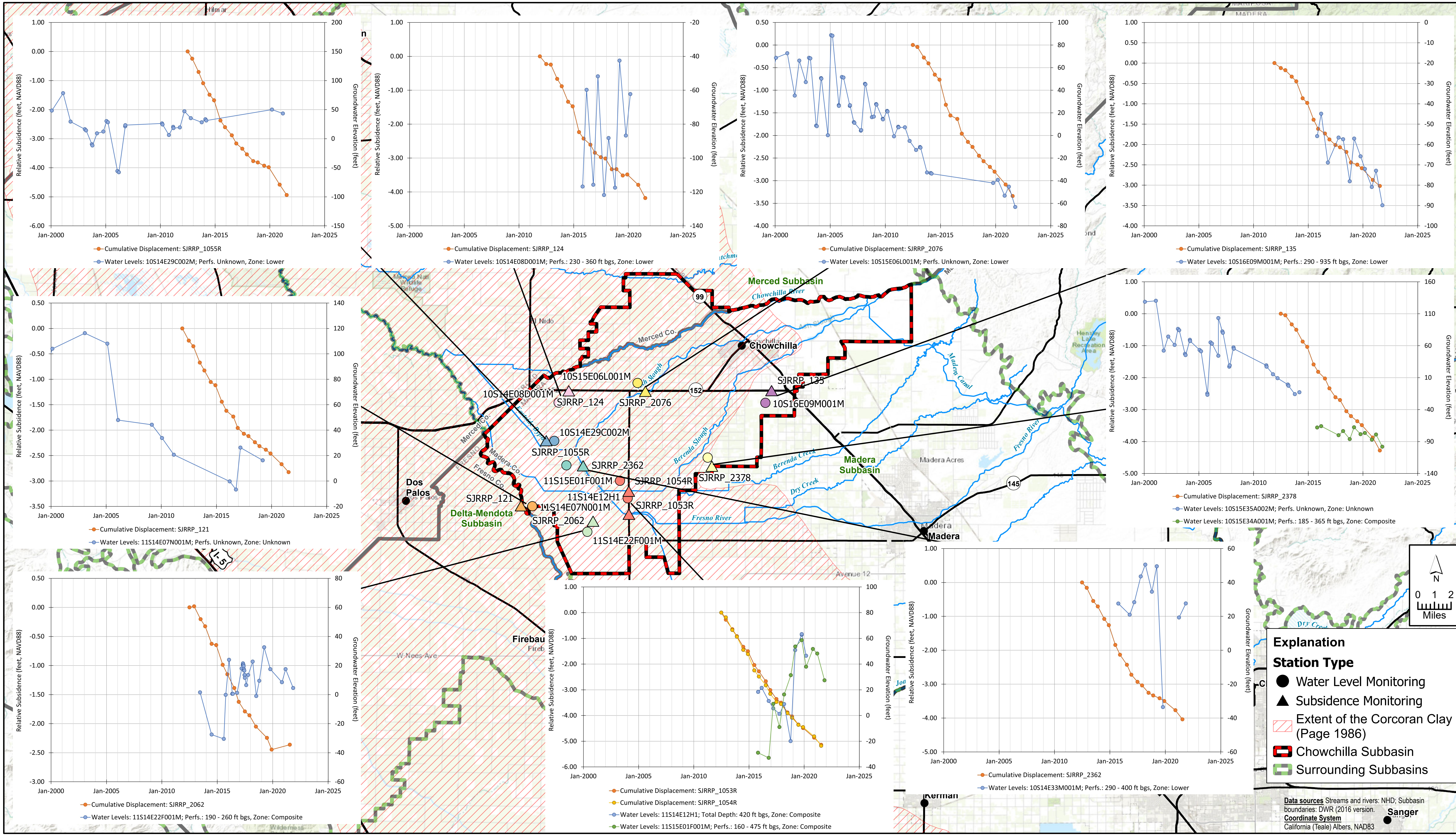

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FIGURE 2-70A
Select Subsidence and Groundwater Level Hydrographs: SJRRP Benchmarks

Chowchilla Subbasin
Groundwater Sustainability Plan

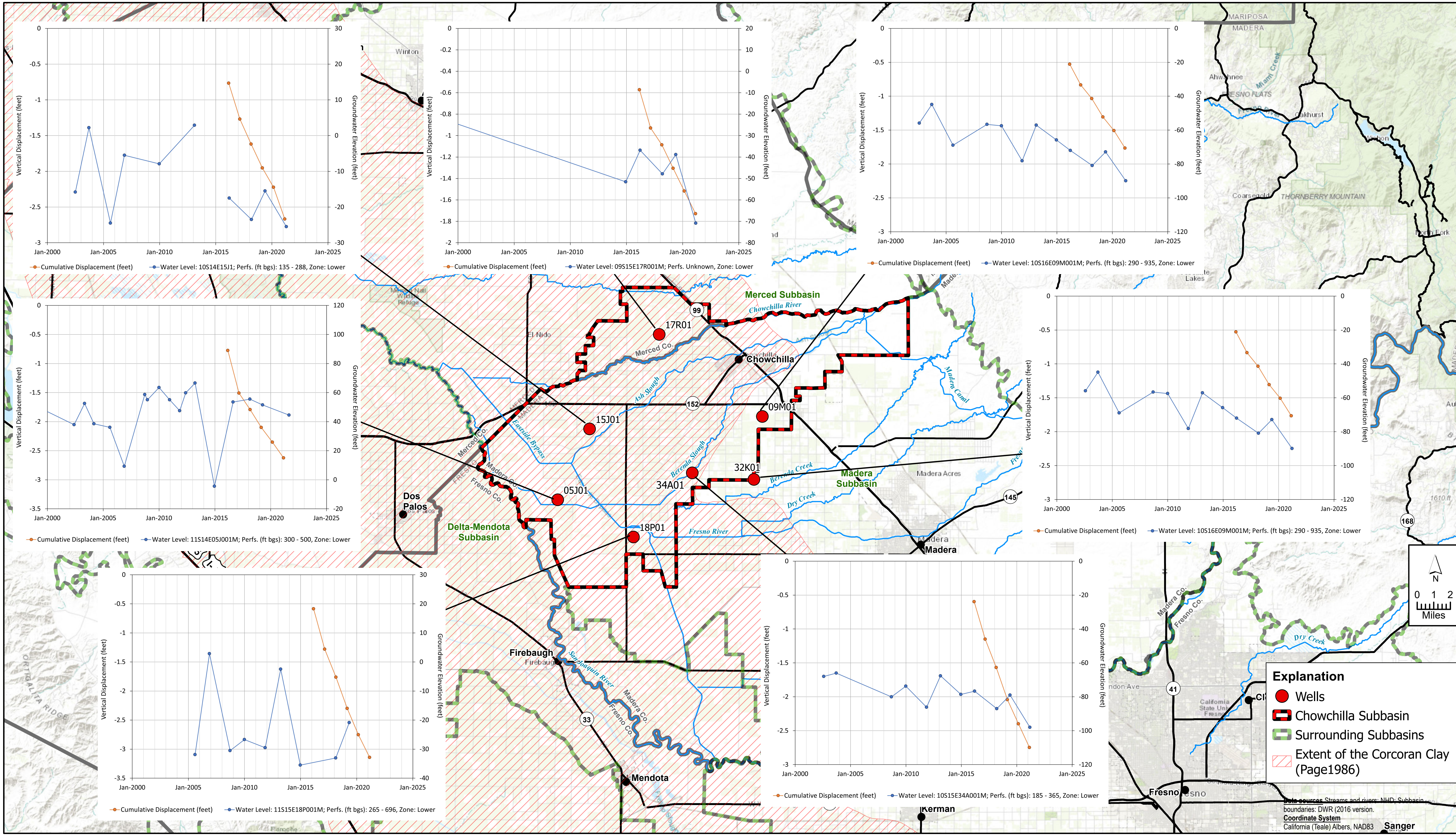

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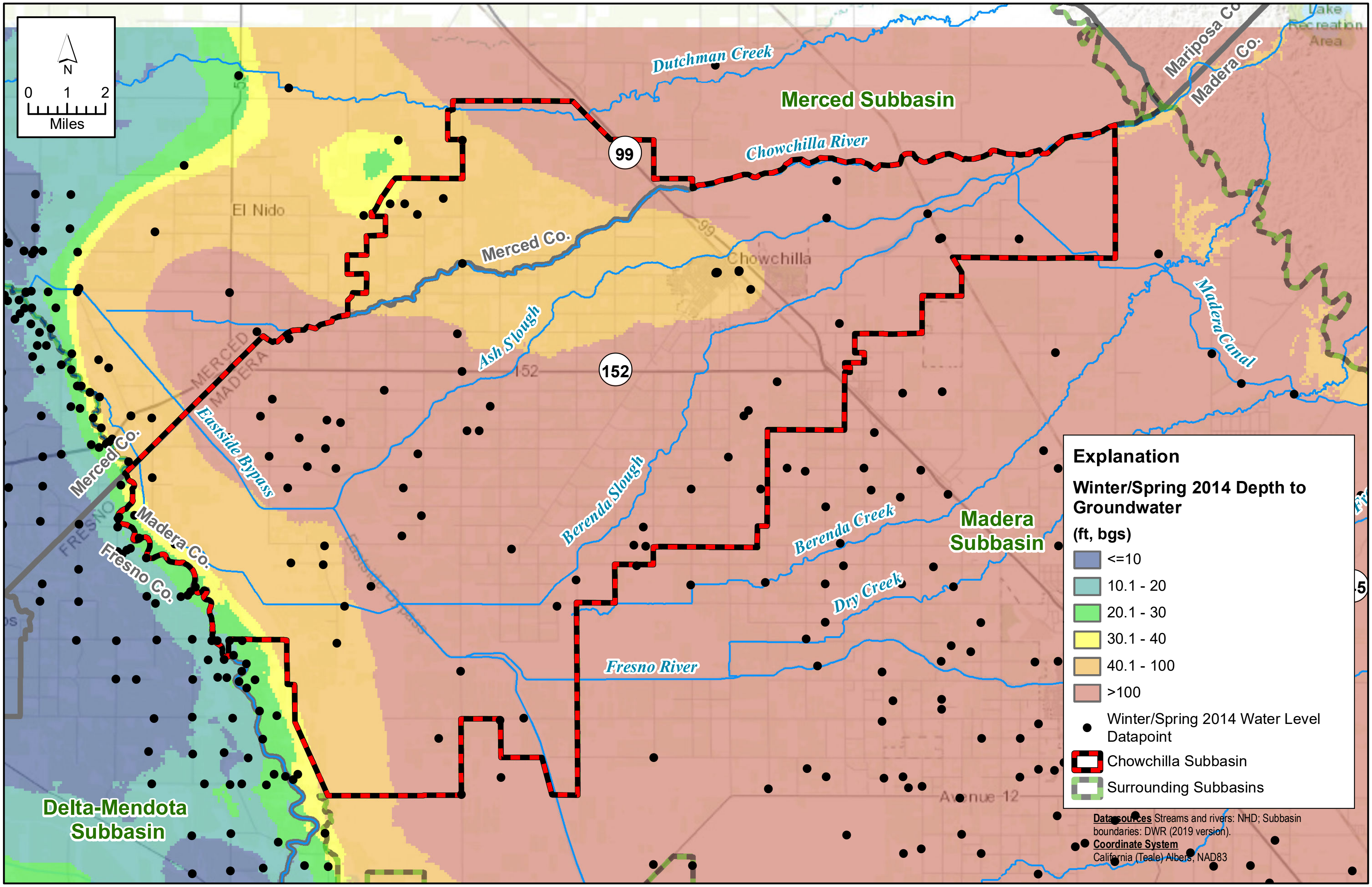
FIGURE 2-70B
Select Subsidence and Groundwater Level Hydrographs: DWR Tre Altamira InSAR

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-70 Chowchilla Subbasin Depth to Unconfined GW WinterSpring 2014.mxd

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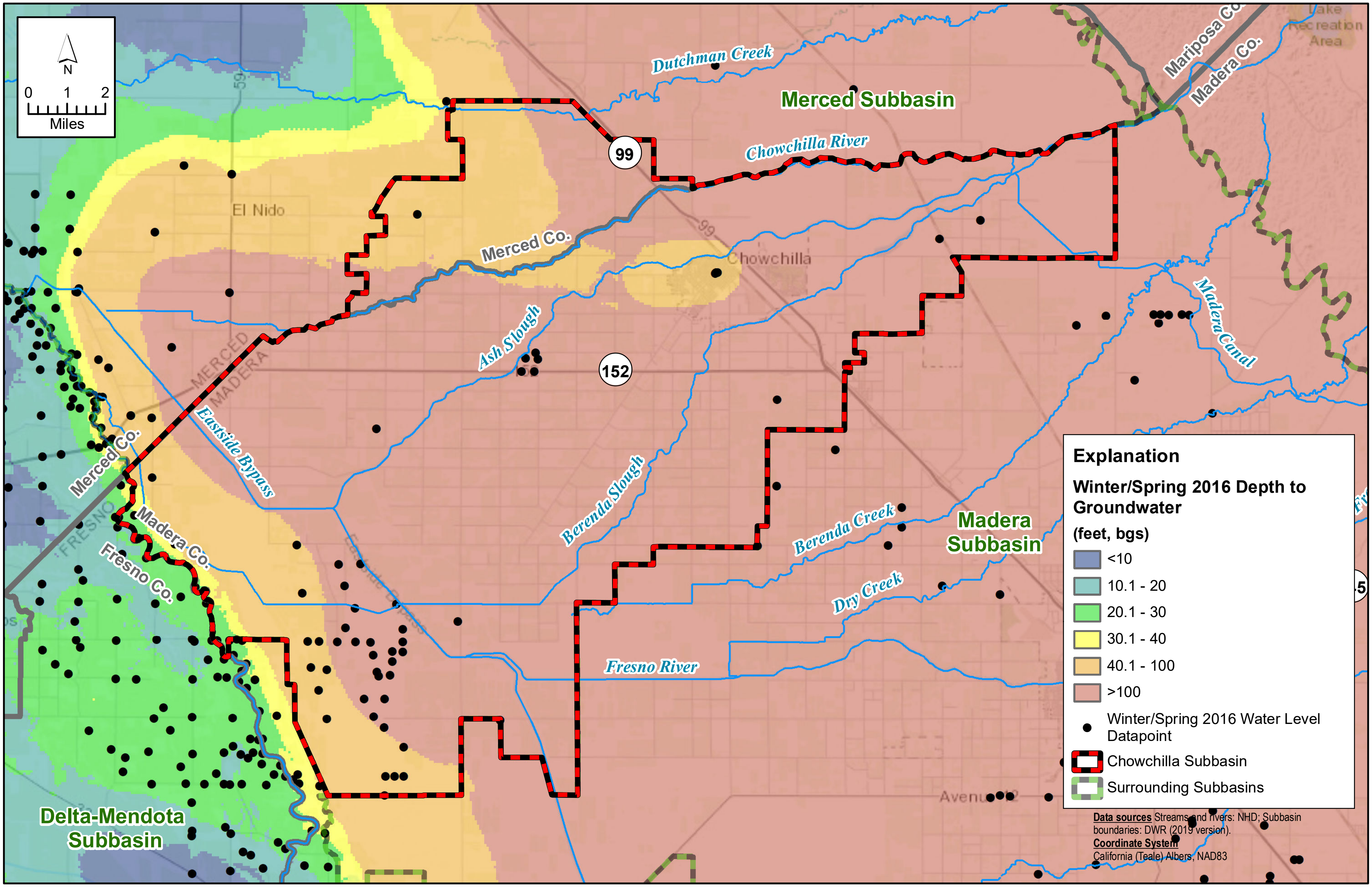
FIGURE 2-71
Map of Depth to Groundwater: Winter/Spring 2014 - Unconfined Groundwater

Chowchilla Subbasin
Groundwater Sustainability Plan



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-71 Chowchilla Subbasin Depth to Unconfined GW WinterSpring 2016.mxd

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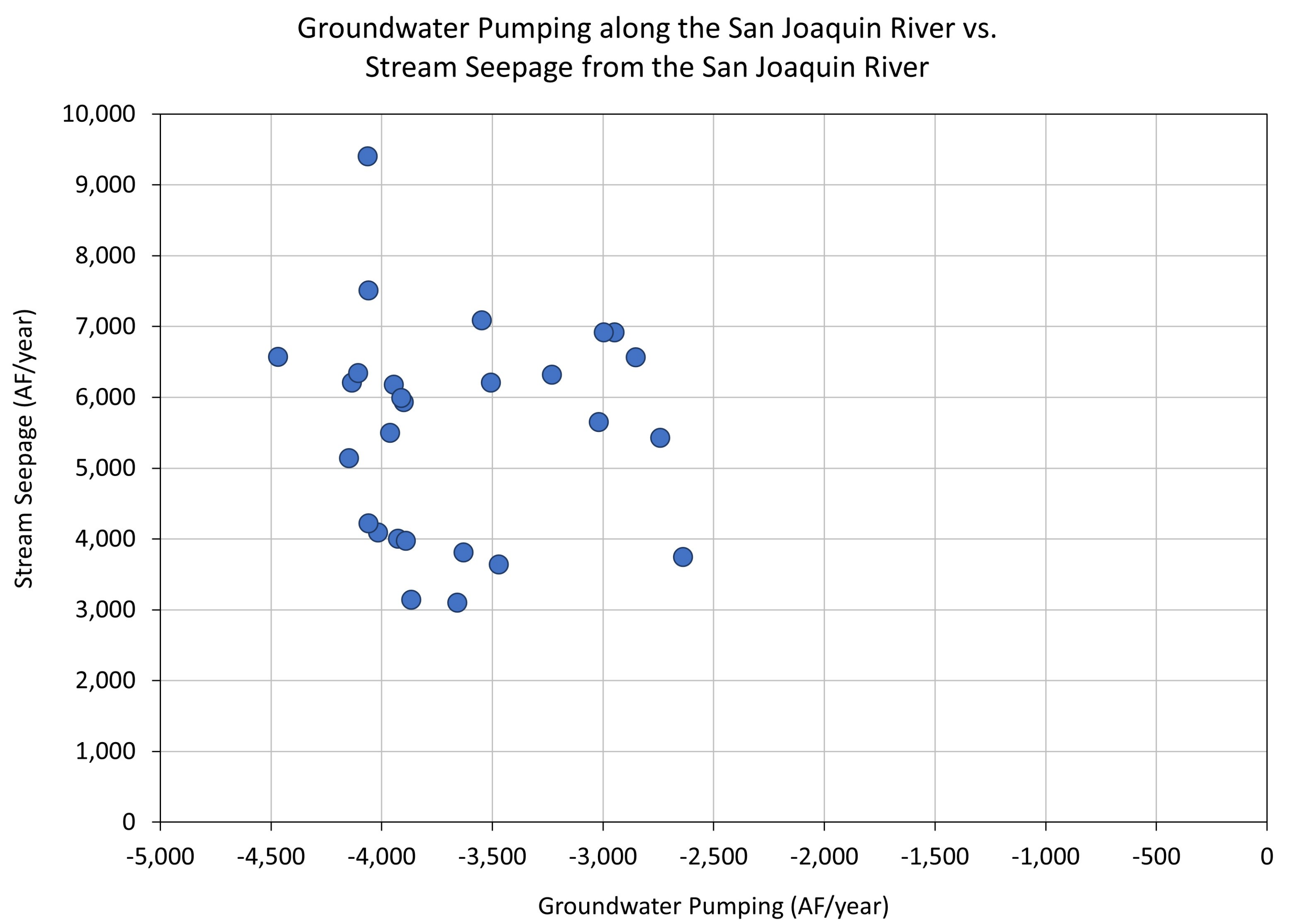
FIGURE 2-72
Map of Depth to Groundwater:
Winter/Spring 2016 - Unconfined Groundwater

Chowchilla Subbasin
Groundwater Sustainability Plan



Data for chart from Madera-Chowchilla Groundwater-Surface Water Simulation Model (MCSim)

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FIGURE 2-73
Groundwater Pumping along the San Joaquin River vs. Stream Seepage from the San Joaquin River

Chowchilla Subbasin
Groundwater Sustainability Plan

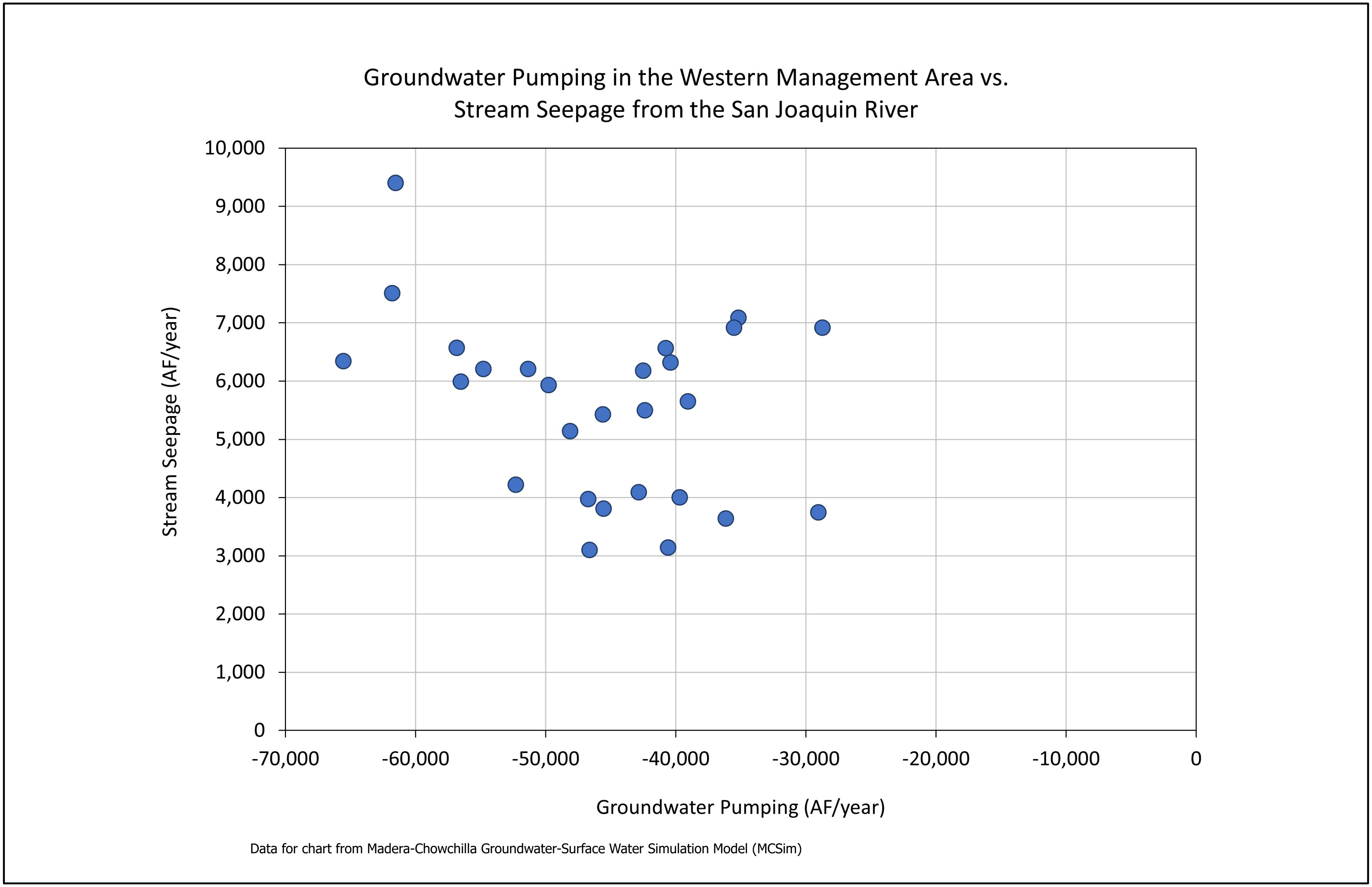

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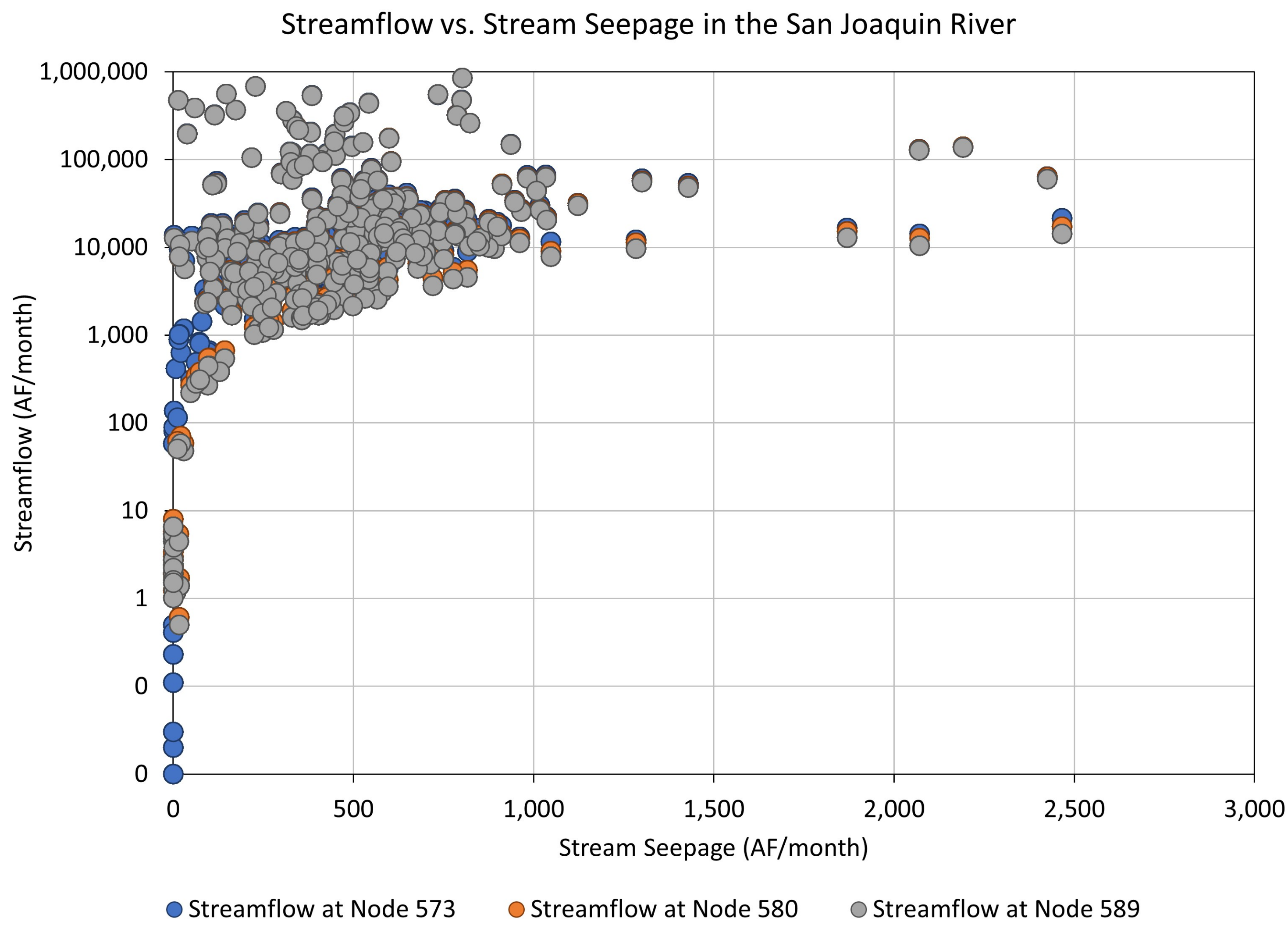
FIGURE 2-74

Groundwater Pumping in the Western Management Area vs. Stream Seepage from the San Joaquin River

Chowchilla Subbasin
Groundwater Sustainability Plan



Data for chart from Madera-Chowchilla Groundwater-Surface Water Simulation Model (MCSim)

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FIGURE 2-75

Streamflow vs. Stream Seepage in the San Joaquin River

Chowchilla Subbasin
Groundwater Sustainability Plan

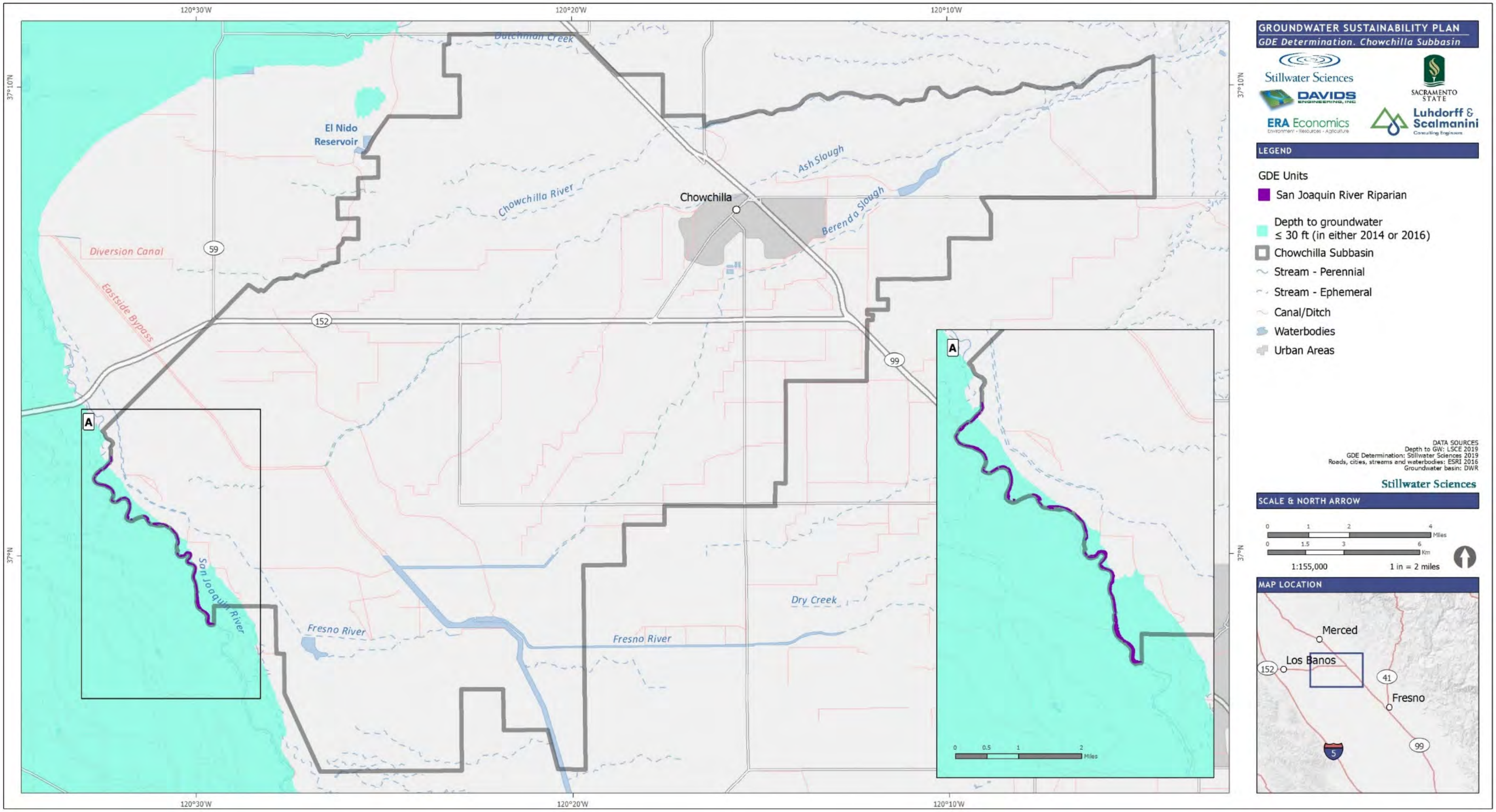
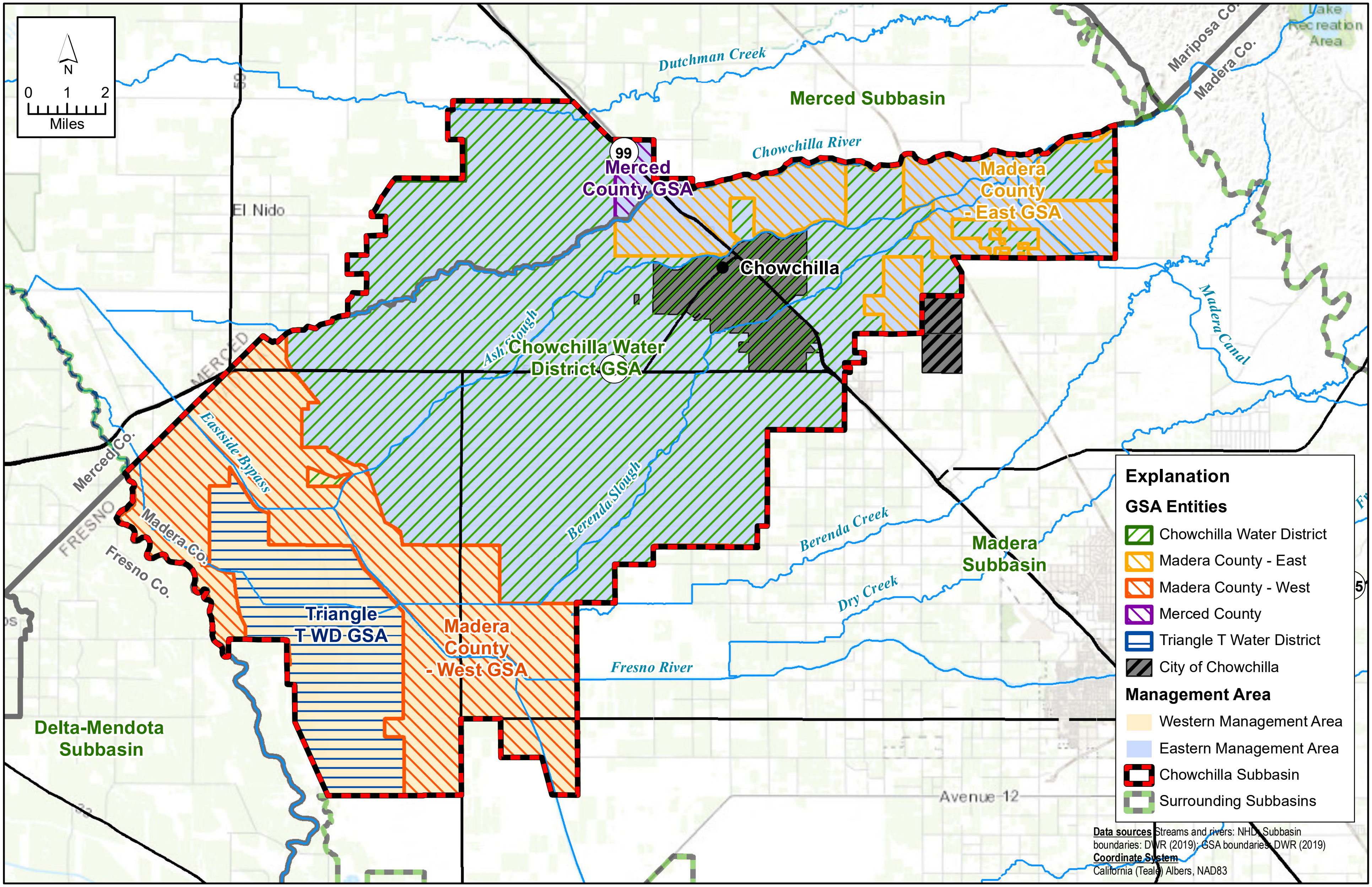


Figure 2-76. GDE units and depth to groundwater in the Chowchilla Subbasin.



X:\2018\18-017 Chowchilla GSP Development\GIS\Map files\Report Figures\Figure 2-93 Chowchilla Subbasin Management Areas.mxd

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FIGURE 2-94

Management Areas

Chowchilla Subbasin
Groundwater Sustainability Plan

3 SUSTAINABLE MANAGEMENT CRITERIA

This chapter of the Groundwater Sustainability Plan (GSP) provides a discussion of the sustainability goals, measurable objectives (MOs), interim milestones, minimum thresholds (MTs), undesirable results, and the monitoring network for each sustainability indicator. Undesirable results occur when significant and unreasonable effects for any sustainability indicators defined by the Sustainability Groundwater Management Act (SGMA) are caused by groundwater conditions occurring in the Subbasin.

This is the fundamental chapter that defines sustainability in the Subbasin, and it addresses significant regulatory requirements. The MOs , MTs , and undesirable results presented in this chapter define the future sustainable conditions in the Subbasin and commit the GSAs to actions that will achieve these future conditions.

Defining Sustainable Management Criteria (SMC) requires considerable analysis and evaluation of many factors. This chapter presents the data and methods used to develop the SMC and demonstrates how they relate to beneficial uses and users. The SMC presented in this chapter are based on current available data and applications of the best available science.

As noted in this GSP, data gaps and uncertainty exist in the characterization of the hydrogeologic conceptual model and groundwater conditions. The uncertainty was considered when developing the SMC and because of these uncertainties, the SMC presented herein are considered initial criteria. The GSAs will periodically evaluate this GSP, assess changing conditions in the Subbasin that may warrant modifications of the GSP or management objectives, and may adjust components accordingly. The GSAs will focus their evaluation on determining whether the actions under the GSP are meeting the GSP's management objectives and whether those objectives are meeting the sustainability goal of the Subbasin.

This chapter is organized to address all the SGMA regulations regarding SMC, and is organized in accordance with DWR's GSP annotated outline. This chapter includes a description of:

- How locally defined significant and unreasonable conditions were developed
- How MTs were developed, including:
    - The information and methodology used to develop MTs
    - The relationship between MTs and relationship of these MTs to other sustainability indicators
    - The effect of MTs on neighboring basins
    - The effect of MTs on beneficial uses and users
    - How MTs are related to relevant Federal, State or local standards
    - The method for quantifying measurable MTs
- How MOs were developed, including:
    - The methodology for setting MOs
    - Interim milestones
- How undesirable results were developed, including:

  - The criteria defining when and where the effect of the groundwater conditions cause undesirable results based on a quantitative description of the combination of minimum threshold exceedances
  - The potential causes of undesirable results
  - The effect of these undesirable results on the beneficial use and users.

The SMC presented in this chapter were developed using information from stakeholder and public input and correspondence with the GSAs, public meetings, hydrogeologic analysis, meetings with GSA technical experts, and meetings with DWRs technical experts. The general process for establishing SMC included:

- GSA public meetings that outlined the GSP development process and introduced stakeholders to the SMC
- Conducting public meetings to present proposed methodologies to establish MTs and MOs and receive additional public input. Two public meetings on SMC were held in the Subbasin
- Reviewing public input on preliminary SMC methodologies with GSA staff/technical experts
- Providing a Draft GSP for public review and comment
- Establishing and modifying MTs, MOs, and definition of undesirable results based on feedback from public meetings, public/stakeholder review of the Draft GSP, and input from GSA staff/technical experts.
- In 2022, SMC for chronic groundwater level decline, subsidence, and interconnected surface water were updated or added to address deficiencies identified by DWR in their January 2029 Subbasin Consultation Letter (supplemented and clarified during five meetings with DWR).
- During the GSP revision process in 2022, the GSAs conducted public outreach to discuss GSP deficiencies identified by DWR and how they were addressed through three public GSP Advisory Committee meetings, through multiple public GSA governing body meetings, and through public notices regarding the GSP revision process.

To ensure the Subbasin meets its sustainable goal by 2040, the GSAs have proposed several projects and management actions (PMAs), described in Chapter 4, to address undesirable results. The projects and management actions expected to be implemented will include several projects (e.g., recharge basins, Flood MAR, in-lieu recharge) and management actions including demand reduction. The overarching sustainability goal and the absence of undesirable results are expected to be achieved by 2040 through implementation of the PMAs. The sustainability goals will be maintained through proactive monitoring and management by the GSAs as described in this and the following chapters. **Table 3-1** summarizes whether each of the six undesirable results has occurred, is occurring, or is expected to occur in the future in the Subbasin without and with GSP implementation.

3.1 Sustainability Goal (23 CCR § 354.24)

3.1.1 Goal Description

The sustainability goal for the Chowchilla Subbasin is to implement a package of PMAs that will, by 2040, balance long-term groundwater system inflows with outflows based on a 50-year period representative of average historical hydrologic conditions. The six sustainability indicators, established MOs, and MTs will ensure that no undesirable results of significant and unreasonable economic, social, or environmental impacts occur as a result of GSP activities, as defined based on local values expressed in this GSP.

Table 3-1. Summary of Undesirable Results Applicable to the Plan Area

Sustainable Indicator	Historical Period (Prior to 2015)	Existing Conditions	Future Conditions without GSP Implementation	Future Conditions with GSP Implementation
Chronic Lowering of Groundwater Levels	Yes	Yes	Yes	No
Reduction of Groundwater Storage	Yes	Yes	Yes	No
Land Subsidence (Western Management Area)	Yes	Yes	Yes	No
Land Subsidence (Eastern Management Area)	No	No	Possibly	No
Seawater Intrusion	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Degraded Water Quality	Yes	Yes	Yes	No[1]
Depletion of Interconnected Surface Water	Yes	Possibly[2]	Possibly	No

[1] There may be future continued degradation of groundwater quality that is not related to GSP Projects and Management Actions.
[2] Surface water and groundwater are disconnected under existing conditions for most of Subbasin; insufficient data exists to fully evaluate interconnected surface water along the San Joaquin River.

3.1.2 Description of Measures

Recharge projects, which include projects that replace groundwater use with surface water use (in lieu recharge), and management actions that reduce total demand are planned to be implemented over the 20-year Implementation Period from 2020 through 2040. Together the projects and the management actions will increase groundwater inflows and decrease groundwater outflows to bring the groundwater system into balance by 2040 and will allow its operation to remain sustainable over a 50-year period representing average hydrologic conditions.

3.1.3 Explanation of How the Goal Will Be Achieved in 20 Years

Implementation of recharge projects will increase inflow to the groundwater system, thus increasing groundwater levels in wet years when water is available for recharge. Implementation of projects that replace groundwater use with surface water use will reduce groundwater pumping to maximize the use of surface water, also contributing to increases or stabilization in groundwater levels. Demand reduction will decrease the consumptive use of groundwater, also contributing to increases or stabilization of groundwater levels. The combination of the increased inflows through recharge, decreased outflows through the projects that replace groundwater use with surface water use, and through the reduced demand resulting from the management actions result in groundwater inflows equaling outflows over the Sustainability Period (2040 to 2090), as described in Section 2.

3.2 Measurable Objectives (23 CCR § 354.30)

As detailed below, the MOs represent the expected operating conditions for the Subbasin. If the GSAs successfully operate to the MOs described, the Subbasin will be operating sustainably. MOs and interim milestones are detailed below. A description of the MOs and how they were established are provided, along with recognition of the anticipated fluctuations in basin conditions around the established MOs. In addition, this section describes how the GSP helps to meet each measurable objective, how each measurable objective is intended to achieve the sustainability goal for the Subbasin for long-term beneficial uses, how MOs are integrated for the two different Management Areas, and how the interim milestones are intended to reflect the anticipated progress toward the MOs during the 2020 to 2040 implementation period.

The GSP regulations define MOs as specific, quantifiable goals for the maintenance or improvement of specific groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin.

Per the GSP regulations:

1. MOs shall be established, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.
2. MOs shall be established for each sustainability indicator, based on quantitative values using the same metric and monitoring sites as are used to define the MTs.
3. MOs shall provide a reasonable margin of operational flexibility under adverse conditions, which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.
4. A representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators may be established where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual MOs as supported by adequate evidence. Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years.

The MOs developed for each applicable sustainability indicator in this GSP are based on the current understanding of the Plan Area and basin setting as discussed in detail in Chapter 2. Representative Monitoring Sites (RMS) are identified for monitoring of interim milestones, MOs, and MTs for each sustainability indicator, and are also known as sustainability indicator wells.

3.2.1 Chronic Lowering of Groundwater Levels

MOs and interim milestones for chronic lowering of groundwater levels are described below.

3.2.1.1 Measurable Objectives

MOs for groundwater levels were established in accordance with the sustainability goal through review and evaluation of measured groundwater level data and future projected fluctuations in groundwater levels utilizing the numerical groundwater flow model (**Appendix 6.D**), which simulated implementation of PMAs. This analysis provides estimates of the expected groundwater level variability due to climatic and operational variability. Both annual (year to year) and seasonal (winter/spring to summer/fall) variability were considered. MOs for groundwater levels were calculated as the model-derived average groundwater levels over the Sustainability Period from 2040 to 2090, modified if necessary to account for occasional offset between historically observed and modeled groundwater levels. MOs for groundwater levels for each sustainability indicator well or RMS are summarized in **Table 3-2**, and locations of groundwater level RMS are shown in **Figure**[61] **3-1**. These MOs are set specific to aquifer zones (where possible) designated as Upper Aquifer (above the Corcoran Clay where present, and equivalent depth to the east where Corcoran Clay is not present) and Lower Aquifer. Groundwater level hydrographs showing MOs for each groundwater level RMS are provided in **Appendix 3.A.**

Groundwater level is the sustainability indicator most likely to affect GDEs in the Subbasin. The Subbasin's single GDE unit, the San Joaquin River Riparian GDE Unit, is located along the San Joaquin River in the Western Management Area (see Section 2.2.2.6 and **Appendix 2.B**). Groundwater in the GDE unit is tightly coupled with surface flow and runoff and is generally maintained at depths within the maximum rooting depth range of the dominant phreatophytic species present in the unit (see Section 2.2.2). The groundwater that is potentially accessible to the vegetation composing the GDE unit likely occurs as a shallow perched/mounded aquifer fed largely by percolation of surface flow from the San Joaquin River. As described in Section 2.2.5, it has been determined that a connection between regional groundwater and streams does not currently exist in most of the Subbasin. However, there remains some potential for shallow groundwater and the associated GDE Unit to be affected by pumping from the regional aquifer (although the risk of this potential impact is considered low). Therefore, MOs for the shallow Upper Aquifer wells in closest proximity to the San Joaquin River Riparian GDE Unit (MCW RMS-10, MCW RMS-11, and MCW RMS-12) are included in the list of RMS and are considered representative of groundwater conditions that could affect the GDE unit.

[61] Figure titles that are bolded can be found at the end of each chapter

Table 3-2. Summary of Groundwater Level Measurable Objectives for Representative Monitoring Sites

Well I.D.	Surface Elevation	Well Depth	Screen Top-Bottom	Model Layer(s)	Aquifer Designation	MO Depth[1]	MO Elev[1]	GSA	CASGEM Well?
CWD RMS-1	171	275	160-275	4	Lower	196	-25	CWD	CASGEM
CWD RMS-2	193	780	230-775	4	Lower	243	-50	CWD	No
CWD RMS-3	206	Unknown	Unknown	4	Lower	238	-32	CWD	No
CWD RMS-4	225	800	320-800	4	Lower	210	15	CWD	CASGEM
CWD RMS-5	207	Unknown	Unknown	4	Lower	219	-12	CWD	Voluntary
CWD RMS-6	275	820	257-726	4	Lower	304	-29	CWD	CASGEM
CWD RMS-7	169	330	135-288	3,4	Lower	134	35	CWD	CASGEM
CWD RMS-8	219	Unknown	Unknown	4	Lower	228	-9	CWD	Voluntary
CWD RMS-9	164	97	82-97	3	Upper	84	80	CWD	CASGEM
CWD RMS-10	182	Unknown	Unknown	4	Lower	188	-6	CWD	Voluntary
CWD RMS-11	199	529	187-529	4	Lower	190	9	CWD	CASGEM
CWD RMS-12	176	Unknown	Unknown	3	Upper	106	70	CWD	Voluntary
CWD RMS-13	167	Unknown	Unknown	4	Lower	133	34	CWD	Voluntary
CWD RMS-14	152	455	185-365	4	Lower	121	31	CWD	CASGEM
CWD RMS-15	213	955	290-935	4	Lower	230	-17	CWD	CASGEM
CWD RMS-16	212	Unknown	Unknown	4	Lower	211	1	CWD	Voluntary
CWD RMS-17	203	624	278-588	4	Lower	171	32	CWD	CASGEM
MCE RMS-1	276	Unknown	Unknown	4	Lower	296	-20	Madera County East	Voluntary
MCE RMS-2	272	466	218-464	4	Lower	284	-12	Madera County East	CASGEM
MCW RMS-1	120	186	Unknown	3	Upper	46	74	Madera County West	Voluntary
MCW RMS-2	123	Unknown	Unknown	2	Upper	31	92	Madera County West	No