Appendix E
Table 1b

Tri-County Water Authority GSA
Historical Surface Water Budget 1986/87 to 2016/17

	Surface Water Outflow (acre-ft)						
Water Year	Areal Recharge of Precipitation	Deep Percolation of Applied Water		Evapotranspiration			Total Out
		Imported Water	Agricultural Pumping	Precipitation Crops/Native	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	
1986 - 1987	0	2,300	11,700	21,000	5,800	37,000	78,000
1987 - 1988	0	900	12,900	30,000	2,600	40,000	86,000
1988 - 1989	0	1,600	12,300	24,000	4,500	38,000	80,000
1989 - 1990	0	1,000	12,800	23,000	2,800	40,000	80,000
1990 - 1991	0	300	13,700	31,000	600	42,000	88,000
1991 - 1992	0	400	13,300	27,000	1,200	42,000	84,000
1992 - 1993	0	2,200	11,800	44,000	6,000	37,000	101,000
1993 - 1994	0	1,300	12,400	28,000	3,800	39,000	85,000
1994 - 1995	5,000	3,300	10,500	52,000	9,500	33,000	113,000
1995 - 1996	0	4,200	13,700	30,000	12,300	44,000	104,000
1996 - 1997	0	3,200	15,100	42,000	9,200	48,000	118,000
1997 - 1998	12,000	1,900	16,400	56,000	5,500	52,000	144,000
1998 - 1999	0	2,500	15,800	35,000	7,300	50,000	111,000
1999 - 2000	0	2,100	16,200	33,000	6,200	51,000	109,000
2000 - 2001	0	1,000	17,300	25,000	2,800	54,000	100,000
2001 - 2002	0	800	17,600	24,000	2,200	55,000	100,000
2002 - 2003	0	1,100	13,200	23,000	3,600	54,000	95,000
2003 - 2004	0	1,000	11,200	19,000	2,400	46,000	80,000
2004 - 2005	0	4,500	9,100	37,000	8,000	39,000	98,000
2005 - 2006	0	4,300	9,100	38,000	7,500	40,000	99,000
2006 - 2007	0	2,700	11,600	16,000	3,900	43,000	77,000
2007 - 2008	0	900	12,500	18,000	1,200	46,000	79,000
2008 - 2009	0	100	12,900	19,000	200	47,000	79,000
2009 - 2010	0	1,100	11,800	31,000	2,300	45,000	91,000
2010 - 2011	0	3,500	12,200	45,000	3,600	51,000	115,000
2011 - 2012	0	1,900	13,800	28,000	1,300	53,000	98,000
2012 - 2013	0	900	16,600	13,000	600	54,000	85,000
2013 - 2014	0	800	15,600	9,000	200	54,000	80,000
2014 - 2015	0	300	15,700	13,000	300	54,000	83,000
2015 - 2016	0	300	15,700	20,000	300	54,000	90,000
2016 - 2017	0	4,200	11,300	21,000	8,000	46,000	91,000
86/87-16/17 Avg	1,000	1,800	13,400	28,000	4,100	46,000	94,000

🟦 Groundwater Inflows to be Included in Sustainable Yield Estimates
🟪 Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
🟨 Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Appendix E
Table 2

Tri-County Water Authority GSA
Historical Groundwater Budget 1986/87 to 2016/17

Water Year	Groundwater Inflows (acre-ft)						Total In	Groundwater Outflows (acre-ft)				Total Out	Change in Storage (acre-ft)
	Areal Recharge from Precipitation	Imported Water Deliveries Return Flow	Agricultural Pumping Return Flow	Release of Water from Compression of Aquitards	Sub-surface Inflow From Outside Subbasin	Sub-surface Inflow From Other GSAs		Groundwater Pumping Agricultural	Groundwater Pumping Exports	Sub-surface Outflow To Outside Subbasin	Sub-surface Outflow To Other GSAs		
1986 - 1987	0	2,300	11,700	19,000	10,000	79,000	122,000	49,000	6,550	16,000	47,000	119,000	3,000
1987 - 1988	0	900	12,900	15,000	12,000	89,000	130,000	53,000	18,240	12,000	48,000	131,000	-1,000
1988 - 1989	0	1,600	12,300	13,000	12,000	85,000	124,000	51,000	12,130	11,000	51,000	125,000	-1,000
1989 - 1990	0	1,000	12,800	17,000	14,000	85,000	130,000	53,000	23,840	11,000	49,000	137,000	-7,000
1990 - 1991	0	300	13,700	18,000	15,000	90,000	137,000	56,000	18,120	16,000	50,000	140,000	-3,000
1991 - 1992	0	400	13,300	18,000	13,000	95,000	140,000	55,000	23,840	13,000	56,000	148,000	-8,000
1992 - 1993	0	2,200	11,800	10,000	9,000	100,000	133,000	49,000	6,610	16,000	58,000	130,000	3,000
1993 - 1994	0	1,300	12,400	12,000	14,000	91,000	131,000	51,000	11,220	12,000	58,000	132,000	-1,000
1994 - 1995	5,000	3,300	10,500	8,000	13,000	83,000	123,000	44,000	1,320	13,000	54,000	112,000	11,000
1995 - 1996	0	4,200	13,700	5,000	15,000	94,000	132,000	57,000	0	12,000	54,000	123,000	9,000
1996 - 1997	0	3,200	15,100	7,000	20,000	97,000	142,000	63,000	0	12,000	60,000	135,000	7,000
1997 - 1998	12,000	1,900	16,400	6,000	20,000	105,000	161,000	68,000	0	12,000	61,000	141,000	20,000
1998 - 1999	0	2,500	15,800	6,000	20,000	101,000	145,000	66,000	0	12,000	63,000	141,000	4,000
1999 - 2000	0	2,100	16,200	6,000	20,000	101,000	145,000	67,000	4,900	11,000	63,000	146,000	-1,000
2000 - 2001	0	1,000	17,300	11,000	17,000	105,000	151,000	72,000	13,310	11,000	63,000	159,000	-8,000
2001 - 2002	0	800	17,600	12,000	17,000	109,000	156,000	73,000	18,930	11,000	65,000	168,000	-12,000
2002 - 2003	0	1,100	13,200	8,000	19,000	100,000	141,000	67,000	13,050	10,000	64,000	154,000	-13,000
2003 - 2004	0	1,000	11,200	9,000	18,000	89,000	128,000	58,000	20,360	11,000	56,000	145,000	-17,000
2004 - 2005	0	4,500	9,100	4,000	13,000	86,000	117,000	48,000	4,000	15,000	51,000	118,000	-1,000
2005 - 2006	0	4,300	9,100	3,000	17,000	77,000	110,000	49,000	150	12,000	49,000	110,000	0
2006 - 2007	0	2,700	11,600	9,000	19,000	82,000	124,000	55,000	21,570	11,000	49,000	137,000	-13,000
2007 - 2008	0	900	12,500	14,000	13,000	100,000	140,000	59,000	23,950	16,000	59,000	158,000	-18,000
2008 - 2009	0	100	12,900	18,000	13,000	112,000	156,000	60,000	27,390	18,000	66,000	171,000	-15,000
2009 - 2010	0	1,100	11,800	15,000	13,000	119,000	160,000	57,000	17,760	24,000	71,000	170,000	-10,000
2010 - 2011	0	3,500	12,200	10,000	15,000	110,000	151,000	63,000	4,180	18,000	63,000	148,000	3,000
2011 - 2012	0	1,900	13,800	14,000	18,000	103,000	151,000	67,000	21,980	15,000	60,000	164,000	-13,000
2012 - 2013	0	900	16,600	17,000	19,000	93,000	147,000	70,000	23,730	9,000	59,000	162,000	-15,000
2013 - 2014	0	800	15,600	18,000	18,000	89,000	141,000	70,000	20,900	9,000	60,000	160,000	-19,000
2014 - 2015	0	300	15,700	20,000	18,000	88,000	142,000	70,000	20,100	9,000	60,000	159,000	-17,000
2015 - 2016	0	300	15,700	18,000	20,000	99,000	153,000	70,000	21,690	10,000	61,000	163,000	-10,000
2016 - 2017	0	4,200	11,300	12,000	17,000	107,000	152,000	58,000	4,520	17,000	69,000	149,000	3,000
6/87-16/17 Avg	1,000	1,800	13,400	12,000	16,000	96,000	140,000	60,000	13,000	13,000	58,000	144,000	-4,000

Cumulative Change in Storage -140,000

🟦 Groundwater Inflows or Outflows to be Included in Sustainable Yield Estimates
🟪 Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
🟨 Groundwater Outflows Not Included in Sustainable Yield Estimates

Projected Future Tri-County Water Authority GSA Surface Water Budget

	Surface Water Inflow (acre-ft)						
Water Year	Precipitation	Imported Water				Discharge from Wells Agricultural	Total In
		Atwell Island WD	Alpaugh ID	Angiola WD	Private		
2017 - 2018	29,000	0	0	5,911	0	63,000	98,000
2018 - 2019	29,000	0	0	5,911	0	63,000	98,000
2019 - 2020	29,000	0	0	7,961	0	61,000	98,000
2020 - 2021	29,000	0	0	9,211	0	60,000	98,000
2021 - 2022	29,000	0	0	10,461	0	59,000	98,000
2022 - 2023	29,000	0	0	13,590	0	58,000	101,000
2023 - 2024	29,000	0	0	18,926	0	58,000	106,000
2024 - 2025	29,000	0	0	24,261	1,500	52,000	107,000
2025 - 2026	29,000	0	0	29,597	1,500	45,000	105,000
2026 - 2027	29,000	0	0	34,933	1,500	39,000	104,000
2027 - 2028	29,000	0	0	40,268	1,500	32,000	103,000
2028 - 2029	29,000	0	0	43,725	1,500	26,000	100,000
2029 - 2030	29,000	0	0	43,430	1,500	20,000	94,000
2030 - 2031	29,000	0	0	43,430	1,500	19,000	93,000
2031 - 2032	29,000	0	0	43,430	1,500	18,000	92,000
2032 - 2033	29,000	0	0	43,430	1,500	17,000	91,000
2033 - 2034	29,000	0	0	43,430	1,500	15,000	89,000
2034 - 2035	29,000	0	0	43,430	1,500	14,000	88,000
2035 - 2036	29,000	0	0	43,430	1,500	14,000	88,000
2036 - 2037	29,000	0	0	43,430	1,500	14,000	88,000
2037 - 2038	29,000	0	0	43,430	1,500	14,000	88,000
2038 - 2039	29,000	0	0	43,430	1,500	14,000	88,000
2039 - 2040	29,000	0	0	43,430	1,500	14,000	88,000
2040 - 2041	29,000	0	0	43,430	1,500	14,000	88,000
2041 - 2042	29,000	0	0	43,430	1,500	14,000	88,000
2042 - 2043	29,000	0	0	43,430	1,500	14,000	88,000
2043 - 2044	29,000	0	0	43,430	1,500	14,000	88,000
2044 - 2045	29,000	0	0	43,430	1,500	14,000	88,000
2045 - 2046	29,000	0	0	43,430	1,500	14,000	88,000
2046 - 2047	29,000	0	0	43,430	1,500	14,000	88,000
2047 - 2048	29,000	0	0	43,430	1,500	14,000	88,000
2048 - 2049	29,000	0	0	43,430	1,500	14,000	88,000
2049 - 2050	29,000	0	0	43,430	1,500	14,000	88,000
2050 - 2051	29,000	0	0	43,209	1,500	13,000	87,000
2051 - 2052	29,000	0	0	43,209	1,500	13,000	87,000
2052 - 2053	29,000	0	0	43,209	1,500	13,000	87,000
2053 - 2054	29,000	0	0	43,209	1,500	13,000	87,000
2054 - 2055	29,000	0	0	43,209	1,500	13,000	87,000
2055 - 2056	29,000	0	0	43,209	1,500	13,000	87,000
2056 - 2057	29,000	0	0	43,209	1,500	13,000	87,000
2057 - 2058	29,000	0	0	43,209	1,500	13,000	87,000
2058 - 2059	29,000	0	0	43,209	1,500	13,000	87,000
2059 - 2060	29,000	0	0	43,209	1,500	13,000	87,000
2060 - 2061	29,000	0	0	43,209	1,500	13,000	87,000
2061 - 2062	29,000	0	0	43,209	1,500	13,000	87,000
2062 - 2063	29,000	0	0	43,209	1,500	13,000	87,000
2063 - 2064	29,000	0	0	43,209	1,500	13,000	87,000
2064 - 2065	29,000	0	0	43,209	1,500	13,000	87,000
2065 - 2066	29,000	0	0	43,209	1,500	13,000	87,000
2066 - 2067	29,000	0	0	43,209	1,500	13,000	87,000
2067 - 2068	29,000	0	0	43,209	1,500	13,000	87,000
2068 - 2069	29,000	0	0	45,214	1,500	13,000	89,000
2069 - 2070	29,000	0	0	24,476	1,500	13,000	68,000
17/18-69/70 Avg	29,000	0	0	37,800	1,300	22,000	90,000

Projected Future Tri-County Water Authority GSA Surface Water Budget

Water Year	Surface Water Outflow (acre-ft)							Total Out
	Areal Recharge of Precipitation	Recharge in Basins	Deep Percolation of Applied Water		Evapotranspiration			
		Imported Water	Imported Water	Agricultural Pumping	Precipitation Crops/Native	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	
2017 - 2018	1,000	0	1,900	12,200	29,000	4,000	50,000	98,000
2018 - 2019	1,000	0	1,900	12,200	29,000	4,000	50,000	98,000
2019 - 2020	1,000	0	2,200	11,900	29,000	5,400	49,000	99,000
2020 - 2021	1,000	0	2,400	11,700	29,000	6,200	48,000	98,000
2021 - 2022	1,000	0	2,600	11,500	29,000	7,000	47,000	98,000
2022 - 2023	1,000	0	2,700	11,300	29,000	7,800	47,000	99,000
2023 - 2024	1,000	0	2,700	11,300	29,000	7,800	47,000	99,000
2024 - 2025	1,000	2,000	3,700	10,100	29,000	12,100	41,000	99,000
2025 - 2026	1,000	2,000	4,700	8,900	29,000	16,500	36,000	98,000
2026 - 2027	1,000	2,000	5,700	7,800	29,000	20,900	31,000	97,000
2027 - 2028	1,000	2,000	6,700	6,600	29,000	25,200	26,000	97,000
2028 - 2029	1,000	2,000	7,600	5,400	29,000	29,600	20,000	95,000
2029 - 2030	1,000	2,000	8,600	4,300	29,000	33,700	15,000	94,000
2030 - 2031	1,000	2,000	8,600	4,100	29,000	33,700	15,000	93,000
2031 - 2032	1,000	2,000	8,600	3,900	29,000	33,700	14,000	92,000
2032 - 2033	1,000	2,000	8,600	3,700	29,000	33,700	13,000	91,000
2033 - 2034	1,000	2,000	8,600	3,500	29,000	33,700	12,000	90,000
2034 - 2035	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2035 - 2036	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2036 - 2037	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2037 - 2038	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2038 - 2039	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2039 - 2040	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2040 - 2041	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2041 - 2042	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2042 - 2043	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2043 - 2044	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2044 - 2045	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2045 - 2046	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2046 - 2047	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2047 - 2048	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2048 - 2049	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2049 - 2050	1,000	2,000	8,600	3,300	29,000	33,700	11,000	89,000
2050 - 2051	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2051 - 2052	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2052 - 2053	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2053 - 2054	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2054 - 2055	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2055 - 2056	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2056 - 2057	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2057 - 2058	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2058 - 2059	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2059 - 2060	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2060 - 2061	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2061 - 2062	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2062 - 2063	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2063 - 2064	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2064 - 2065	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2065 - 2066	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2066 - 2067	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2067 - 2068	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2068 - 2069	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
2069 - 2070	1,000	2,000	8,500	3,000	29,000	33,500	10,000	87,000
17/18-69/70 Avg	1,000	2,000	7,500	4,800	29,000	28,800	18,000	91,000

Appendix E
Table 4

Projected Future Tri-County Water Authority GSA Groundwater Budget

	Groundwater Inflows (acre-ft)								Groundwater Outflows (acre-ft)					
Water Year	Areal Recharge from Precipitation	Imported Water Deliveries		Agricultural Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow		Total In	Groundwater Pumping		Sub-surface Outflow		Total Out	Change in Storage (acre-ft)
		Return Flow	Recharge in Basins	Return Flow		From Outside Subbasin	From Other GSAs		Agricultural	Exports	To Outside Subbasin	To Other GSAs		
2017 - 2018	1,000	1,900	0	12,200	13,000	14,000	99,000	141,000	63,000	11,280	13,000	61,000	148,000	-7,000
2018 - 2019	1,000	1,900	0	12,200	13,000	14,000	96,000	138,000	63,000	11,280	13,000	61,000	148,000	-10,000
2019 - 2020	1,000	2,200	0	11,900	13,000	13,000	96,000	137,000	61,000	11,280	13,000	62,000	147,000	-10,000
2020 - 2021	1,000	2,400	0	11,700	13,000	12,000	94,000	134,000	60,000	11,280	13,000	62,000	146,000	-12,000
2021 - 2022	1,000	2,600	0	11,500	13,000	10,000	93,000	131,000	59,000	11,280	13,000	61,000	144,000	-13,000
2022 - 2023	1,000	2,700	0	11,300	13,000	10,000	91,000	129,000	58,000	11,280	14,000	61,000	144,000	-15,000
2023 - 2024	1,000	2,700	0	11,300	13,000	10,000	92,000	130,000	58,000	11,280	14,000	61,000	144,000	-14,000
2024 - 2025	1,000	3,700	1,500	10,100	12,000	8,000	90,000	126,000	52,000	11,280	15,000	61,000	139,000	-13,000
2025 - 2026	1,000	4,700	1,500	8,900	11,000	8,000	86,000	121,000	45,000	11,280	18,000	60,000	134,000	-13,000
2026 - 2027	1,000	5,700	1,500	7,800	10,000	8,000	84,000	118,000	39,000	11,280	20,000	60,000	130,000	-12,000
2027 - 2028	1,000	6,700	1,500	6,600	10,000	8,000	82,000	116,000	32,000	11,280	22,000	61,000	126,000	-10,000
2028 - 2029	1,000	7,600	1,500	5,400	9,000	8,000	81,000	114,000	26,000	11,280	24,000	62,000	123,000	-9,000
2029 - 2030	1,000	8,600	1,500	4,300	8,000	9,000	82,000	114,000	20,000	11,280	25,000	64,000	120,000	-6,000
2030 - 2031	1,000	8,600	1,500	4,100	8,000	9,000	81,000	113,000	19,000	11,280	25,000	66,000	121,000	-8,000
2031 - 2032	1,000	8,600	1,500	3,900	8,000	9,000	82,000	114,000	18,000	11,280	25,000	67,000	121,000	-7,000
2032 - 2033	1,000	8,600	1,500	3,700	8,000	9,000	82,000	114,000	17,000	11,280	24,000	69,000	121,000	-7,000
2033 - 2034	1,000	8,600	1,500	3,500	7,000	9,000	83,000	114,000	15,000	11,280	23,000	71,000	120,000	-6,000
2034 - 2035	1,000	8,600	1,500	3,300	6,000	9,000	86,000	115,000	14,000	11,280	24,000	72,000	121,000	-6,000
2035 - 2036	1,000	8,600	1,500	3,300	6,000	9,000	85,000	114,000	14,000	11,280	23,000	73,000	121,000	-7,000
2036 - 2037	1,000	8,600	1,500	3,300	6,000	10,000	84,000	114,000	14,000	11,280	22,000	73,000	120,000	-6,000
2037 - 2038	1,000	8,600	1,500	3,300	6,000	10,000	84,000	114,000	14,000	11,280	21,000	74,000	120,000	-6,000
2038 - 2039	1,000	8,600	1,500	3,300	6,000	11,000	83,000	114,000	14,000	11,280	20,000	74,000	119,000	-5,000
2039 - 2040	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	75,000	121,000	-6,000
2040 - 2041	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2041 - 2042	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2042 - 2043	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2043 - 2044	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2044 - 2045	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2045 - 2046	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2046 - 2047	1,000	8,600	1,500	3,300	5,000	11,000	84,000	114,000	14,000	11,280	21,000	74,000	120,000	-6,000
2047 - 2048	1,000	8,600	1,500	3,300	5,000	11,000	85,000	115,000	14,000	11,280	21,000	74,000	120,000	-5,000
2048 - 2049	1,000	8,600	1,500	3,300	4,000	11,000	84,000	113,000	14,000	11,280	21,000	73,000	119,000	-6,000
2049 - 2050	1,000	8,600	1,500	3,300	4,000	11,000	84,000	113,000	14,000	11,280	21,000	73,000	119,000	-6,000
2050 - 2051	1,000	8,500	1,500	3,000	4,000	11,000	83,000	112,000	13,000	11,280	21,000	73,000	118,000	-6,000
2051 - 2052	1,000	8,500	1,500	3,000	4,000	11,000	83,000	112,000	13,000	11,280	21,000	73,000	118,000	-6,000
2052 - 2053	1,000	8,500	1,500	3,000	4,000	11,000	83,000	112,000	13,000	11,280	21,000	72,000	117,000	-5,000
2053 - 2054	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	21,000	72,000	117,000	-6,000
2054 - 2055	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2055 - 2056	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	21,000	72,000	117,000	-6,000
2056 - 2057	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2057 - 2058	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2058 - 2059	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2059 - 2060	1,000	8,500	1,500	3,000	4,000	12,000	82,000	112,000	13,000	11,280	20,000	72,000	116,000	-4,000
2060 - 2061	1,000	8,500	1,500	3,000	4,000	11,000	82,000	111,000	13,000	11,280	20,000	72,000	116,000	-5,000
2061 - 2062	1,000	8,500	1,500	3,000	4,000	12,000	82,000	112,000	13,000	11,280	20,000	71,000	115,000	-3,000
2062 - 2063	1,000	8,500	1,500	3,000	4,000	12,000	82,000	112,000	13,000	11,280	20,000	71,000	115,000	-3,000
2063 - 2064	1,000	8,500	1,500	3,000	4,000	12,000	82,000	112,000	13,000	11,280	20,000	72,000	116,000	-4,000
2064 - 2065	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	20,000	71,000	115,000	-4,000
2065 - 2066	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	20,000	71,000	115,000	-4,000
2066 - 2067	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	20,000	71,000	115,000	-4,000
2067 - 2068	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	20,000	71,000	115,000	-4,000
2068 - 2069	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	19,000	71,000	114,000	-3,000
2069 - 2070	1,000	8,500	1,500	3,000	4,000	12,000	81,000	111,000	13,000	11,280	19,000	71,000	114,000	-3,000
17/18-69/70 Avg	1,000	7,500	1,300	4,800	7,000	11,000	85,000	118,000	22,000	11,300	20,000	69,000	122,000	-4,000

Tri-County Water Authority GSA
Land Surface Elevations at Representative Monitoring Sites

Site	Land Surface Elevation (ft amsl)[1]			
	2020 (Baseline)	2021	Measurable Objective	Minimum Threshold
T0014_B_RMS	219.4	219.0	212.6	211.6
T0015_B_RMS	217.1	216.8	211.3	210.3
T0016_B_RMS	201.3	200.9	195.4	194.4
T0021_B_RMS	183.0	182.4	175.1	174.1

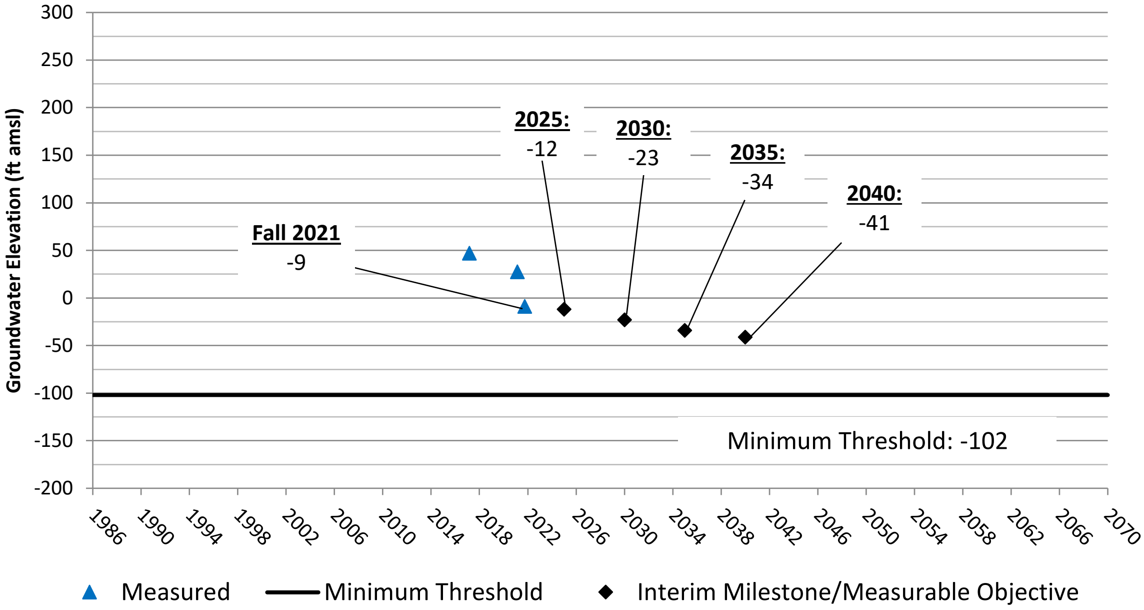
Note:

[1] Benchmarks surveyed in July and August of each year.

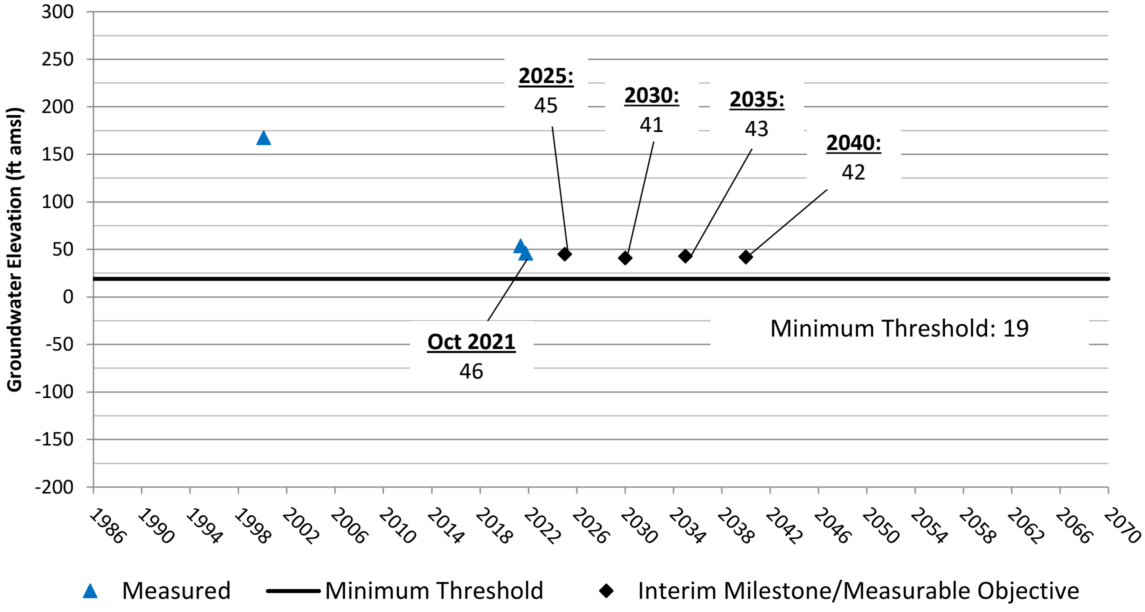
Appendix E
Figure 1

Tri-County Water Authority GSA
RMS Groundwater Elevation Hydrographs

22S/23E-25C01 (E20) (Upper)
Tri-County GSA



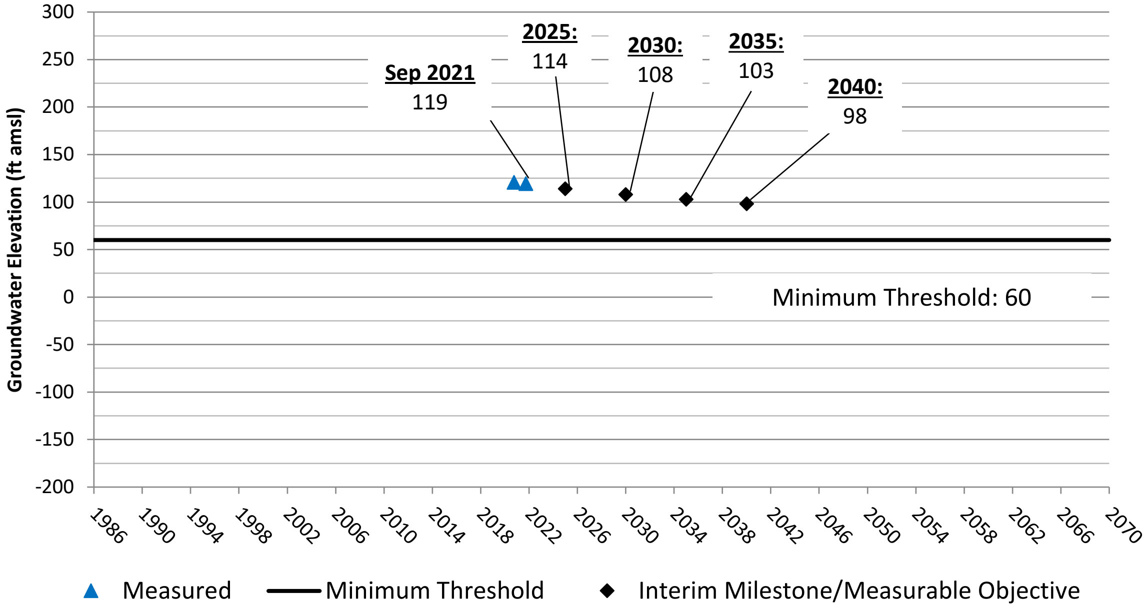
24S/23E-22E01 (Upper)
Tri-County GSA



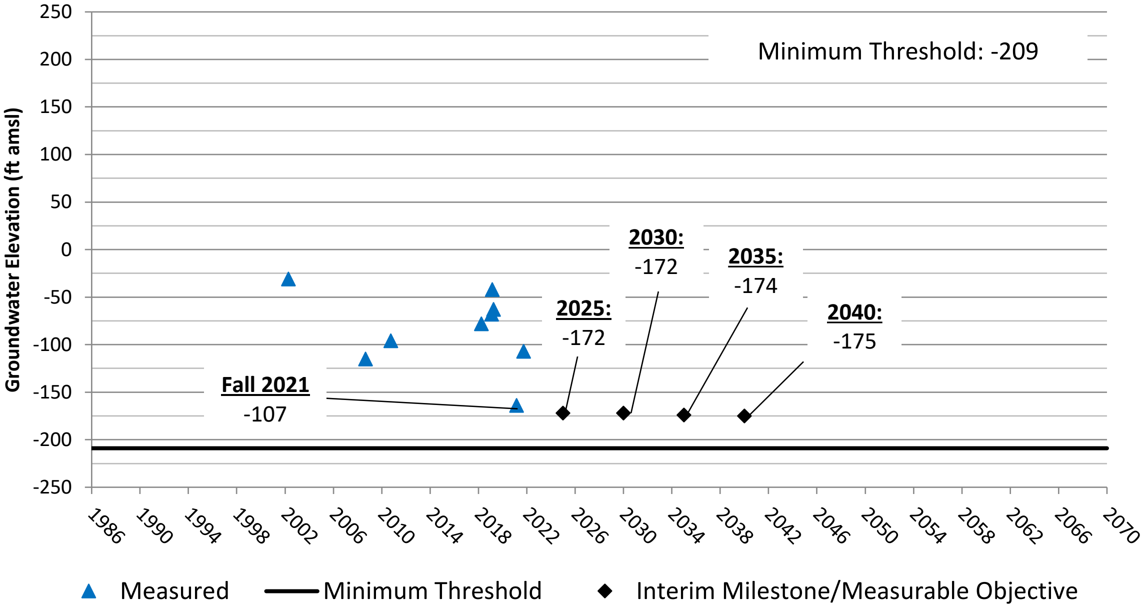
Appendix E
Figure 2

Tri-County Water Authority GSA
RMS Groundwater Elevation Hydrographs

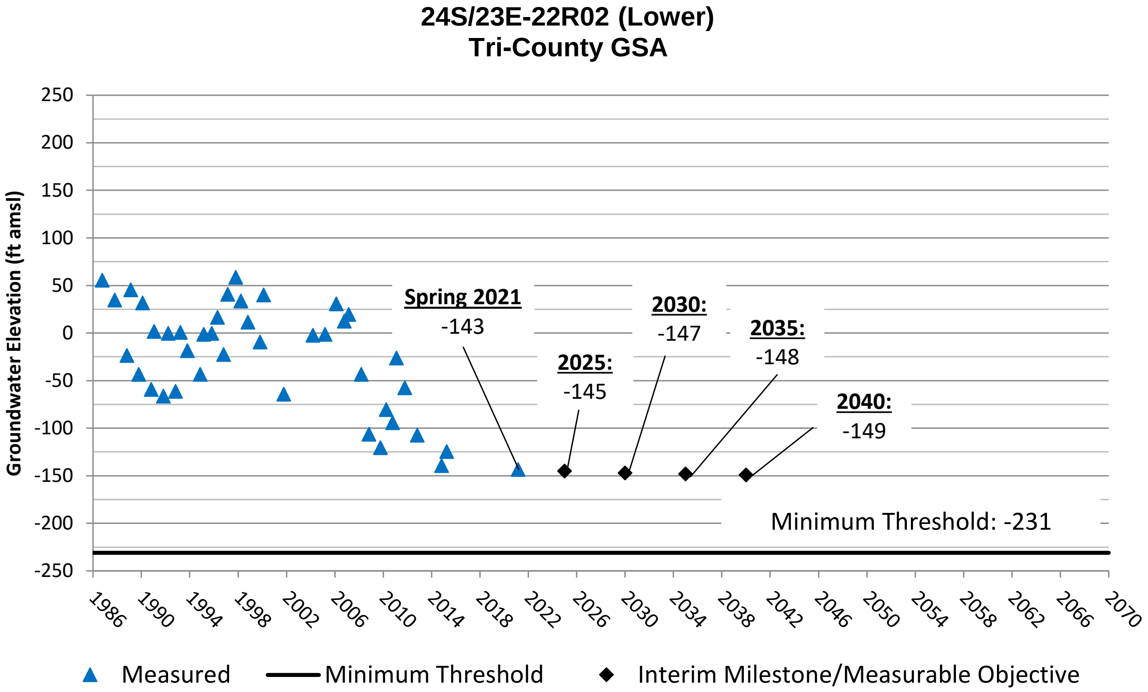
TSMW 5U (Upper)
Tri-County GSA

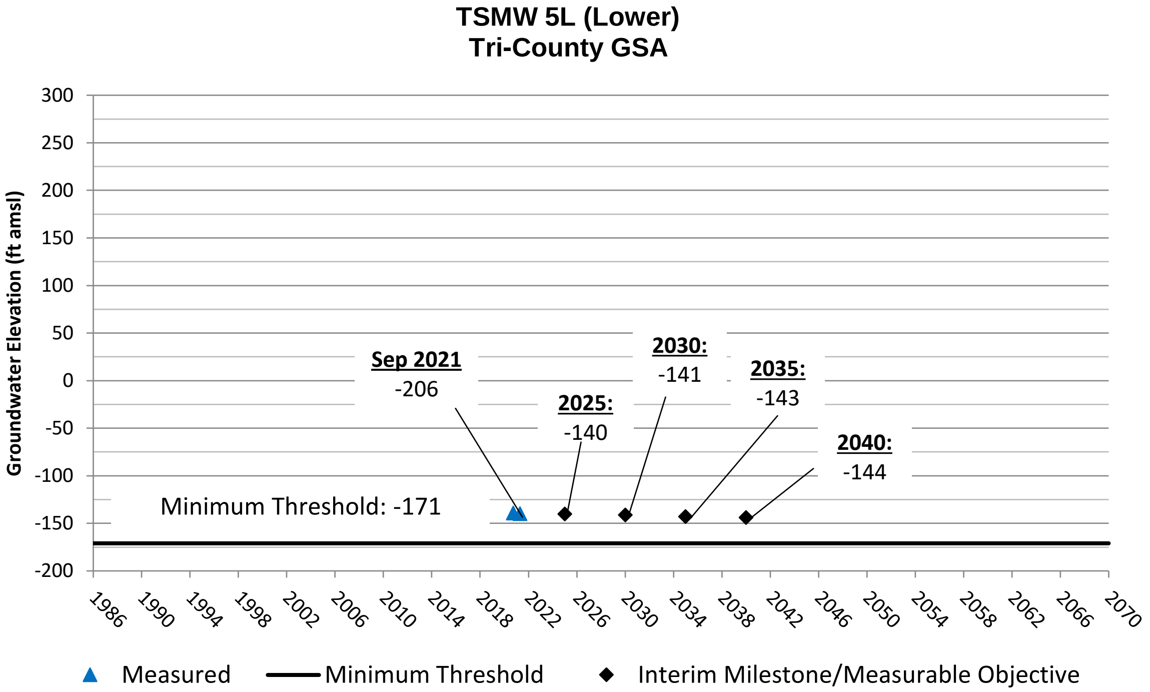


22S/23E-27F01 (G-13) (Lower)
Tri-County GSA



Tri-County Water Authority GSA
RMS Groundwater Elevation Hydrographs





Appendix F

Alpaugh Irrigation District GSA

Water Budgets, Land Surface Elevations at Representative Monitoring Sites, and RMS Groundwater Elevation Hydrographs

Appendix F
Table 1a

Alpaugh GSA
Historical Surface Water Budget 1986/87 to 2016/17

	Surface Water Inflow (acre-ft)					
Water Year	Precipitation	Imported Water		Discharge from Wells		Total In
		Alpaugh ID	Atwell Island WD	Agricultural	Municipal	
1986 - 1987	5,000	748	397	35,000	200	41,000
1987 - 1988	7,000	0	0	36,000	200	43,000
1988 - 1989	6,000	0	0	36,000	200	42,000
1989 - 1990	6,000	0	0	36,000	200	42,000
1990 - 1991	7,000	0	0	36,000	200	43,000
1991 - 1992	6,000	0	0	36,000	200	42,000
1992 - 1993	10,000	11,519	2,302	22,000	200	46,000
1993 - 1994	7,000	3,398	717	32,000	200	43,000
1994 - 1995	14,000	7,790	1,934	26,000	200	50,000
1995 - 1996	7,000	10,493	1,888	21,000	200	41,000
1996 - 1997	10,000	0	0	33,000	200	43,000
1997 - 1998	16,000	0	0	33,000	200	49,000
1998 - 1999	8,000	0	0	33,000	200	41,000
1999 - 2000	8,000	0	91	33,000	200	41,000
2000 - 2001	6,000	0	0	33,000	200	39,000
2001 - 2002	6,000	0	0	33,000	200	39,000
2002 - 2003	6,000	98	0	33,000	200	39,000
2003 - 2004	5,000	0	0	30,000	200	35,000
2004 - 2005	9,000	13,660	0	17,000	300	40,000
2005 - 2006	9,000	15,189	0	16,000	300	40,000
2006 - 2007	4,000	0	0	30,000	300	34,000
2007 - 2008	4,000	0	0	30,000	300	34,000
2008 - 2009	5,000	2,009	0	28,000	300	35,000
2009 - 2010	7,000	2,518	0	27,000	300	37,000
2010 - 2011	11,000	10,324	0	10,000	300	32,000
2011 - 2012	7,000	889	0	18,000	300	26,000
2012 - 2013	3,000	0	0	19,000	300	22,000
2013 - 2014	2,000	0	0	19,000	300	21,000
2014 - 2015	3,000	0	0	19,000	300	22,000
2015 - 2016	5,000	0	0	19,000	300	24,000
2016 - 2017	5,000	2,232	0	16,000	300	24,000
86/87-16/17 Avg	7,000	2,600	200	27,000	200	37,000

Appendix F
Table 1b

Alpaugh GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Outflow (acre-ft)								Total Out
	Areal Recharge of Precip-itation	Deep Percolation of Applied			Evapotranspiration				
		Imported Water	Agri-cultural Pumping	Municipal Pumping	Precipitation Crops/Native	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	Municipal (Landscape ET)	
1986 - 1987	0	300	8,600	100	5,000	900	26,000	100	41,000
1987 - 1988	0	0	8,900	100	7,000	0	27,000	100	43,000
1988 - 1989	0	0	8,900	100	6,000	0	27,000	100	42,000
1989 - 1990	0	0	8,900	100	6,000	0	27,000	100	42,000
1990 - 1991	0	0	8,900	100	7,000	0	27,000	100	43,000
1991 - 1992	0	0	8,900	100	6,000	0	27,000	100	42,000
1992 - 1993	0	3,500	5,500	100	10,000	10,400	16,000	100	46,000
1993 - 1994	0	1,000	7,900	100	7,000	3,100	24,000	100	43,000
1994 - 1995	1,000	2,400	6,500	100	12,000	7,300	20,000	100	49,000
1995 - 1996	0	3,100	5,300	100	7,000	9,300	16,000	100	41,000
1996 - 1997	0	0	8,400	100	10,000	0	25,000	100	44,000
1997 - 1998	3,000	0	8,400	100	13,000	0	25,000	100	50,000
1998 - 1999	0	0	8,400	100	8,000	0	25,000	100	42,000
1999 - 2000	0	0	8,300	100	8,000	100	25,000	100	42,000
2000 - 2001	0	0	8,400	100	6,000	0	25,000	100	40,000
2001 - 2002	0	0	8,400	100	6,000	0	25,000	100	40,000
2002 - 2003	0	0	7,500	200	6,000	100	25,000	100	39,000
2003 - 2004	0	0	6,900	200	5,000	0	23,000	100	35,000
2004 - 2005	0	3,700	3,900	200	9,000	10,000	13,000	100	40,000
2005 - 2006	0	4,700	3,700	200	9,000	10,500	13,000	100	41,000
2006 - 2007	0	0	6,800	200	4,000	0	23,000	100	34,000
2007 - 2008	0	0	6,800	200	4,000	0	23,000	100	34,000
2008 - 2009	0	500	6,400	200	5,000	1,500	21,000	100	35,000
2009 - 2010	0	600	6,200	200	7,000	1,900	21,000	100	37,000
2010 - 2011	0	3,100	2,400	200	11,000	7,200	8,000	100	32,000
2011 - 2012	0	400	4,100	200	7,000	500	14,000	100	26,000
2012 - 2013	0	0	4,200	200	3,000	0	14,000	100	22,000
2013 - 2014	0	0	4,200	200	2,000	0	14,000	100	21,000
2014 - 2015	0	0	4,200	200	3,000	0	14,000	100	22,000
2015 - 2016	0	0	4,200	200	5,000	0	14,000	100	24,000
2016 - 2017	0	500	3,700	200	5,000	1,700	13,000	100	24,000
86/87-16/17 Avg	0	800	6,600	100	7,000	2,100	21,000	100	38,000

🟦 Groundwater Inflows to be Included in Sustainable Yield Estimates
🟪 Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
🟨 Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Alpaugh GSA
Historical Groundwater Budget 1986/87 to 2016/17

	Groundwater Inflows (acre-ft)								Groundwater Outflows (acre-ft)					
Water Year	Areal Recharge from Precipitation	Imported Water Deliveries	Agricultural Pumping	Municipal Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow		Total In	Groundwater Pumping		Sub-surface Outflow		Total Out	Change in Storage (acre-ft)
		Return Flow	Return Flow	Return Flow		From Outside Subbasin	From Other GSAs		Municipal	Agricultural	To Outside Subbasin	To Other GSAs		
1986 - 1987	0	300	8,600	100	3,000	10,000	32,000	54,000	200	35,000	2,000	12,000	49,000	5,000
1987 - 1988	0	0	8,900	100	3,000	9,000	35,000	56,000	200	36,000	2,000	14,000	52,000	4,000
1988 - 1989	0	0	8,900	100	3,000	9,000	38,000	59,000	200	36,000	2,000	15,000	53,000	6,000
1989 - 1990	0	0	8,900	100	3,000	9,000	35,000	56,000	200	36,000	2,000	15,000	53,000	3,000
1990 - 1991	0	0	8,900	100	4,000	10,000	36,000	59,000	200	36,000	2,000	17,000	55,000	4,000
1991 - 1992	0	0	8,900	100	4,000	8,000	40,000	61,000	200	36,000	3,000	18,000	57,000	4,000
1992 - 1993	0	3,500	5,500	100	2,000	5,000	36,000	52,000	200	22,000	5,000	22,000	49,000	3,000
1993 - 1994	0	1,000	7,900	100	3,000	8,000	37,000	57,000	200	32,000	3,000	20,000	55,000	2,000
1994 - 1995	1,000	2,400	6,500	100	2,000	8,000	32,000	52,000	200	26,000	3,000	20,000	49,000	3,000
1995 - 1996	0	3,100	5,300	100	1,000	10,000	29,000	49,000	200	21,000	2,000	23,000	46,000	3,000
1996 - 1997	0	0	8,400	100	1,000	14,000	36,000	60,000	200	33,000	2,000	24,000	59,000	1,000
1997 - 1998	3,000	0	8,400	100	1,000	15,000	38,000	66,000	200	33,000	2,000	26,000	61,000	5,000
1998 - 1999	0	0	8,400	100	1,000	13,000	38,000	61,000	200	33,000	2,000	24,000	59,000	2,000
1999 - 2000	0	0	8,300	100	1,000	13,000	38,000	60,000	200	33,000	2,000	24,000	59,000	1,000
2000 - 2001	0	0	8,400	100	2,000	11,000	40,000	62,000	200	33,000	3,000	24,000	60,000	2,000
2001 - 2002	0	0	8,400	100	2,000	9,000	41,000	61,000	200	33,000	3,000	25,000	61,000	0
2002 - 2003	0	0	7,500	200	2,000	9,000	40,000	59,000	200	33,000	3,000	24,000	60,000	-1,000
2003 - 2004	0	0	6,900	200	2,000	11,000	33,000	53,000	200	30,000	2,000	21,000	53,000	0
2004 - 2005	0	3,700	3,900	200	0	11,000	26,000	45,000	300	17,000	2,000	26,000	45,000	0
2005 - 2006	0	4,700	3,700	200	0	11,000	25,000	45,000	300	16,000	2,000	25,000	43,000	2,000
2006 - 2007	0	0	6,800	200	1,000	14,000	29,000	51,000	300	30,000	1,000	21,000	52,000	-1,000
2007 - 2008	0	0	6,800	200	3,000	7,000	38,000	55,000	300	30,000	3,000	24,000	57,000	-2,000
2008 - 2009	0	500	6,400	200	4,000	5,000	42,000	58,000	300	28,000	6,000	26,000	60,000	-2,000
2009 - 2010	0	600	6,200	200	3,000	6,000	45,000	61,000	300	27,000	6,000	28,000	61,000	0
2010 - 2011	0	3,100	2,400	200	2,000	8,000	33,000	49,000	300	10,000	6,000	31,000	47,000	2,000
2011 - 2012	0	400	4,100	200	3,000	8,000	32,000	48,000	300	18,000	6,000	26,000	50,000	-2,000
2012 - 2013	0	0	4,200	200	3,000	6,000	33,000	46,000	300	19,000	6,000	24,000	49,000	-3,000
2013 - 2014	0	0	4,200	200	4,000	5,000	32,000	45,000	300	19,000	6,000	23,000	48,000	-3,000
2014 - 2015	0	0	4,200	200	4,000	5,000	31,000	44,000	300	19,000	6,000	23,000	48,000	-4,000
2015 - 2016	0	0	4,200	200	3,000	6,000	33,000	46,000	300	19,000	5,000	25,000	49,000	-3,000
2016 - 2017	0	500	3,700	200	2,000	8,000	37,000	51,000	300	16,000	6,000	29,000	51,000	0
36/87-16/17 Avg	0	800	6,600	100	2,000	9,000	35,000	54,000	200	27,000	3,000	23,000	53,000	1,000
												Cumulative Change in Storage		31,000

🟦 Groundwater Inflows or Outflows to be Included in Sustainable Yield Estimates
🟪 Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
🟨 Groundwater Outflows Not Included in Sustainable Yield Estimates

Projected Future Alpaugh GSA Surface Water Budget

	Surface Water Inflow (acre-ft)						
Water Year	Precipitation	Stream Inflow	Imported Water		Discharge from Wells		Total In
		Deer Creek	Alpaugh ID	Atwell Island WD	Agricultural	Municipal	
2017 - 2018	7,000	280	3,680	0	15,000	300	26,000
2018 - 2019	7,000	280	3,680	0	15,000	300	26,000
2019 - 2020	7,000	280	3,680	0	15,000	300	26,000
2020 - 2021	7,000	280	3,680	0	15,000	300	26,000
2021 - 2022	7,000	280	3,680	0	14,000	300	25,000
2022 - 2023	7,000	280	3,680	0	14,000	300	25,000
2023 - 2024	7,000	280	3,680	0	13,000	300	24,000
2024 - 2025	7,000	280	3,680	0	13,000	300	24,000
2025 - 2026	7,000	1,380	4,813	0	10,000	300	23,000
2026 - 2027	7,000	1,380	4,751	0	10,000	300	23,000
2027 - 2028	7,000	1,380	4,689	0	10,000	300	23,000
2028 - 2029	7,000	1,380	4,627	0	9,000	300	22,000
2029 - 2030	7,000	1,380	4,565	0	9,000	300	22,000
2030 - 2031	7,000	1,380	5,737	0	8,000	300	22,000
2031 - 2032	7,000	1,380	5,737	0	8,000	300	22,000
2032 - 2033	7,000	1,380	5,737	0	8,000	300	22,000
2033 - 2034	7,000	1,380	5,737	0	8,000	300	22,000
2034 - 2035	7,000	1,380	5,737	0	8,000	300	22,000
2035 - 2036	7,000	1,380	6,970	0	7,000	300	23,000
2036 - 2037	7,000	1,380	6,970	0	7,000	300	23,000
2037 - 2038	7,000	1,380	6,970	0	7,000	300	23,000
2038 - 2039	7,000	1,380	6,970	0	7,000	300	23,000
2039 - 2040	7,000	1,380	6,970	0	7,000	300	23,000
2040 - 2041	7,000	1,380	7,793	0	6,000	300	22,000
2041 - 2042	7,000	1,380	7,793	0	6,000	300	22,000
2042 - 2043	7,000	1,380	7,793	0	6,000	300	22,000
2043 - 2044	7,000	1,380	7,793	0	6,000	300	22,000
2044 - 2045	7,000	1,380	7,793	0	6,000	300	22,000
2045 - 2046	7,000	1,380	7,793	0	6,000	300	22,000
2046 - 2047	7,000	1,380	7,793	0	6,000	300	22,000
2047 - 2048	7,000	1,380	7,793	0	6,000	300	22,000
2048 - 2049	7,000	1,380	7,793	0	6,000	300	22,000
2049 - 2050	7,000	1,380	7,793	0	6,000	300	22,000
2050 - 2051	7,000	1,380	7,793	0	6,000	300	22,000
2051 - 2052	7,000	1,380	7,793	0	6,000	300	22,000
2052 - 2053	7,000	1,380	7,793	0	6,000	300	22,000
2053 - 2054	7,000	1,380	7,793	0	6,000	300	22,000
2054 - 2055	7,000	1,380	7,793	0	6,000	300	22,000
2055 - 2056	7,000	1,380	7,793	0	6,000	300	22,000
2056 - 2057	7,000	1,380	7,793	0	6,000	300	22,000
2057 - 2058	7,000	1,380	7,793	0	6,000	300	22,000
2058 - 2059	7,000	1,380	7,793	0	6,000	300	22,000
2059 - 2060	7,000	1,380	7,793	0	6,000	300	22,000
2060 - 2061	7,000	1,380	7,793	0	6,000	300	22,000
2061 - 2062	7,000	1,380	7,793	0	6,000	300	22,000
2062 - 2063	7,000	1,380	7,793	0	6,000	300	22,000
2063 - 2064	7,000	1,380	7,793	0	6,000	300	22,000
2064 - 2065	7,000	1,380	7,793	0	6,000	300	22,000
2065 - 2066	7,000	1,380	7,793	0	6,000	300	22,000
2066 - 2067	7,000	1,380	7,793	0	6,000	300	22,000
2067 - 2068	7,000	1,380	7,793	0	6,000	300	22,000
2068 - 2069	7,000	1,380	7,793	0	6,000	300	22,000
2069 - 2070	7,000	1,380	7,793	0	6,000	300	22,000
17/18-69/70 Avg	7,000	1,200	6,600	0	8,000	300	23,000

Projected Future Alpaugh GSA Surface Water Budget

Water Year	Surface Water Outflow (acre-ft)										Total Out
	Areal Recharge of Precipitation	Deep Percolation of Applied Water				Evapotranspiration					
		Imported Water	Deer Creek	Agricultural Pumping	Municipal Pumping	Precipitation Crops/Native	Imported Water Agricultural Cons. Use	Deer Creek Agricultural Cons. Use	Ag. Cons. Use from Pumping	Municipal (Landscape ET)	
2017 - 2018	0	800	100	3,300	200	7,000	2,800	200	11,000	100	26,000
2018 - 2019	0	800	100	3,300	200	7,000	2,800	200	11,000	100	26,000
2019 - 2020	0	800	100	3,300	200	7,000	2,800	200	11,000	100	26,000
2020 - 2021	0	800	100	3,300	200	7,000	2,800	200	11,000	100	26,000
2021 - 2022	0	800	100	3,200	200	7,000	2,800	200	11,000	100	25,000
2022 - 2023	0	800	100	3,200	200	7,000	2,800	200	11,000	100	25,000
2023 - 2024	0	800	100	3,100	200	7,000	2,800	200	10,000	100	24,000
2024 - 2025	0	800	100	3,000	200	7,000	2,800	200	10,000	100	24,000
2025 - 2026	0	1,100	300	2,400	200	7,000	3,700	1,100	8,000	100	24,000
2026 - 2027	0	1,100	300	2,300	200	7,000	3,700	1,100	8,000	100	24,000
2027 - 2028	0	1,100	300	2,200	200	7,000	3,600	1,100	7,000	100	23,000
2028 - 2029	0	1,100	300	2,100	200	7,000	3,600	1,100	7,000	100	23,000
2029 - 2030	0	1,000	300	2,100	200	7,000	3,500	1,100	7,000	100	22,000
2030 - 2031	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2031 - 2032	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2032 - 2033	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2033 - 2034	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2034 - 2035	0	1,300	300	1,800	200	7,000	4,400	1,100	6,000	100	22,000
2035 - 2036	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2036 - 2037	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2037 - 2038	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2038 - 2039	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2039 - 2040	0	1,600	300	1,500	200	7,000	5,400	1,100	5,000	100	22,000
2040 - 2041	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2041 - 2042	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2042 - 2043	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2043 - 2044	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2044 - 2045	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2045 - 2046	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2046 - 2047	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2047 - 2048	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2048 - 2049	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2049 - 2050	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2050 - 2051	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2051 - 2052	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2052 - 2053	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2053 - 2054	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2054 - 2055	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2055 - 2056	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2056 - 2057	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2057 - 2058	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2058 - 2059	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2059 - 2060	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2060 - 2061	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2061 - 2062	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2062 - 2063	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2063 - 2064	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2064 - 2065	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2065 - 2066	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2066 - 2067	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2067 - 2068	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2068 - 2069	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
2069 - 2070	0	1,800	300	1,400	200	7,000	6,000	1,100	5,000	100	23,000
17/18-69/70 Avg	0	1,500	300	1,800	200	7,000	5,100	1,000	6,000	100	23,000

Projected Future Alpaugh GSA Groundwater Budget

	Groundwater Inflows (acre-ft)									Groundwater Outflows (acre-ft)					
Water Year	Areal Recharge from Precipitation	Imported Water Deliveries	Deer Creek	Agricultural Pumping	Municipal Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow		Total In	Groundwater Pumping		Sub-surface Outflow		Total Out	Change in Storage (acre-ft)
		Return Flow	Return Flow	Return Flow	Return Flow		From Outside Subbasin	From Other GSAs		Municipal	Agricultural	To Outside Subbasin	To Other GSAs		
2017 - 2018	0	800	100	3,300	200	3,000	5,000	29,000	41,000	300	15,000	3,000	25,000	43,000	-2,000
2018 - 2019	0	800	100	3,300	200	3,000	4,000	29,000	40,000	300	15,000	4,000	24,000	43,000	-3,000
2019 - 2020	0	800	100	3,300	200	3,000	4,000	28,000	39,000	300	15,000	4,000	23,000	42,000	-3,000
2020 - 2021	0	800	100	3,300	200	3,000	3,000	28,000	38,000	300	15,000	4,000	22,000	41,000	-3,000
2021 - 2022	0	800	100	3,200	200	3,000	3,000	27,000	37,000	300	14,000	4,000	21,000	39,000	-2,000
2022 - 2023	0	800	100	3,200	200	3,000	3,000	27,000	37,000	300	14,000	5,000	21,000	40,000	-3,000
2023 - 2024	0	800	100	3,100	200	3,000	2,000	27,000	36,000	300	13,000	5,000	20,000	38,000	-2,000
2024 - 2025	0	800	100	3,000	200	3,000	2,000	27,000	36,000	300	13,000	5,000	20,000	38,000	-2,000
2025 - 2026	0	1,100	300	2,400	200	3,000	2,000	25,000	34,000	300	10,000	6,000	19,000	35,000	-1,000
2026 - 2027	0	1,100	300	2,300	200	3,000	2,000	26,000	35,000	300	10,000	7,000	19,000	36,000	-1,000
2027 - 2028	0	1,100	300	2,200	200	3,000	2,000	26,000	35,000	300	10,000	8,000	19,000	37,000	-2,000
2028 - 2029	0	1,100	300	2,100	200	3,000	2,000	27,000	36,000	300	9,000	8,000	19,000	36,000	0
2029 - 2030	0	1,000	300	2,100	200	3,000	2,000	30,000	39,000	300	9,000	9,000	20,000	38,000	1,000
2030 - 2031	0	1,300	300	1,800	200	2,000	2,000	30,000	38,000	300	8,000	10,000	21,000	39,000	-1,000
2031 - 2032	0	1,300	300	1,800	200	2,000	2,000	32,000	40,000	300	8,000	10,000	22,000	40,000	0
2032 - 2033	0	1,300	300	1,800	200	2,000	2,000	33,000	41,000	300	8,000	11,000	23,000	42,000	-1,000
2033 - 2034	0	1,300	300	1,800	200	2,000	2,000	35,000	43,000	300	8,000	11,000	24,000	43,000	0
2034 - 2035	0	1,300	300	1,800	200	2,000	2,000	36,000	44,000	300	8,000	12,000	24,000	44,000	0
2035 - 2036	0	1,600	300	1,500	200	2,000	2,000	37,000	45,000	300	7,000	12,000	25,000	44,000	1,000
2036 - 2037	0	1,600	300	1,500	200	2,000	2,000	37,000	45,000	300	7,000	12,000	26,000	45,000	0
2037 - 2038	0	1,600	300	1,500	200	2,000	2,000	38,000	46,000	300	7,000	13,000	26,000	46,000	0
2038 - 2039	0	1,600	300	1,500	200	2,000	2,000	38,000	46,000	300	7,000	13,000	26,000	46,000	0
2039 - 2040	0	1,600	300	1,500	200	1,000	2,000	39,000	46,000	300	7,000	13,000	26,000	46,000	0
2040 - 2041	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	27,000	46,000	0
2041 - 2042	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	27,000	46,000	0
2042 - 2043	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	26,000	45,000	1,000
2043 - 2044	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	27,000	46,000	0
2044 - 2045	0	1,800	300	1,400	200	1,000	2,000	39,000	46,000	300	6,000	13,000	26,000	45,000	1,000
2045 - 2046	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2046 - 2047	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2047 - 2048	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2048 - 2049	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2049 - 2050	0	1,800	300	1,400	200	1,000	1,000	39,000	45,000	300	6,000	13,000	26,000	45,000	0
2050 - 2051	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2051 - 2052	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2052 - 2053	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2053 - 2054	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2054 - 2055	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2055 - 2056	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	26,000	45,000	-1,000
2056 - 2057	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2057 - 2058	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2058 - 2059	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2059 - 2060	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2060 - 2061	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2061 - 2062	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2062 - 2063	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2063 - 2064	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2064 - 2065	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2065 - 2066	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2066 - 2067	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2067 - 2068	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2068 - 2069	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
2069 - 2070	0	1,800	300	1,400	200	1,000	1,000	38,000	44,000	300	6,000	13,000	25,000	44,000	0
17/18-69/70 Avg	0	1,500	300	1,800	200	2,000	2,000	35,000	43,000	300	8,000	11,000	24,000	43,000	0

Alpaugh Irrigation District GSA
Land Surface Elevations at Representative Monitoring Sites

Site	Land Surface Elevation (ft amsl)[1]			
	2020 (Baseline)	2021	Measurable Objective	Minimum Threshold
A0013_B_RMS	196.814	196.338	189.645	187.876
A0017_B_RMS	204.396	204.137	199.110	197.996
A0018_B_RMS	196.141	195.977	192.203	191.153
A0019_B_RMS	192.326	191.857	186.921	185.921
A0020_B_RMS	195.065	191.08	189.463	188.463
A0092_B_RMS	N/A	200.37	N/A	N/A

Notes:

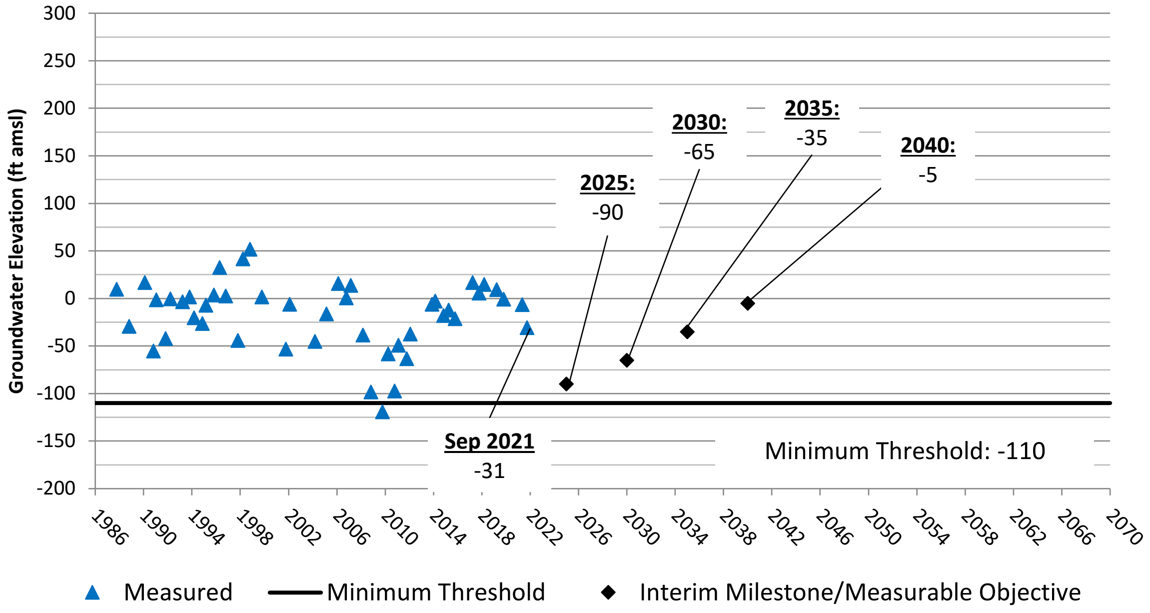
N/A = Not available

[1] Benchmarks surveyed in July and August of each year.

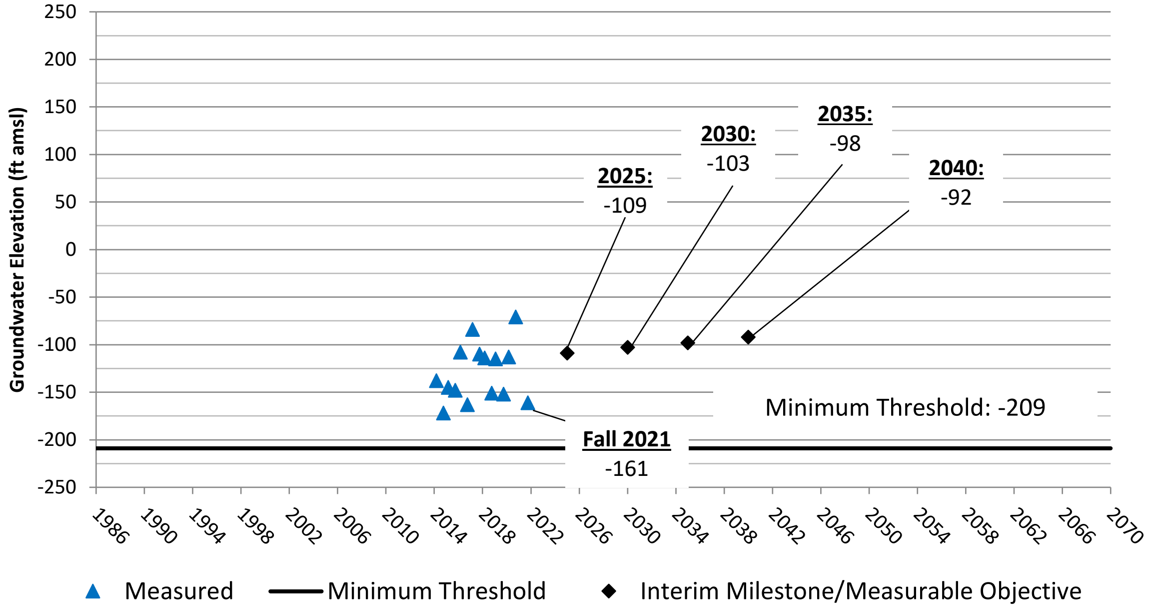
Appendix F
Figure 1

Alpaugh Irrigation District GSA
RMS Groundwater Elevation Hydrographs

23S/23E-25N01 (Lower)
Alpaugh GSA



Well 55 (Lower)
Alpaugh GSA



Groundwater Flow Model of the Tule Subbasin

January 2020

Prepared for

Tule Subbasin MOU Group

CERTIFIED HYDROGEOLOGIST
THOMAS E. HARDER
No: 588
STATE OF CALIFORNIA

Prepared by

Thomas Harder

Thomas Harder, PG, CHG
Principal Hydrogeologist

Benjamin Lewis, PG, CHG
Senior Hydrogeologist

CERTIFIED HYDROGEOLOGIST
BENJAMIN TRENT LEWIS
No: 1047
STATE OF CALIFORNIA

Jim Van de Water

Jim Van de Water, PG, CHG
Principal Hydrogeologist

CERTIFIED HYDROGEOLOGIST
JAMES VAN DE WATER
No: 508
STATE OF CALIFORNIA

Table of Contents

Tables

Figures

Plates

Appendices

Acronyms

AFY – Acre-ft per year

ASTM – American Society for Testing and Materials

AWD – Angiola Water District

BGS - Below Ground Surface

BMP – Best Management Practices

CASGEM – California Statewide Groundwater Elevation Monitoring

CDWR – Department of Water Resources (California)

CGS – California Geological Survey

CHB - Constant Head Boundary

CIMIS – California Irrigation Management Information System

DCTRA- Deer Creek and Tule River Authority

DEID – Delano-Earlimart Irrigation District

DEM – Digital Elevation Model

DOGGR – California Division of Oil, Gas and Geothermal Resources

ET- Evapotranspiration

ET_o – Reference Evapotranspiration

FMP – Farm Process Package of MODFLOW

FWA – Friant Water Authority

GFM – Tule Subbasin Groundwater Flow Model

GIS – Geographic Information System

GPM - Gallons per Minute

GPS – Global Positioning System

GSA – Groundwater Sustainability Agency

GSP – Groundwater Sustainability Plan

InSAR – Interferometric Synthetic Aperture Radar

ITRC – Irrigation Training and Research Center

JPL – Jet Propulsion Laboratory

KTWD – Kern-Tulare Water District

LPF – Layer Property Flow Package of MODFLOW

LTRID – Lower Tule River Irrigation District

MNWD2 – Multi-Node Well Package of Modflow
MOU – Memorandum of Understanding
NASA – National Aeronautics and Space Administration
NRMSE – Normalized Root Mean Squared Error
RMS - Root Mean Squared
SGMA – Sustainable Groundwater Management Act
SUB – Land Subsidence Simulation Package of MODFLOW
SWP – State Water Project
TAC – Tule Subbasin Technical Advisory Committee
TH&Co - Thomas Harder & Company
TRA – Tule River Association
USBR – United States Bureau of Reclamation
USGS – United States Geological Survey
UWMP - Urban Water Management Plan
WBA – Water Budget Area

1.0 Introduction

1.1 Background

In order to assist in groundwater basin management planning and inform the preparation of Groundwater Sustainability Plans (GSPs) as required by the Sustainable Groundwater Management Act (SGMA), the Tule Subbasin Technical Advisory Committee (TAC) commissioned the preparation of a numerical groundwater flow model (GFM) of the Tule Subbasin. The Tule Subbasin is approximately 733 square miles located in the southwestern portion of Tulare County within the southern San Joaquin Valley Groundwater Basin (CDWR, 2003; see Figure 1). The Subbasin is divided into seven Groundwater Sustainability Agencies (GSAs):

1. Lower Tule River Irrigation District GSA
2. Pixley Irrigation District GSA
3. Eastern Tule GSA
4. Delano-Earlimart Irrigation District GSA
5. Tri-County Water Authority GSA
6. Alpaugh Irrigation District GSA
7. County of Tulare GSA - Tule

It is noted that the entire geographic area of the Subbasin is covered and managed by the first six GSAs. While the County of Tulare GSA is responsible for some lands within the Tule Subbasin, these areas are managed by the other GSAs through agreements. As such, this report presents results relating to the areas of the first six GSAs listed above.

Utilization of a calibrated groundwater flow model is a CDWR Best Management Practice (BMP) for developing GSPs to comply with SGMA. A BMP "*... refers to a practice, or combination of practices, that are designed to achieve sustainable groundwater management and have been determined to be technologically and economically effective, practicable, and based on best available science.*" (GSP Regulations, §351[i]). Prior to preparing the GFM, TH&Co prepared a detailed hydrogeologic conceptual model (BMP No. 3) and water budget (BMP No. 4) of the Tule Subbasin. These documents provide the foundational information on which the GFM is based.

1.2 Groundwater Flow Model Objectives

The GFM was prepared to address the following:

- Validate the preliminary Subbasin-wide groundwater and surface water budget and, as necessary, refine the least-known elements of the water budget via model calibration;
- Evaluate the Subbasin-wide Sustainable Yield estimate based on a future projection of groundwater projects, management actions, and climate change;
- Develop water budget estimates for each of the six GSAs of the Subbasin, which incorporates historical hydrological data, surface water rights specific to the individual GSAs, and future projections of groundwater pumping and imported water; and
- Evaluate historical land subsidence in the Subbasin and predict future land subsidence in areas of critical infrastructure.

1.3 Model Domain

The model domain is the three-dimensional volume of hydrogeologic media evaluated by the model. Based on the objectives of the GFM, and in consideration of potential impacts of pumping and recharge outside the Tule Subbasin boundaries on the water budget within the Tule Subbasin, the lateral model area was selected as shown on Figure 2. This model area extends approximately five to ten miles north of the northern Tule Subbasin boundary, four miles west of the western boundary, three to six miles south of the southern Tule Subbasin boundary, and a few miles into the Sierra Nevada Mountains on the east. The area of the Sierra Nevada Mountains between the alluvial/bedrock interface and eastern model boundary is inactive. The total model area is 1,472 square miles and the active model area is approximately 1,320 square miles (i.e., approximately 845,000 acres).

The vertical model domain was developed to simulate groundwater flow in the primary aquifers and aquitards that were identified in the conceptual model of the Tule Subbasin. Accordingly, the model consists of five layers of variable thickness throughout the model domain based on cross-sections developed from the conceptual model. The layers are described as follows:

- Layer 1 simulates groundwater flow in the upper unconfined aquifer;
- Layer 2 is an underlying comparatively low permeability unit separating the upper and lower aquifers and generally coincides with the Corcoran Clay west of Highway 99;
- Layer 3 simulates groundwater flow in the lower aquifer. This layer is semi-confined in the east and confined below the Corcoran Clay in the west;
- Layer 4 simulates groundwater flow in the Pliocene marine deposits between the overlying lower aquifer and, in the eastern portion of the Subbasin, the underlying Santa Margarita Formation aquifer;
- Layer 5 simulates groundwater flow in the Santa Margarita Formation aquifer in the eastern portion of the Subbasin.

1.4 Model Development Approach

The process for developing the groundwater flow model was consistent with standard procedures outlined in literature and other guidelines (Anderson and Woessner, 1992; ASTM, 1993; CDWR, 2016). The process is outlined in Figure 3 and included:

1. **Identification of the Model Domain**. The model domain was selected to encompass the entire Tule Subbasin as described in Section 1.3 (see Figure 2). The model domain was presented to the Tule Subbasin TAC in TH&Co (2017a).

2. **Identification of the Model Software.** TH&Co selected a model code with capabilities to address the modeling objectives and provide a foundation for future model updates and applications. A detailed description of the model code and suite of modeling tools selected for the Tule Subbasin groundwater flow model are provided in Section 3.1 of this report. Selection of the model software was presented to the Tule Subbasin TAC in TH&Co (2017a).

3. **Data Compilation and Review.** It was necessary to compile and review geological, hydrological, hydrogeological, and other data (see Section 1.5) to develop the hydrogeologic conceptual model and provide data for calibration targets and boundary conditions. Compiled data was organized and stored in a database for easy access and analysis.

4. **Hydrogeologic Conceptual Model Development.** The conceptual model was developed through the generation of hydrogeologic cross sections, groundwater contour maps, hydrographs, pumping test data, and groundwater quality data. The data analyses resulted in determination of model boundary conditions, layers, initial groundwater levels, and an initial aquifer parameter distribution. The hydrogeologic conceptual model was presented to the Tule Subbasin TAC in TH&Co (2017b).

5. **Development of Preliminary Surface Water and Groundwater Budgets.** Streamflow, surface water imports, evapotranspiration data, land use, groundwater underflow, groundwater pumping, and other hydrogeologic data were compiled into comprehensive surface water and groundwater budgets. The water budgets provided initial flux estimates for input into the groundwater flow model. The preliminary detailed historical surface water

and groundwater budgets were presented to the Tule Subbasin TAC in TH&Co (2017b), prior to development of the numerical model.

6. **Selection of the Calibration Period.** The model calibration period was selected based on the quality and quantity of data available for development of the conceptual model and preliminary water budget. Using this criterion, the transient period for calibration was selected to be October 1986 through September 2017.

7. **Numerical Model Development.** Data and analyses from the conceptual model were converted into a form suitable for input into the numerical model. This included designing the model grid, determining the simulation stress periods, importing layer boundaries, developing model input files for the various hydrogeological stresses (e.g. groundwater production and recharge), and importing initial aquifer parameter zones.

8. **Model Calibration.** The process of model calibration involved adjusting aquifer properties and stresses until an acceptable match was obtained between measured groundwater levels and simulated groundwater levels. Simulated changes in land surface elevation were also calibrated to data from Global Positioning System (GPS) stations and satellite data.

9. **Sensitivity Analysis.** A sensitivity analysis was conducted to assess the impact of varying aquifer properties and stresses on the model calibration.

10. **Uncertainty Analysis.** Using Sustainable Yield as the metric for evaluating model uncertainty, TH&Co developed a range in potential Sustainable Yield values from over 200 calibrated realizations of the model. The range in potential Sustainable Yield represented the uncertainty in the model.

1.5 Types and Sources of Data

Compilation, review and analysis of multiple types of data were necessary to develop the groundwater flow model. The various types of data are summarized in Figure 4 and include geology, soils/lithology, hydrogeology, surface water hydrology, climate, crop types/land use, topography, and groundwater recharge and recovery. Groundwater levels, well construction information, groundwater quality, and pumping test data were stored in a relational database. Other types of data necessary for analysis were compiled into spreadsheets.

Data for the development of the groundwater flow model were obtained from multiple sources:

Geological Data including geologic maps and cross sections were obtained from the United States Geological Survey (USGS) and the California Geological Survey (CGS).

Soils/Lithological Data including detailed lithologic logs from wells and test boreholes, geophysical logs, and driller's logs from wells and test boreholes from the CDWR, the USGS, the City of Porterville, the California Division of Oil, Gas and Geothermal Resources (DOGGR), and various local irrigation districts.

Hydrogeologic Data including groundwater levels and pumping tests were obtained from the CDWR, Lower Tule River Irrigation District (LTRID), Deer Creek and Tule River Authority (DCTRA), Angiola Water District (AWD), the City of Porterville, Kern-Tulare Water District (KTWD), DEID, and the California Statewide Groundwater Elevation Monitoring (CASGEM) website.

Groundwater Recharge and -Pumping Data including spreading basin locations and dimensions, artificial recharge, water well construction, well locations, groundwater production, surface water diversions, canal losses, and river losses were obtained from LTRID, Pixley Irrigation District, DEID, AWD, CDWR, Porterville Irrigation District, Tule River Association (TRA) annual reports, and DCTRA annual reports.

Hydrological (i.e., Surface Water) Data consisted of stream gage data along the Tule River, Deer Creek, and White River were obtained from the USGS, DCTRA reports and TRA annual reports. Imported water deliveries were obtained from LTRID, Pixley ID, DEID, KTWD, AWD, and the United States Bureau of Reclamation (USBR).

Climate Data was acquired from CDWR's California Irrigation Management Information System (CIMIS), TRA reports, and the Western Regional Climate Center website.

Land Use Data was obtained from the CDWR, LTRID, Pixley ID, Porterville ID, Saucelito ID, and the USGS Earth Resources Observation and Science Center. Political boundaries were obtained from the California Cal-Atlas Geospatial Clearinghouse and the LTRID.

Topographical Data including Digital Elevation Models (DEMs), topographical maps, GPS data, and Interferometric Synthetic Aperture Radar (InSAR) satellite data were acquired from the USGS, CDWR, and National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL).

In addition to the various types of data, TH&Co reviewed numerous historical reports on the geology, hydrogeology and groundwater management of the model area. These reports included

USGS publications, CDWR reports and bulletins, consultant reports and academic publications. Publications relied on for the model preparation are summarized in the References (Section 7).

2.0 Hydrogeologic Conceptual Model

The hydrogeologic conceptual model is a description of the groundwater flow system of the Tule Subbasin and how it interacts with surface water and land use of the area. The conceptual model includes a description of the geologic setting, boundary conditions, principal aquifers, and aquitards. The hydrogeologic conceptual model for the GFM domain is addressed in detail in TH&Co (2017b). This section presents a summary of the hydrogeologic conceptual model from that report.

2.1 Geology

Geologic formations observed at the land surface and in the subsurface beneath the Tule Subbasin can be grouped into five generalized geologic units, described below in order of increasing age:

> **Unconsolidated Continental Deposits** – These sediments consist of alluvial, fluvial (i.e., streambed deposits), flood plain, and lacustrine (i.e., lakebed) deposits (labeled “surficial deposits” on Figure 5). The unconsolidated continental deposits range in thickness from 0 ft at the eastern contact with the Sierra Nevada Mountains to more than 3,000 ft near the margins of Tulare Lake in the western part of the Subbasin (see Figure 5; Lofgren and Klausing, 1969). Subsurface alluvial sediments consist of highly stratified layers of more permeable sand and gravel interbedded with lower permeability silt and clay. Clear correlation of individual sand or clay layers laterally across the Tule Subbasin is difficult due to the interbedded nature of the sediments. However, it is noted that the thickness of clay sediments in the upper 1,000 ft below ground surface (bgs) generally increases in the western portion of the Subbasin in the vicinity of Tulare Lake. The unconsolidated continental deposits form the primary groundwater reservoir in the Tule Subbasin.
>
> The lowermost portion of unconsolidated continental deposits is generally correlated with the Tulare Formation. The Tulare Formation is notable in that it includes the Corcoran Clay, a regionally extensive confining layer that has also been referred to as the “E-Clay” (see Figure 5) (Frink and Kues, 1954). The Corcoran Clay consists of a Pleistocene diatomaceous fine-grained lacustrine deposit (primarily clay; Faunt, 2009). In the Tule Subbasin, the Corcoran Clay is as much as 150 ft thick beneath the Tulare Lake lakebed but becomes progressively thinner to the east, eventually pinching out immediately east of Highway 99 (Lofgren and Klausing, 1969).
>
> **Pliocene Marine Deposits** – These sediments underlie the continental deposits and consist of consolidated to loosely consolidated marine siltstone with minor interbedded sandstone beds. The marine siltstone unit thickens to the west, ranging from approximately 500 ft thick near State Highway 65 to more than 1,600 ft beneath Highway 99 (Lofgren and

Klausing, 1969; see Figures 2-5 and 2-6). The marine siltstone beds dip sharply from the base of the Sierra Nevada Mountains on the east to the central portion of the valley in the west. The Pliocene marine strata have relatively low permeability and do not yield significant water to wells.

Santa Margarita Formation – This formation occurs beneath the Pliocene marine strata and consists of Miocene (approximately 5.3 to 23 million years before present) sand and gravel that is relatively permeable and yields water to wells. The formation is approximately 150 to 520 feet thick and occurs at depths ranging from 1,200 feet near State Highway 65 to greater than 3,000 feet beneath State Highway 99. This formation is a significant source of groundwater to wells in the southeastern portion of the Tule Subbasin near the community of Richgrove (Lofgren and Klausing, 1969).

Tertiary Sedimentary Deposits – Beneath the Santa Margarita Formation exists an interbedded assemblage of semi-consolidated to consolidated sandstone, siltstone and claystone of Tertiary age (approximately 2.6 to 66 million years before present). Some irrigation wells in the southeastern part of the Tule Subbasin are known to produce fresh water from the Olcese Sand Formation, which is in the uppermost portion of the unit (Ken Schmidt, 2019. Personal Communication). The water quality of the groundwater in the Tertiary sedimentary deposits becomes increasingly saline to the southwest and most of the groundwater in the unit is not useable for crop irrigation or municipal supply except near Highway 65 (Lofgren and Klausing, 1969).

Granitic Crystalline Basement – Sedimentary deposits beneath the Tule Subbasin are underlain by a basement consisting of Mesozoic granitic rocks that compose the Sierra Nevada batholith (Faunt, 2009). At depth, the basement rocks are assumed to be relatively impermeable.

There are no significant faults mapped in the Tule Subbasin that would form a groundwater flow barrier or affect groundwater flow.

2.2 Hydrology

The hydrology of the model domain includes five significant surface water features (see Figure 6):

Tule River and Lake Success

The Tule River is the largest natural drainage feature in the Tule Subbasin. From its headwaters in the Sierra Nevada Mountains, the Tule River flows first into Lake Success. Lake Success is a manmade reservoir created by the construction of Success Dam (see Figure 6). Success Dam controls and measures releases of the Tule River. Lake Success is not explicitly included in the model although releases from the reservoir to the Tule River and Pioneer Canal, as recorded in TRA reports, are the basis for inflows to these surface water features.

Downstream of Lake Success, the Tule River flows through the City of Porterville where it is diverted at various points before flowing into the LTRID. A significant diversion point is the Porter Slough, which flows to the north and semi-parallel to the main river channel and is used to convey surface water to various recharge facilities and canals. Downstream of Porterville, the Tule River ultimately discharges onto the Tulare Lakebed during periods of above-normal precipitation. Stream flow is measured via gages located below Success Dam, at Rockford Station downstream of Porterville, and at Turnbull Weir (see Figure 6).

Releases of water below Lake Success dam are diverted from the Tule River channel at various locations. Diversion points along the river are located at the Porter Slough headgate, Campbell and Moreland Ditch Company, Vandalia Water District, Poplar Irrigation Company, Hubbs and Miner Ditch Company, and Woods-Central Ditch Company. In the water budget, infiltration that occurs in the Porter Slough is included as infiltration from the Tule River. Downstream of the Friant-Kern Canal the Tule River channel is also used as a conveyance mechanism to convey imported water to the Porterville Irrigation District (Porterville ID), LTRID and AWD. Within the Porterville ID and LTRID, a combination of natural stream flow and imported water are further diverted into unlined canals for distribution to artificial recharge basins and farms. Any residual stream flow left in the Tule River after diversions is measured at the Turnbull Weir, located at the west end of the LTRID (see Figure 6).

As streambed infiltration in the Tule River is measured between the various stream gages by the TRA, the Tule River is incorporated into the GFM as part of the recharge package with separate zones delineated between the stream gages where streambed infiltration has been measured.

Deer Creek

Deer Creek is a natural drainage that originates in the Sierra Nevada Mountains, flowing in a westerly direction north of Terra Bella and into Pixley (see Figure 6). Although the Deer Creek channel extends past Pixley, discharges rarely reach the Tulare Lake lakebed. Stream flow in Deer Creek has been measured at the USGS gaging station at Fountain Springs from 1968 to present time. Friant-Kern Canal water is also diverted into the Deer Creek channel and again measured at Trenton Weir before being delivered to riparian lands via unlined canals (see Figure 6). During wet years, water that reaches the terminus of Deer Creek is discharged into the Homeland Canal.

Deer Creek is included in the GFM as part of the recharge package, with separate zones delineated between stream gages where streambed infiltration has been estimated.

White River

The White River drains out of the Sierra Nevada Mountains east of the community of Richgrove in the southern portion of the Tule Subbasin (see Figure 6). Stream flow in the White River has been measured at the USGS gaging station near Ducor from 1972 to 2005. Data after 2005 has been extrapolated. The White River channel extends as far as State Highway 99 but does not reach the Tulare Lake lakebed. All streamflow in the White River that is not lost to evaporation is assumed to become groundwater recharge.

The White River is included in the Tule Subbasin model as part of the recharge package.

Tulare Lake

During the calibration period (1986 through 2017), Tulare Lake has been a dry lakebed except for localized residual marshes and wetlands and occasional flooding. This surface water feature is not explicitly included in the model.

2.3 Hydrogeology

In general, five aquifer/aquitard units comprise the Tule Subbasin:

1. Upper Aquifer (Model Layer 1)
2. The Corcoran Clay Confining Unit and Other Confining Units (Model Layer 2)
3. Lower Aquifer (Model Layer 3)
4. Pliocene Marine Deposits (generally considered an aquitard) (Model Layer 4)
5. Santa Margarita and Olcese Formations of the Southeastern Subbasin (Model Layer 5)

Detailed descriptions of these aquifers/aquitards are provided in TH&Co (2017b) and TH&Co (2020).

In general, groundwater in the Tule Subbasin flows from areas of natural recharge along major streams at the base of the Sierra Nevada Mountains on the eastern boundary towards a groundwater pumping depression in the west-central portion of the Subbasin (see Figures 7, 8 and 9). The pumping depression has reversed the natural groundwater flow direction in the western portion of the Subbasin, inducing subsurface inflow across the southern and western boundaries. Recharge from the Tule River results in a groundwater flow divide in the upper aquifer along the northern boundary of the Tule Subbasin. As such, upper aquifer groundwater on the north side of the river flows to the north and out of the Subbasin. Groundwater flow patterns in the upper aquifer have generally not changed significantly since the late 1980s (see Figures 7 and 8).

In the lower aquifer, groundwater flows to the southwest toward a pumping depression in the western portion of the Subbasin (see Figure 9). This pumping depression extends from west of Corcoran in the northwest to the Alpaugh area in the southwestern Tule Subbasin west of Highway 43.

Groundwater level changes over time can be observed from hydrographs for wells monitored in the Tule Subbasin. Despite a relatively wet hydrologic period between 1995 and 1999 and periodic wet years (2005 and 2011), groundwater levels in upper aquifer wells show a persistent downward trend between approximately 1987 and 2017 (see Figure 10). Groundwater level trends in wells perforated exclusively in the lower aquifer vary depending on location in the Subbasin (see Figure 11). In the northwestern part of the Subbasin, lower aquifer groundwater levels have shown a persistent downward trend from 1987 to 2017. In the southern part of the Subbasin, groundwater levels were relatively stable between 1987 and 2007 but began declining after 2007.

Comparisons of hydrographs for wells perforated in the upper aquifer with nearby wells perforated predominantly in the lower aquifer show that groundwater levels in the upper aquifer are higher than groundwater levels in the lower aquifer (see Figure 12). This indicates a downward hydraulic gradient and indicates that the upper aquifer is recharging the lower aquifer of the Tule Subbasin. Faunt (2009) has suggested that the recharge of the lower aquifer via wells that are perforated across both aquifers has increased with the number of deep wells constructed in the San Joaquin Valley.

2.4 Land Subsidence

Land subsidence in the Tule Subbasin as a result of lowering the groundwater level due to groundwater production has been well documented (Ireland et al., 1984; Faunt, 2009; Luhdorff and Scalmanini, 2014). Prior to 1970, as much as 12 ft of land surface subsidence was documented for the area immediately south of Pixley (Ireland et al., 1984). As groundwater levels stabilized in the area throughout the 1970s and early 1980s, land subsidence was largely arrested. During this time, monitoring for land subsidence that had previously been conducted along the portion of the Friant-Kern Canal that is within the Tule Subbasin was discontinued.

From the late 1980s into the 2000s, it is suspected that land subsidence in the Tule Subbasin was reactivated as groundwater levels declined. Groundwater flow model simulations of land subsidence in the Central Valley by Faunt et al. (2009), which were calibrated to historical land subsidence that occurred in the 1960s, simulated an additional two to four feet of land subsidence between 1986 and 2003.

The reactivation of land subsidence in the Subbasin was confirmed in the late 2000s based on data from InSAR satellites and one GPS station located in Porterville, California. InSAR data showed as much as four feet of additional land subsidence occurring in the northwestern portion of the Tule Subbasin between 2007 and 2011 (see Figure 13) (Luhdorff and Scalmanini, 2014). The GPS data showed that approximately 0.4 ft of land subsidence occurred in the Porterville area between 2007 and 2011. From 2015 through 2018, land subsidence in the Tule Subbasin, as observed from InSAR data, continued with as much as 2.75 ft of additional land subsidence in the northwest portion of the Subbasin and as much as 0.75 ft of additional land subsidence at the Porterville GPS station (see Figure 14). GPS data from the Delano, California station, located outside the Subbasin, showed approximately 1 ft of subsidence between 2012 and 2016. Based on benchmarks located along the Friant-Kern Canal and monitored by the Friant Water Authority (FWA), cumulative land subsidence along the canal between 1959 and 2017 has ranged from approximately 1.7 ft in the Porterville area to 9 feet in the vicinity of Deer Creek (see Figure 13).

The rate of land subsidence in the Tule Subbasin varies both spatially, according to the geology of the subsurface sediments and scale of groundwater level declines, and temporally with changes in groundwater levels associated with wet and dry periods. The average rate of change in land surface elevation between 1987 and 2018 for the area of maximum subsidence was estimated to be approximately 12 feet over the 32-year period for a rate of 0.4 ft/yr. At the Porterville GPS station, the annual rate of subsidence between 2006 and 2013 was approximately 0.1 ft/yr but increased to approximately 0.3 ft/yr between 2013 and 2019 (see Figure 14).

3.0 Groundwater Flow Model

3.1 Description of Model Codes

The Tule Subbasin groundwater flow model was developed using the numerical groundwater flow model code MODFLOW. MODFLOW is a block centered, finite difference groundwater flow modeling code developed by the USGS for simulating groundwater flow (McDonald and Harbaugh, 1988). MODFLOW is one of the most widely used and critically accepted model codes available (Anderson and Woessner, 1992).

In order to simulate surface water and groundwater interaction, land surface subsidence, and agricultural water budget components in the Tule Subbasin, TH&Co utilized the MODFLOW variant One-Water Hydrologic-Flow Model or MODFLOW-OWHM (Hanson et al.,2014, Boyce et al., 2018, and Boyce et al., in review). Specifically listed in CDWR (2016), this model code is designed to simulate the use and movement of water in irrigated agricultural areas with unmetered pumping and is particularly applicable to the Tule Subbasin where the majority of surface water and groundwater use is for agricultural irrigation.

3.2 Model Size and Grid Geometry

The GFM domain is approximately 41 miles in the east-west direction and 36 miles in the north-south direction and encompasses approximately 1,472 square miles at the western base of the Sierra Nevada Mountains in the south-central portion of the San Joaquin Valley Groundwater Basin (see Figures 1 and 2).

The model domain is discretized into 216 columns and 190 rows with 1,000 ft by 1,000 ft cells (see Figure 15). Each model layer is divided into 41,040 cells with a total of 205,200 cells in the entire five-layer model. The site coordinate system for the model was established in NAD 83 State Plane CA Zone 4.

3.3 Temporal Discretization

Both recharge and discharge were applied to the GFM in monthly stress periods for the calibration period (October 1986 through September 2017). October 1986 was selected as the starting time to include multiple dry and wet hydrologic periods and to avail the analysis of a previous water budget conducted by TH&Co (2015) that accounts back to 1986. The model period ended in September 2017 which corresponds to the end of the 2016/17 water year because that was the last month of complete surface water data.

3.4 Water Budget Areas

The Farm Process Package of MODFLOW accounts for the application, consumption and movement of water at the land surface in irrigated agricultural areas. The surface water budget is coupled with the groundwater flow system in the sense that the applied water demand of any given agricultural area that is not met by surface water supplies (i.e., imported water, diverted streamflow, or precipitation) is assumed to be supplied by pumped groundwater. In the Farm Process Package, agricultural areas can be subdivided to account for differences in crop type, e.g., irrigation efficiency, and available surface water supply, among others. To account for these unique water budget areas, the Farm Process Package (FMP) for the Tule Subbasin model was divided into agricultural water budget areas (referred to as “Farms” in Schmid and Hanson, 2009 and “water budget areas” (WBAs) in subsequent publications [Boyce et al., in review]).

The water budget areas assigned to the GFM are shown on Figure 16. Some of the water budget areas in the Tule Subbasin were delineated to match, or at least resemble, established irrigation districts or GSA political boundaries (e.g., WBAs 9, 11 and 12, which represent LTRID, Pixley Irrigation District and DEID, respectively). Other WBAs were identified for areas of similar crop types or areas not specifically identified with an agency. Agricultural water budgets were developed for each WBA in accordance with the land use and surface water supply data available for those areas.

3.5 Agricultural Water Use

Agricultural water use is simulated in the GFM using the FMP. Agricultural water use is a function of the total water demand of any given water budget zone, which is supplied through a combination of precipitation, surface water supplies, and groundwater pumping.

3.5.1 Estimates of Total Agricultural Irrigation Demand

Total agricultural irrigation demand is the total water demand necessary to sustain a crop in any given area. It is estimated based on land use data showing the types and areas of crops grown, evapotranspiration estimates for the individual crop types, and assumptions for irrigation efficiency based on the types of irrigation used to supply water to the crops (e.g., spray, drip, row and furrow, etc.).

Information on the types and areas of crops for the LTRID, Pixley Irrigation District, Porterville Irrigation District, and Saucelito Irrigation District were obtained from annual crop surveys from each respective district. The types and areas of crops in other parts of the Tule Subbasin were estimated from land use maps and associated data published by the CDWR for 1993, 1999, 2007 and 2014 (see Figure 17). For the portion of the model in Kern County, land use maps were obtained from CDWR (1990 and 2014) and Kern County Department of Agriculture and

Measurement Standards (1999 and 2007). For the portion of the model in Kings County, land use maps were obtained from CDWR for 1991, 1996, 2003, and 2014.

Consumptive use estimates for the various crop types were based on demands specific to the crops in the Tule Subbasin area, as published in ITRC (2003). The crop consumptive use estimates took into account effective precipitation (i.e. consumptive use associated with precipitation was removed from the total demand resulting in consumptive use associated with irrigation only). Crop types were grouped into the following categories (see Table 1):

- Grain and Grain Hay
- Truck
- Corn and Silage
- Miscellaneous Field Crops
- Grapes
- Cotton
- Deciduous and Fruit Trees
- Alfalfa and Pasture
- Nuts

Where appropriate, crop consumptive use estimates for any given area accounted for double cropping.

Deep percolation of applied irrigation water (i.e., return flow) was estimated based on the irrigation method for each land use type reported in CDWR land use maps. Irrigation efficiencies were applied to the different irrigation methods based on tables reported in California Energy Commission (2006). The irrigation types and their respective efficiencies are as follows:

- Border Strip Irrigation – 77.5 percent
- Micro Sprinkler – 87.5 percent
- Surface Drip Irrigation – 87.5 percent
- Furrow Irrigation – 67.5 percent

TH&Co assigned a single crop consumptive use and irrigation efficiency estimate to each water budget zone for any given time period. Each was area-weighted according to the land use in that zone (see Table 2). In order to simulate changes in cropping patterns over time, TH&Co relied on CDWR land use maps for 1993, 1999, 2007, and 2014. TH&Co estimated area-weighted irrigation efficiencies for two time periods: 1986 to 2002 and 2003 to 2017.

Total estimated agricultural irrigation demand for any given time period was based on the area-weighted consumptive use estimate multiplied by the area of the water budget zone divided by the irrigation efficiency.

3.5.2 Estimates of Individual Water Supplies to Meet Irrigation Demand

Agricultural irrigation demand is met from three sources: precipitation, surface water deliveries, and groundwater pumping. Consumptive use estimates from ITRC accounted for effective precipitation (see Section 3.5.1). Thus, irrigation demand in the WBAs of the model was met from surface water supplies and groundwater pumping.

Surface water deliveries to crops occur via imported water from the Friant-Kern Canal and other canals in the Subbasin as well as diverted streamflow from the Tule River and Deer Creek. Monthly imported surface water deliveries for WBAs covering Porterville ID, Saucelito Irrigation District, Tea Pot Dome Water District, Alpaugh Irrigation District, Atwell Island Irrigation District, and Terra Bella Irrigation District were obtained from United States Bureau of Reclamation (USBR) Central Valley Operation Annual Reports. Monthly imported water data for LTRID and other agencies was provided by the respective agencies. Monthly surface water deliveries of diverted streamflow from the Tule River are based on TRA annual reports. Monthly surface water deliveries of diverted streamflow from Deer Creek were provided by agencies that divert the water.

Groundwater pumping is estimated in each water budget zone as the balance of the total water demand not met from precipitation and surface water supplies.

Historical agricultural water demand by source is summarized in Appendix A.

3.6 Boundary Conditions

Boundary conditions specify groundwater elevations (head boundaries) or flows (flux boundaries, for example pumping wells) near the perimeter and/or within the model domain. Functionally speaking, boundary conditions add or remove water from the groundwater system and can be specified anywhere in the model.

3.6.1 Lateral Model Boundaries

Boundary conditions applied near the perimeter of the model domain include no-flow cells (inactive), recharge points along the base of the Sierra Nevada Mountains, and time-varying specified head cells (see Figure 15). Due to the uncertainty of groundwater flow in the fractured bedrock of the Sierra Nevada Mountains, the portion of the model domain overlying the surface expression of the bedrock in this area was designated as “inactive” and assigned with “no-flow” cells. Groundwater recharge attributed to subsurface inflow from the mountain-block to the alluvial aquifer system was addressed using recharge points (i.e. injection wells) placed at the base of the mountains within the active model area. Groundwater levels at the north, west and southern Subbasin boundaries are constrained to measured groundwater levels in 29 wells located near the model boundary; 15 wells perforated in the upper aquifer and 14 wells perforated in the lower aquifer (see Figure 15). Groundwater levels in between the control wells were spatially and temporally interpolated for any given monthly stress period. Hydrographs for boundary control wells are provided in Appendix B.

3.6.2 Layer Elevations

Model layers were developed based on analysis of five hydrogeologic cross sections extended through the model domain (see Figures 5, 18, and 19; Plates 1 through 5). The cross sections were developed based on driller's logs, geophysical logs, and well construction information. The top of Layer 1 is the ground surface as imported from USGS DEMs with a horizontal 1 arc-second (approximately 10-meter) resolution and vertical accuracy of approximately 3 meters; these values were averaged for each 1,000 ft x 1,000 ft cell. The boundaries between each model layer were contoured using ESRI ArcMap v. 10.6.1 based on the layer top and bottom elevations from the cross sections and other control points from well logs and geophysical logs.

Model Layer 1 corresponds to the Upper Aquifer. The bottom of Layer 1 was selected to correlate with the top of the Corcoran Clay, where it exists, and is generally shallower than the top of perforations for most wells in the eastern part of the Tule Subbasin. The thickness of Layer 1 ranges from less than 50 feet in an area north of Porterville to approximately 450 feet near Corcoran (see Figure 20). This layer was designated as convertible (i.e., variably unconfined/confined) although given that groundwater levels are always below the land surface, this layer is always unconfined.

Layer 2 corresponds to the Corcoran Clay, where it exists, primarily west of Highway 99 (see Figure 18). The thickness of Layer 2 ranges from approximately 50 feet at the base of the Sierra Nevada Mountains in the eastern model domain to approximately 500 feet in the western part of the model domain (see Figure 21). This layer was designated as convertible such that when groundwater levels are above the top of the model layer, storage properties associated with confined conditions were applied and when groundwater levels are below the top of the model layer, storage properties associated with unconfined conditions were applied.

Layer 3 generally corresponds to the Lower Aquifer. This aquifer ranges in thickness from less than 250 feet at the base of the Sierra Nevada Mountains to approximately 2,000 feet in the northwest model domain (see Figure 22). Like the overlying layers, Layer 3 was designated as convertible.

Layer 4 generally correlates to Pliocene marine sedimentary deposits in the eastern portion of the Tule Subbasin. This layer is generally considered an aquitard separating the overlying Lower Aquifer (Layer 3) from the underlying Santa Margarita Formation aquifer (Layer 5). The thickness of Layer 4 ranges from less than 250 feet along the model edges to greater than 1,700 feet in the south-central model area (see Figure 23). This layer is modeled as confined.

Layer 5 represents the Santa Margarita Formation and upper portion of the Olcese Formation in the eastern part of the Tule Subbasin. The thickness of this layer ranges from 0 to 1,000 feet thick (see Figure 24). The bottom of Layer 5 is a no flow boundary. This layer is modeled as confined.

3.6.3 Groundwater Level Initial Conditions

The initial groundwater level conditions for the start of the model transient period was based on a groundwater contour map of the model domain generated from groundwater levels measured in from October 1986 to March 1990 (see Figure 7).

3.6.4 Groundwater Recharge

3.6.4.1 Agricultural Return Flow – Farm Process Package

Deep percolation and groundwater recharge of applied water from agricultural irrigation (i.e., return flow) was addressed using the FMP. Return flow was simulated using FMP based on the average consumptive use and irrigation efficiency assigned to each water budget zone.

3.6.4.2 Mountain-Block Recharge – Well Package

Subsurface inflow to the alluvial aquifer system from the fractured bedrock along the base of the Sierra Nevada Mountains was simulated using the Well Package (WEL). Thirty-seven injection wells were placed at the base of the Sierra Nevada Mountains along the bedrock alluvial interface to simulate the recharge (see Figure 15). Recharge was directed into Layer 3 of the model. As the contribution of recharge to the alluvial aquifer system from the mountain block is one of the least known aspects of the water budget, recharge rates in the injection wells were varied across a wide range during the calibration process in order to find the optimum recharge rate to achieve model calibration.

3.6.4.3 Subsurface Inflow in the Alluvial Channel of the Tule River

Some subsurface inflow of groundwater is expected in the Tule River channel at the eastern boundary of the active model area. This inflow was simulated with a time-varying specified head cell placed at the location of Well 22S/28E-03H01. The specified heads were fixed at the groundwater levels measured in this well for its period of record from October 1986 to February

2008 (see Appendix B). The flows from this boundary condition are represented as the Mountain Block Recharge in the water budget.

3.6.4.4 Other Recharge

For all other recharge in the Tule Subbasin Model, recharge was applied to the uppermost active model layer within 71 individual recharge zones using the MODFLOW Recharge Package (RCH). The following sources of groundwater recharge were simulated in the model using the Recharge Package:

- Deep percolation of precipitation
- Streambed infiltration and recharge in the Tule River (including Porter Slough), Deer Creek, and White River channels
- Artificial recharge in basins
- Infiltration in unlined canals
- Areas of septic return flow and urban landscape return flow

3.6.5 Groundwater Pumping

Groundwater pumping was simulated using the MODFLOW Multi-Node Well Package (MNW2). For agricultural groundwater production, pumping was assigned to individual wells based on the required pumping demand estimated from the FMP. For most areas of the model, representative wells were placed at mile-square centers and perforated in accordance with the average perforation interval of wells in their respective water budget zone from driller's logs in the CDWR driller's log database (see Figure 25). In the 10-mile corridor centered on the Friant-Kern Canal, a more detailed accounting of actual pumping wells was input with reported perforation intervals in order to provide for a more detailed analysis of land subsidence along the canal. A total of 1406 agricultural wells were included in the model.

For municipal pumping (e.g., City of Porterville) and agency pumping (e.g., Angiola Water District) where the locations and depth intervals of the wells were known or inferred, the wells were included in the model explicitly. A total of 273 municipal or irrigation district wells were included in the model (see Figure 25)

Groundwater production was assigned to each well in the model in monthly stress periods. Agricultural pumping was assigned to individual wells based on the required pumping demand estimated from the FMP. Annual agricultural and municipal groundwater pumping for the period of the model is shown in Figure 26.

3.7 Aquifer Characteristics

The propensity of aquifer sediments to transmit and store water is described in terms of transmissivity, hydraulic conductivity, and storativity. The aquifer system of the Tule Subbasin is highly heterogeneous and aquifer permeability and storage characteristics vary greatly both laterally and vertically. Where possible, TH&Co relied on long-term pumping test data to develop initial ranges of aquifer parameter estimates for input to the model (see Table 3). In the absence of this type of test, aquifer parameter estimates were also obtained from analysis of short-term pumping tests, textural analysis obtained from Faunt et al. (2009), and/or assignment of literature values based on the soil types observed in driller's logs. This section describes the aquifer parameters used in the GFM.

3.7.1 Transmissivity and Hydraulic Conductivity

Transmissivity is a measure of the propensity for groundwater to flow within an aquifer and was primarily developed for analysis of well hydraulics in confined aquifers (Freeze and Cherry, 1979). Multiple sources of data for estimating transmissivity were obtained, reviewed, and analyzed, including previous modeling efforts (Faunt et al., 2009), other technical reports, and pumping test data from local agencies (Schmidt, 2018). Transmissivity estimates were obtained from pumping test data for 225 wells, 29 of which were perforated only within the Upper Aquifer, 70 of which were perforated only within the Lower Aquifer, and 126 of which were perforated across multiple aquifers. Of the available pumping test data, 43 tests were known to be long-term tests (i.e., 24 hours or greater) and 55 tests were known to be short-term specific capacity tests (see Table 3). Details on the test duration for the remaining 125 wells was unknown.

The permeability of the sediments with respect to a given fluid (in this case, groundwater) in each layer of the model is expressed as hydraulic conductivity. Horizontal hydraulic conductivity is related to transmissivity through the following relationship:

$$K = \frac{T}{b}$$

Where:

K = Horizontal hydraulic conductivity (ft/day);
T = Transmissivity (ft/day); and
b = Aquifer thickness (ft)

Given our configuration of MODFLOW-OWHM, hydraulic conductivity was an input to the GFM whereas transmissivity was not. The distribution of horizontal hydraulic conductivity in each layer of the model was initially developed based on pumping test data and associated transmissivity estimates, supplemented with interpretation of soil properties through texture analysis, and finalized through the calibration process described in Section 3.8. The initial horizontal hydraulic conductivity distribution of each model layer was developed as a map that included pumping test-derived values overlaid on a visualization of percent coarse sediment by layer from soil textural analysis obtained from Faunt et al. (2009). Higher percentages of coarse-grained sediment were correlated with higher hydraulic conductivity values.

Hydraulic communication between adjacent model layers was addressed through vertical hydraulic conductivity. Because sediments are generally deposited in layers in alluvial/fluvial environments, horizontal hydraulic conductivity is often significantly greater than vertical hydraulic conductivity. Such sediments are said to be vertically anisotropic. Quantification of vertical hydraulic conductivity was accomplished via model calibration as described in Section 3.8. Similarly, the sediments may also be horizontally anisotropic as noted in Neuman et al. (1984) and more recently in Gianni et al. (2019). Like the vertical hydraulic conductivity, horizontal anisotropy was also quantified through model calibration.

3.7.2 Storage Properties

The release and uptake of water to and from storage was simulated using specific yield, specific storage, the elastic storage coefficient, and the inelastic storage coefficient. Specific yield and the elastic storage coefficient govern the reversible release and uptake of water whereas the inelastic storage coefficient governs the irreversible release of water due to compaction of porous media.

- Specific yield represents unconfined storage associated with draining or filling of porous media due to changes in the water table. It is defined as the difference between porosity and specific retention, where porosity is associated with the pore space volume and specific retention is associated with that portion of the pore space volume that does not drain.
- Specific storage represents confined storage associated with expansion or compression of both water and soil 'skeleton'. These processes are simulated within MODFLOW-OWHM by considering both elastic (reversible) compression and expansion of the soil skeleton and inelastic (irreversible) compression of the soil skeleton. As the term is used here, inelastic compression is the irreversible reduction in pore space that results in land subsidence.

The values of these storage properties were quantified through model calibration as described in Section 3.8.

3.7.2.1 Specific Yield

Layers 1, 2, and 3 of the GFM may be unconfined or confined (i.e., they are specified to be 'convertible' as noted above) depending on groundwater level conditions, which vary transiently throughout the model simulation. The specific yield values for these three uppermost model layers are specified exclusively in the LPF package. Conversely, being specified as confined layers, values of specific yield are not assigned to Layers 4 and 5.

Although previous model studies of the Tule Subbasin provided estimates of specific yield (Ruud et el, 2003; Faunt et al., 2009), to date, there are no measured data with which to estimate specific yield.

3.7.2.2 Specific, Elastic, and Inelastic Storage

In MODFLOW, the layer property flow package (LPF) is linked to the subsidence package (SUB) displacements through changes in the elevations of cell-by-cell layer boundaries. Given this linkage, parameters associated with the elastic and inelastic storage are specified in both packages. Specifically, subsidence is computed using the values for specific storage in the LPF package (which have dimensions of 1/ft) and the dimensionless elastic and inelastic storage coefficients in the SUB package. The portion of elastic and inelastic storage associated with the compressibility of water is specified in the LPF package as the 'specific storage' whereas the portion associated with compressibility of the soil skeleton were assigned in the MODFLOW subsidence package. Elastic storage is associated with the reversible compressibility of the soil skeleton whereas inelastic storage is associated with the irreversible compressibility of the soil skeleton.

3.7.3 Critical Hydraulic Head

Land subsidence in the SUB package of the model is a function of the effective stress of the aquifer system and changes in hydraulic head.

Non-recoverable (i.e., irreversible or inelastic) land subsidence occurs in the SUB package when the change in effective stress under a given hydraulic head condition exceeds the previous maximum effective stress (or pre-consolidation stress) of the aquifer system. This maximum effective stress can generally be defined by the previous lowest groundwater level (Sneed, 2001), herein referred to as the "critical head."

In order to define the critical head in the Tule Subbasin groundwater model, TH&Co analyzed the previous lowest groundwater level in the Tule Subbasin prior to the start of the model transient period in 1986. In general, this groundwater level condition is indicative of the early to mid-1960s, as documented in Ireland et al., 1984. The historical low groundwater level prior to 1986 in each calibration target well was used to provide an initial estimate of critical head, which was refined through model calibration.

3.8 Model Calibration

As noted in CDWR (2016), model calibration is required by the GSP Regulations (§352.4(f)(2)). Calibration is performed to demonstrate that the model can reasonably reproduce (simulate) historical measurements (e.g., groundwater elevations and land subsidence measurements). Calibration generally involves iterative adjustments of various model parameters until the simulated results reasonably match historical measurements. As their precise values are unknown, aquifer characteristics such as those described in the previous subsection are commonly modified during model calibration. Adjustment of parameter values is constrained within a range of reasonable values through review of aquifer test data, borehole data, hydrographs, and literature data.

The precise values of the numerous aquifer characteristics described in the previous subsection (i.e., horizontal hydraulic conductivity, vertical hydraulic conductivity, horizontal anisotropy, specific yield, specific storage, elastic storage, inelastic storage, and critical head) vary laterally and vertically throughout the Subbasin and are unknown. Therefore, these characteristics were quantified through calibration. Given the functionality provided by MODFLOW-OWHM, consumptive use and mountain block recharge were refined from initial values through calibration.

Given the large number of these ‘calibration parameters’, their spatial variability within and across model layers, the interconnection between water levels and land subsidence, and the goal of conducting a predictive uncertainty analysis as described in CDWR (2016), ‘trial-and-error’ calibration (as described in Anderson and Woessner, 1992) was largely abandoned in favor of automated calibration using PEST (Doherty, 2003 and 2015). The GFM was calibrated to both measured groundwater levels and measured changes in land surface elevation.

3.8.1 Calibration Targets for Groundwater Levels

Simulated groundwater levels were calibrated to measured data collected between October 1986 and September 2017 in selected monitoring wells throughout the Tule Subbasin. The 32 target wells for the model calibration are shown on Figure 27. The model was specifically calibrated to groundwater level observations from wells perforated exclusively in either model Layers 1, 3, or 4. Calibration to observed groundwater levels in Layer 2 was not conducted due to a lack of observation wells perforated in this layer. Groundwater level data specific to Layer 5 is not available. Other criteria for selection of calibration target wells included:

1. Adequate historical groundwater level record.

2. Relative assurance that the measured data were indicative of static groundwater level conditions.

3.8.2 Calibration Targets for Land Subsidence

Land subsidence was calibrated at 45 target locations to Interferometric Synthetic Aperture Radar (InSAR) satellite data (see Figure 28). InSAR is a technique for measuring changes in land surface elevation using two or more radar images of the earth's surface to determine any change in land surface elevation. TH&Co obtained historical InSAR land subsidence data for the 45 target locations from the Jet Propulsion Laboratory (JPL). The 45 target calibration locations are generally evenly space across the Tule Subbasin area at 3- to 4-mile spacings. Data were available for the following periods of time:

- 2007 - 2011
- 2014 - 2015
- 2015 - 2017

TH&Co was also able to calibrate land subsidence to land surface elevation data from two Global Positioning Stations (GPS) located near the Porterville Airport and the City of Delano. Land surface elevation data was available for both stations for the period from November 2005 to May 2018 (see Figure 14).

Calibration of changes in land surface elevation was conducted based on relative changes in land surface elevation rather than actual elevation. Land surface elevation datum was not available at an accuracy that would provide a meaningful reference for calibrating actual land surface elevation. The top of the model is defined based on the USGS DEM, which has a vertical accuracy of plus/minus 3 meters (see Section 3.6.2). In addition, it is possible that the elevation defined by the DEM, which is based on NAVD 88, changed between the time the reference was defined and 1986 (the start of the transient model period). Given these limitations, TH&Co instead calibrated land subsidence based on relative change in land surface elevation indicated by the InSAR data for the three time periods indicated above and the data from the Porterville and Delano GPS stations.

3.8.3 Calibration Process

The general calibration process for the GFM included the following steps:

1. A plausible range of values for each of the 41 parameters was assigned to each of 109 pilot points evenly spaced within Layers 1 through 4 and 53 pilot points evenly spaced within

Layer 5 (see Figure 27). The magnitude of the range assigned to each parameter at each pilot point varied based on the quality of the data in the vicinity of the pilot point. For example, pilot points near wells with controlled pumping test data were given a smaller range than those in areas with no available pumping test data. The input parameter groupings that were adjusted during the calibration process included:

- Horizontal hydraulic conductivity ('kh');
- Vertical hydraulic conductivity ('kv');
- Horizontal anisotropy ('hani');
- Specific yield ('sy');
- Specific storage('ss');
- Elastic storage ('ske');
- Inelastic storage ('skv');
- Critical head ('ch');
- Mountain block recharge (MBR; 'wm');
- Crop consumptive use ('um'); and
- Well radius ('rad').

2. Some parameters are expected to be correlated with horizontal hydraulic conductivity ('kh'). Therefore, they were expressed as functions of 'kh' based on literature values and professional judgment within PEST to maintain a reasonable degree of consistency among such parameters. For example, soils with high 'kh' values generally have high 'sy' values; conversely, soils with high 'kh' values generally have low 'ske' values.
3. Given the number of pilot points and associated calibration parameters, several thousand MODFLOW-OWHM runs through PEST and its utility programs were required to calibrate the GFM, complete the sensitivity analysis, and provide the information needed for the predictive uncertainty analysis.
4. The calibration parameters most sensitive parameters to model outcome (defined as the change to the objective function) are horizontal hydraulic conductivity of Layers 1 through 4 (kh1 through kh4) and specific yield of Layer 1 (sy1).

3.8.4 Calibration Results

Using PEST and its associated utility programs, over 200 calibrated models were generated. That is, owing to the non-uniqueness of the solution to hydrogeologic models in general, over 200 different spatial configurations of the calibration parameters that resulted in a calibrated model were generated. Additional calibrated models could have been generated but given the ultimate objective of quantifying the sustainable yield and its uncertainty, having over 200 calibrated models was deemed sufficient. Plan-view plots showing the spatial distribution of the calibration parameters for all five model layers for one of these calibrated models are provided in Appendix C. Visual inspection of these plots shows the calibrated values to be reasonable given the available Subbasin-specific and literature data (e.g., the calibrated values of horizontal hydraulic conductivity are in generally good agreement with those obtained from pumping tests as shown on the plan-view plots). The range of values for the most sensitive parameter groups (i.e., hydraulic conductivity and specific yield) are as follows:

	Horizontal Hydraulic Conductivity; kh (ft/day)*			**Specific Yield; sy (unitless)**		
Model Layer	**Minimum**	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**
1	2	20	160	0.001	0.09	0.25
2	0.01	9	120	0.007	0.06	0.25
3	1	20	200	0.01	0.1	0.25
4	0.1	2	20	Not applicable for confined layer		
5	3	4	5	Not applicable for confined layer		

* The anisotropy ratio is the ratio of horizontal hydraulic conductivity along model columns to that along model rows. It ranged from 0.3 to 3.0.

The range of values for elastic and inelastic storage are provided in the table below.

	Elastic Storage, S_e (unitless)			**Inelastic Storage, S_i (unitless)**		
Model Layer	**Minimum**	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**
1	1.00×10^{-5}	4.92×10^{-5}	2.68×10^{-4}	1.00×10^{-3}	4.49×10^{-3}	6.77×10^{-2}
2	1.00×10^{-5}	4.71×10^{-4}	1.00×10^{-3}	1.00×10^{-3}	5.17×10^{-2}	1.00×10^{-1}
3	1.00×10^{-5}	6.82×10^{-5}	4.61×10^{-4}	1.00×10^{-3}	5.33×10^{-3}	3.57×10^{-2}
4	1.27×10^{-5}	1.29×10^{-4}	6.62×10^{-4}	1.00×10^{-3}	2.61×10^{-2}	1.00×10^{-1}
5	1.20×10^{-5}	8.53×10^{-5}	3.17×10^{-4}	1.14×10^{-3}	9.74×10^{-3}	4.65×10^{-2}

Model calibration is typically judged using qualitative and quantitative methods. At first, a qualitative visual comparison of simulated groundwater elevations and subsidence rates to measured values was performed. Upon achieving visually acceptable results, quantitative methods as presented in the subsections below were applied to further evaluate the quality of the calibration. Finally, from a water accounting perspective, water budget errors are expected to be less than 1 percent (Hill and Tiedeman, 2007; Anderson and Woessner, 1992). The numerical water budget error for the final calibration was 0.1 percent, which is within the limits of acceptable error.

3.8.4.1 Groundwater Elevations

Calibration hydrographs showing both measured and model-generated groundwater elevations are provided in Appendix D. The simulated groundwater elevations reasonably match the measured elevations at most of the target wells in the model. A scatter plot of simulated versus measured groundwater elevations for the 1,371 groundwater level observations in the calibration is shown in Figure 29. The correlation coefficient between the simulated and measured values is 0.95, which is an acceptably large value that exceeds the benchmark value of 0.90 noted in CDWR (2016) and Hill and Tiedemann (2007).

Another common measure of model calibration is the normalized root mean squared error (NRMSE). The 'error' is the difference between the simulated head value and the measured head value. The error is referred to as the 'residual' and the RMSE, which is normalized by the measured range of groundwater elevations in the model ('range').

$$NRMSE = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n} R_i^2}}{range}$$

Where:

n = Number of observations; and
R = Residual (ft).

The NRMSE is expressed as a percent with results less than 10 percent generally considered to be acceptable. The NRMSE for the GFM with respect to groundwater elevations is at an acceptably low value of 6.6 percent (see Figure 29).

3.8.4.2 Land Subsidence

Calibration graphs showing both measured and simulated subsidence are provided in Appendix E. The simulated land subsidence reasonably matches that measured at the Porterville and Delano GPS stations and via satellite at most of the target locations. A scatter plot of simulated versus measured land subsidence for the 2,616 observations in the calibration is shown in Figure 30. The correlation coefficient between the simulated and measured values is at an acceptably large value of 0.94 and the NRMSE for the GFM with respect to land subsidence is at an acceptably low value of 6.5 percent (see Figure 30).

Given the nature of the subsidence data to which the GFM is calibrated, simulated land subsidence by the model is acceptably calibrated to enable projections of relative change in land surface elevation in the future (e.g. 2.1 feet of subsidence). It is not recommended to determine absolute values of projected land surface elevation.

3.8.4.3 Calibration Summary

Based on the acceptably low water budget error and NRMSE values along with the acceptably high correlation coefficients, the GFM is acceptable for its intended use to estimate the future water budget, project future groundwater level changes, and estimate relative changes in future land elevation for evaluating projects and managements actions and estimating the Sustainable Yield of the Subbasin.

The resulting surface and groundwater budgets produced by the calibrated model are presented in Tables 4a, 4b, and 5. A detailed description of the individual water budget items can be found in the Tule Subbasin Setting document (TH&Co, 2020).

4.0 Future Subbasin Management Scenario for Analysis with the Model

In order to evaluate planned projects and management actions of each of the six GSAs within the Tule Subbasin, refine the sustainable yield and develop a future water budget for inclusion in the Subbasin Setting document of the GSPs, TH&Co analyzed a future subbasin management scenario with the calibrated GFM. The future scenario began in October 2017 (the end of the model calibration period) and extended through September 2070 and utilized yearly (i.e., water year) stress periods. Projects and management actions were incorporated into the GFM starting in 2020. The purpose for analyzing the scenario was to assess the sustainability of the planned actions, assess the interaction of the planned actions on groundwater levels between the GSAs, and estimate the sustainable yield of the Subbasin.

4.1 Projects and Management Actions

Projects for incorporation in the future scenario were provided by basin managers from each of the six Tule Subbasin GSAs (see Table 6). Most of the projects involve increases in recycled water recharge, increased basin recharge, changes in water deliveries, capture of flood water, and water banking operations.

Management actions for incorporation into the model were focused on the reduction in crop consumptive use necessary to achieve sustainability (see Table 7). The reduction in crop consumptive use is directly correlated to a reduction in irrigated water demand and groundwater pumping. Each GSA provided a schedule to reduce consumptive use, starting in 2020, in order to achieve sustainable groundwater pumping by 2040. As the availability of surface water supplies from imported water and diverted streamflow is different between the GSAs, each GSA established a different consumptive use reduction, or “transitional pumping,” schedule (see Table 7).

4.2 Assumptions for Municipal Pumping

Future projections for municipal pumping were applied to the City of Porterville. Other cities and communities (e.g., Tipton, Richgrove, etc.) were assumed to continue 2017 pumping rates into the future.

4.3 Assumptions for Hydrology and Surface Water Deliveries on Major Streams

Baseline stream flow hydrology for the Tule River, Deer Creek and White River for the future projection model was based on the 20-yr average of historical stream flows measured or estimated between water years 1990/91 and 2009/10. This base period approximates the 115-year average surface water flow within the Tule River between 1903/04 and 2016/17 (TRA 2018 Annual Report, Appendix). Baseline surface water deliveries to agencies with diversion rights in the future projection were also based on the 20-yr average of deliveries for the period 1990/91 to 2009/10.

The baseline streamflow on the major streams used in the future projection for the model were adjusted to account for projections of future climate change. Adjustments were applied based on output from the DWR's CalSim-II model, which provided adjusted historical hydrology for major drainages based on scenarios recommended by the California Department of Water Resources Climate Change Technical Advisory Group (2015). Climate change adjustments to hydrology and surface water deliveries were applied over two time periods within the SGMA planning horizon, as defined by California Water Commission (2016):

1. A 2030 central tendency time period, which provides near-term projections of potential climate change impacts on hydrology, centered on the year 2030, and
2. A 2070 central tendency time period, which provides long-term projections of potential climate change impacts on hydrology, centered on the year 2070.

Change factors for the 2030 and 2070 central tendency time periods are shown for the hydrology associated with the Tule River historical baseline time period of 1990/91 to 2009/10 on Figure 31. Both the annual change factors and weighted average change factors are shown. In the future projection scenario for the model, TH&Co used the average 2030 change factor for each major stream providing water within the model domain (see Figure 32). The climate adjusted hydrology for these major streams after applying the 2030 change factors ranges from 98 percent to 101 percent of the historical baseline average. The climate adjusted hydrology after applying the 2070 change factors ranges from 95 percent to 101 percent of the historical baseline average. The 2030 central tendency change factors were applied to the future projection scenario from 2025 to 2049. The 2070 central tendency change factors were applied to the future projection from 2050 to 2070.

4.4 Assumptions for Friant-Kern Canal Deliveries

Projected surface water deliveries from the Friant-Kern Canal were based on climate adjusted historical average deliveries from 1990/91 to 2009/10 provided by the Friant Water Authority (FWA, 2018 and supporting Excel files). It is noted that the climate adjusted historical FWA data extended only to 2002/03. Thus, it was necessary to estimate the climate adjusted deliveries for 2003/04 through 2009/10 based on proxy years according to the following schedule:

- 2003/04 – 1946/47
- 2004/05 – 1935/36
- 2005/06 – 1939/40
- 2006/07 – 1975/76

- 2007/08 – 2001/02
- 2008/09 – 1963/64
- 2009/10 – 1950/51

The proxy years were selected based on years when the inflow to Success Reservoir was as close as possible.

The climate adjusted deliveries to each agency included Class I, Class II, and 16B deliveries. Climate adjusted deliveries were also adjusted to account for impacts to deliveries as a result of the San Joaquin River Restoration Project (SJRRP) implementation. All climate change and SJRRP adjustments were applied starting in 2025. Deliveries from the Friant-Kern Canal between 2020 and 2025 were based on the 20-year historical baseline based on 1990/91 to 2009/10. Climate change and SJRRP adjustments were phased in between 2025 and 2030 through a linear interpolation between 2025 baseline deliveries and full application of FWA adjusted deliveries in 2030. TH&Co applied the 2070 central tendency time period climate-related adjustments to imported water deliveries in the Tule Subbasin model projection for the period from 2050 to 2070.

Results of the climate adjustments show that future water deliveries are projected to be generally comparable to historical water deliveries for DEID, KTWD, and Tea Pot Dome WD. Future water deliveries for Porterville ID and Terra Bella ID are projected to increase relative to historical deliveries primarily due to a reduction or elimination of sales and/or transfers that historically occurred. Future water deliveries for LTRID are projected to decrease relative to historical deliveries due to the high proportion of Class 2 supplies which are most impacted by the FWA analysis. Finally, future water deliveries for Saucelito ID are projected to decrease relative to historical deliveries due to changes in sales and/or transfers. Results of the analysis are summarized on Figure 33.

5.0 Analysis of the Future Subbasin Management Scenario

TH&Co used the calibrated GFM to analyze the consumptive use that can be accommodated in the future, given each GSA's planned projects and management actions, without a long-term, subbasin-wide net negative change in groundwater storage. Consumptive use is linked to groundwater pumping (and, therefore, change in groundwater storage) as described in Section 3.5.

While the projects and management actions developed for the future projection scenario provided a conceptual schedule for reduction in consumptive use, they cannot provide the consumptive use necessary to make the Subbasin sustainable. Through an iterative process, the consumptive use in the future projection of the model was adjusted until there was no net negative change in groundwater storage from 2040 to 2050[1]. During this process, neither streamflow diversions nor imported water deliveries were modified from their projected values; the only changes were consumptive use and associated groundwater pumping. In order to maximize the available consumptive use in the Subbasin while avoiding a net negative change in storage, the target consumptive use in all WBAs, and therefore the transitional pumping schedule, was incrementally reduced from an initial condition that resulted in a negative change in storage to one that resulted in no net negative change in storage. The resulting sustainable level of consumptive use was estimated to be approximately 65,000 acre-ft/year. Additional consumptive use can be supported in any given area of the Subbasin by streamflow diversions and imported water supplies, where available.

5.1 Projected Groundwater Budget

The projected surface water and groundwater budgets, based on the future basin management scenario and sustainable consumptive use target for the Tule Subbasin, are shown in Tables 8a, 8b, and 9. The tables are based on the 50th percentile sustainable yield representation of the calibrated GFM. As shown in Table 9 the average annual projected change in groundwater storage between 2040 and 2050, after full implementation of transitional pumping, is positive 900 acre-ft/yr.

5.2 Projected Groundwater Levels

Projected groundwater level trends at calibration target wells within the Tule Subbasin are provided in Appendix F. All projected groundwater levels were generated using the 50th percentile sustainable yield representation of the calibrated GFM. As shown, groundwater levels simulated after 2040 level out for most of the upper and lower aquifer wells relative to their historical and transitional pumping downward trends. Exceptions are upper aquifer wells in the western part of

---

[1] Stress periods in the future projection portion of the GFM are based on water years (i.e. October 1 through September 30) and all results are presented as water years (i.e. 2020 is October 1, 2019 through September 30, 2020).

the Subbasin (e.g., Angiola G1 and 32K01) where downward groundwater level trends continue beyond 2040.

5.2.1 2020 – 2040 Transitional Pumping Period

Projected changes in groundwater levels in the upper aquifer (Layer 1) for the transitional pumping time period from 2020 to 2040 are shown on Figure 34. As shown, groundwater levels are below the bottom of Layer 1 throughout much of the eastern portion of the Subbasin, except in the Porterville area where groundwater levels are above the bottom of the layer and projected to remain relatively stable during the transitional pumping period. Groundwater levels in this layer are projected to decline another 100 to 120 feet in the central portion of the Subbasin during the transitional pumping period. Layer 1 groundwater levels in the western portion of the Subbasin are projected to decline another 40 to 80 feet during the transitional pumping period.

Projected changes in groundwater levels in the lower aquifer (Layer 3) for the transitional pumping period from 2020 to 2040 are shown on Figure 35. Layer 3 groundwater levels in the eastern and southeastern parts of the Subbasin are projected to rise. Groundwater levels in the central and northwest parts of the Subbasin are projected to decline another 20 to 40 feet in Layer 3.

5.2.2 2040 – 2050 Sustainability Period

Projected changes in groundwater levels in the upper aquifer (Layer 1) for the time period from 2040 to 2050 are shown on Figure 36. Groundwater levels in Layer 1 during this time period are relatively stable throughout the Tule Subbasin, with slight groundwater level rise predicted for the Porterville area. In Layer 3 (Figure 37), groundwater levels show increases of 20 to 40 feet in the eastern portion of the Subbasin and stable to slightly decreasing groundwater levels in the western portion of the Subbasin.

5.2.3 2050 – 2070 Sustainability Period with Extended Climate Adjustments

Projected changes in groundwater levels in the upper aquifer (Layer 1) for the time period from 2050 to 2070 are shown on Figure 38. Groundwater levels in Layer 1 during this time period trend downward again in the central portion of the Tule Subbasin, with slight groundwater level rise predicted for the Porterville area. In Layer 3 (Figure 39), groundwater levels are predicted to remain stable during this time period with increases of 20 to 40 feet in the eastern portion of the Subbasin. It is noted that the 2070 central tendency climate adjustments were applied during this time period, which reduce the amount of surface water deliveries available to the GSAs and result in downward trends in groundwater levels in Layer 1.

5.3 Projected Land Subsidence

Projected groundwater level trends at calibration target wells within the Tule Subbasin are provided in Appendix G. As land subsidence is correlated with groundwater level decline, continued land subsidence is expected during the transitional pumping period from 2020 to 2040 as groundwater levels continue to drop in the central and northwest parts of the Subbasin (see Figure 40). As much as eight feet (average of 0.4 ft/yr) of additional land subsidence is predicted in the northern Tri-County Water Agency GSA, western Pixley Irrigation District GSA, and northern LTRID GSA. Up to four feet (average of 0.2 ft/yr) of land subsidence is also predicted beneath the Friant-Kern Canal between Deer Creek and White River (see Figure 40).

Between 2040 and 2050, the rate of land subsidence decreases as groundwater levels stabilize throughout most of the Subbasin (see Figure 41). Up to three feet (average of 0.3 ft/yr) of land subsidence is still predicted to occur in isolated areas of the northern Tri-County Water Agency GSA, western Pixley Irrigation District GSA, and northern LTRID GSA. Less than 0.5 feet (average of 0.05 ft/yr) of land subsidence is predicted in the vicinity of the Friant-Kern Canal during this time period.

Land subsidence between 2050 and 2070 is predicted to continue in the western part of the Tule Subbasin as a result of declining groundwater levels in Layer 1 in this area (see Figure 42). Up to four feet (average of 0.2 ft/yr) of land subsidence is predicted during this time period for the northern Tri-County Water Agency GSA at the western boundary of the Subbasin. Up to three feet (average of 0.15 ft/yr) of additional land subsidence is predicted for the southern Tri-County Water Agency GSA and Alpaugh Irrigation District GSA areas.

5.4 Sustainable Yield

The sustainable yield of the Tule Subbasin is a function of the overall water balance of the area. Changes in surface water/groundwater inflow to the basin and surface water/groundwater outflow from the basin impact the sustainable yield. As groundwater management and land use changes impact the water balance, they also impact the sustainable yield. A generalized expression of the water balance is as follows:

$$\text{Inflow} - \text{Outflow} = +/- \text{ Change in Storage} \qquad (1)$$

The water balance equation for pre-developed conditions (prior to human occupation) can be further expressed as:

$$(I_{pr} + I_{str} + I_{ss} + I_{mb}) - (O_{ss} + O_{et}) = \Delta S \qquad (2)$$

Where:

I_{pr} = Inflow from Areal Recharge of Precipitation
I_{str} = Inflow from Infiltration of Runoff in Stream Beds
I_{ss} = Inflow from Subsurface Underflow
I_{mb} = Inflow from Mountain-Block Recharge
O_{ss} = Subsurface Outflow
O_{et} = Evapotranspiration
ΔS = Change in Groundwater Storage

Under pre-developed conditions, the Subbasin would be in a state of equilibrium such that the inflow and outflow would balance and there would be no significant long-term change in storage assuming a static climatic condition. Under this condition, groundwater levels would be relatively stable.

Under developed land use conditions, the water balance changes as groundwater is pumped from the basin for irrigation and municipal supply, diversions of streamflow occur, and imported water is delivered to the Subbasin. Lowering of the groundwater table resulting from pumping reduces the amount of groundwater that would otherwise leave the Subbasin and reduces evapotranspiration losses in areas of shallow groundwater (e.g., Tulare Lake). Some of the pumped groundwater used for irrigation infiltrates past the roots of the plants and returns to the groundwater as return flow. Water imported into the area is applied to crops but some is lost as infiltration in unlined canals and as return flow. Groundwater return flow also occurs as a result of discharges from individual septic systems. Inflow from the compression of aquitards as a result of subsidence also contributes water to the aquifer system. Other sources of recharge to the groundwater under developed land use include wastewater treatment plant discharges and artificial recharge in spreading basins.

The water balance equation for developed land use conditions can be modified as follows (flows in **bold** are not included in the sustainable yield):

$$(I_{pr} + I_{str} + \mathbf{I_{can}} + \mathbf{I_{ar}} + \mathbf{I_{rfgw}} + \mathbf{I_{rfimp}} + \mathbf{I_{com}} + I_{ss} + I_{mb}) - (O_{ss} + O_{et} + \mathbf{O_{p}}) = \Delta S \qquad (3)$$

Where:

I_{can} = Inflow from Canal Losses
I_{ar} = Inflow from Artificial Recharge

I_{rfgw} = Inflow from Return Flow of Applied Water from Groundwater Pumping
I_{rfimp} = Inflow from Return Flow of Applied Water from Imported Water
I_{com} = Inflow of Water Released from Compression of Aquitards
O_p = Outflow from Groundwater Pumping

If the inflow terms exceed the outflow terms, then the groundwater in storage increases (become positive) and groundwater levels rise. If the outflow terms exceed the inflow, then the groundwater in storage decreases (become negative) and groundwater levels drop. It is assumed that the sustainable yield of the Tule Subbasin is the long-term average groundwater pumping rate, under projected land use conditions, that results in no significant long-term net negative change in groundwater storage in the basin. Based on this premise, the water balance equation can be rearranged and simplified to estimate sustainable yield:

$$\text{Sustainable Yield} = \Delta S + \mathbf{O_p} - \mathbf{I_{can}} - \mathbf{I_{ar}} - \mathbf{I_{rfimp}} - \mathbf{I_{com}} \tag{4}$$

Thus, if the change in groundwater storage over the planning period is zero and there is no imported water or release of water from compression of aquitards, then the sustainable yield is equal to the pumping. This relationship is valid if the following conditions are met:

1. The sustainable yield incorporates a hydrology that is representative of a relatively long period of record that includes multiple wet and dry hydrologic cycles.
2. The land use conditions are representative of the time period.

The sustainable yield can also be expressed as all of the components of the water balance not explicitly expressed in Equation 4:

$$\text{Sustainable Yield} = I_{pr} + I_{str} + I_{rfgw} + I_{ss} + I_{mb} - O_{ss} \tag{5}$$

It is noted that the Tule Subbasin Technical Advisory Committee has determined that recharge to the Tule Subbasin associated with the delivery of imported water and the diversion of water from the Tule River and Deer Creek associated with Pre-1914 water rights will not be included in the sustainable yield of the Subbasin. This includes canal losses from delivery of imported water and diverted stream flow, deep percolation of applied imported water and diverted stream flow, and managed recharge in basins.

Applying Equations 4 and 5 to the historical water budget of the Tule Subbasin does not result in a representative sustainable yield because the Subbasin was in overdraft during the historical water budget period. Groundwater pumping depressions that have developed in the western portion of the Subbasin have historically captured groundwater that would have otherwise left the Subbasin. This increase in groundwater inflow and decrease in groundwater outflow resulted in an apparent sustainable yield that was higher than was actually sustainable. Further, some of the return flow associated with historical overdraft contributed to the unrealistically high historical sustainable yield. The apparent sustainable yield based on the water budget from water year 1990/91 to 2009/10 was reported to be approximately 258,000 acre-ft/yr (TH&Co, 2017b). However, since the downward groundwater trends that resulted in this condition are not sustainable, the associated sustainable yield from this water budget is not representative.

The sustainable yield of the Tule Subbasin will change in the future as a result of changes in groundwater levels and flows associated with planned projects and management actions and changes in deep percolation of applied water (i.e., return flow) from reduced groundwater pumping. This necessary action will change the water budget by not only decreasing outflow from groundwater pumping but also reducing deep percolation of applied water (return flow) and changing the dynamics of inflow and outflow at the Subbasin boundaries. This new water budget regime will result in a sustainable yield that is different from what was realized historically. The projected groundwater budget from the analysis of the future basin management scenario using the calibrated groundwater flow model was the basis for the sustainable yield estimate of the Tule Subbasin. This analysis resulted in a sustainable yield of 130,000 acre-ft/yr.

5.5 Uncertainty Analysis

To paraphrase from CDWR (2016), gaining a sense of the magnitude of the uncertainty in model predictions allows decision makers to accommodate the reality that model results are imperfect forecasts and actual subbasin responses to management actions will vary from those predicted by modeling. To this end, output from PEST and its associated utility programs were used to address the uncertainty in estimates of sustainable yield for the Subbasin and subsidence along the Friant-Kern Canal. This approach provided 240 calibrated versions (‘realizations’) of the GFM. Each realization was comprised of different configurations of aquifer parameters, consumptive use, and mountain block recharge.

5.5.1 Uncertainty in Sustainable Yield Estimate

The future water budgets from each of the 240 calibrated realizations of the model were processed, based on Equation 5 in Section 5.4, to produce sustainable yield estimates for each year of the 50-yr implementation and planning horizon (2020 to 2070). Of the original 240 model realizations, 175 resulted in a projected average annual change in groundwater storage greater than -5,000 acre-ft/yr. The 50th percentile sustainable yield for the time period from 2040 to 2050 was used as the sustainable yield for the 175 model realizations resulting in greater than -5,000 acre-ft/yr of annual storage change. The 175 estimates of sustainable yield are normally distributed (see Figure 43). The time period from 2040 to 2050 was selected because it occurs after all planned projects and management actions have been implemented but before the time when the less reliable long-term climate change adjustments to hydrology and water deliveries are applied to the projected water budget (2050).

The projected future sustainable yield of the Tule Subbasin, which is the 50th percentile of the distribution of estimates derived from the uncertainty analysis, is estimated to be approximately 130,000 acre-ft/yr (see Table 10). The plausible range of sustainable yield was selected as the values between the 20th and 80th percentile, resulting in a range of approximately 108,000 to 162,000 acre-ft/yr (see Figure 43). The projected sustainable yield does not include:

- Diverted Tule River water canal losses, recharge in basins, and deep percolation of applied water,
- Diverted Deer Creek water canal losses, recharge in basins, and deep percolation of applied water,
- Imported water canal losses, recharge in basins, and deep percolation of applied water, and
- Deep percolation of applied recycled water and recycled water recharge in basins.

As the groundwater model predicts some continued land subsidence in the Tule Subbasin between 2040 and 2050, there is a contribution of approximately 18,000 acre-ft/yr of water to the aquifer from the compression of aquitards during this time period (see Table 9). This contribution is included in the water budget that results in no net negative change in groundwater storage over the time period. The implication for this is that the sustainable yield for the Subbasin is somewhat lower than reported because the contribution of water to the aquifer from compression of aquitards is not sustainable. Nonetheless, given the uncertainty in model results, the current estimate of 130,000 acre-ft/yr is recommended until more data are collected and the model is updated.

5.5.2 Uncertainty in Friant-Kern Canal Subsidence

The 240 realizations of the GFM were also used to assess the uncertainty in simulated land subsidence along the Friant-Kern Canal for the future subbasin management scenario. The target period for this assessment is the 2020 to 2040 transitional pumping period. Figure 44 displays the uncertainty in simulated subsidence at various milepost locations along the Canal using 'box-and-whisker' diagrams. These diagrams show various statistics for simulated subsidence. Specifically, the top of the 'box' portion (the brown-shaded, vertically-oriented rectangle) is the 25th percentile whereas the bottom is the 75th percentile. Within the box is a horizontal line (i.e., the 50th percentile or 'median') and an 'X', which identifies the arithmetic average (i.e. 'mean') value. The top and bottom of each whisker represents the 'local minimum' and 'local maximum' values. These 'local' statistics are those associated with the simulated values after outliers are removed. Outliers are defined as those values less than or greater than 1.5 times the interquartile range (i.e., 1.5 times the difference between the 25th and 75th percentile values).

Considering the simulated subsidence shown on Figure 44 for the two locations between Milepost 106 and 108, the plot shows the simulated values to range from 1.0 to 5.1 feet and 1.6 to 4.6 feet for the northern and southern locations, respectively.

For comparison, the simulated land subsidence associated with the realization for the 50th percentile sustainable yield (shown as the continuous thick black line extending from left to right across the figure) is approximately 3.2 feet at both locations. Considering the southern location (i.e., closer to Milepost 108), this value roughly corresponds to the 75th percentile. That is, the simulated subsidence for 25 percent of the 240 realizations (60 realizations) for this location exceed 3.2 feet. The simulated subsidence associated with the realization for the 50th percentile sustainable yield exceeds the median subsidence value at those locations with the highest simulated medians (i.e., those located between Milepost 105 and Milepost 108).

6.0 Summary of Findings

A calibrated numerical groundwater flow model has been developed for the Tule Subbasin in support of informing GSPs for the six GSAs within the Subbasin. The model has been calibrated to industry standards with respect to both groundwater levels and land subsidence and is sufficient for informing future potential groundwater level and land surface elevation changes associated with planned projects and management actions. The calibrated groundwater flow model was used to assess a future groundwater budget and determine a sustainable yield for the Tule Subbasin based on planned projects and management actions that resulted in no net negative change in groundwater storage for the ten-year period after the 2040 SGMA sustainability deadline.

The following summarizes the findings from the model analysis:

- The sustainable yield of the Tule Subbasin is estimated to be approximately 130,000 acre-ft/yr. The sustainable yield does not include recharge from imported water delivery losses, recharge in basins and return flow; recharge from surface water diversion from the Tule River and Deer Creek associated with delivery losses, recharge in basins and return flow; and recharge of recycled water return flow and recharge in basins.
- Uncertainty analysis indicates that the plausible range of sustainable yield is approximately 108,000 to 162,000 acre-ft/yr.
- The future sustainable yield of the Subbasin is lower than the historical sustainable yield as a result of reduced irrigation return flow, reduced subsurface inflow, and increased subsurface outflow along the subbasin boundaries.
- The amount of crop consumptive use that can be supported by the sustainable yield is estimated to be approximately 65,000 acre-ft/yr with additional consumptive use supported by streamflow diversions and imported water supplies, where available.
- Although the overall water budget for the Tule Subbasin is projected to be in balance between 2040 and 2050, there are areas of the Subbasin where groundwater levels are still projected to decline through the planning horizon. It is anticipated that these localized areas of recharge and discharge imbalance can be addressed through basin management actions in the individual GSAs in which they occur.
- As much as approximately four feet of additional land subsidence is projected to occur beneath the Friant-Kern Canal during the transitional pumping period from 2020 to 2040. The greatest land subsidence is projected to occur in the area of the canal between Deer Creek and White River.
- Land subsidence is projected to be arrested after 2040 throughout most of the Tule Subbasin as a result of projected stabilizing of groundwater levels. Continued land subsidence is projected in the northwestern portion of the Subbasin and in the northern

portion of the Subbasin at the boundary with the Kaweah Subbasin to the north. This land subsidence is associated with localized continued decline in upper aquifer groundwater levels through the planning horizon.

7.0 References

Anderson, M.P, and Woessner, W.W., 1992. *Applied Groundwater Modeling, Simulation of Flow and Advective Transport*. Academic Press.

ASTM, 1993. Standard Guide for Application of a Groundwater Flow Model to a Site-Specific Problem. ASTM Standard D 5447-93.

Boyce, S.E., Hanson, R.T., Ferguson, I., Henson, W., Schmid, W., Reimann, T., Mehl, S.M., and Earll, M.M., 2018. *One-Water Hydrologic Flow Model—MODFLOW OWHM, version 2*. U.S. Geological Survey. https://doi.org/10.5066/P9CZM46C.

Boyce, S.E., Hanson, R.T., Ferguson, I., Schmid, W., Henson, W., Reimann, T., Mehl, S.M., and Earll, M.M., In Review. *One-Water Hydrologic Flow Model: A MODFLOW Based Conjunctive Use and Integrated Hydrologic Flow Model*. U.S. Geological Survey Techniques and Methods 6-AXX, 576 p.

California Department of Water Resources, 2003. *California's Groundwater*. Bulletin 118 – Update 2003.

California Department of Water Resources, 2016. *Best Management Practices for the Sustainable Management of Groundwater; Modeling BMP*. Sustainable Groundwater Management Program. December.

California Department of Water Resources Climate Change Technical Advisory Group, 2015. *Perspectives and Guidance for Climate Change Analysis*. DWR Technical Information Record.

California Energy Commission, 2006. Estimating Irrigation Water Use for California Agriculture: 1950s to Present. California Energy Commission, Public Interest Energy Research Program.

California Water Commission, 2016. Technical Reference – Water Storage Investment Program. Dated November 2016.

Doherty, J., 2003. Ground Water Model Calibration Using Pilot Points and Regularization. Groundwater 41, no. 2: 170-177.

Doherty, J., 2015. *Calibration and Uncertainty Analysis for Complex Environmental Models*. Watermark Numerical Computing, Brisbane, Australia. ISBN: 978-0-9943786-0-6.

Faunt, C.C., 2009. *Groundwater Availability of the Central Valley Aquifer, California*. USGS Professional Paper 1766.

Freeze, R.A., and Cherry, J.A., 1979. Groundwater. Prentice Hall.

Friant Water Authority, 2018. Technical Memorandum – Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans, California.

Frink, J.W., and Kues, H.A., 1954. *Corcoran Clay – A Pleistocene Lacustrine Deposit in San Joaquin Valley, California*. American Association of Petroleum Geologists Bulletin Vol. 38, No. 11, pgs. 2357 – 2371.

Gianni, G., J. Doherty, and P. Brunner, 2019. Conceptualization and Calibration of Anisotropic Alluvial Systems: Pitfalls and Biases. Groundwater 57, no. 3: 409-419.

Hanson, R.T., Boyce, S.E., Schmid, Wolfgang, Hughes, J.D., Mehl, S.M., Leake, S.A., Maddock, Thomas, III, and Niswonger, R.G., 2014. *One-Water Hydrologic Flow Model (MODFLOW-OWHM)*: U.S. Geological Survey Techniques and Methods 6–A51, 120 p.

Hill, Mary C., and Tiedeman, Claire R., 2007. Effective Groundwater Model Calibration, with Analysis of Data, Sensitivities, Predictions, and Uncertainty. Wiley-Interscience, New Jersey.

Ireland, R.L., Poland, J.F., and Riley, F.S., 1984. Land Subsidence in the San Joaquin Valley, California, as of 1980. U.S. Geological Survey Professional Paper 437-I.

ITRC, 2003. California Crop and Soil Evapotranspiration for Water Balances and Irrigation Scheduling/Design. ITRC No. 03-001, dated January 2003.

Lofgren, B.E., and Klausing, R.L., 1969. *Land Subsidence due to Ground-Water Withdrawal Tulare-Wasco Area California*. USGS Professional Paper 437-B.

Luhdorff and Scalmanini, 2014. Land Subsidence from Groundwater Use in California. Prepared in Cooperation with the California Water Foundation.

Neuman, S.P., G.R. Walter, H.W. Bentley, J.J. Ward, and D.D. Gonzalez, 1984. Determination of horizontal aquifer anisotropy with three wells. Groundwater 22, no. 1: 66–72.

Ruud, N., Harter, T., and Naugle, A., 2003. *A Conjunctive Use Model for the Tule Groundwater Sub-basin Area in the Southern Eastern San Joaquin Valley, California*. Prepared for the U.S. Bureau of Reclamation.

Schmid, W. and Hanson, R.T., 2009, *The Farm Process Version 2 (FMP2) for MODFLOW-2005 – Modifications and Upgrades to FMP1*. U.S. Geological Survey Techniques in Water Resources Investigations, Book 6, Chapter A32, 102 p.

Schmidt, K., 2018. Hydrogeological Conceptual Model and Groundwater Conditions for the Tri-County WA GSP (Draft). Prepared for Tri-County Water Authority, Corcoran, California.

Sneed, M., 2001. *Hydraulic and Mechanical Properties Affecting Ground-Water Flow and Aquifer- System Compaction, San Joaquin Valley, California*. U.S. Geological Survey Open-File Report 01-35. Prepared in cooperation with the U.S. Bureau of Reclamation.

TH&Co, 2015. Analysis of the Hydrogeological Condition of the Tule Subbasin. Prepared for Spaletta Law PC and Lower Tule River Irrigation District, January 9, 2015.

TH&Co, 2017a. Technical Memorandum – Part II: Provide Support to Develop a Groundwater Flow Model. Prepared for Tule Subbasin MOU Group.

TH&Co, 2017b. Hydrogeological Conceptual Model and Water Budget of the Tule Subbasin. Prepared for the Tule Subbasin MOU Group.

TH&Co, 2020. Tule Subbasin Setting. Prepared for the Tule Subbasin Technical Advisory Committee. Dated January 2020.

TRA, 2018. Annual Report 2018 Water Year. Dated April 10, 2019.

Tables

Monthly Crop Consumptive Use

Month	Grain and Grain Hay	Truck	Corn and Silage	Misc Field Crops	Grapes	Cotton	Deciduous & Fruit Trees	Alfalfa, Pasture	Nuts
	Consumptive Use (acre-ft/acre per month)	Consumptive Use (acre-ft/acre per month)	Consumptive Use (acre-ft/acre per month)	Consumptive Use (acre-ft/acre per month)	Consumptive Use (acre-ft/acre per month)	Consumptive Use (acre-ft/acre per month)	Consumptive Use (acre-ft/acre per month)	Consumptive Use (acre-ft/acre per month)	Consumptive Use (acre-ft/acre per month)
January	0.0631	0.0654	0.0000	0.0638	0.0627	0.0661	0.0655	0.0727	0.0666
Febuary	0.1362	0.0916	0.0000	0.0528	0.0556	0.0705	0.0728	0.1604	0.0729
March	0.2708	0.2445	0.0000	0.0689	0.0307	0.0092	0.0652	0.2829	0.0825
April	0.3941	0.3986	0.0000	0.1057	0.1147	0.1066	0.2591	0.4054	0.2797
May	0.2258	0.1097	0.1672	0.1620	0.2672	0.1288	0.5535	0.4944	0.4300
June	0.0000	0.0228	0.4521	0.4560	0.3819	0.4033	0.5758	0.5147	0.4440
July	0.0000	0.0006	0.5198	0.4681	0.3754	0.6839	0.5574	0.4931	0.4643
August	0.0000	0.0648	0.3509	0.1585	0.2991	0.6210	0.5029	0.4302	0.3805
September	0.0000	0.0887	0.0271	0.0011	0.1525	0.4401	0.3711	0.3359	0.2822
October	0.0186	0.0782	0.0194	0.0190	0.0301	0.1204	0.1917	0.1375	0.1288
November	0.0501	0.0811	0.0000	0.0494	0.0491	0.0659	0.0629	0.0917	0.0520
December	0.0676	0.0735	0.0000	0.0655	0.0656	0.0874	0.0843	0.0832	0.0698
Total:	1.23	1.32	1.54	1.67	1.88	2.80	3.36	3.50	2.75

Table 2

Water Budget Area Irrigation Efficiencies

Water Budget Area	Irrigation Efficiency	
	1986 - 2002	2003 - 2017
1	NA	NA
2	0.81	0.83
3	0.75	0.79
4	0.87	0.87
5	0.83	0.86
6	0.76	0.82
7	0.87	0.87
8	0.85	0.85
9	0.85	0.85
10	0.72	0.76
11	0.75	0.78
12	0.81	0.86
13	0.74	0.79
14	0.74	0.77
15	0.77	0.84
16	0.76	0.77
17	0.72	0.83
18	0.75	0.77
19	0.87	0.87
20	0.74	0.78
21	0.83	0.85
22	0.72	0.76
23	0.76	0.79
24	0.71	0.74
25	0.72	0.72
26	0.74	0.74
27	0.75	0.69
28	0.76	0.76
29	0.77	0.77
30	0.76	0.78
31	0.76	0.79
32	0.78	0.82
33	0.84	0.87

Table 3

Summary of Pumping Test Data

State Well Number	DWR Number or Well Name	Well Owner	Northing[1]	Easting[1]	Year of Pumping Test	Pumping Test Type[2]	Pumping Duration (hours)	Specific Capacity (gpm/ft)[3]	Estimated Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Model Layer(s)	Aquifer[4]
20S/22E-03	69299	Private	1964458	6393954	1961	N/A[5]	N/A	10	3,580	8.1	1,2,3	C
20S/22E-11D	30877	Corcoran Irrigation District	1960307	6395313	1968	Short-Term	5	58	18,460	29	2,3	C
20S/22E-12	93080	Corcoran Irrigation District	1957724	6402835	1962	N/A	N/A	44	18,070	15	1,2,3	C
20S/22E-14	816223	Corcoran Irrigation District	1952412	6395485	2005	N/A	N/A	53	18,440	38	1,2,3	C
20S/22E-22	E0088663	Corcoran Irrigation District	1948606	6391849	2008	N/A	N/A	71	29,260	70	3	L
20S/22E-23	52338	Corcoran Irrigation District	1945904	6397224	1977	Short-Term	12	52	16,820	36	2,3	C
20S/22E-23	E0089134	Private	1946826	6397596	2008	N/A	N/A	18	7,170	38	2,3	C
20S/22E-23	30853	Private	1946788	6397137	N/A	N/A	N/A	71	25,030	40	1,2,3	C
20S/22E-24	23069	Corcoran Irrigation District	1946972	6402910	1966	N/A	N/A	10	3,330	6.5	1,2,3	C
20S/22E-25	23097	Corcoran Irrigation District	1941725	6402809	1967	N/A	N/A	37	13,000	19	1,2,3	C
20S/22E-26	816208	Corcoran Irrigation District	1942115	6396942	2005	N/A	N/A	22	8,890	59	2,3	C
20S/22E-26	816208	Corcoran Irrigation District	1942176	6397777	2005	N/A	N/A	22	8,890	59	2,3	C
20S/22E-33	E067353	Corcoran Irrigation District	1936561	6386700	2007	N/A	N/A	28	11,390	60	2,3	C
20S/22E-34	E064073	Corcoran Irrigation District	1934773	6394290	2007	N/A	N/A	53	21,560	65	3	L
20S/22E-34	23096	Corcoran Irrigation District	1936572	6392187	1967	N/A	N/A	37	15,120	54	3	L
20S/24E-26	51339	Private	1943782	6461424	1970	N/A	N/A	92	32,250	81	1,2,3	C
20S/24E-32	23065	Private	1934397	6444318	N/A	N/A	N/A	50	14,250	34	1,2,3	C
20S/24E-36	63090	Private	1937445	6466482	1960	N/A	N/A	15	4,390	44	1	U
20S/25E-26	77730	Private	1943785	6494191	1963	Short-Term	7	12	2,830	13	1,2,3	C
20S/25E-26	16908	Private	1941527	6493089	1960	N/A	N/A	30	11,840	118	1	U
20S/25E-32	817526	Private	1935863	6475757	1999	Short-Term	8	33	10,550	39	1,2,3	C
20S/26E-24	489251	Private	1943619	6529476	1992	Long-Term	12	13	3,010	17	2,3	C
20S/27E-19	104868	Private	1946702	6534872	1968	Short-Term	14	1.7	370	1.9	3	L
20S/27E-23	457006	N/A	1947311	6554769	1993	Short-Term	13	3.0	670	3.2	1,2,3	C
20S/27E-24	70661	Private	1944626	6561411	1972	Long-Term	24	1.0	220	2.4	2	U
20S/27E-24	104912	Private	1944010	6558821	N/A	N/A	N/A	5.4	1,540	7.3	1,2,3	C
20S/27E-26J	29264	Private	1941327	6556243	N/A	N/A	N/A	60	17,100	90	2,3	C
20S/27E-28	488474	N/A	1940323	6544742	1994	Short-Term	2.5	2.1	420	6.9	2,3	C
20S/27E-29	111529	Private	1941443	6540274	1965	N/A	N/A	50	14,250	475	3	L
20S/27E-30	24440	Private	1939464	6535006	1968	Short-Term	8.5	5.6	1,270	8.5	2,3	C
20S/27E-33	104875	Private	1935664	6544484	1970	Short-Term	4	12	2,750	13	2,3	C
20S/27E-33	93487	Strathmore Public Utilities District	1936750	6544158	1964	N/A	N/A	2.3	660	2.3	2,3	C
20S/27E-36	145307	Private	1934775	6561597	1976	Short-Term	8	1.6	340	3.4	2	U
20S/27E-36	145311	Private	1938414	6560586	1976	Short-Term	6	7.9	1,790	9.0	1,2,3	C

Summary of Pumping Test Data

State Well Number	DWR Number or Well Name	Well Owner	Northing[1]	Easting[1]	Year of Pumping Test	Pumping Test Type[2]	Pumping Duration (hours)	Specific Capacity (gpm/ft)[3]	Estimated Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Model Layer(s)	Aquifer[4]
20S/27E-36	145312	Private	1938643	6562660	1976	N/A	N/A	3.6	1,030	5.6	1,2,3	C
21S/22E-01	726707	Corcoran Irrigation District	1930975	6402045	2002	Long-Term	47.83	2.1	770	1.8	2,3	C
21S/22E-01	726941	Corcoran Irrigation District	1930710	6403161	2004	N/A	N/A	44	17,830	41	3	L
21S/22E-01	816298	Corcoran Irrigation District	1934102	6399776	2005	N/A	N/A	31	12,830	32	3	L
21S/22E-01	E049826	Corcoran Irrigation District	1933595	6399594	2006	N/A	N/A	25	10,250	37	2,3	C
21S/22E-01	E049834	Corcoran Irrigation District	1933591	6399671	2006	N/A	N/A	46	13,050	50	1,2	C
21S/22E-02	1095719	City of Corcoran	1932572	6396670	2004	Long-Term	24	16	5,070	7.9	1,2,3	C
21S/22E-03	394345	Private	1933561	6388968	1992	Short-Term	2	6.0	1,260	12	1	U
21S/22E-24	93089	Private	1915216	6400010	1963	N/A	N/A	17	7,130	10	3	L
21S/22E-25	e077132	Private	1910179	6399351	2008	Long-Term	44	48	19,440	20	3	L
21S/22E-34	E077079	Private	1902762	6387498	2008	Long-Term	40	35	13,910	21	3	L
21S/23E-24	458728	Private	1915152	6430754	1996	N/A	N/A	50	14,250	356	1	U
21S/23E-25	Well #1	Private	1912488	6432652	2008	Long-Term	37	9.3	3,550	5.7	3	L
21S/23E-32	726554	Private	1901947	6409656	2001	N/A	N/A	1.0	280	3.5	1	U
21S/23E-34	726586	Private	1902306	6421830	2001	N/A	N/A	3.8	1,560	7.8	2,3	C
21S/23E-34Q01	34Q1	Private	1902308	6421770	2001	Long-Term	35	3.8	1,410	10	2,3	C
21S/23E-36	N/A	N/A	1906615	6434185	1966	Short-Term	1	27	5,860	34	1	U
21S/23E-36	23053	Private	1904603	6432254	N/A	N/A	N/A	27	7,610	38	1	U
21S/23E-6P1	112310	City of Corcoran	1928880	6405443	1975	Long-Term	24	41	10,790	43	1,2	C
21S/23E-7	515951	City of Corcoran	1927957	6405612	1997	Short-Term	12	0.5	170	0.3	2,3	C
21S/23E-7D1	112307	City of Corcoran	1927686	6403833	1975	Long-Term	24	34	9,000	33	1,2	C
21S/24E-15H01	15H1	Private	1921654	6455927	1979	Short-Term	3	17	3,800	95	1	U
21S/25E-17	517127	Private	1918909	6474558	2001	N/A	N/A	7.1	2,020	14	1	U
21S/25E-31	23057	Private	1901978	6468938	1966	N/A[4]	N/A	30	8,550	47	2,3	C
21S/26E-10	81896	Private	1926630	6519517	1965	Short-Term	6.5	10	2,380	15	2,3	C
21S/26E-14R01	14R1	N/A	1917675	6524644	2009	Short-Term	3	8.3	1,810	45	2	U
21S/26E-15B02	15B2	N/A	1922308	6517928	1992	Short-Term	3	1.9	380	3.8	1,2	C
21S/26E-28	R-7	City of Porterville	1907421	6543355	1979	N/A	N/A	17	4,930	123	1,2	C
21S/26E-34	27803	Poplar CSD	1903301	6519268	1966	N/A	N/A	55	15,530	55	1,2,3	C
21S/26E-34	748825	Private	1906530	6518086	2001	Short-Term	12	4.5	1,030	9.0	3	L
21S/27E-06	29627	Private	1931317	6533292	1980	Short-Term	5	13	2,880	90	2	U
21S/27E-1	145308	Private	1933470	6559675	N/A	N/A	N/A	3.2	910	9.1	2,3	C
21S/27E-1	145309	Private	1933496	6561552	N/A	N/A	N/A	1.8	510	5.1	2	U
21S/27E-21	C-29	City of Porterville	1912585	6541526	2006	N/A	N/A	7.7	2,700	10	4	L
21S/27E-22	C-10	City of Porterville	1913697	6550312	1968	N/A	N/A	5.6	1,600	4.8	2,3,4	C

Summary of Pumping Test Data

State Well Number	DWR Number or Well Name	Well Owner	Northing[1]	Easting[1]	Year of Pumping Test	Pumping Test Type[2]	Pumping Duration (hours)	Specific Capacity (gpm/ft)[3]	Estimated Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Model Layer(s)	Aquifer[4]
21S/27E-22	40862	City of Porterville	1913430	6549953	N/A	N/A	N/A	17	4,820	15	2,3,4	C
21S/27E-24	53069	Private	1913654	6561699	N/A	N/A	N/A	1.3	370	2.1	1,2	C
21S/27E-24	64151	Private	1915011	6559028	N/A	N/A	N/A	1.5	430	1.1	1,2,3,4	C
21S/27E-25	64157	Private	1909663	6559097	N/A	N/A	N/A	1.9	540	2.7	1,2	C
21S/27E-25	19552	City of Porterville	1909780	6556729	N/A	N/A	N/A	5.0	1,420	10	2,3	C
21S/27E-25N01	C-11	City of Porterville	1907493	6557878	1959	N/A	N/A	3.6	1,260	4.9	3,4,5	C
21S/27E-25N1	53062	City of Porterville	1907680	6558074	1959	N/A	N/A	1.6	460	2.3	1	U
21S/27E-26	63436	City of Porterville	1908059	6553404	1960	Long-Term	24	2.2	500	1.5	2,3,4,5	C
21S/27E-26	C-16	City of Porterville	1912334	6546977	1978	N/A	N/A	11	3,860	13	3,4	C
21S/27E-26	C-21	City of Porterville	1909465	6555799	1987	N/A	N/A	18	4,990	55	2,3	C
21S/27E-26	C-3	City of Porterville	1907493	6555834	1961	N/A	N/A	4.1	1,440	4.4	3,4,5	C
21S/27E-26	C-6	City of Porterville	1910828	6553898	1949	N/A	N/A	14	3,930	12	2,3,4	C
21S/27E-26	19561	City of Porterville	1911164	6552505	1957	N/A	N/A	37	10,460	52	1	U
21S/27E-27	498597	Private	1912701	6549072	1992	Short-Term	1.5	21	4,650	52	2,3	C
21S/27E-27	L-7	City of Porterville	1909250	6549810	1979	N/A	N/A	25	7,210	60	1,2,3	C
21S/27E-27	C-17	City of Porterville	1907708	6547479	1986	N/A	N/A	13	3,620	19	3,4	C
21S/27E-27	C-20	City of Porterville	1910039	6546260	1988	N/A	N/A	4.3	1,230	4.9	2,3	C
21S/27E-27	L-1	City of Porterville	1908999	6547300	1958	N/A	N/A	16	4,620	33	1,2	C
21S/27E-28	C-18	City of Porterville	1912334	6544215	1986	N/A	N/A	7.6	2,660	5.0	1,2,3,4	C
21S/27E-28	L-8	City of Porterville	1911258	6542709	1979	N/A	N/A	11	3,220	22	1,2	C
21S/27E-28	C-22	City of Porterville	1907708	6545829	1996	N/A	N/A	21	6,070	24	1,2,3	C
21S/27E-28	L-5	City of Porterville	1907672	6544789	1967	N/A	N/A	28	8,010	57	1,2	C
21S/27E-34	942147	Private	1906000	6547259	2008	Short-Term	8	20	4,830	59	1,2	C
21S/27E-35	C-19	City of Porterville	1903943	6553862	1986	N/A	N/A	3.3	1,160	3.3	1,2,3,4,5	C
21S/27E-35	C-23	City of Porterville	1904983	6551459	1991	N/A	N/A	6.3	1,800	7.2	2,3,4	C
21S/27E-35	C-4	City of Porterville	1905628	6555117	1934	N/A	N/A	7.3	2,080	6.8	1,2,3	C
21S/27E-35F01	C-7	City of Porterville	1905556	6553217	1949	N/A	N/A	12	4,100	9.5	2,3,4,5	C
21S/27E-36	942151	Private	1902608	6558254	2009	Short-Term	4	0.4	70	1.1	1,2	C
21S/27E-36	e064534	Private	1904102	6556817	2007	Short-Term	4	0.2	40	0.5	1,2	C
21S/27E-36	e066452	Private	1903836	6559685	2007	Short-Term	0.75	0.1	30	0.9	1	U
21S/27E-36F01	C-8	City of Porterville	1906202	6557914	1965	N/A	N/A	5	1,480	4.2	1,2,3,4	C
22S/22E-02	E077072	Private	1901958	6397829	2008	Long-Term	40.5	39	15,640	23	3	L
22S/22E-02	E077119	Private	1897903	6397617	2008	Long-Term	38	55	22,290	13	3	L
22S/22E-03	101797	Private	1899103	6392312	1977	Long-Term	40	60	24,350	24	2,3	C
22S/22E-03	E077103	Private	1899874	6392401	2008	Long-Term	41.75	61	24,510	41	3	L

Summary of Pumping Test Data

State Well Number	DWR Number or Well Name	Well Owner	Northing[1]	Easting[1]	Year of Pumping Test	Pumping Test Type[2]	Pumping Duration (hours)	Specific Capacity (gpm/ft)[3]	Estimated Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Model Layer(s)	Aquifer[4]
22S/22E-09	N/A	Private	1894109	6384592	2008	N/A	N/A	31	12,540	22	3	L
22S/22E-10	489122	Private	1895519	6391555	1994	Long-Term	36	46	18,420	34	3	L
22S/22E-9	E072646	Private	1894097	6384597	2008	N/A	N/A	31	12,540	157	3	L
22S/23E-05	E0079777	Private	1896575	6410653	2008	Short-Term	6	3.8	1,330	3.0	2,3	C
22S/23E-05	E0079779	Private	1867655	6426985	2008	N/A	N/A	5.0	2,050	3.1	3	L
22S/23E-06	69286	Private	1899108	6406730	1961	N/A	N/A	14	3,930	15	1,2	C
22S/23E-06	69271	Private	1899594	6404681	N/A	N/A	N/A	13	3,790	14	1,2	C
22S/23E-15	30891	Private	1886811	6423555	1970	Short-Term	4.5	40	9,600	53	1	U
22S/23E-17	489121	Private	1891332	6410938	1994	Long-Term	36	46	18,170	44	2,3	C
22S/23E-17	489124	Private	1891389	6389758	1994	Long-Term	30	19	7,320	11	2,3	C
22S/23E-18	30889	Private	1887434	6408224	1970	Short-Term	4	33	7,970	40	1	U
22S/23E-33	W7	Angiola W.D.	1875526	6418412	2007	N/A	N/A	26	7,290	10	2,3	C
22S/23E-33	W14	Angiola W.D.	1873383	6418660	2007	N/A	N/A	14	3,960	17	1,2	C
22S/23E-21	W13	Angiola W.D.	1873370	6418665	1997	N/A	N/A	39	15,900	15	3	L
22S/23E-21	W13	Angiola W.D.	1873370	6418665	2002	N/A	N/A	30	8,610	8	3	L
22S/23E-33	W18	Angiola W.D.	1875511	6417588	2015	N/A	N/A	16	N/A	N/A	N/A	N/A
22S/23E-21	G16	Angiola W.D.	1882036	6416141	1997	N/A	N/A	11	3,110	13	1,2	C
22S/23E-21	G18	Angiola W.D.	1883404	6416263	1997	N/A	N/A	23	9,470	30	3	L
22S/23E-21	G18	Angiola W.D.	1883404	6416263	2007	N/A	N/A	14	3,900	12	3	L
22S/23E-21	G19	Angiola W.D.	1880947	6416260	1997	N/A	N/A	38	15,490	55	3	L
22S/23E-21	G19	Angiola W.D.	1880947	6416260	2007	N/A	N/A	17	4,700	17	3	L
22S/23E-21L1	G1	Angiola W.D.	1883434	6416104	1997	N/A	N/A	8.1	2,310	12	1,2	C
22S/23E-21L1	G1	Angiola W.D.	1883434	6416104	2007	N/A	N/A	6.4	1,820	9	1,2	C
22S/23E-22	E072308	Angiola WD	1881613	6419172	2008	N/A	N/A	33	13,650	38	3	L
22S/23E-22	69285	Private	1883399	6421610	N/A	N/A	N/A	11	3,160	15	1,2	C
22S/23E-23	E-5	Angiola W.D.	1882044	6427880	1948	N/A	N/A	57	23,280	47	1	U
22S/23E-23	E-5	Angiola W.D.	1882044	6427880	2007	N/A	N/A	15	4,190	8	1	U
22S/23E-23	E-1	Angiola W.D.	1882043	6424309	1997	N/A	N/A	27	10,940	22	1	U
22S/23E-23	E-19	Angiola W.D.	1880938	6424567	1997	N/A	N/A	38	15,410	48	3	L
22S/23E-23	E-19	Angiola W.D.	1880938	6424567	2007	N/A	N/A	20	5,760	18	3	L
22S/23E-23J1	E-14	Angiola W.D.	1883355	6429374	2007	N/A	N/A	38	10,880	9	3	L
22S/23E-23J1	E-14	Angiola W.D.	1883355	6429374	1997	N/A	N/A	57	23,520	20	3	L
22S/23E-24	E064735	Angiola Water District	1883487	6433497	2007	N/A	N/A	42	17,210	172	3	L
22S/23E-25	E0078570	Angiola WD	1878313	6431119	2008	Long-Term	35	28	11,020	23	3	L
22S/23E-25	E-10	Angiola W.D.	1879483	6434628	1997	N/A	N/A	23	9,470	19	1	U

Summary of Pumping Test Data

State Well Number	DWR Number or Well Name	Well Owner	Northing[1]	Easting[1]	Year of Pumping Test	Pumping Test Type[2]	Pumping Duration (hours)	Specific Capacity (gpm/ft)[3]	Estimated Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Model Layer(s)	Aquifer[4]
22S/23E-25	E-10	Angiola W.D.	1882044	6427880	2007	N/A	N/A	17	4,900	10	1	U
22S/23E-25	E-15	Angiola W.D.	1882044	6427880	2002	N/A	N/A	46	12,990	30	2,3	C
22S/23E-25	E-15	Angiola W.D.	1880672	6434027	1997	N/A	N/A	57	23,160	54	2,3	C
22S/23E-25	E-25	Angiola W.D.	1879532	6434581	2015	N/A	N/A	9	N/A	N/A	N/A	N/A
22S/23E-23	E-26	Angiola W.D.	1881019	6424628	2015	N/A	N/A	19	N/A	N/A	N/A	N/A
22S/23E-23	E-27	Angiola W.D.	1883431	6428305	2015	N/A	N/A	14	N/A	N/A	N/A	N/A
22S/23E-25	G25	Angiola W.D.	1875835	6419974	2010	N/A	N/A	16	4,560	19	1,2	C
22S/23E-25	G25	Angiola W.D.	1875835	6419974	2007	N/A	N/A	28.9	8,230	34.3	1,2	C
22S/23E-25F1	E-13	Angiola W.D.	1878305	6431117	1997	N/A	N/A	54	N/A	N/A	3	L
22S/23E-25F1	E-13	Angiola W.D.	1878305	6431117	2007	N/A	N/A	33	9,260	8	3	L
22S/23E-26	E-16	Angiola W.D.	1880723	6429293	1997	N/A	N/A	42	17,250	39	2,3	C
22S/23E-26	E-16	Angiola W.D.	1880723	6429293	2007	N/A	N/A	33	9,490	22	2,3	C
22S/23E-26	E-18	Angiola W.D.	1880789	6426889	1997	N/A	N/A	36	14,840	42	3	L
22S/23E-26	E-18	Angiola W.D.	1880789	6426889	2007	N/A	N/A	31	8,920	25	3	L
22S/23E-27	G11	Angiola W.D.	1877992	6421183	1997	N/A	N/A	60	24,430	49	1	U
22S/23E-27	G11	Angiola W.D.	1877992	6421183	2007	N/A	N/A	50	14,190	28	1	U
22S/23E-27	G14	Angiola W.D.	1875835	6419974	1997	N/A	N/A	4.4	1,250	13	1	U
22S/23E-27F1	W6	Angiola W.D.	1878271	6420551	2002	N/A	N/A	7.6	2,170	10	1,2	C
22S/23E-27F1	W6	Angiola W.D.	1878271	6420551	1997	N/A	N/A	6.1	1,740	8.3	1,2	C
22S/23E-28	G2 (new)	Angiola W.D.	1880493	6416151	1997	N/A	N/A	12	3,530	17	1,2	C
22S/23E-28	G20	Angiola W.D.	1878490	6416188	1997	N/A	N/A	15	6,150	10	1,2,3	C
22S/23E-28	G20	Angiola W.D.	1878490	6416188	2007	N/A	N/A	11	3,130	5	1,2,3	C
22S/23E-28	G23	Angiola W.D.	1882036	6416141	2010	N/A	N/A	3.6	1,030	4.9	1	U
22S/23E-28	G24	Angiola W.D.	1880147	6416158	2010	N/A	N/A	7.1	2,020	10	1,2	C
22S/23E-28	G29	Angiola W.D.	1878490	6416188	2010	N/A	N/A	15	6,190	17	3	L
22S/23E-27	G30	Angiola W.D.	1876132	6420248	2015	N/A	N/A	13	N/A	N/A	N/A	N/A
22S/23E-28A1	G3	Angiola W.D.	1880729	6417584	2007	N/A	N/A	10	2,820	9	1,2	C
22S/23E-28A1	G3	Angiola W.D.	1880729	6417584	1997	N/A	N/A	10	2,960	10	1,2	C
22S/23E-28J1	G5	Angiola W.D.	1878153	6418746	2007	N/A	N/A	9	1,250	4	1,2	C
22S/23E-28J1	G5	Angiola W.D.	1878153	6418746	1997	N/A	N/A	18	5,100	17	1,2	C
22S/23E-29	60512	Private	1878299	6410919	N/A	N/A	N/A	12	3,390	15	1,2	C
22S/23E-3	394406	Private	1896917	6421603	1992	N/A	N/A	15	4,270	61	1	U
22S/23E-33	Well 15	Angiola W.D.	1870545	6418643	2008	Long-Term	30	12	4,380	15	3	L
22S/23E-33	E077032	Angiola Water District	1870498	6418613	2008	N/A	N/A	12	4,710	20	3	L
22S/23E-34	E059018	Angiola Water District	1873846	6418472	2007	N/A	N/A	50	20,490	49	3	L

Summary of Pumping Test Data

State Well Number	DWR Number or Well Name	Well Owner	Northing[1]	Easting[1]	Year of Pumping Test	Pumping Test Type[2]	Pumping Duration (hours)	Specific Capacity (gpm/ft)[3]	Estimated Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Model Layer(s)	Aquifer[4]
22S/23E-27	G21	Angiola Water District	1876256	6420150	2007	N/A	N/A	8	1,180	4	2,3	C
22S/23E-34	G22	Angiola W.D.	1873673	6423686	1997	N/A	N/A	3.0	1,230	3.8	3	L
22S/23E-34	G26	Angiola W.D.	1873673	6423686	2010	N/A	N/A	56.5	8,050	19.2	3	L
22S/23E-34	G26	Angiola W.D.	1873673	6423686	2010	N/A	N/A	101	41,560	99	3	L
22S/23E-34	G27	Angiola W.D.	1871634	6419991	2010	N/A	N/A	27	11,190	33	3	L
22S/23E-34	G28	Angiola W.D.	1870490	6423818	2010	N/A	N/A	13	5,160	14	3	L
22S/23E-6	60743	Private	1901983	6405985	1960	N/A	N/A	11	3,080	10	1,2	C
22S/24E-04	715329	Private	1896720	6446743	2000	Short-Term	4	33	10,270	38	1,2,3	C
22S/24E-6L	23071	Private	1899259	6437368	1966	N/A	N/A	22	6,270	31	1	U
22S/25E-19	23094	Private	1883307	6471350	1967	N/A	N/A	73	25,690	61	2,3	C
22S/26E-12	145318	Private	1896566	6524621	1977	Short-Term	4	35	8,500	43	1,2,3	C
22S/26E-16	489115	Private	1889982	6511214	1993	Long-Term	30	5.4	1,680	5.8	3	L
22S/26E-24	E0094537	Private	1881999	6529798	2009	Short-Term	12	14	5,100	9.3	3,4	C
22S/27E-01	81882	Private	1900689	6557479	1963	Short-Term	12	20	5,040	41	1,2	C
22S/27E-02B02	C-13	City of Porterville	1901145	6554185	1965	N/A	N/A	4.3	1,510	2.7	2,3,4,5	C
22S/27E-04	C-28	City of Porterville	1898492	6555368	2005	N/A	N/A	3.9	1,370	3.3	1,2,3,4,5	C
22S/27E-08B01	AP-2	City of Porterville	1892754	6539159	1969	N/A	N/A	11	3,790	8.4	3,4	C
22S/27E-09G01	AP-1	City of Porterville	1893220	6545040	1959	N/A	N/A	3.7	1,300	3.1	3,4	C
22S/27E-111	258408	Private	1894126	6555327	1987	N/A	N/A	1.9	540	7.1	1,2	C
22S/27E-14	29629	Private	1887668	6552052	1980	Short-Term	3	2.0	400	5.0	1,2	C
22S/27E-2	C-15	City of Porterville	1909645	6554866	1975	N/A	N/A	4.7	1,340	11	2,3	C
22S/27E-2	68313	Private	1897922	6556137	1970	N/A	N/A	9.1	2,590	108	1	U
22S/27E-23	C-1	City of Porterville	1909465	6557627	1982	N/A	N/A	20	5,810	48	2,3	C
22S/27E-24	48679	Private	1882267	6557577	1985	Long-Term	24	1.9	560	2.8	4,5	C
22S/27E-36	394404	Private	1870648	6560234	1992	Short-Term	4	0.4	70	0.5	1,2	C
23S/23E-27	E0080474	Private	1845436	6419740	2008	Long-Term	40	7.5	2,850	4.5	3	L
23S/23E-34	1095876	Alpaugh JPA	1842264	6418966	2004	Short-Term	12	13	4,910	27	3	L
23S/23E-4	E077033	Angiola Water District	1867979	6418614	2008	N/A	N/A	10	4,220	35	3	L
23S/24E-21	17959	Pixley Wildlife Refuge	1851746	6447543	N/A	N/A	N/A	6.0	2,460	8.2	3	L
23S/25E-11	23083	Private	1862033	6490060	1962	N/A	N/A	5.0	1,750	5.8	1,2	C
23S/25E-16N4	55087	U.S. Geological Survey	1855362	6477883	1959	N/A	N/A	4.0	1,140	28	1,2	C
23S/25E-27P01	3	DEID	1826671	6508537	2010	Step Test	12	26	6,440	7.0	3	L
23S/25E-28J02	2	DEID	1826688	6507154	2010	Step Test	12	26	6,720	7.0	3	L
23S/25E-33	944088	Private	1839910	6478963	2008	Short-Term	2	5.0	1,390	2.9	2,3	C
23S/25E-35G01	5	DEID	1826049	6506009	2010	Step Test	12	41	9,680	11	3	L

Summary of Pumping Test Data

State Well Number	DWR Number or Well Name	Well Owner	Northing[1]	Easting[1]	Year of Pumping Test	Pumping Test Type[2]	Pumping Duration (hours)	Specific Capacity (gpm/ft)[3]	Estimated Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Model Layer(s)	Aquifer[4]
23S/25E-6P1	37263	Private	1865081	6468973	1956	Short-Term	20	44	14,470	49	2,3	C
23S/27E-03	120307	Terra Bella Irrigation District	1867501	6550348	1968	Short-Term	20	2.0	590	1.5	2,3,4	C
23S/27E-07	942277	Private	1859684	6531568	2008	Short-Term	16	2.4	850	0.7	3,4,5	C
23S/27E-12	942269	Private	1859644	6558813	2008	N/A	N/A	29	11,930	11	4	L
23S/27E-19R1	14164	Private	1849038	6535105	1957	Short-Term	6	95	36,620	38	3,4,5	C
23S/27E-20	16380	Private	1850262	6537921	1960	N/A	N/A	52	21,150	23	3,4,5	C
23S/27E-21	512022	Private	1854221	6541118	2002	Short-Term	8	0.6	160	0.4	2,3	C
23S/27E-27	925804	Private	1844925	6546660	2004	Long-Term	24	5.7	2,110	6.0	4,5	C
23S/27E-27	120303	Private	1846254	6543059	1967	N/A	N/A	1.8	630	0.9	2,3,4	C
23S/27E-33	e077722	Private	1840078	6543427	2008	Short-Term	3	34	12,400	13	4,5	C
23S/27E-34	E059519	Private	1839736	6548507	2007	Short-Term	8	77	29,840	30	4,5	C
23S/27E-7	104854	Private	1862230	6534629	1966	N/A	N/A	2.7	950	2.4	2,3	C
23S/27E-8	53055	Private	1863543	6536385	1958	N/A	N/A	1.3	370	1.2	2,3	C
24S/23E-29B	N/A	Tri County	1817447	6410754	N/A	Long-Term	12 to 24	26	4,950	15	3	L
24S/23E-30B	N/A	Tri County	1817561	6405468	N/A	Long-Term	12 to 24	52	11,900	22	3	L
24S/23E-3P	146126	Private	1835941	6421173	1978	N/A	N/A	47	16,370	55	1,2,3	C
24S/24E-14R	N/A	Tri County	1822868	6460904	N/A	Long-Term	12 to 24	30	4,810	5.9	3	L
24S/24E-1G	49066	Private	1836050	6463568	1982	Short-Term	12	74	28,830	39	3	L
24S/24E-22M	N/A	Tri County	1819619	6450477	N/A	Long-Term	12 to 24	27	7,890	12	3	L
24S/24E-23D	N/A	Tri County	1822669	6456143	N/A	Long-Term	12 to 24	10	3,340	4.5	3	L
24S/24E-23R	N/A	Tri County	1817617	6459648	N/A	Long-Term	12 to 24	20	3,740	4.5	3	L
24S/24E-24Q	N/A	Tri County	1817603	6464981	N/A	Long-Term	12 to 24	8.6	4,140	5.8	3	L
24S/24E-27F	N/A	Tri County	1814907	6451725	N/A	Long-Term	12 to 24	23	4,950	6.1	3	L
24S/24E-28R	N/A	Tri County	1812293	6449947	N/A	Long-Term	12 to 24	38	10,160	12	3	L
24S/24E-36E	58330	Private	1833430	6453091	1959	N/A	N/A	47	13,280	443	1	U
24S/24E-36E	N/A	Tri County	1809791	6460999	N/A	Long-Term	12 to 24	17	4,550	4.8	3	L
24S/25E-10	942275	Private	1832319	6484774	2008	Short-Term	16	16	4,930	11	3	L
24S/25E-19R	N/A	Tri County	1817586	6470931	N/A	Long-Term	12 to 24	14	2,010	5.3	3	L
24S/25E-20B	N/A	Tri County	1821475	6474297	N/A	Long-Term	12 to 24	19	8,960	12	3	L
24S/25E-30H	N/A	Tri County	1814947	6471559	N/A	Long-Term	12 to 24	19	3,880	5.2	3	L
24S/26E-15	N/A	Private	1827763	6516494	2008	Short-Term	6	13	4,540	3.5	3,4	C
24S/26E-17	942284	DEID	1826745	6505884	2008	Short-Term	12	11	3,330	4.2	3	L
24S/26E-17	1	DEID	1827088	6506032	2009	Step Test	12	30	5,530	7.0	3	L
24S/26E-17	4	DEID	1827967	6508026	2010	Step Test	12	19	4,450	5.0	3,4	C
24S/26E-22	N/A	Private	1817592	6516518	2008	Short-Term	6	7.8	2,310	3.8	3,4	C

Summary of Pumping Test Data

State Well Number	DWR Number or Well Name	Well Owner	Northing[1]	Easting[1]	Year of Pumping Test	Pumping Test Type[2]	Pumping Duration (hours)	Specific Capacity (gpm/ft)[3]	Estimated Transmissivity (ft^2/day)	Estimated Hydraulic Conductivity (ft/day)	Model Layer(s)	Aquifer[4]
24S/26E-30	e0094489	Private	1814991	6503110	2009	Short-Term	12	9.0	3,310	5.3	3	L
24S/27E-31	489110	Private	1812175	6530537	1992	Short-Term	14.5	0.1	10	0.1	3	L
25S/22E-1B	N/A	Tri County	1806903	6397730	N/A	Long-Term	12 to 24	65	13,900	30	2,3	C
25S/22E-2A	N/A	Tri County	1807009	6395021	N/A	Long-Term	12 to 24	58	18,050	41	2,3	C
25S/25E-17G	N/A	Tri County	1795022	6471792	N/A	Long-Term	12 to 24	21	4,010	9.1	3	L
25S/25E-5B	N/A	Tri County	1806820	6472905	N/A	Long-Term	12 to 24	23	3,340	8.1	3	L
25S/25E-7C	N/A	Tri County	1800572	6466017	N/A	Long-Term	12 to 24	37	11,230	19	3	L
25S/25E-7F	N/A	Tri County	1799281	6466010	N/A	Long-Term	12 to 24	45	11,360	19	3	L

Notes:

[1] NAD 83 California State Plane Zone 4

[2] Short-Term indicates less than 24 hours pumping duration, and long-term indicates 24 hours or more pumping duration.

[3] gpm/ft = gallons per minute per foot of drawdown

[4] U = Upper Aquifer, L = Lower Aquifer, C = Composite Aquifer

[5] N/A = Not Available

Tule Subbasin Historical Surface Water Budget - Inflow

		Surface Water Inflow (acre-ft)																	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
Water Year	Water Year Type	Precipitation	Stream Inflow			Imported Water											Discharge from Wells		Total In
			Tule River	Deer Creek	White River	Saucelito ID	Terra Bella ID	Kern-Tulare WD	Porterville ID	Tea Pot Dome WD	LTRID	Pixley ID	Delano-Earlimart ID	Angiola WD	Alpaugh ID	Atwell Island WD	Agriculture Pumping	Municipal Pumping	
1986 - 1987	Below Average	219,000	70,029	8,389	2,496	23,879	13,136	10,899	15,337	5,490	89,541	9,356	114,782	7,278	794	1,109	724,000	13,500	1,329,000
1987 - 1988	Average	315,000	39,842	6,095	1,420	19,666	21,961	12,210	13,067	5,493	64,654	0	110,345	3,530	0	0	768,000	15,100	1,396,000
1988 - 1989	Below Average	254,000	49,667	7,795	1,942	22,426	22,561	11,991	13,106	6,226	63,922	5,289	105,980	6,026	0	0	728,000	15,700	1,315,000
1989 - 1990	Below Average	245,000	29,342	4,706	778	16,166	23,159	11,371	11,520	6,193	24,325	0	83,837	3,847	0	0	838,000	16,300	1,315,000
1990 - 1991	Average	331,000	51,275	7,247	1,362	19,848	18,725	9,762	11,322	5,636	71,430	0	106,877	925	0	0	799,000	16,700	1,451,000
1991 - 1992	Below Average	285,000	34,325	4,080	739	21,336	20,743	11,700	15,569	6,607	51,949	0	92,567	1,611	0	0	817,000	17,000	1,380,000
1992 - 1993	Above Average	462,000	115,640	15,422	3,623	41,261	18,180	12,357	12,310	6,968	321,973	96,890	133,359	3,420	12,219	6,423	496,000	17,200	1,775,000
1993 - 1994	Below Average	293,000	61,313	6,908	1,148	22,064	18,740	14,255	12,895	6,526	71,784	7,793	92,394	3,640	3,605	2,000	791,000	17,600	1,427,000
1994 - 1995	Above Average	610,000	218,480	32,053	10,596	37,477	16,186	11,681	9,455	6,562	229,683	55,365	124,388	8,918	8,263	5,395	574,000	17,600	1,976,000
1995 - 1996	Average	321,000	174,473	23,095	5,957	48,924	21,617	15,415	13,808	7,993	236,845	60,931	144,069	12,551	11,130	5,267	508,000	17,800	1,629,000
1996 - 1997	Above Average	450,000	353,968	58,781	12,920	40,908	20,158	15,736	13,379	7,298	192,934	37,048	153,967	12,383	0	0	567,000	18,700	1,955,000
1997 - 1998	Above Average	728,000	439,125	88,360	36,764	28,221	13,165	11,745	10,159	4,913	101,180	41,823	119,815	7,460	0	0	630,000	17,900	2,279,000
1998 - 1999	Above Average	373,000	108,466	18,410	7,469	37,062	17,567	14,527	16,107	9,218	183,971	34,736	124,051	9,778	0	0	620,000	18,000	1,592,000
1999 - 2000	Average	354,000	102,354	15,230	4,878	39,734	19,200	16,476	15,545	7,191	177,192	40,076	134,272	8,118	0	253	651,000	18,900	1,604,000
2000 - 2001	Below Average	265,000	55,249	7,016	4,695	25,252	19,194	17,550	15,436	6,456	83,405	9,098	117,746	3,824	0	0	719,000	19,100	1,368,000
2001 - 2002	Below Average	252,000	73,206	10,370	6,176	26,131	20,234	15,088	13,628	6,388	78,511	13,588	126,747	2,932	0	0	713,000	20,900	1,379,000
2002 - 2003	Below Average	247,000	125,004	15,678	5,875	33,692	18,356	14,591	14,646	5,844	131,470	32,195	121,277	4,728	104	0	610,000	20,600	1,401,000
2003 - 2004	Below Average	207,000	51,738	6,882	2,350	26,988	20,352	15,755	14,698	6,913	71,472	9,839	127,364	3,434	0	0	656,000	21,700	1,242,000
2004 - 2005	Above Average	395,000	172,558	22,758	6,502	42,840	15,266	13,495	14,748	5,217	247,595	59,211	119,847	11,741	14,490	0	479,000	20,600	1,641,000
2005 - 2006	Above Average	401,000	195,667	23,868	7,588	45,106	21,763	14,507	13,251	6,436	194,019	60,634	121,005	10,909	16,112	0	490,000	21,600	1,643,000
2006 - 2007	Below Average	170,000	38,587	6,901	1,815	16,280	20,797	15,133	9,775	5,489	33,174	7,200	79,111	6,641	0	0	746,000	22,700	1,180,000
2007 - 2008	Below Average	189,000	74,030	8,411	2,355	24,083	18,192	17,689	12,988	6,894	71,872	12,243	106,470	2,165	0	0	637,000	23,000	1,206,000
2008 - 2009	Below Average	203,000	54,737	6,620	1,751	31,282	19,701	15,524	18,000	6,165	113,189	23,620	111,556	191	2,131	0	660,000	22,500	1,290,000
2009 - 2010	Average	325,000	144,778	16,470	5,080	42,855	17,574	14,027	14,335	5,845	200,064	32,972	118,671	3,243	2,671	0	483,000	21,800	1,448,000
2010 - 2011	Above Average	479,000	266,473	44,873	14,997	46,733	16,381	13,405	9,387	6,105	229,763	48,391	127,447	6,476	10,951	0	514,000	21,800	1,856,000
2011 - 2012	Below Average	302,000	87,533	11,311	3,334	19,189	19,757	14,309	9,318	4,680	67,684	5,914	114,108	3,156	943	0	730,000	22,500	1,416,000
2012 - 2013	Below Average	139,000	30,283	4,777	1,145	14,102	20,628	14,955	10,298	4,354	37,073	5,012	87,302	1,492	0	0	790,000	22,700	1,183,000
2013 - 2014	Below Average	99,000	13,171	2,957	535	5,724	12,390	9,986	178	1,030	0	0	38,106	1,048	0	0	900,000	21,900	1,106,000
2014 - 2015	Below Average	142,000	8,820	1,994	253	1,503	12,012	5,438	114	260	0	0	18,591	575	0	0	890,000	19,700	1,101,000
2015 - 2016	Below Average	217,000	74,330	14,559	4,547	20,049	14,357	11,805	13,271	4,627	73,382	3,442	93,806	587	0	0	614,000	19,700	1,179,000
2016 - 2017	Below Average	227,000	352,963	51,145	17,241	51,137	16,089	14,203	21,651	6,694	273,151	82,363	137,773	12,146	2,367	0	429,000	20,100	1,715,000
86/87-16/17 Avg		306,000	118,300	17,800	5,800	28,800	18,300	13,500	12,600	5,900	122,200	25,600	109,900	5,300	2,800	700	664,000	19,400	1,477,000

Thomas Harder & Co.
Groundwater Consulting

Tule Subbasin Historical Surface Water Budget

Water Year	Water Year Type	Surface Water Outflow (acre-ft)																		
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
		Areal Recharge of Precipitation	Streambed Infiltration					Canal Loss			Recharge in Basins				Deep Percolation of Applied Water					
			Tule River		Native Deer Creek		White River	Tule River	Deer Creek	Imported Water	Tule River	Deer Creek	Imported Water	Recycled Water	Tule River	Deer Creek	Imported Water	Recycled Water	Agricultural Pumping	Municipal Pumping
			Success to Oettle Bridge	Oettle Bridge to Turnbull Weir	Before Trenton Weir	Trenton Weir to Homeland Canal														
1986 - 1987	Below Average	0	11,600	1,100	8,100	0	2,400	20,700	0	52,500	5,400	0	0	2,600	8,500	0	56,100	200	169,900	5,200
1987 - 1988	Average	4,000	8,000	900	5,800	0	1,300	8,800	0	32,700	5,000	0	0	3,200	5,500	0	48,100	200	183,200	5,400
1988 - 1989	Below Average	0	8,700	0	7,500	0	1,800	7,400	0	20,500	6,200	0	0	3,400	6,100	0	51,800	200	172,100	5,600
1989 - 1990	Below Average	0	5,000	0	4,400	0	700	2,900	0	7,400	3,700	0	0	3,600	2,700	0	36,200	200	199,700	5,700
1990 - 1991	Average	7,000	6,400	300	6,900	0	1,300	6,800	0	24,300	5,200	0	0	3,700	5,900	0	46,900	200	190,300	5,800
1991 - 1992	Below Average	1,000	4,300	0	3,800	0	700	3,100	0	16,100	3,700	0	0	3,800	3,500	0	44,700	200	194,900	5,900
1992 - 1993	Above Average	57,000	18,500	3,000	15,100	0	3,500	27,800	0	184,400	8,200	0	5,600	3,900	16,800	0	118,000	200	111,300	6,000
1993 - 1994	Below Average	2,000	6,100	200	6,600	0	1,100	14,200	0	35,600	5,000	0	700	4,000	8,700	0	51,800	200	187,400	6,100
1994 - 1995	Above Average	144,000	36,400	10,400	21,200	1,000	10,500	39,500	3,800	128,500	7,800	1,800	10,400	3,900	34,600	1,000	88,900	200	130,900	6,100
1995 - 1996	Average	5,000	20,700	4,000	13,700	700	5,800	26,200	2,800	87,600	21,200	700	39,500	3,900	31,800	1,200	119,000	200	115,700	6,200
1996 - 1997	Above Average	50,000	34,600	9,700	45,100	1,800	12,800	47,300	6,900	64,200	25,300	1,900	14,100	4,300	31,400	700	117,300	200	130,700	6,300
1997 - 1998	Above Average	219,000	41,100	9,000	14,900	12,700	36,600	79,100	48,800	54,100	32,000	900	16,200	3,900	41,100	3,100	65,200	200	143,800	6,300
1998 - 1999	Above Average	18,000	14,300	2,800	13,300	600	7,300	19,500	2,500	58,200	17,600	400	19,800	3,900	14,100	300	88,700	200	143,200	6,400
1999 - 2000	Average	12,000	16,900	2,900	10,100	600	4,800	11,100	2,400	64,400	8,900	500	13,000	4,200	15,200	300	93,200	200	152,400	6,500
2000 - 2001	Below Average	0	12,300	0	6,700	0	4,600	7,000	0	28,500	5,000	0	2,700	4,300	7,800	0	61,700	200	169,600	6,600
2001 - 2002	Below Average	0	14,800	700	10,100	0	6,100	13,400	0	24,800	5,800	0	100	4,900	9,000	0	65,200	300	169,100	6,900
2002 - 2003	Below Average	0	19,700	3,700	13,600	100	5,800	22,800	400	53,600	12,200	300	5,000	4,800	11,500	200	65,700	200	123,200	6,900
2003 - 2004	Below Average	0	9,900	300	6,600	0	2,300	7,700	0	19,600	3,900	0	0	5,100	6,200	0	57,800	200	134,000	7,100
2004 - 2005	Above Average	26,000	24,200	4,700	14,400	400	6,400	22,900	1,500	91,200	19,000	2,900	32,000	2,400	15,300	700	89,700	500	92,600	7,100
2005 - 2006	Above Average	28,000	28,100	7,200	14,400	900	7,500	40,500	3,400	78,000	23,300	3,200	26,600	2,000	29,300	400	91,000	700	95,700	7,300
2006 - 2007	Below Average	0	6,200	1,500	6,600	0	1,700	5,100	0	15,500	4,300	0	100	2,000	4,800	0	36,000	700	151,600	7,500
2007 - 2008	Below Average	0	11,700	1,100	8,100	0	2,300	15,900	0	22,100	6,900	0	1,600	2,000	7,800	0	45,500	800	129,700	7,600
2008 - 2009	Below Average	0	9,500	1,400	6,300	0	1,600	7,100	0	43,800	5,200	0	8,100	2,000	7,600	0	57,400	700	135,300	7,600
2009 - 2010	Average	6,000	25,600	4,500	16,100	0	5,000	34,600	0	72,700	14,300	0	29,900	2,000	19,200	0	77,700	600	93,900	7,500
2010 - 2011	Above Average	65,000	37,100	7,500	24,400	1,300	14,800	82,400	5,000	89,500	39,000	9,700	45,700	2,000	30,300	1,400	84,700	600	101,900	7,600
2011 - 2012	Below Average	3,000	13,600	300	11,000	0	3,200	17,800	0	23,100	8,100	0	7,000	2,000	11,900	0	46,200	700	151,300	7,700
2012 - 2013	Below Average	0	4,900	0	4,500	0	1,000	4,400	0	13,000	5,300	0	100	2,000	3,400	0	35,000	700	165,100	7,800
2013 - 2014	Below Average	0	2,300	0	2,700	0	400	0	0	0	3,800	0	0	2,000	1,000	0	13,000	600	183,400	7,700
2014 - 2015	Below Average	0	1,000	0	1,800	0	200	0	0	0	3,600	0	0	2,000	1,100	0	5,600	500	178,800	7,500
2015 - 2016	Below Average	0	16,000	5,500	14,300	0	4,400	11,400	0	28,600	6,600	0	3,700	2,000	5,900	0	35,300	400	123,500	7,600
2016 - 2017	Below Average	0	42,100	15,900	37,000	800	17,100	82,600	3,100	133,700	37,300	3,700	61,000	2,000	41,400	1,400	99,000	500	83,300	7,700
86/87-16/17 Avg		21,000	16,500	3,200	12,100	700	5,600	22,300	2,600	50,600	11,600	800	11,100	3,200	14,200	300	64,300	400	145,400	6,700

🟦	Groundwater Inflows to be Included in Sustainable Yield Estimates
🟪	Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
🟨	Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Tule Subbasin Historical Surface Water Budget - Outflow

		Surface Water Outflow (acre-ft)													
		T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	
		Evapotranspiration											Surface Outflow		
			Tule River		Deer Creek		White River	Imported Water		Recycled Water					
Water Year	Water Year Type	Precipitation Crops/Native	Agricultural Cons. Use	Stream Channel	Agricultural Cons. Use	Stream Channel	Stream Channel	Agricultural Cons. Use	Ag. Cons. Use from Pumping	Recharge in Basins	Agricultural Cons. Use	Municipal (Landscape ET)	Tule River	Deer Creek	Total Out
1986 - 1987	Below Average	219,000	24,700	800	0	300	100	183,000	553,900	50	700	4,800	0	0	1,332,000
1987 - 1988	Average	311,000	13,800	400	0	300	100	170,100	584,700	50	900	5,300	0	0	1,399,000
1988 - 1989	Below Average	254,000	17,600	400	0	300	100	185,200	556,200	50	1,000	5,500	0	0	1,312,000
1989 - 1990	Below Average	245,000	8,800	400	0	300	100	136,700	638,100	50	1,000	5,700	0	0	1,308,000
1990 - 1991	Average	324,000	16,800	500	0	300	100	173,300	608,700	50	1,000	5,900	0	0	1,442,000
1991 - 1992	Below Average	284,000	10,800	400	0	300	100	161,300	622,000	50	1,100	6,000	0	0	1,372,000
1992 - 1993	Above Average	406,000	34,900	800	0	400	100	357,500	385,000	50	1,100	6,100	0	0	1,771,000
1993 - 1994	Below Average	291,000	21,100	500	0	300	100	167,600	603,800	50	1,100	6,200	0	0	1,421,000
1994 - 1995	Above Average	466,000	71,600	900	2,900	400	100	285,600	442,700	50	1,100	6,200	25,000	0	1,983,000
1995 - 1996	Average	316,000	62,600	1,000	3,600	400	100	332,300	392,200	50	1,100	6,300	7,000	0	1,629,000
1996 - 1997	Above Average	399,000	57,100	1,000	2,000	400	100	298,200	436,100	50	1,200	6,600	121,000	0	1,927,000
1997 - 1998	Above Average	509,000	98,000	1,000	9,100	400	200	203,000	485,800	50	1,100	6,300	132,000	0	2,274,000
1998 - 1999	Above Average	354,000	37,700	1,000	1,000	400	200	280,600	477,200	50	1,100	6,300	0	0	1,591,000
1999 - 2000	Average	342,000	39,200	700	900	400	100	286,800	498,600	50	1,200	6,600	5,000	0	1,601,000
2000 - 2001	Below Average	264,000	21,900	700	0	300	100	205,000	548,900	50	1,200	6,700	0	0	1,366,000
2001 - 2002	Below Average	252,000	22,600	700	0	300	100	213,200	543,800	50	1,400	7,400	0	0	1,373,000
2002 - 2003	Below Average	247,000	37,500	700	700	400	100	252,500	487,300	50	1,400	7,300	5,000	0	1,390,000
2003 - 2004	Below Average	207,000	18,200	600	0	300	100	219,400	522,200	50	1,500	7,700	1,000	0	1,239,000
2004 - 2005	Above Average	369,000	43,800	800	2,500	400	100	322,200	386,800	50	3,300	7,300	22,000	0	1,612,000
2005 - 2006	Above Average	373,000	58,800	800	1,300	400	100	308,200	394,100	50	4,000	7,600	11,000	0	1,647,000
2006 - 2007	Below Average	170,000	14,200	400	0	300	100	142,000	594,200	50	4,400	8,000	0	0	1,177,000
2007 - 2008	Below Average	189,000	24,300	600	0	300	100	203,400	507,600	50	4,500	8,100	1,000	0	1,202,000
2008 - 2009	Below Average	203,000	22,300	500	0	300	100	233,000	524,600	50	4,200	7,900	0	0	1,290,000
2009 - 2010	Average	320,000	45,400	800	0	400	100	275,700	388,600	50	3,900	7,700	0	0	1,452,000
2010 - 2011	Above Average	414,000	65,300	800	4,700	400	200	295,900	412,300	50	3,800	7,700	8,000	0	1,863,000
2011 - 2012	Below Average	299,000	33,800	600	0	300	100	182,700	578,500	50	4,100	7,900	10,000	0	1,424,000
2012 - 2013	Below Average	139,000	10,300	500	0	300	100	147,100	625,000	50	4,200	8,000	0	0	1,182,000
2013 - 2014	Below Average	99,000	2,400	300	0	300	100	55,500	716,500	50	3,800	7,700	0	0	1,103,000
2014 - 2015	Below Average	142,000	2,300	300	0	200	100	32,900	711,500	50	2,700	7,000	0	0	1,101,000
2015 - 2016	Below Average	217,000	19,400	500	0	300	100	167,700	490,200	50	2,700	7,000	0	0	1,170,000
2016 - 2017	Below Average	227,000	67,100	900	4,800	400	200	323,800	345,900	50	2,800	7,100	71,000	0	1,721,000
86/87-16/17 Avg		286,000	33,000	700	1,100	300	100	219,400	518,200	50	2,200	6,800	14,000	0	1,474,000

🟦	Groundwater Inflows to be Included in Sustainable Yield Estimates
🟪	Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
🟨	Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Tule Subbasin Historical Groundwater Budget

Water Year	Water Year Type	Groundwater Inflows (acre-ft)																						Total In
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
			Tule River Infiltration					Deer Creek Infiltration						Imported Water Deliveries				Municipal Pumping						
																			Recycled Water					
		Areal Recharge from Precipitation	Success to Oettle Bridge Infiltration	Oettle Bridge to Turnbull Weir Infiltration	Canal Loss	Recharge in Basins	Return Flow	Before Trenton Weir Infiltration	Trenton Weir to Homeland Canal Infiltration	Canal Loss	Recharge in Basins	Return Flow	White River Infiltration	Canal Loss	Recharge in Basins	Return Flow	Agricultural Pumping Return Flow	Return Flow	Agricultural Return Flow	Artificial Recharge	Release of Water from Compression of Aquitards	Sub-surface Inflow	Mountain-Block Recharge	
1986 - 1987	Below Average	0	11,600	1,100	20,700	5,400	8,500	8,100	0	0	0	0	2,400	52,500	0	56,100	169,900	5,200	200	2,600	120,000	113,000	28,000	605,000
1987 - 1988	Average	4,000	8,000	900	8,800	5,000	5,500	5,800	0	0	0	0	1,300	32,700	0	48,100	183,200	5,400	200	3,200	88,000	131,000	29,000	560,000
1988 - 1989	Below Average	0	8,700	0	7,400	6,200	6,100	7,500	0	0	0	0	1,800	20,500	0	51,800	172,100	5,600	200	3,400	71,000	131,000	29,000	522,000
1989 - 1990	Below Average	0	5,000	0	2,900	3,700	2,700	4,400	0	0	0	0	700	7,400	0	36,200	199,700	5,700	200	3,600	132,000	133,000	29,000	566,000
1990 - 1991	Average	7,000	6,400	300	6,800	5,200	5,900	6,900	0	0	0	0	1,300	24,300	0	46,900	190,300	5,800	200	3,700	126,000	144,000	29,000	610,000
1991 - 1992	Below Average	1,000	4,300	0	3,100	3,700	3,500	3,800	0	0	0	0	700	16,100	0	44,700	194,900	5,900	200	3,800	143,000	140,000	30,000	599,000
1992 - 1993	Above Average	57,000	18,500	3,000	27,800	8,200	16,800	15,100	0	0	0	0	3,500	184,400	5,600	118,000	111,300	6,000	200	3,900	44,000	93,000	30,000	746,000
1993 - 1994	Below Average	2,000	6,100	200	14,200	5,000	8,700	6,600	0	0	0	0	1,100	35,600	700	51,800	187,400	6,100	200	4,000	85,000	123,000	30,000	568,000
1994 - 1995	Above Average	144,000	36,400	10,400	39,500	7,800	34,600	21,200	1,000	3,800	1,800	1,000	10,500	128,500	10,400	88,900	130,900	6,100	200	3,900	33,000	101,000	30,000	845,000
1995 - 1996	Average	5,000	20,700	4,000	26,200	21,200	31,800	13,700	700	2,800	700	1,200	5,800	87,600	39,500	119,000	115,700	6,200	200	3,900	19,000	95,000	27,000	647,000
1996 - 1997	Above Average	50,000	34,600	9,700	47,300	25,300	31,400	45,100	1,800	6,900	1,900	700	12,800	64,200	14,100	117,300	130,700	6,300	200	4,300	19,000	111,000	28,000	763,000
1997 - 1998	Above Average	219,000	41,100	9,000	79,100	32,000	41,100	14,900	12,700	48,800	900	3,100	36,600	54,100	16,200	65,200	143,800	6,300	200	3,900	17,000	126,000	30,000	1,001,000
1998 - 1999	Above Average	18,000	14,300	2,800	19,500	17,600	14,100	13,300	600	2,500	400	300	7,300	58,200	19,800	88,700	143,200	6,400	200	3,900	18,000	122,000	30,000	601,000
1999 - 2000	Average	12,000	16,900	2,900	11,100	8,900	15,200	10,100	600	2,400	500	300	4,800	64,400	13,000	93,200	152,400	6,500	200	4,200	20,000	131,000	30,000	601,000
2000 - 2001	Below Average	0	12,300	0	7,000	5,000	7,800	6,700	0	0	0	0	4,600	28,500	2,700	61,700	169,600	6,600	200	4,300	42,000	142,000	30,000	531,000
2001 - 2002	Below Average	0	14,800	700	13,400	5,800	9,000	10,100	0	0	0	0	6,100	24,800	100	65,200	169,100	6,900	300	4,900	59,000	135,000	30,000	555,000
2002 - 2003	Below Average	0	19,700	3,700	22,800	12,200	11,500	13,600	100	400	300	200	5,800	53,600	5,000	65,700	123,200	6,900	200	4,800	42,000	123,000	29,000	544,000
2003 - 2004	Below Average	0	9,900	300	7,700	3,900	6,200	6,600	0	0	0	0	2,300	19,600	0	57,800	134,000	7,100	200	5,100	70,000	127,000	29,000	487,000
2004 - 2005	Above Average	26,000	24,200	4,700	22,900	19,000	15,300	14,400	400	1,500	2,900	700	6,400	91,200	32,000	89,700	92,600	7,100	500	2,400	26,000	96,000	29,000	605,000
2005 - 2006	Above Average	28,000	28,100	7,200	40,500	23,300	29,300	14,400	900	3,400	3,200	400	7,500	78,000	26,600	91,000	95,700	7,300	700	2,000	16,000	97,000	29,000	630,000
2006 - 2007	Below Average	0	6,200	1,500	5,100	4,300	4,800	6,600	0	0	0	0	1,700	15,500	100	36,000	151,600	7,500	700	2,000	78,000	125,000	29,000	476,000
2007 - 2008	Below Average	0	11,700	1,100	15,900	6,900	7,800	8,100	0	0	0	0	2,300	22,100	1,600	45,500	129,700	7,600	800	2,000	96,000	113,000	30,000	502,000
2008 - 2009	Below Average	0	9,500	1,400	7,100	5,200	7,600	6,300	0	0	0	0	1,600	43,800	8,100	57,400	135,300	7,600	700	2,000	125,000	108,000	30,000	557,000
2009 - 2010	Average	6,000	25,600	4,500	34,600	14,300	19,200	16,100	0	0	0	0	5,000	72,700	29,900	77,700	93,900	7,500	600	2,000	70,000	83,000	29,000	592,000
2010 - 2011	Above Average	65,000	37,100	7,500	82,400	39,000	30,300	24,400	1,300	5,000	9,700	1,400	14,800	89,500	45,700	84,700	101,900	7,600	600	2,000	34,000	93,000	29,000	806,000
2011 - 2012	Below Average	3,000	13,600	300	17,800	8,100	11,900	11,000	0	0	0	0	3,200	23,100	7,000	46,200	151,300	7,700	700	2,000	86,000	123,000	29,000	545,000
2012 - 2013	Below Average	0	4,900	0	4,400	5,300	3,400	4,500	0	0	0	0	1,000	13,000	100	35,000	165,100	7,800	700	2,000	145,000	130,000	29,000	551,000
2013 - 2014	Below Average	0	2,300	0	0	3,800	1,000	2,700	0	0	0	0	400	0	0	13,000	183,400	7,700	600	2,000	186,000	132,000	30,000	565,000
2014 - 2015	Below Average	0	1,000	0	0	3,600	1,100	1,800	0	0	0	0	200	0	0	5,600	178,800	7,500	500	2,000	189,000	124,000	30,000	545,000
2015 - 2016	Below Average	0	16,000	5,500	11,400	6,600	5,900	14,300	0	0	0	0	4,400	28,600	3,700	35,300	123,500	7,600	400	2,000	140,000	112,000	30,000	547,000
2016 - 2017	Below Average	0	42,100	15,900	82,600	37,300	41,400	37,000	800	3,100	3,700	1,400	17,100	133,700	61,000	99,000	83,300	7,700	500	2,000	61,000	95,000	29,000	855,000
86/87-16/17 Avg		21,000	16,500	3,200	22,300	11,600	14,200	12,100	700	2,600	800	300	5,600	50,600	11,100	64,300	145,400	6,700	400	3,200	77,000	118,000	29,000	617,000

🟦	Groundwater Inflows to be Included in Sustainable Yield Estimates
🟪	Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
🟨	Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Tule Subbasin Groundwater Budget

		Groundwater Outflows (acre-ft)						
		W	X	Y	Z	AA		
		Groundwater Pumping						
Water Year	Water Year Type	Municipal	Irrigated Agriculture	Exports	Groundwater Banking Extraction	Sub-surface Outflow	Total Out	Change in Storage (acre-ft)
1986 - 1987	Below Average	13,500	724,000	6,550	0	61,000	805,000	-200,000
1987 - 1988	Average	15,100	768,000	34,180	0	53,000	870,000	-310,000
1988 - 1989	Below Average	15,700	728,000	38,290	0	51,000	833,000	-311,000
1989 - 1990	Below Average	16,300	838,000	50,430	0	53,000	958,000	-392,000
1990 - 1991	Average	16,700	799,000	46,300	0	61,000	923,000	-313,000
1991 - 1992	Below Average	17,000	817,000	41,250	0	52,000	927,000	-328,000
1992 - 1993	Above Average	17,200	496,000	14,550	0	73,000	601,000	145,000
1993 - 1994	Below Average	17,600	791,000	11,220	0	59,000	879,000	-311,000
1994 - 1995	Above Average	17,600	574,000	1,320	0	61,000	654,000	191,000
1995 - 1996	Average	17,800	508,000	0	0	65,000	591,000	56,000
1996 - 1997	Above Average	18,700	567,000	0	0	65,000	651,000	112,000
1997 - 1998	Above Average	17,900	630,000	0	0	62,000	710,000	291,000
1998 - 1999	Above Average	18,000	620,000	0	0	62,000	700,000	-99,000
1999 - 2000	Average	18,900	651,000	7,720	0	60,000	738,000	-137,000
2000 - 2001	Below Average	19,100	719,000	30,600	0	60,000	829,000	-298,000
2001 - 2002	Below Average	20,900	713,000	44,520	0	58,000	836,000	-281,000
2002 - 2003	Below Average	20,600	610,000	33,660	0	55,000	719,000	-175,000
2003 - 2004	Below Average	21,700	656,000	37,790	0	55,000	770,000	-283,000
2004 - 2005	Above Average	20,600	479,000	11,720	0	66,000	577,000	28,000
2005 - 2006	Above Average	21,600	490,000	150	0	64,000	576,000	54,000
2006 - 2007	Below Average	22,700	746,000	49,500	0	54,000	872,000	-396,000
2007 - 2008	Below Average	23,000	637,000	50,090	0	68,000	778,000	-276,000
2008 - 2009	Below Average	22,500	660,000	48,860	550	78,000	810,000	-253,000
2009 - 2010	Average	21,800	483,000	28,530	70	92,000	625,000	-33,000
2010 - 2011	Above Average	21,800	514,000	8,060	0	86,000	630,000	176,000
2011 - 2012	Below Average	22,500	730,000	43,570	3,860	76,000	876,000	-331,000
2012 - 2013	Below Average	22,700	790,000	63,640	5,990	68,000	950,000	-399,000
2013 - 2014	Below Average	21,900	900,000	58,030	5,590	69,000	1,055,000	-490,000
2014 - 2015	Below Average	19,700	890,000	53,270	1,150	64,000	1,028,000	-483,000
2015 - 2016	Below Average	19,700	614,000	50,000	70	70,000	754,000	-207,000
2016 - 2017	Below Average	20,100	429,000	11,330	0	90,000	550,000	305,000
		19,400	664,000	28,200	600	65,000	777,000	-160,000
							Cummulative Change in Storage	-4,948,000

🟦 Groundwater Inflows to be Included in Sustainable Yield Estimates
🟪 Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
🟨 Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Table 6

Summary of Projects Exclusive of Transitional Pumping

Eastern Tule GSA

No.	Lead Entity	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	City of Porterville	Population Increase	Increase GW Production	2.5%/yr 2020-2040	9,500 af/yr by 2040	N/A	High
2	City of Porterville	Recycling Increase	Increase RW Applied to Ag	2.5%/yr 2020-2040	1,900 af/yr by 2040	Recycled Water	High
3	City of Porterville	Recycling Increase	Increase RW Recharge	2.5%/yr 2020-2040	1,600 af/yr by 2040	Recycled Water	High
4	City of Porterville	Tule River Recharge	Recharge Project	Starting 2019/20	900 af/yr	Tule River	High
5	City of Porterville	FKC Recharge	Recharge Project	Starting 2020/21	1,100 af/yr	FKC via Porterville ID	High
6	Porterville ID	SA 1 & 2	Expand distribution system	Starting 2018/19	3,200 af/yr	Tule River and FKC	High
7	Porterville ID	Falconer Bank	Develop water bank	Starting 2020/21	3,300 af/yr of leave-behind	FKC and others	High
8	Porterville ID	Recharge Policy	On-Farm recharge	Starting 2019/20	3,000 af/yr	Tule River and FKC	High
9	Saucelito ID	Conway Bank	Develop water bank	Starting 2020/21	1,100 af/yr of leave-behind	FKC and others	High
10	Saucelito ID	Recharge Policy	On-Farm recharge	Starting 2019/20	2,000 af/yr	FKC	High
11	Kern-Tulare WD	In-District Pricing	Pricing change	Starting 2020/21	2,600 af/yr	N/A	High
12	Kern-Tulare WD	Reservoir Storage	Surface water storage	Starting 2029/30	500 af/yr	FKC and others	Medium
13	Kern-Tulare WD	CRC Pipeline	Deliver produced water	Starting 2024/25	680 af/yr	CRC Produced water	High
14	Terra Bella ID	Deer Creek Recharge	Divert and recharge DC	Starting 2017/18	800 af/yr	Deer Creek	High
15	PWC, VWD, & CMDC	SREP	Success Dam Enlargement	Starting 2024/25	400 af/yr	Tule River	High
16	Hope WD	In-District Recharge	Recharge Project	Starting 2022/23	5,000 af/yr every 3 years	FKC and others / unknown	Medium
17	Ducor ID	In-District Recharge	Pipeline and Recharge Project	Starting 2023/24	4,000 af/yr	FKC and others / unknown	High

LTRID GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	Creighton Ranch	Groundwater exports	Unknown	Unknown	Not applicable	N/A
2	LTRID - Pixley ID FKC	Continue FKC transfers to Pixley ID	Ongoing	13,670 af/yr	FKC	N/A
3	SREP	Success Dam Enlargement	Starting 2024/25	2,600 af/yr	Tule River	N/A

Pixley GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	LTRID - Pixley ID FKC	Continue FKC transfers from LTRID	Ongoing	13,670 af/yr	FKC	N/A

DEID GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
N/A	No planned projects	N/A	N/A	N/A	N/A	N/A

Tri-County GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	Deep Pumping Reduction	Replace deep pumping with 24 new shallow wells	Start in 2019/20, completed in 2023/24	24,000 af/yr	Not applicable	High
2	Duck Club Project	Duck Club water transferred to farms	2019/20	5,400 af every 7 years	Unknown	High
3	Liberty Project	Participation in the Liberty Project surface water storage	Start in 2019/20, completed in 2022/23	5,000 af/yr	FID, FKC, KR, TR, KW, SWP	High
4	Recharge Scenario	Confidential. Capture and recharge flood water	Unknown	1,200 to 1,800 af/yr	Unknown	N/A

Alpaugh GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	Water Capture	Deer Creek flood capture	Starting in 2022/23	1,100 af 2.5x per yr every 2 yrs	Deer Creek	N/A
2	Cropping Changes	Install drip irrigation on 1,900 acres	Starting 2019/20	Not applicable	Not applicable	N/A

Summary of Projects Exclusive of Transitional Pumping

Notes:

N/A= Not Available
af/yr = acre-foot per year
ID = Irrigation District
GW = Groundwater
RW = Recycled water
Ag = Agricultural
DC = Deer Creek
FKC = Friant-Kern Canal
SA = Service Area
CRC = California Resources Corporation
PWC = Pioneer Water Company
VMD = Vandalia Water District
CMDC = Campbell Moreland Ditch Company
SREP = Success Reservoir Enlargement Project
WD = Water District
MA = Management Area
FID = Fresno Irrigation District (Fresno Slough)
KR = Kaweah River
TR = Tule River
KW = Kaweah River
SWP = State Water Project

Table 7

Planned Transitional Pumping by GSA

	Eastern Tule GSA	LTRID GSA	Pixley ID GSA	DEID-District Area	DEID White Lands Area	Tri-Co GSA	Alpaugh GSA
2020-2025	90% of over-pumping[1]	2.0 af/ac Over Cons. Use Target	Fallow 5,000 acres; Remaining 2.0 af/ac Over Cons. Use Target	No Change/ Sustainable	100% of over-pumping	100% of over-pumping	Reduce cropped area by 880 acres; 80% of overpumping
2025-2030	80% of over-pumping	1.5 af/ac Over Cons. Use Target	Fallow 5,000 acres; Remaining 1.5 af/ac Over Cons. Use Target[2]		Linear Transitional Pumping	Reduce pumping 10,000 af/yr	
2030-2035	30% of over-pumping	1.0 af/ac Over Cons. Use Target	Fallow 5,000 acres; Remaining 1.0 af/ac Over Cons. Use Target				50% of overpumping
2035-2040	Sustainable	0.5 af/ac Over Cons. Use Target	Fallow 5,000 acres; Remaining 0.5 af/ac Over Cons. Use Target		Sustainable	Sustainable	20% of overpumping
2040+		Sustainable	Sustainable				Sustainable

Notes:

[1] Over-pumping means pumping in excess of the consumptive use target

[2] Over consumptive use target means over pumping

Table 8a

Projected Future Tule Subbasin Surface Water Budget

	Surface Water Inflow (acre-ft)																					
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	
Water Year	Precipitation	Stream Inflow			Imported Water															Discharge from Wells		Total In
		Tule River	Deer Creek	White River	Saucelito ID	Terra Bella ID	Kern-Tulare WD	Porterville ID	Tea Pot Dome WD	City of Porterville	Hope WD	Ducor ID	LTRID	Pixley ID	Delano-Earlimart ID	Angiola WD	Alpaugh ID	Atwell Island WD	Private	Agriculture Pumping	Municipal Pumping	
2017 - 2018	306,000	131,258	19,410	6,347	34,567	18,786	15,335	19,803	6,528	0	0	0	143,186	31,763	116,902	5,911	3,680	0	0	549,000	21,700	1,430,000
2018 - 2019	306,000	131,258	19,410	6,347	34,567	18,786	15,335	19,803	6,528	0	0	0	143,186	31,763	116,902	5,911	3,680	0	0	548,000	23,400	1,431,000
2019 - 2020	306,000	131,258	19,410	6,347	34,567	18,786	15,335	23,103	6,528	0	0	0	143,186	31,763	116,902	7,961	3,680	0	0	529,000	25,000	1,419,000
2020 - 2021	306,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	0	0	143,186	31,763	116,902	9,211	3,680	0	0	526,000	25,400	1,422,000
2021 - 2022	306,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	0	0	143,186	31,763	116,902	10,461	3,680	0	0	524,000	25,700	1,422,000
2022 - 2023	306,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	1,667	0	143,186	31,763	116,902	13,590	3,680	0	0	523,000	26,100	1,426,000
2023 - 2024	306,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	1,667	4,000	143,186	31,763	116,902	18,926	3,680	0	0	522,000	26,500	1,435,000
2024 - 2025	306,000	134,258	19,410	6,347	34,893	20,304	18,229	24,339	6,594	1,100	1,667	4,000	135,513	31,763	117,661	24,261	3,680	0	1,500	494,000	26,900	1,412,000
2025 - 2026	306,000	134,258	19,410	6,347	34,118	21,823	17,843	25,575	6,661	1,100	1,667	4,000	127,841	31,763	118,420	29,597	4,813	0	1,500	487,000	27,400	1,407,000
2026 - 2027	306,000	134,258	19,410	6,347	33,343	23,341	17,458	26,812	6,727	1,100	1,667	4,000	120,168	31,763	119,180	34,933	4,751	0	1,500	481,000	27,800	1,402,000
2027 - 2028	306,000	134,258	19,410	6,347	32,568	24,860	17,072	28,048	6,793	1,100	1,667	4,000	112,496	31,763	119,939	40,268	4,689	0	1,500	474,000	28,200	1,395,000
2028 - 2029	306,000	134,258	19,410	6,347	31,794	26,378	16,687	29,285	6,860	1,100	1,667	4,000	104,823	31,763	120,698	43,725	4,627	0	1,500	468,000	28,700	1,388,000
2029 - 2030	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	4,565	0	1,500	412,000	29,200	1,328,000
2030 - 2031	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	413,000	29,600	1,331,000
2031 - 2032	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	410,000	30,100	1,328,000
2032 - 2033	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	407,000	30,600	1,326,000
2033 - 2034	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	405,000	31,100	1,324,000
2034 - 2035	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	345,000	31,700	1,265,000
2035 - 2036	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	344,000	32,200	1,266,000
2036 - 2037	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	344,000	32,800	1,266,000
2037 - 2038	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	344,000	33,300	1,267,000
2038 - 2039	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	344,000	33,900	1,267,000
2039 - 2040	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	303,000	34,500	1,227,000
2040 - 2041	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2041 - 2042	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2042 - 2043	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2043 - 2044	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2044 - 2045	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2045 - 2046	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2046 - 2047	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2047 - 2048	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2048 - 2049	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2049 - 2050	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2050 - 2051	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2051 - 2052	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2052 - 2053	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2053 - 2054	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2054 - 2055	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2055 - 2056	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2056 - 2057	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2057 - 2058	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2058 - 2059	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2059 - 2060	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2060 - 2061	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2061 - 2062	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2062 - 2063	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2063 - 2064	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2064 - 2065	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2065 - 2066	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2066 - 2067	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2067 - 2068	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2068 - 2069	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	45,214	7,793	0	1,500	297,000	34,500	1,191,000
2069 - 2070	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	24,476	7,793	0	1,500	297,000	34,500	1,170,000
17/18-69/70 Avg	306,000	132,500	19,200	6,300	31,200	25,700	17,800	28,300	6,700	1,000	1,500	3,500	100,500	31,800	117,100	37,800	6,600	0	1,300	361,000	32,000	1,268,000

Table 8b

Projected Future Tule Subbasin Surface Water Budget

	Surface Water Outflow (acre-ft)																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Water Year	Areal Recharge of Precipitation	Streambed Infiltration					Canal Loss			Recharge in Basins				Deep Percolation of Applied Water					
		Tule River		Native Deer Creek		White River	Tule River	Deer Creek	Imported Water	Tule River	Deer Creek	Imported Water	Recycled Water	Tule River	Deer Creek	Imported Water	Recycled Water	Agricultural Pumping	Municipal Pumping
		Success to Oettle Bridge	Oettle Bridge to Turnbull Weir	Before Trenton Weir	Trenton Weir to Homeland Canal														
2017 - 2018	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	12,200	1,300	15,900	2,000	15,500	800	66,900	600	110,400	7,900
2018 - 2019	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	12,200	1,300	15,900	2,000	15,500	800	66,900	700	110,300	8,100
2019 - 2020	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	19,200	2,500	15,500	800	68,100	400	106,600	8,300
2020 - 2021	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	21,400	2,600	15,500	800	68,700	400	106,000	8,300
2021 - 2022	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	21,400	2,600	15,500	800	68,900	400	105,700	8,400
2022 - 2023	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	23,000	2,700	15,500	800	69,100	500	105,400	8,400
2023 - 2024	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	27,000	2,800	15,500	800	69,100	500	105,300	8,500
2024 - 2025	21,000	17,900	3,900	11,600	600	6,200	18,200	2,100	62,400	13,700	1,300	27,900	2,800	15,800	800	69,600	500	100,200	8,500
2025 - 2026	21,000	17,900	3,900	11,600	600	6,200	18,400	2,100	59,600	13,700	1,300	27,300	2,900	15,800	1,100	70,200	500	98,900	8,600
2026 - 2027	21,000	17,900	3,900	11,600	600	6,200	18,700	2,100	56,800	13,700	1,300	26,700	3,000	15,800	1,100	70,500	500	98,000	8,600
2027 - 2028	21,000	17,900	3,900	11,600	600	6,200	19,000	2,100	53,900	13,700	1,300	26,100	3,100	15,800	1,100	70,900	500	97,000	8,700
2028 - 2029	21,000	17,900	3,900	11,600	600	6,200	19,300	2,100	51,100	13,700	1,300	25,500	3,100	15,800	1,100	71,300	500	96,000	8,700
2029 - 2030	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,200	15,500	1,100	71,800	500	86,900	8,800
2030 - 2031	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,300	15,500	1,100	72,100	600	86,900	8,800
2031 - 2032	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,400	15,500	1,100	72,100	600	86,400	8,900
2032 - 2033	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,500	15,500	1,100	72,100	600	85,900	8,900
2033 - 2034	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,500	15,500	1,100	72,100	600	85,400	9,000
2034 - 2035	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,600	15,500	1,100	72,100	600	74,000	9,100
2035 - 2036	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,700	15,500	1,100	72,400	600	73,700	9,100
2036 - 2037	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,800	15,500	1,100	72,400	700	73,700	9,200
2037 - 2038	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,900	15,500	1,100	72,400	700	73,700	9,300
2038 - 2039	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,000	15,500	1,100	72,400	700	73,700	9,300
2039 - 2040	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,400	700	64,300	9,400
2040 - 2041	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2041 - 2042	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2042 - 2043	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2043 - 2044	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2044 - 2045	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2045 - 2046	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2046 - 2047	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2047 - 2048	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2048 - 2049	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2049 - 2050	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2050 - 2051	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2051 - 2052	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2052 - 2053	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2053 - 2054	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2054 - 2055	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2055 - 2056	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2056 - 2057	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2057 - 2058	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2058 - 2059	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2059 - 2060	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2060 - 2061	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2061 - 2062	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2062 - 2063	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2063 - 2064	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2064 - 2065	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2065 - 2066	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2066 - 2067	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2067 - 2068	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2068 - 2069	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2069 - 2070	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
17/18-69/70 Avg	21,000	17,700	3,900	11,500	600	6,100	19,000	2,100	49,500	13,200	1,300	24,100	3,700	15,500	1,100	70,200	600	75,300	9,100

Table 8b

Projected Future Tule Subbasin Surface Water Budget

Water Year	Surface Water Outflow (acre-ft)													Total Out
	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	
	Evapotranspiration											Surface Outflow		
	Precipitation Crops/Native	Tule River		Deer Creek		White River	Imported Water	Ag. Cons. Use from Pumping	Recycled Water		Municipal (Landscape ET)	Tule River	Deer Creek	
		Agricultural Cons. Use	Stream Channel	Agricultural Cons. Use	Stream Channel	Stream Channel	Agricultural Cons. Use		Recharge in Basins	Agricultural Cons. Use				
2017 - 2018	285,000	47,400	700	2,900	300	100	250,700	438,600	50	3,500	7,700	15,000	0	1,431,000
2018 - 2019	285,000	47,400	700	2,900	300	100	250,700	437,800	50	4,300	8,200	8,000	0	1,425,000
2019 - 2020	285,000	47,400	700	2,900	300	100	254,400	420,400	50	2,600	11,200	8,000	0	1,414,000
2020 - 2021	285,000	47,400	700	2,900	300	100	257,400	417,300	50	2,600	11,400	8,000	0	1,417,000
2021 - 2022	285,000	47,400	700	2,900	300	100	258,200	416,100	50	2,700	11,600	8,000	0	1,417,000
2022 - 2023	285,000	47,400	700	2,900	300	100	259,000	414,900	50	2,800	11,800	8,000	0	1,418,000
2023 - 2024	285,000	47,400	700	2,900	300	100	259,000	414,500	50	2,800	12,000	8,000	0	1,422,000
2024 - 2025	285,000	48,500	700	2,900	300	100	262,700	392,000	50	2,900	12,200	8,000	0	1,400,000
2025 - 2026	285,000	48,500	700	3,800	300	100	266,800	385,800	50	3,000	12,400	8,000	0	1,396,000
2026 - 2027	285,000	48,500	700	3,800	300	100	269,800	380,300	50	3,000	12,600	8,000	0	1,390,000
2027 - 2028	285,000	48,500	700	3,800	300	100	272,900	374,800	50	3,100	12,800	7,000	0	1,383,000
2028 - 2029	285,000	48,600	700	3,800	300	100	276,000	369,300	50	3,200	13,100	7,000	0	1,378,000
2029 - 2030	285,000	47,400	700	3,800	300	100	280,300	322,400	50	3,300	13,300	7,000	0	1,322,000
2030 - 2031	285,000	47,400	700	3,800	300	100	281,200	323,200	50	3,400	13,600	7,000	0	1,325,000
2031 - 2032	285,000	47,400	700	3,800	300	100	281,200	321,100	50	3,400	13,800	7,000	0	1,323,000
2032 - 2033	285,000	47,400	700	3,800	300	100	281,200	319,000	50	3,500	14,100	7,000	0	1,321,000
2033 - 2034	285,000	47,400	700	3,800	300	100	281,200	316,900	50	3,600	14,300	7,000	0	1,318,000
2034 - 2035	285,000	47,400	700	3,800	300	100	281,200	268,900	50	3,700	14,600	7,000	0	1,260,000
2035 - 2036	285,000	47,400	700	3,800	300	100	282,200	267,800	50	3,800	14,900	7,000	0	1,260,000
2036 - 2037	285,000	47,400	700	3,800	300	100	282,200	267,700	50	3,900	15,200	7,000	0	1,261,000
2037 - 2038	285,000	47,400	700	3,800	300	100	282,200	267,600	50	4,000	15,500	7,000	0	1,261,000
2038 - 2039	285,000	47,400	700	3,800	300	100	282,200	267,500	50	4,100	15,800	7,000	0	1,261,000
2039 - 2040	285,000	47,400	700	3,800	300	100	282,200	236,000	50	4,200	16,100	7,000	0	1,221,000
2040 - 2041	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2041 - 2042	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2042 - 2043	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2043 - 2044	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2044 - 2045	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2045 - 2046	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2046 - 2047	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2047 - 2048	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2048 - 2049	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2049 - 2050	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2050 - 2051	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2051 - 2052	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2052 - 2053	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2053 - 2054	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2054 - 2055	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2055 - 2056	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2056 - 2057	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2057 - 2058	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2058 - 2059	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2059 - 2060	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2060 - 2061	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2061 - 2062	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2062 - 2063	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2063 - 2064	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2064 - 2065	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2065 - 2066	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2066 - 2067	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2067 - 2068	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2068 - 2069	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2069 - 2070	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
86/87-16/17 Avg	285,000	46,900	700	3,600	300	100	270,800	283,800	50	3,800	14,700	7,000	0	1,262,000

Projected Future Tule Subbasin Groundwater Budget

	Groundwater Inflows (acre-ft)																						
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
		Tule River Infiltration					Deer Creek Infiltration						Imported Water Deliveries				Municipal Pumping						
																		Recycled Water					
Water Year	Areal Recharge from Precipitation	Success to Oettle Bridge Infiltration	Oettle Bridge to Turnbull Weir Infiltration	Canal Loss	Recharge in Basins	Return Flow	Before Trenton Weir Infiltration	Trenton Weir to Homeland Canal Infiltration	Canal Loss	Recharge in Basins	Return Flow	White River Infiltration	Canal Loss	Recharge in Basins	Return Flow	Agricultural Pumping Return Flow	Return Flow	Agricultural Return Flow	Artificial Recharge	Release of Water from Compression of Aquitards	Sub-surface Inflow	Mountain-Block Recharge	Total In
2017 - 2018	21,000	17,900	3,900	17,000	12,200	15,500	11,600	600	2,100	1,300	800	6,200	65,200	15,900	66,900	110,400	7,900	600	2,000	52,000	73,000	33,000	537,000
2018 - 2019	21,000	17,900	3,900	17,000	12,200	15,500	11,600	600	2,100	1,300	800	6,200	65,200	15,900	66,900	110,300	8,100	700	2,000	56,000	71,000	33,000	539,000
2019 - 2020	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	19,200	68,100	106,600	8,300	400	2,500	58,000	68,000	33,000	540,000
2020 - 2021	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	21,400	68,700	106,000	8,300	400	2,600	60,000	64,000	33,000	541,000
2021 - 2022	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	21,400	68,900	105,700	8,400	400	2,600	62,000	60,000	33,000	539,000
2022 - 2023	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	23,000	69,100	105,400	8,400	500	2,700	64,000	57,000	33,000	539,000
2023 - 2024	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	27,000	69,100	105,300	8,500	500	2,800	66,000	55,000	33,000	543,000
2024 - 2025	21,000	17,900	3,900	18,200	13,700	15,800	11,600	600	2,100	1,300	800	6,200	62,400	27,900	69,600	100,200	8,500	500	2,800	61,000	51,000	33,000	530,000
2025 - 2026	21,000	17,900	3,900	18,400	13,700	15,800	11,600	600	2,100	1,300	1,100	6,200	59,600	27,300	70,200	98,900	8,600	500	2,900	59,000	50,000	33,000	524,000
2026 - 2027	21,000	17,900	3,900	18,700	13,700	15,800	11,600	600	2,100	1,300	1,100	6,200	56,800	26,700	70,500	98,000	8,600	500	3,000	59,000	50,000	33,000	520,000
2027 - 2028	21,000	17,900	3,900	19,000	13,700	15,800	11,600	600	2,100	1,300	1,100	6,200	53,900	26,100	70,900	97,000	8,700	500	3,100	59,000	50,000	33,000	516,000
2028 - 2029	21,000	17,900	3,900	19,300	13,700	15,800	11,600	600	2,100	1,300	1,100	6,200	51,100	25,500	71,300	96,000	8,700	500	3,100	59,000	51,000	33,000	514,000
2029 - 2030	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	71,800	86,900	8,800	500	3,200	52,000	51,000	33,000	495,000
2030 - 2031	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	86,900	8,800	600	3,300	50,000	50,000	33,000	492,000
2031 - 2032	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	86,400	8,900	600	3,400	49,000	51,000	33,000	492,000
2032 - 2033	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	85,900	8,900	600	3,500	48,000	51,000	33,000	490,000
2033 - 2034	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	85,400	9,000	600	3,500	47,000	51,000	33,000	489,000
2034 - 2035	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	74,000	9,100	600	3,600	38,000	50,000	33,000	468,000
2035 - 2036	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	73,700	9,100	600	3,700	35,000	50,000	33,000	465,000
2036 - 2037	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	73,700	9,200	700	3,800	34,000	50,000	32,000	463,000
2037 - 2038	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	73,700	9,300	700	3,900	33,000	51,000	32,000	463,000
2038 - 2039	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	73,700	9,300	700	4,000	32,000	53,000	32,000	465,000
2039 - 2040	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	64,300	9,400	700	4,100	23,000	51,000	32,000	444,000
2040 - 2041	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	21,000	51,000	32,000	442,000
2041 - 2042	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	20,000	52,000	32,000	442,000
2042 - 2043	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	19,000	52,000	32,000	441,000
2043 - 2044	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	19,000	52,000	32,000	441,000
2044 - 2045	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	18,000	52,000	32,000	440,000
2045 - 2046	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	17,000	53,000	32,000	440,000
2046 - 2047	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	17,000	53,000	32,000	440,000
2047 - 2048	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	16,000	53,000	32,000	439,000
2048 - 2049	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	16,000	53,000	32,000	439,000
2049 - 2050	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	16,000	53,000	32,000	439,000
2050 - 2051	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	16,000	52,000	31,000	423,000
2051 - 2052	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	16,000	52,000	32,000	424,000
2052 - 2053	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	16,000	53,000	31,000	424,000
2053 - 2054	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	15,000	53,000	31,000	423,000
2054 - 2055	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	15,000	53,000	31,000	423,000
2055 - 2056	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	15,000	53,000	32,000	424,000
2056 - 2057	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	14,000	53,000	31,000	422,000
2057 - 2058	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	14,000	53,000	31,000	422,000
2058 - 2059	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	14,000	53,000	31,000	422,000
2059 - 2060	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	14,000	54,000	31,000	423,000
2060 - 2061	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	13,000	54,000	31,000	422,000
2061 - 2062	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	13,000	54,000	31,000	422,000
2062 - 2063	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	13,000	54,000	31,000	422,000
2063 - 2064	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	13,000	54,000	31,000	422,000
2064 - 2065	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	12,000	54,000	31,000	421,000
2065 - 2066	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	12,000	54,000	31,000	421,000
2066 - 2067	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	12,000	54,000	31,000	421,000
2067 - 2068	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	12,000	55,000	31,000	422,000
2068 - 2069	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	11,000	55,000	31,000	421,000
2069 - 2070	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	11,000	55,000	31,000	421,000
17/18-69/70 Avg	21,000	17,700	3,900	19,000	13,200	15,500	11,500	600	2,100	1,300	1,100	6,100	49,500	24,100	70,200	75,300	9,100	600	3,700	30,000	54,000	32,000	462,000

Projected Future Tule Subbasin Groundwater Budget

	Groundwater Outflows (acre-ft)						
	W	X	Y	Z	AA		
	Groundwater Pumping						
Water Year	Municipal	Irrigated Agriculture	Exports	Groundwater Banking Extraction	Sub-surface Outflow	Total Out	Change in Storage (acre-ft)
2017 - 2018	21,700	549,000	22,920	2,200	83,000	679,000	-142,000
2018 - 2019	23,400	548,000	22,920	2,200	82,000	679,000	-140,000
2019 - 2020	25,000	529,000	22,920	2,200	83,000	662,000	-122,000
2020 - 2021	25,400	526,000	22,920	2,200	83,000	660,000	-119,000
2021 - 2022	25,700	524,000	22,920	2,200	84,000	659,000	-120,000
2022 - 2023	26,100	523,000	22,920	2,200	85,000	659,000	-120,000
2023 - 2024	26,500	522,000	22,920	2,200	85,000	659,000	-116,000
2024 - 2025	26,900	494,000	22,920	2,200	86,000	632,000	-102,000
2025 - 2026	27,400	487,000	20,010	2,200	90,000	627,000	-103,000
2026 - 2027	27,800	481,000	20,010	2,200	92,000	623,000	-103,000
2027 - 2028	28,200	474,000	20,010	2,200	94,000	618,000	-102,000
2028 - 2029	28,700	468,000	20,010	2,200	96,000	615,000	-101,000
2029 - 2030	29,200	412,000	20,010	2,200	94,000	557,000	-62,000
2030 - 2031	29,600	413,000	17,100	2,200	95,000	557,000	-65,000
2031 - 2032	30,100	410,000	17,100	2,200	94,000	553,000	-61,000
2032 - 2033	30,600	407,000	17,100	2,200	93,000	550,000	-60,000
2033 - 2034	31,100	405,000	17,100	2,200	92,000	547,000	-58,000
2034 - 2035	31,700	345,000	17,100	2,200	93,000	489,000	-21,000
2035 - 2036	32,200	344,000	14,190	2,200	93,000	486,000	-21,000
2036 - 2037	32,800	344,000	14,190	2,200	91,000	484,000	-21,000
2037 - 2038	33,300	344,000	14,190	2,200	89,000	483,000	-20,000
2038 - 2039	33,900	344,000	14,190	2,200	88,000	482,000	-17,000
2039 - 2040	34,500	303,000	11,280	2,200	90,000	441,000	3,000
2040 - 2041	34,500	302,000	11,280	2,200	90,000	440,000	2,000
2041 - 2042	34,500	302,000	11,280	2,200	90,000	440,000	2,000
2042 - 2043	34,500	302,000	11,280	2,200	90,000	440,000	1,000
2043 - 2044	34,500	302,000	11,280	2,200	90,000	440,000	1,000
2044 - 2045	34,500	302,000	11,280	2,200	90,000	440,000	0
2045 - 2046	34,500	302,000	11,280	2,200	89,000	439,000	1,000
2046 - 2047	34,500	302,000	11,280	2,200	89,000	439,000	1,000
2047 - 2048	34,500	302,000	11,280	2,200	89,000	439,000	0
2048 - 2049	34,500	302,000	11,280	2,200	89,000	439,000	0
2049 - 2050	34,500	302,000	11,280	2,200	88,000	438,000	1,000
2050 - 2051	34,500	297,000	11,280	2,200	88,000	433,000	-10,000
2051 - 2052	34,500	297,000	11,280	2,200	88,000	433,000	-9,000
2052 - 2053	34,500	297,000	11,280	2,200	87,000	432,000	-8,000
2053 - 2054	34,500	297,000	11,280	2,200	87,000	432,000	-9,000
2054 - 2055	34,500	297,000	11,280	2,200	87,000	432,000	-9,000
2055 - 2056	34,500	297,000	11,280	2,200	87,000	432,000	-8,000
2056 - 2057	34,500	297,000	11,280	2,200	86,000	431,000	-9,000
2057 - 2058	34,500	297,000	11,280	2,200	86,000	431,000	-9,000
2058 - 2059	34,500	297,000	11,280	2,200	86,000	431,000	-9,000
2059 - 2060	34,500	297,000	11,280	2,200	86,000	431,000	-8,000
2060 - 2061	34,500	297,000	11,280	2,200	85,000	430,000	-8,000
2061 - 2062	34,500	297,000	11,280	2,200	85,000	430,000	-8,000
2062 - 2063	34,500	297,000	11,280	2,200	85,000	430,000	-8,000
2063 - 2064	34,500	297,000	11,280	2,200	85,000	430,000	-8,000
2064 - 2065	34,500	297,000	11,280	2,200	85,000	430,000	-9,000
2065 - 2066	34,500	297,000	11,280	2,200	84,000	429,000	-8,000
2066 - 2067	34,500	297,000	11,280	2,200	84,000	429,000	-8,000
2067 - 2068	34,500	297,000	11,280	2,200	84,000	429,000	-7,000
2068 - 2069	34,500	297,000	11,280	2,200	84,000	429,000	-8,000
2069 - 2070	34,500	297,000	11,280	2,200	84,000	429,000	-8,000
17/18-69/70 Avg	32,000	361,000	14,600	2,200	88,000	498,000	-36,000

Projected Future Tule Subbasin Sustainable Yield

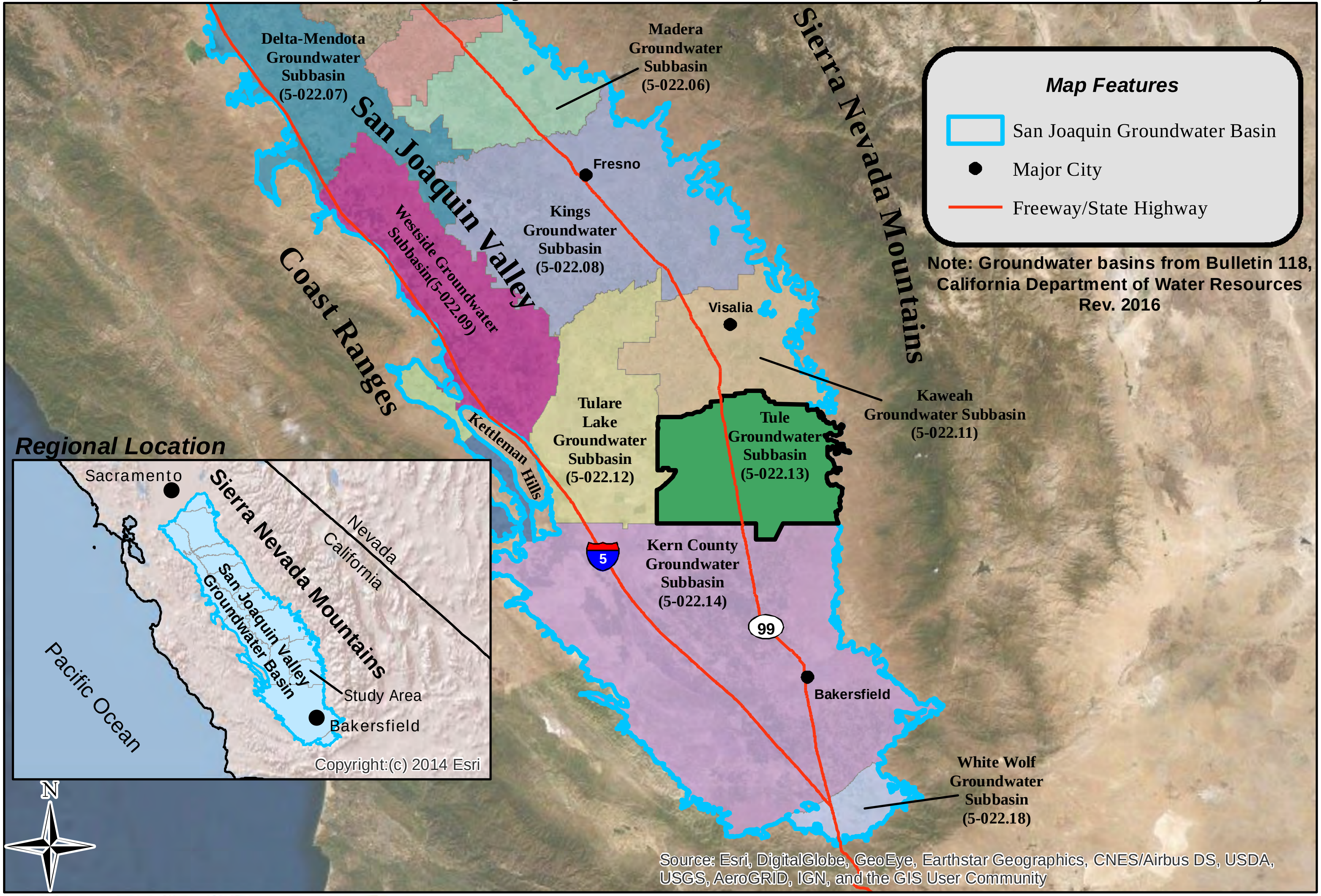
	Groundwater Inflows (acre-ft)										Groundwater Outflow (acre-ft)	
	A	B	C	D	E	F	G	H	I	J	K	
Water Year	Areal Recharge from Precipitation	Streambed Infiltration					Return Flow		Sub-surface Inflow	Mountain-Block Recharge	Sub-surface Outflow	Sustainable Yield
		Tule River		Deer Creek		White River	Irrigated Agriculture	Municipal				
		Success to Oettle Bridge	Oettle Bridge to Turnbull Weir	Before Trenton Weir Infiltration	Trenton Weir to Homeland Canal Infiltration							
2040 - 2041	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	51,000	32,000	90,000	127,700
2041 - 2042	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	90,000	128,700
2042 - 2043	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	90,000	128,700
2043 - 2044	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	90,000	128,700
2044 - 2045	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	90,000	128,700
2045 - 2046	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	89,000	130,700
2046 - 2047	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	89,000	130,700
2047 - 2048	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	89,000	130,700
2048 - 2049	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	89,000	130,700
2049 - 2050	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	88,000	131,700
40/41-49/50 Avg	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	89,000	129,700

Figures

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Note: Groundwater basins from Bulletin 118, California Department of Water Resources Rev. 2016

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 10 20 40
Miles

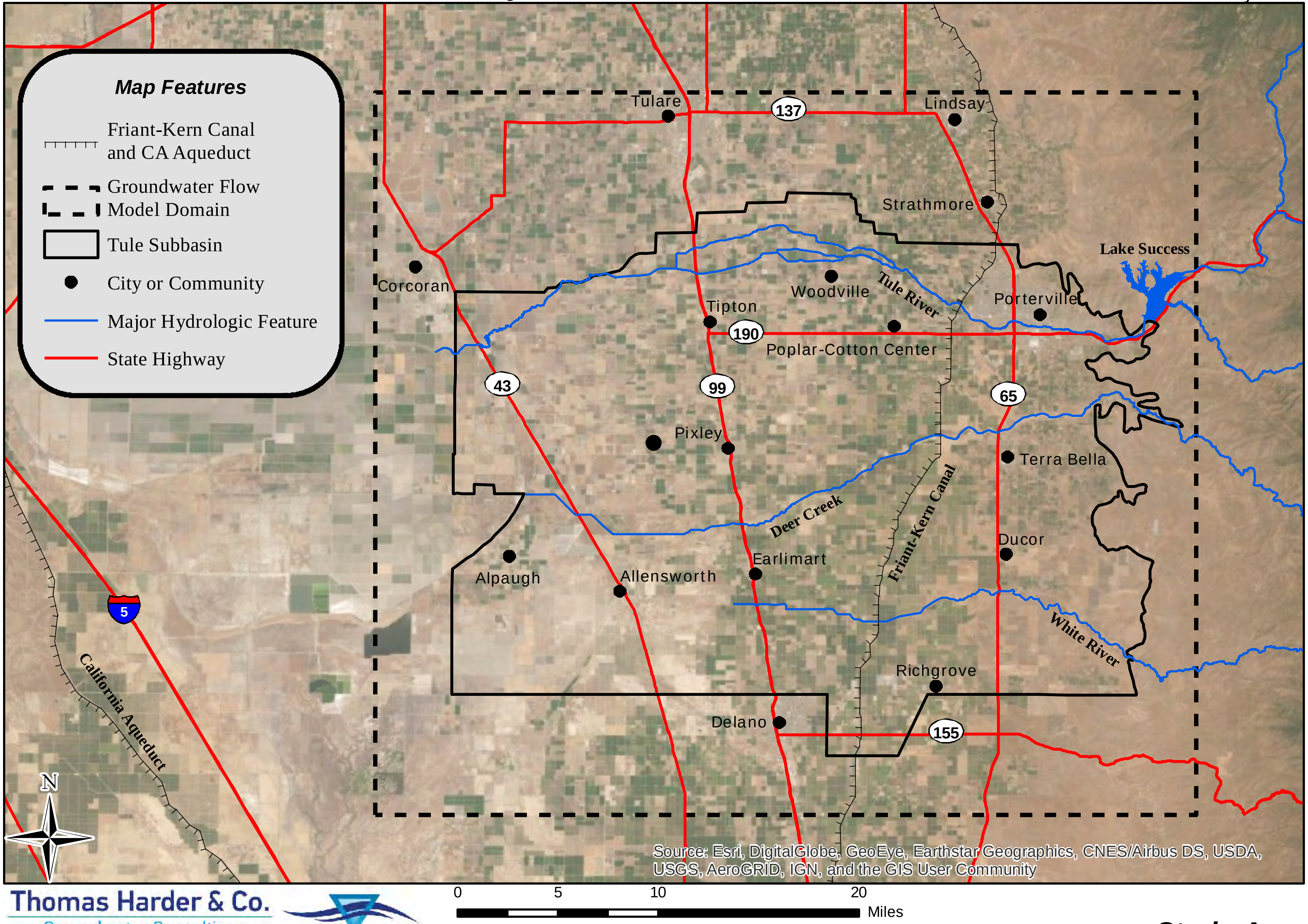
Regional Map

Figure 1

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

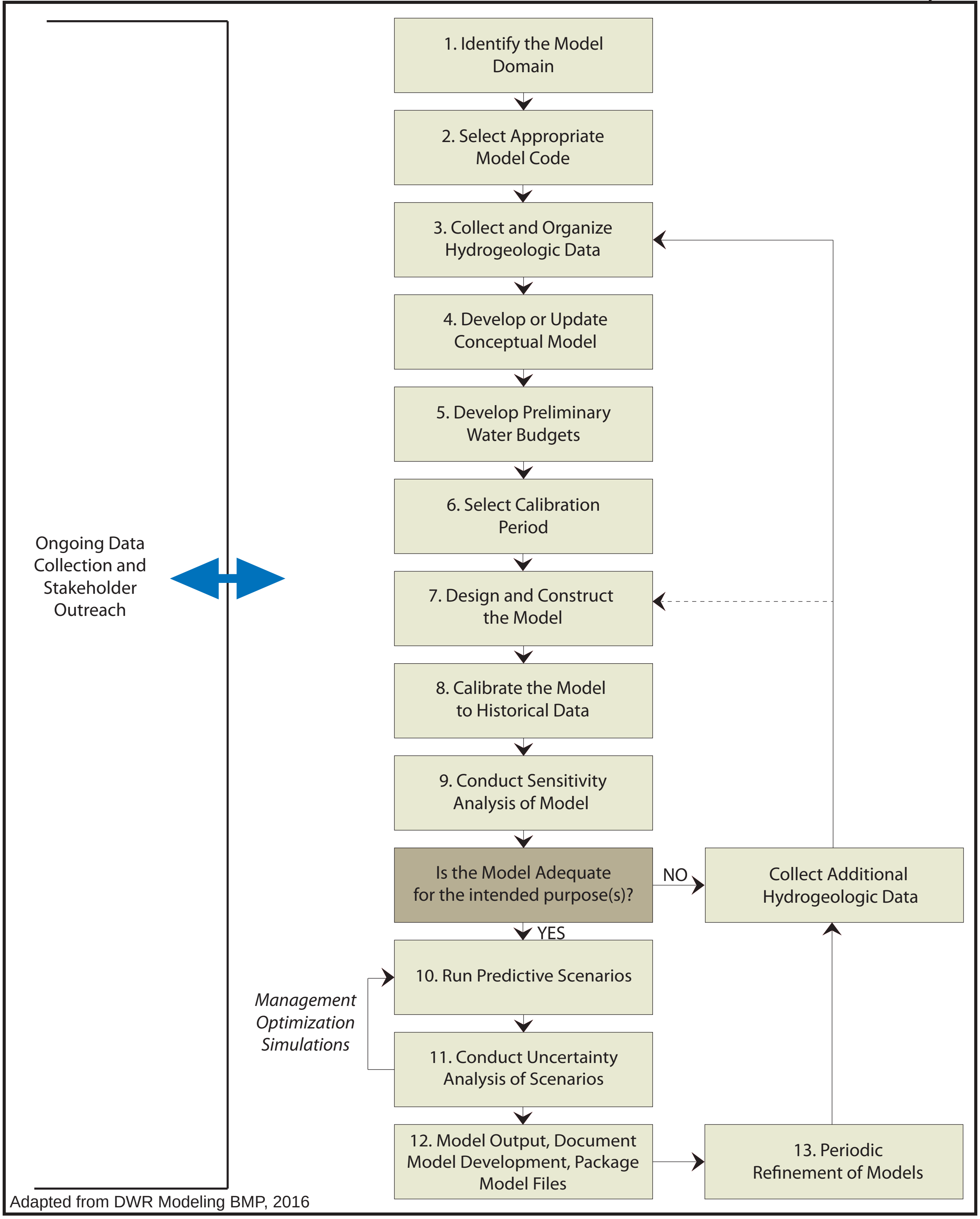
Study Area

Figure 2

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

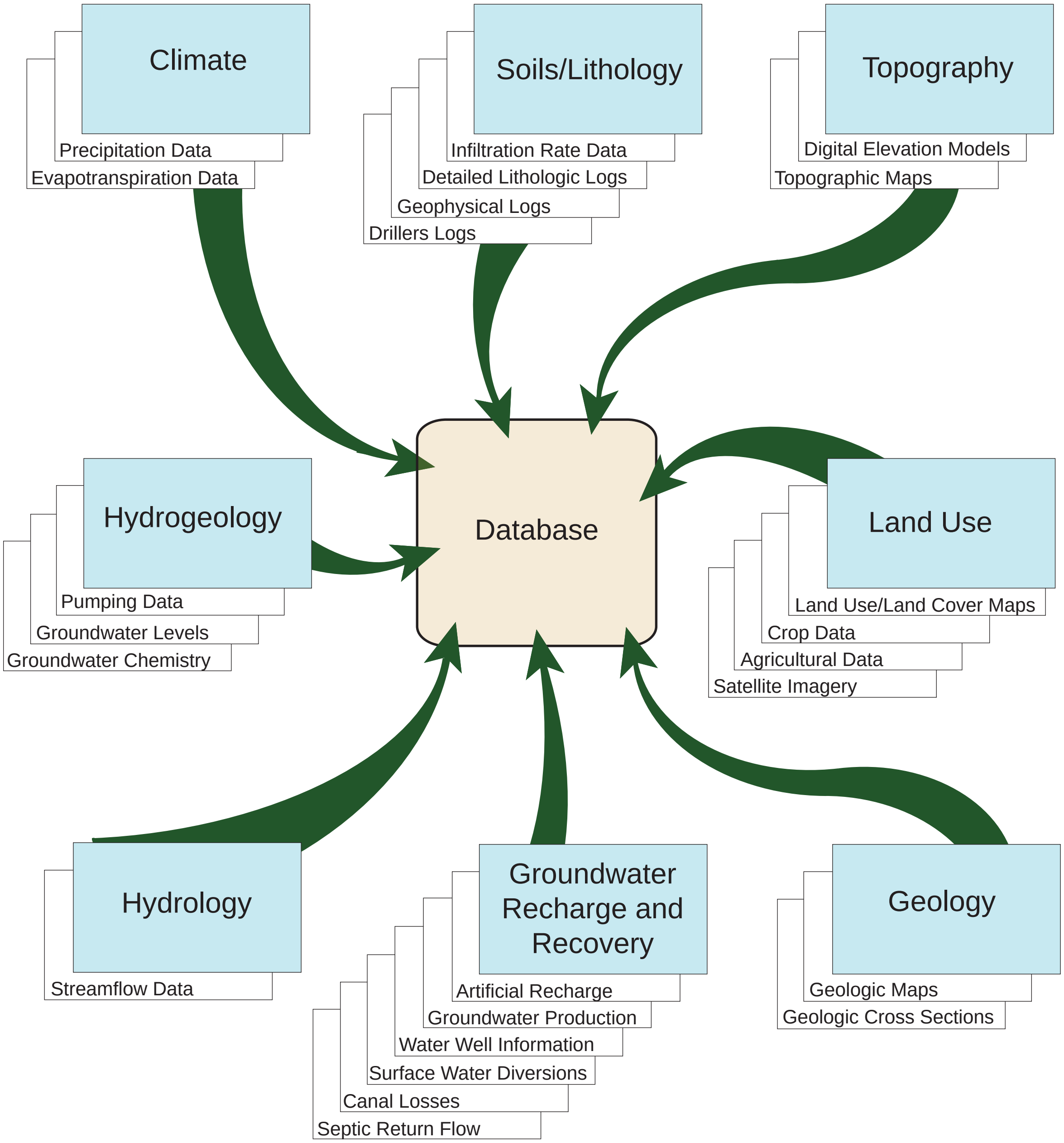
January 2020



Adapted from DWR Modeling BMP, 2016

Thomas Harder & Co.
Groundwater Consulting

General Modeling Process
Figure 3

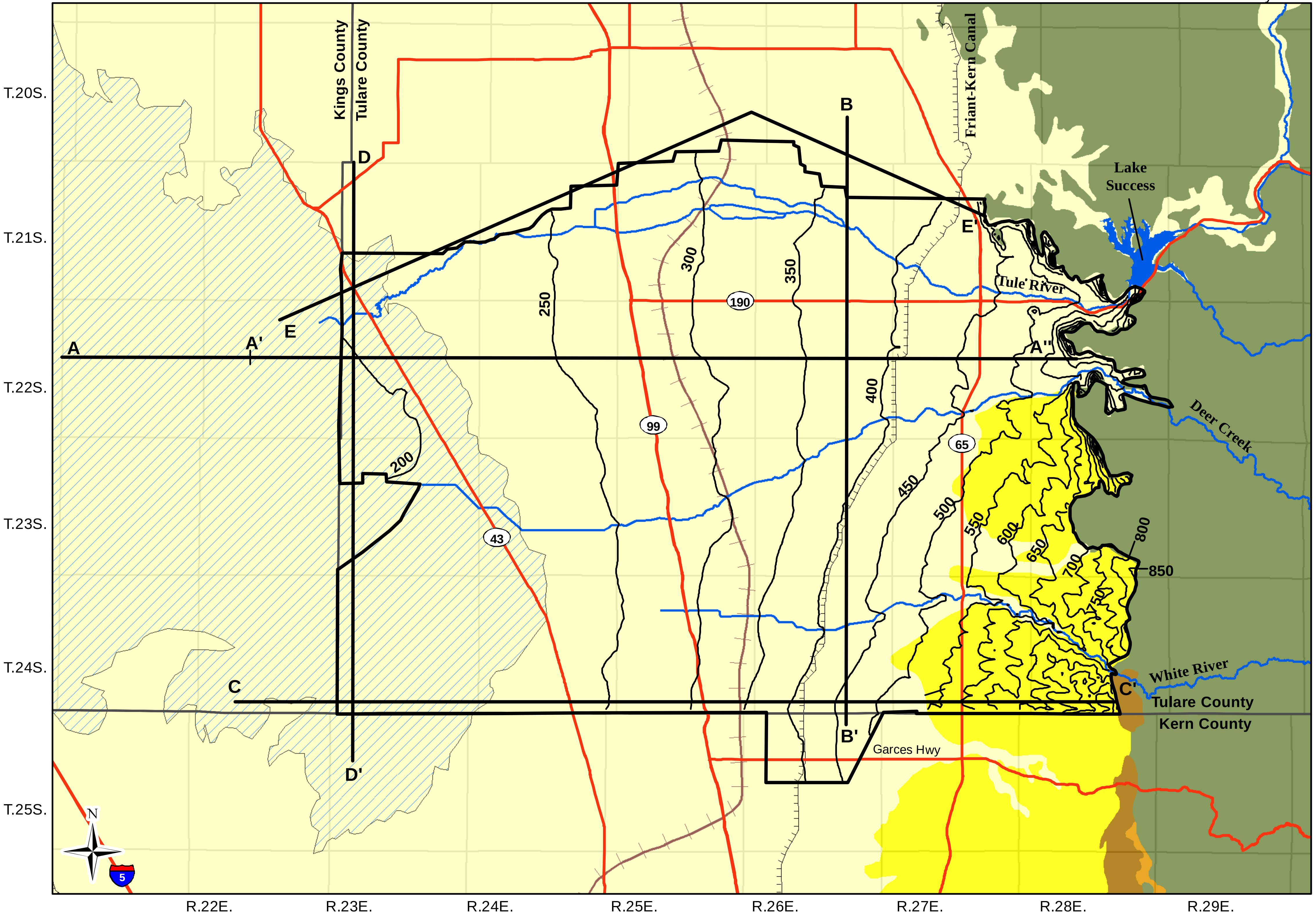


Adapted from Faunt et al., 2009

Groundwater Flow Model of the Tule Subbasin

Tule Subbasin Technical Advisory Committee

January 2020



0 3 6 12 Miles

NAD 83 State Plane Zone 4

Map Features

- 300 Land Surface Elevation Contour (ft amsl)
- Cross Section
- ☐ County Boundary
- Surficial Deposits
- Tertiary Loosely Consolidated Deposits
- Non-Marine Sedimentary Rocks
- Marine Sedimentary Rocks
- Crystalline Basement
- Approximate Eastern Extent of the Corcoran Clay
- ▨ Tulare Lake Surface Deposits
- Friant-Kern Canal
- Tule Subbasin
- Major Hydrologic Feature
- State Highway/Major Road

Corcoran Clay from USGS Professional Paper 1766,
http://water.usgs.gov/GIS/dsdl/pp1766_CorcoranClay.zip

Geologic units modified from USGS Open-File Report 2005-1305

Lake Deposits from California Geological Survey
Geologic Atlas of California Map No. 002
1:250,000 scale, Compiled by A.R. Smith, 1964
and Geologic Atlas of California Map No. 005,
1:250,000 scale, Compiled by: R.A. Matthews and J.L. Burnett

Thomas Harder & Co.
Groundwater Consulting

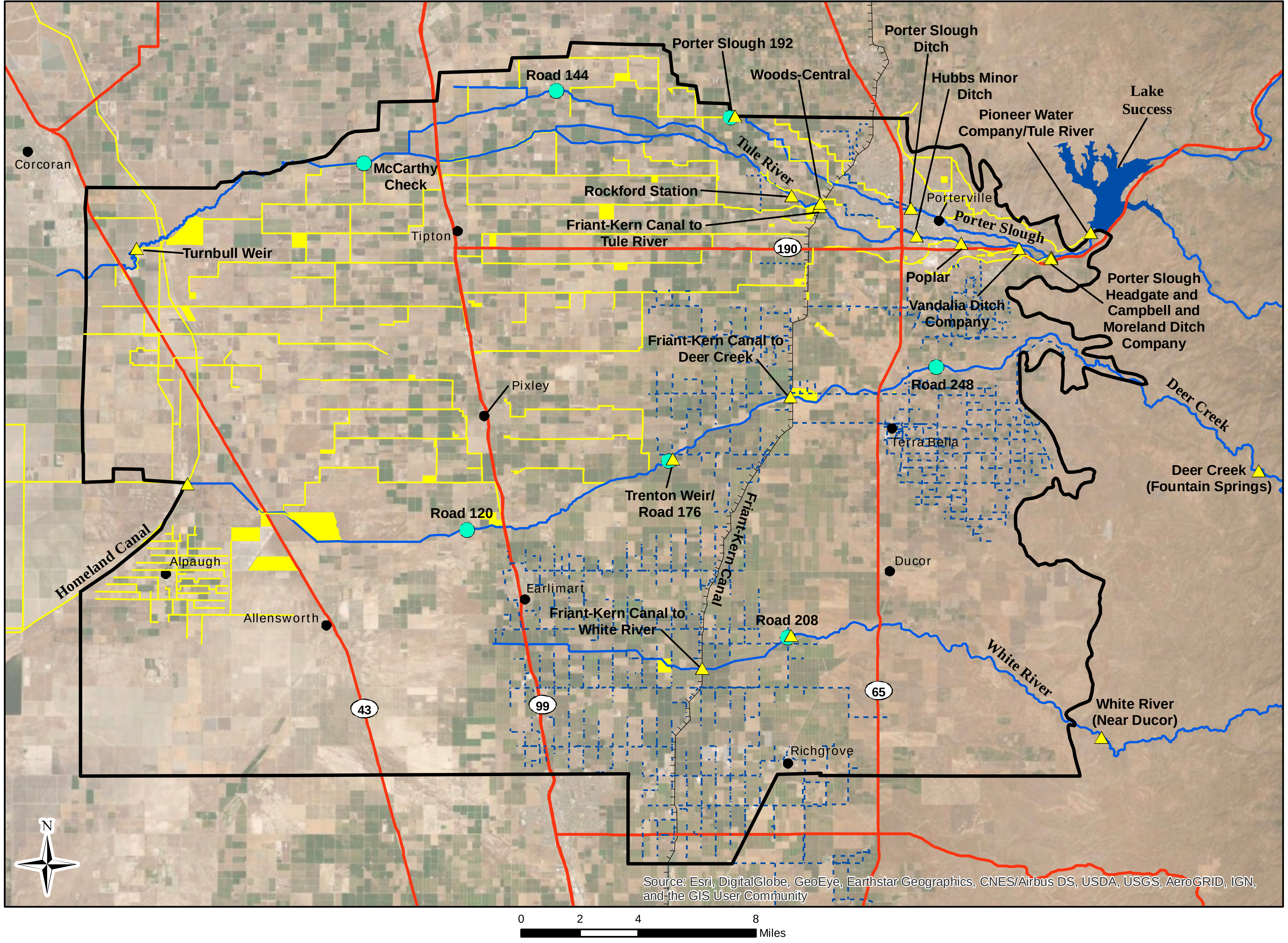
Geology and Cross Section Locations

Figure 5

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model of the Tule Subbasin



NAD 83 State Plane Zone 4

Map Features

- 🟨 Artificial Recharge Basin
- ● Surface Water Quality Monitoring Location
- △ Gaging Location/Surface Water Diversion
- — Major Hydrologic Feature
- ┬┬┬ Friant-Kern Canal and California Aqueduct
- — Canal
- - - Pipe
- ▭ Tule Subbasin
- ● City or Community
- — Freeway/State Highway

Thomas Harder & Co.
Groundwater Consulting

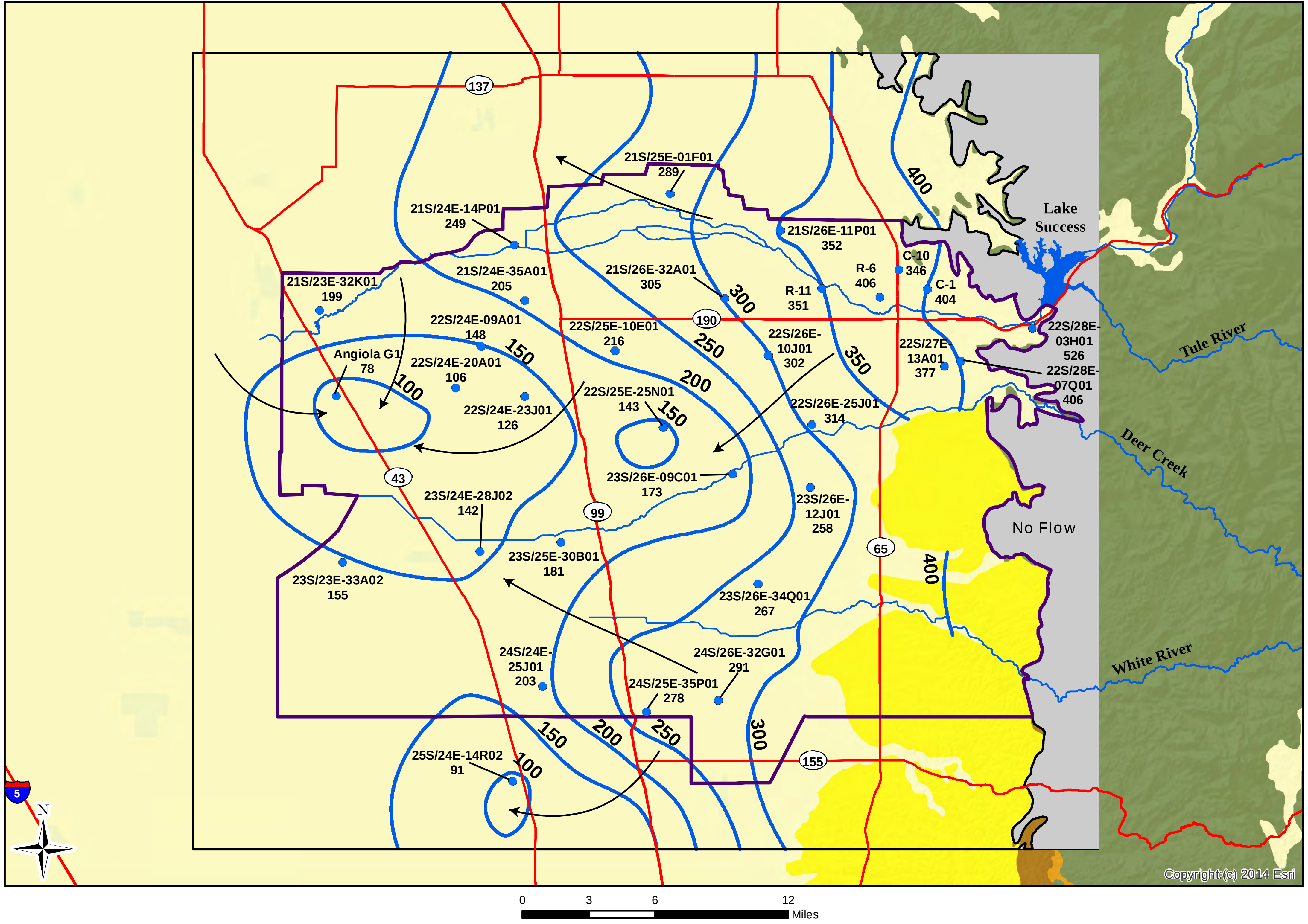
Surface Water Features in the Tule Subbasin and Vicinity

Figure 6

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model
of the Tule Subbasin



NAD 83 State Plane Zone 4

Map Features

22S/25E-25N01
143

● Well with Groundwater Elevation (ft amsl)

150 Groundwater Elevation Contour (ft amsl)

← Groundwater Flow Direction

🟨 Surficial Deposits

🟨 Tertiary Loosely Consolidated Deposits

🟧 Non-Marine Sedimentary Rocks

🟫 Marine Sedimentary Rocks

🟩 Crystalline Basement

— State Highway/Major Road

☐ Tule Subbasin

▨ No Flow

☐ Model Domain

Note: All groundwater elevations in feet above mean sea level. Groundwater elevations measured from October 1986 to March 1990.

Thomas Harder & Co.
Groundwater Consulting

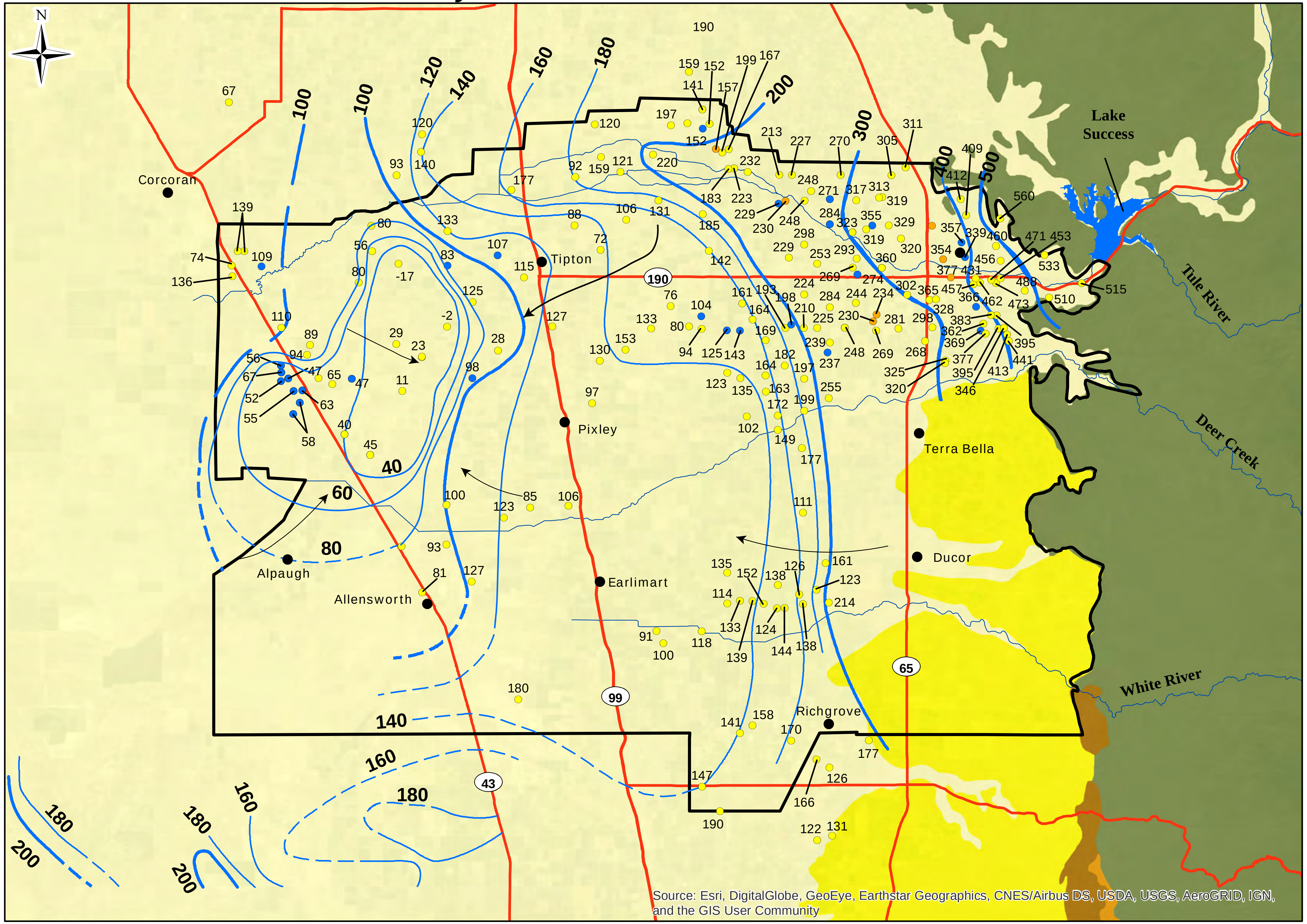
Initial Groundwater Elevations
Upper Aquifer - Model Layer 1

Figure 7

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model
of the Tule Subbasin



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map Features

- **140** Groundwater Elevation Contour, dashed where approximate (ft amsl)
- ← Groundwater Flow Direction
- ● Groundwater Elevations from Well with Unknown Perforation Interval
- ● Groundwater Elevations from Well with Perforations in the Upper and Lower Aquifer
- ● Groundwater Elevations from Well with Perforations in the Upper Aquifer
- ▭ Tule Subbasin
- ● City or Community
- Major Hydrologic Feature
- State Highway/Major Road
- ▨ Surficial Deposits
- ▨ Tertiary Loosely Consolidated Deposits
- ▨ Non-Marine Sedimentary Rocks
- ▨ Marine Sedimentary Rocks
- ▨ Crystalline Basement

Groundwater contours shown south of the Tule Subbasin and west of Highway 43 are depicted based on Water-Level Elevations And Direction of Groundwater Flow For the Upper Zone (Spring 2017)

Note: All groundwater elevations are in feet above mean sea level.

Groundwater Elevations are measured from January to May.

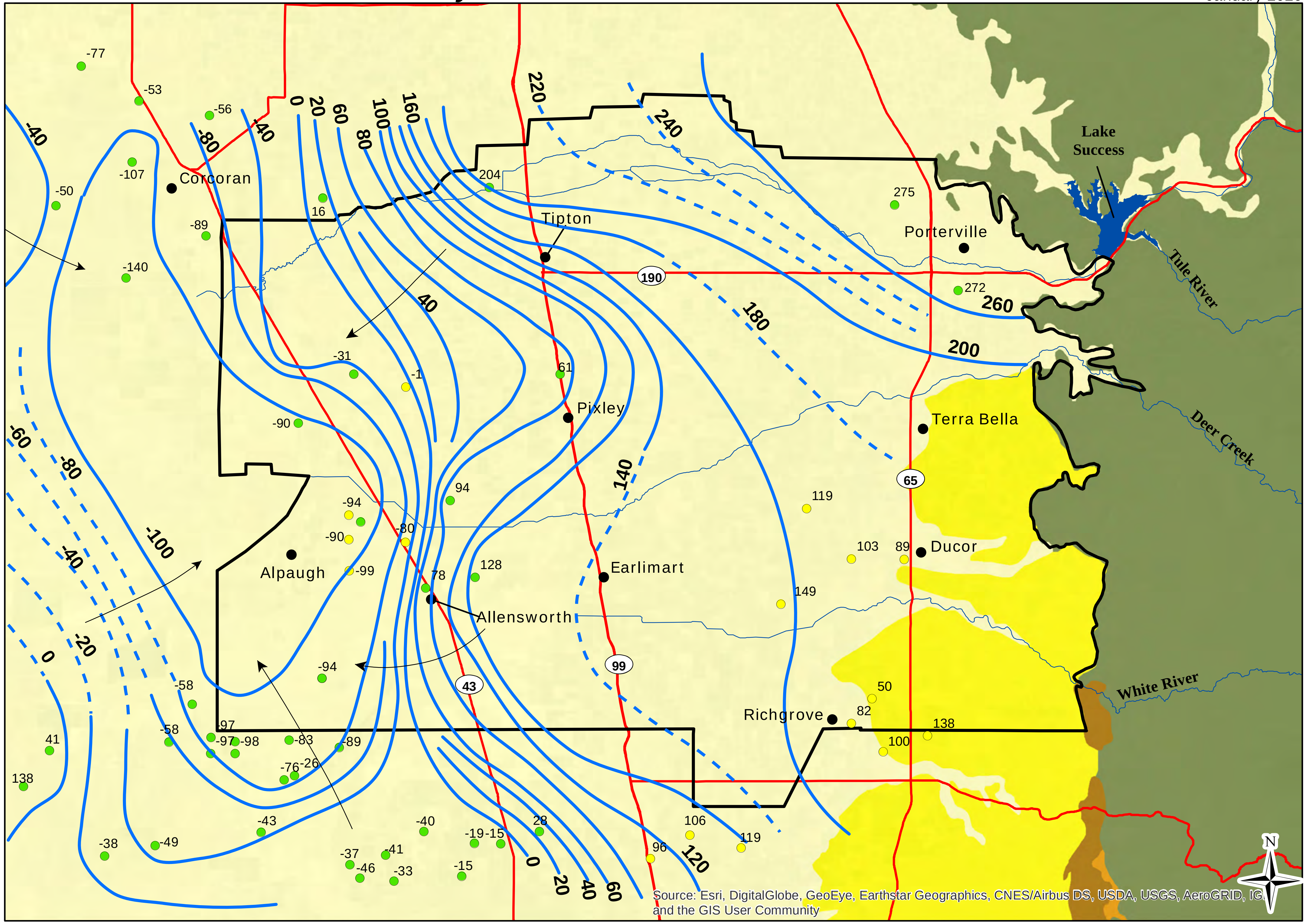
Spring 2017 Upper Aquifer Groundwater Elevation Contours

Figure 8

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model of the Tule Subbasin



0 3 6 12 Miles

NAD 83 State Plane Zone 4

Map Features

140 Groundwater Elevation Contour, dashed where approximate (ft amsl)

← Groundwater Flow Direction

● Groundwater Elevations from Well with Perforations in the Deep Aquifer

○ Groundwater Elevations from Well with Unknown Perforation Interval

☐ Tule Subbasin

● City or Community

— Major Hydrologic Feature

— State Highway/Major Road

▨ Surficial Deposits

▨ Tertiary loosely consolidated deposits

▨ Non-Marine Sedimentary Rocks

▨ Marine Sedimentary Rocks

▨ Crystalline Basement

Note: All groundwater elevations are in feet above mean sea level.

Groundwater Elevations are measured from October to December.

Thomas Harder & Co.
Groundwater Consulting

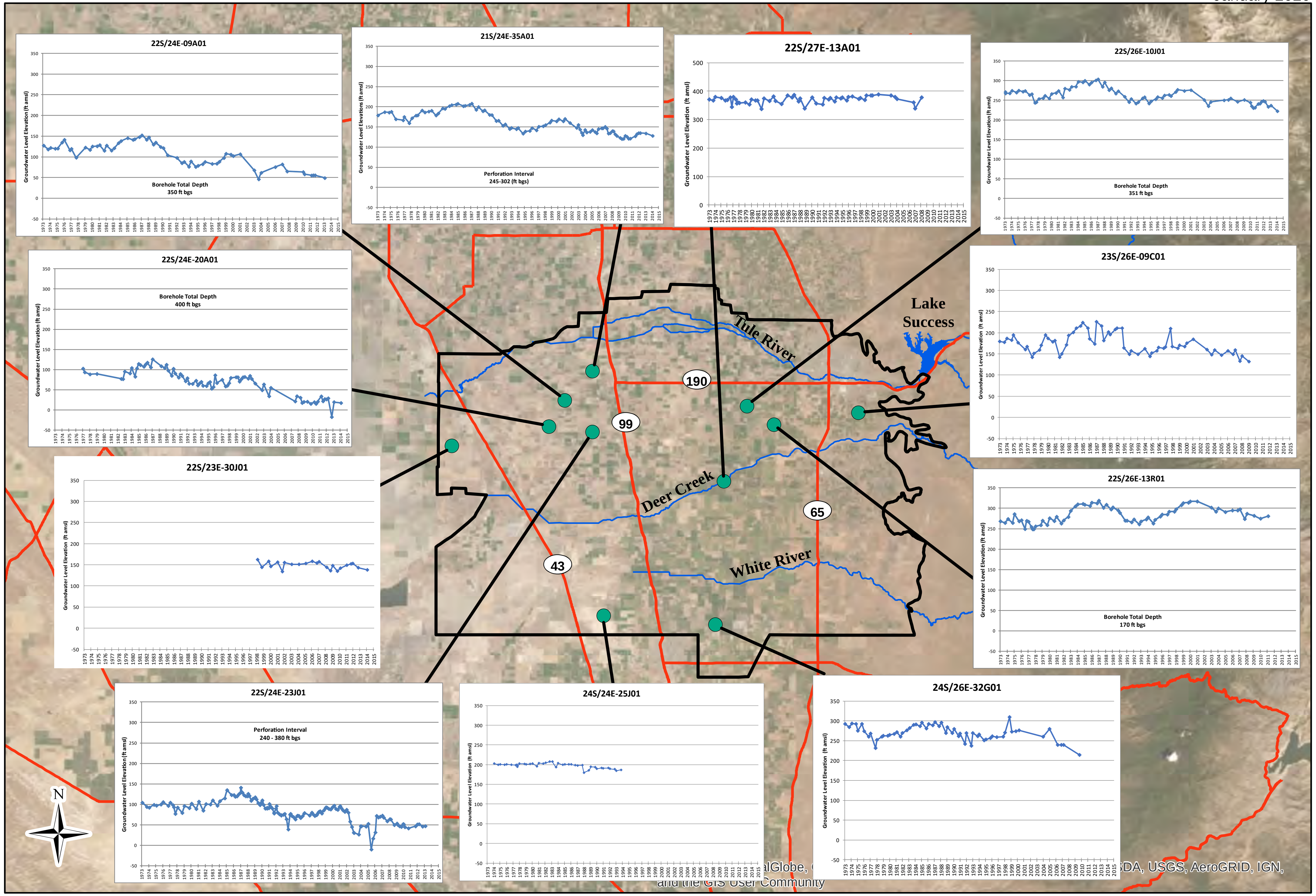
Fall 2010 Lower Aquifer Groundwater Elevation Contours

Figure 9

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model
of the Tule Subbasin



Map Features

- ● Hydrograph Well
- ☐ Tule Subbasin
- Major Hydrologic Feature
- State Highway/Major Road

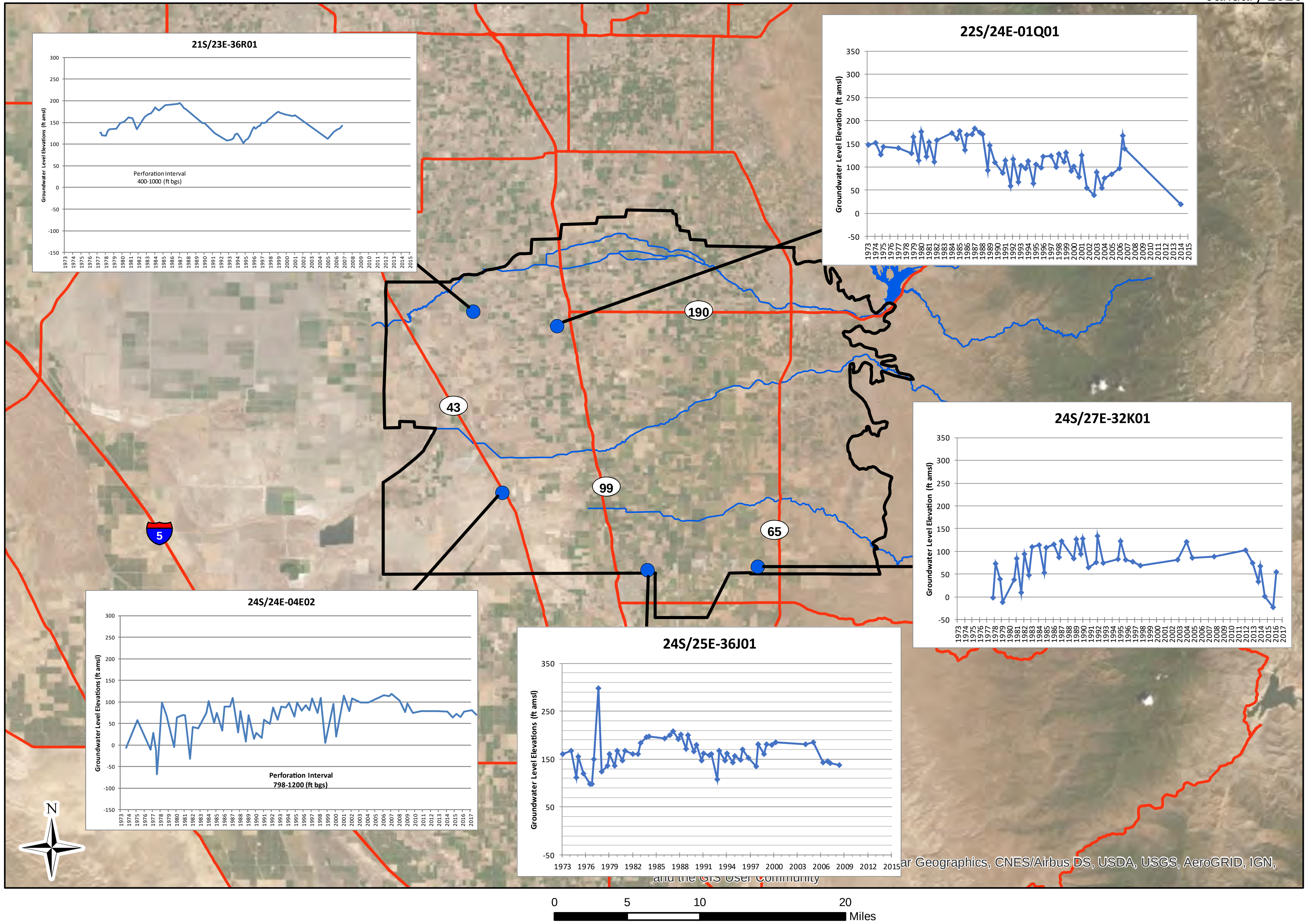
0 5 10 20 Miles

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

Upper Aquifer Groundwater Level Hydrographs

Figure 10



NAD 83 State Plane Zone 4

Map Features

● Hydrograph Well

▭ Tule Subbasin

— Major Hydrologic Feature

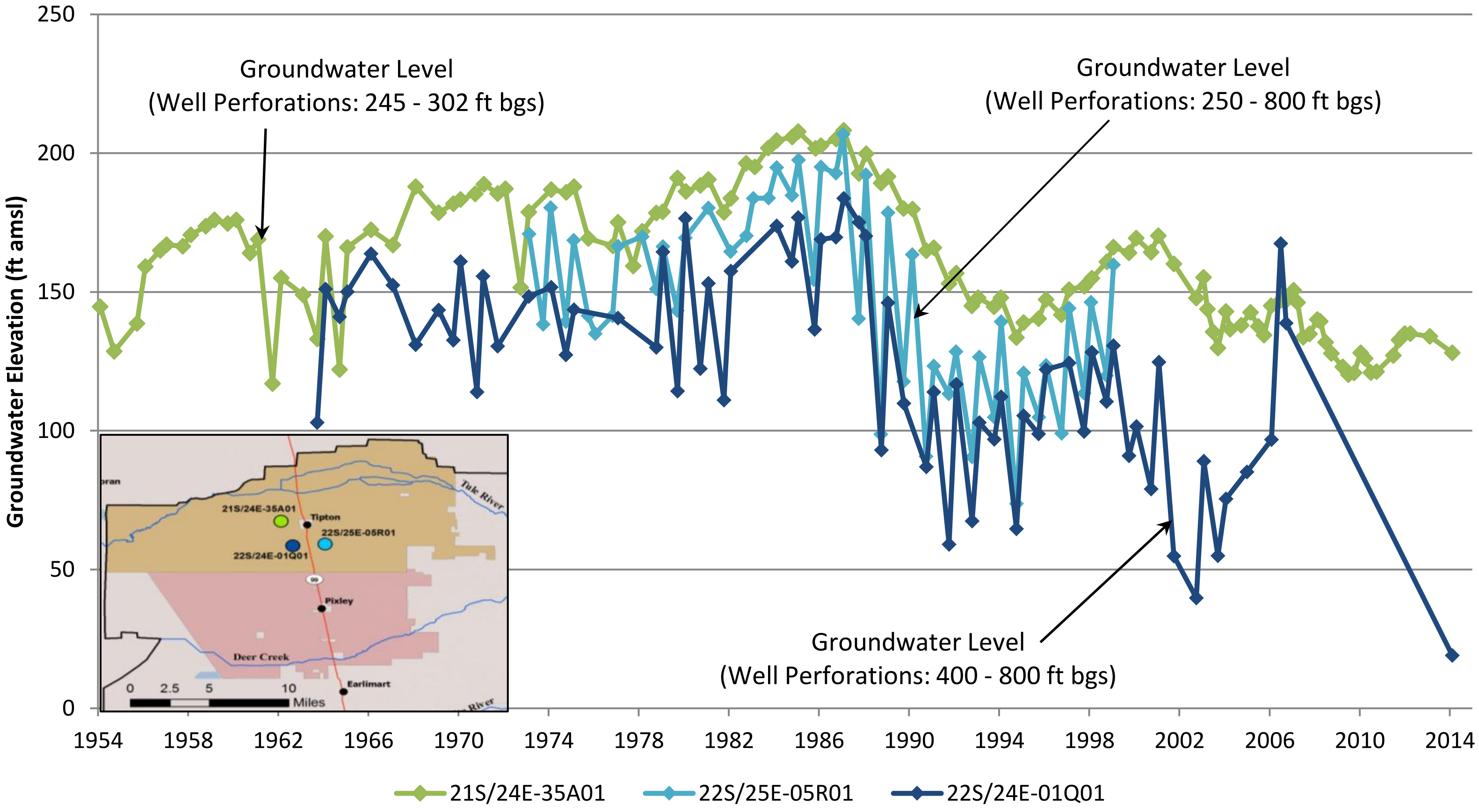
— State Highway/Major Road

Thomas Harder & Co.
Groundwater Consulting

Lower Aquifer Groundwater Level Hydrographs

Figure 11

Comparison of Upper Aquifer and Lower Aquifer Groundwater Levels



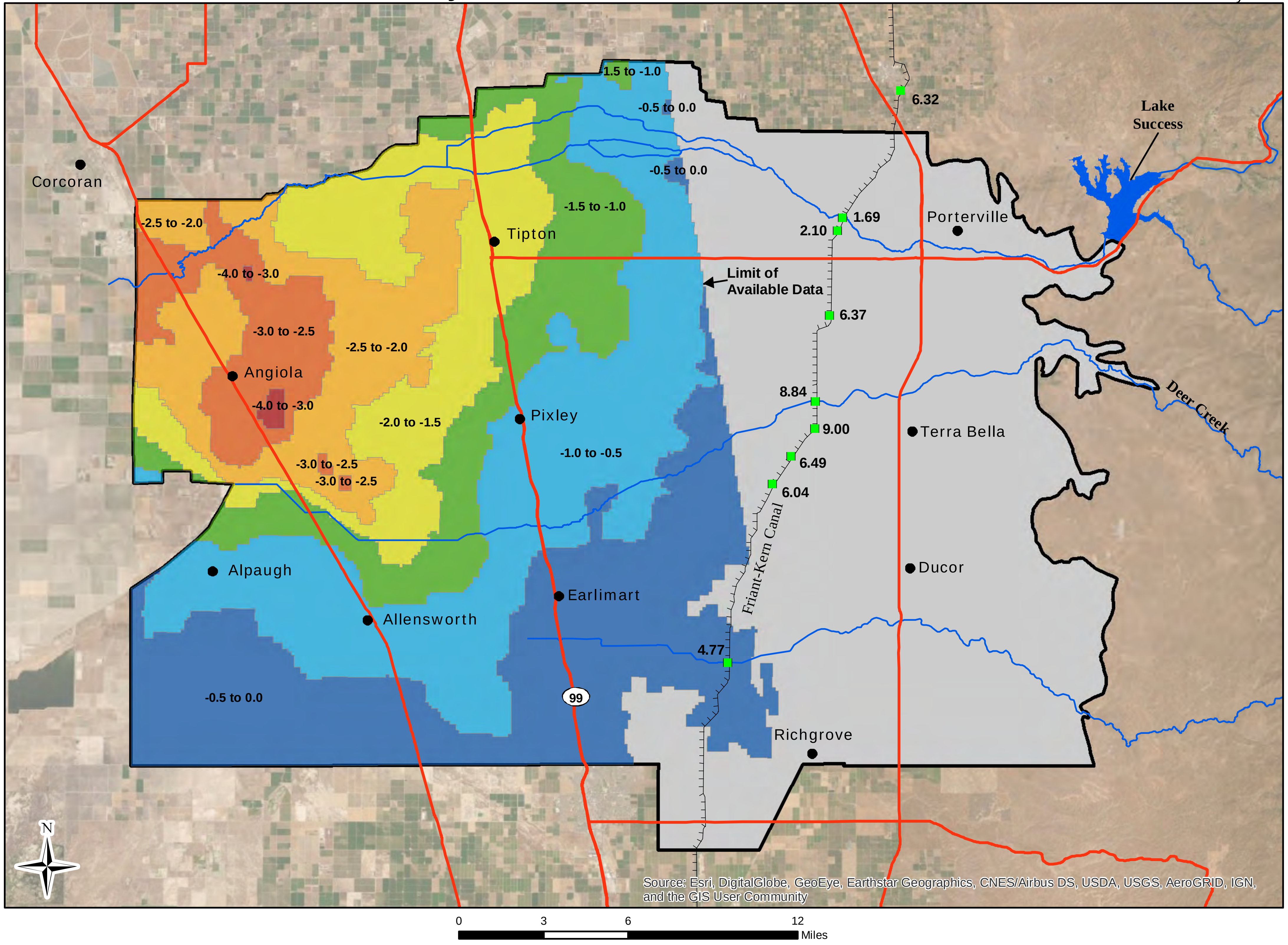
Note:

ft bgs = feet below ground surface.

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model of the Tule Subbasin



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Map Features

2007 - 2011 Land Surface Subsidence* (ft)

🟥	-4.0 to -3.0
🟧	-3.0 to -2.5
🟧	-2.5 to -2.0
🟨	-2.0 to -1.5
🟩	-1.5 to -1.0
🟦	-1.0 to -0.5
🟦	-0.5 to 0.0
🟩	Measured Subsidence Points along the Friant-Kern Canal (ft) 1959-2017
┬┬┬┬	Friant-Kern Canal
▢	Basin Boundary
●	City or Community
—	Major Hydrologic Feature
—	Freeway/State Highway

*From LSCE, 2014

Thomas Harder & Co.
Groundwater Consulting

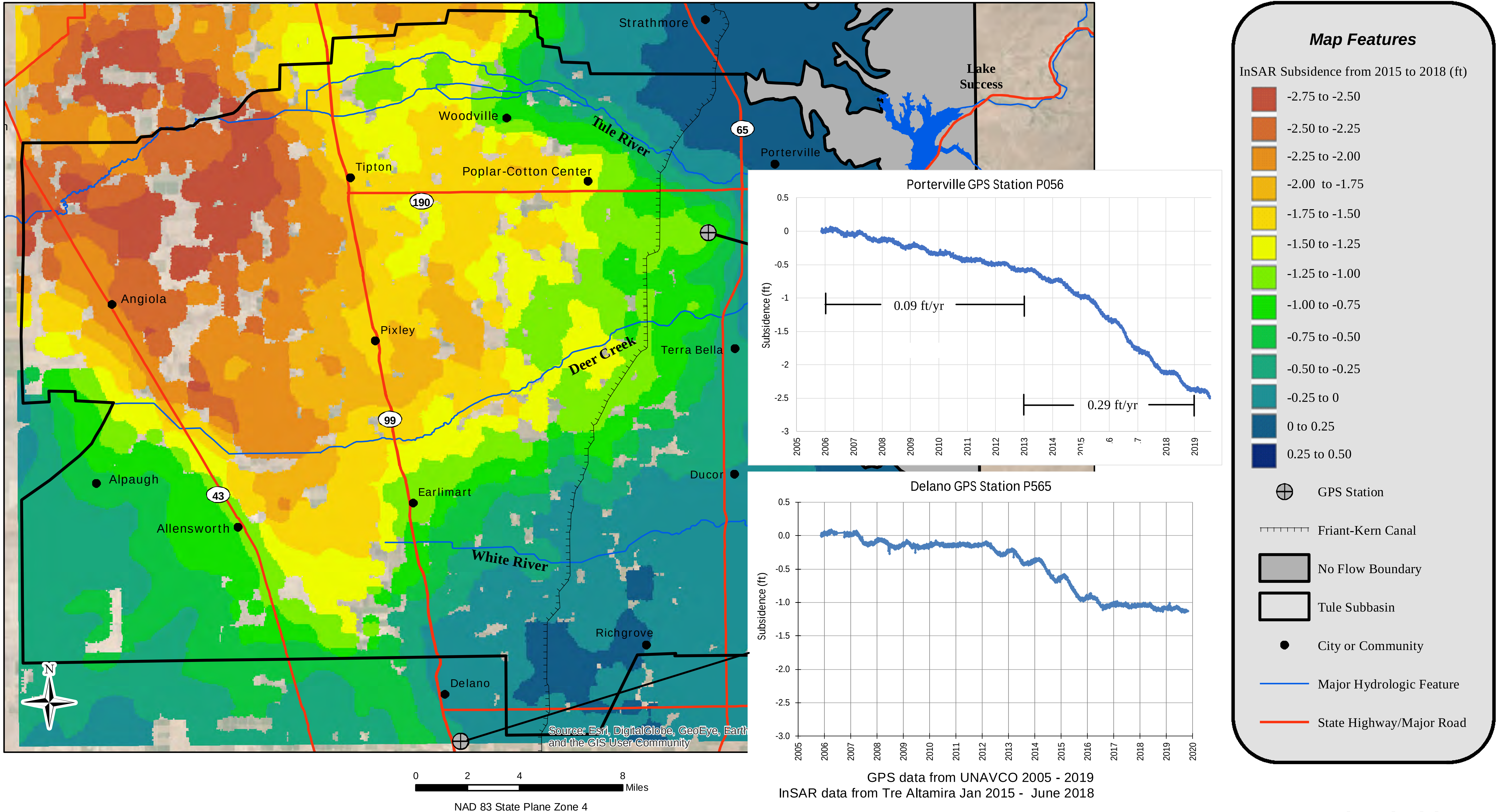
2007 to 2011 Land Subsidence

Figure 13

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model of the Tule Subbasin



GPS data from UNAVCO 2005 - 2019
InSAR data from Tre Altamira Jan 2015 - June 2018

Thomas Harder & Co.
Groundwater Consulting

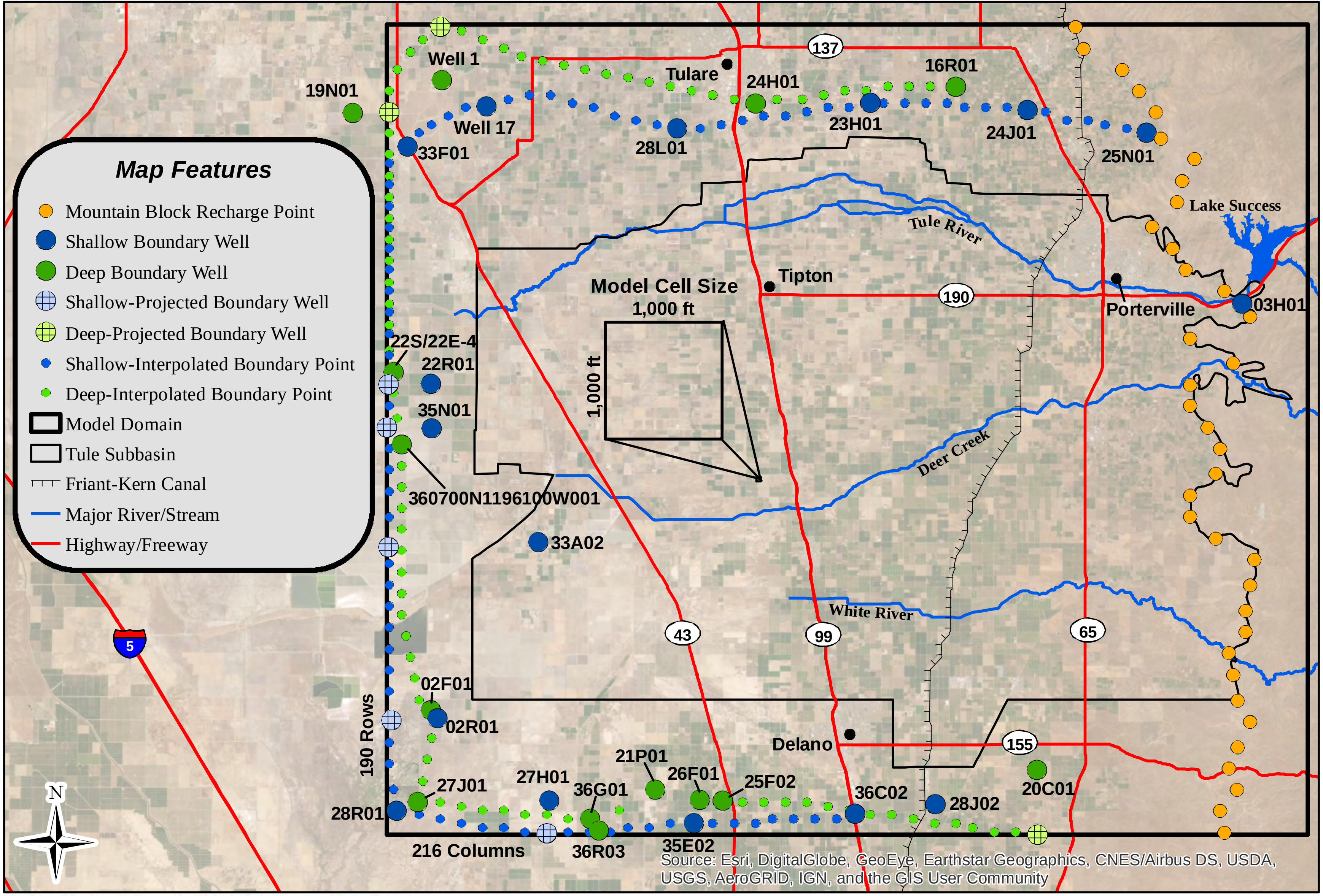
2015 to 2018 Land Subsidence

Figure 14

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 2.5 5 10 Miles

NAD 83 State Plane Zone 4

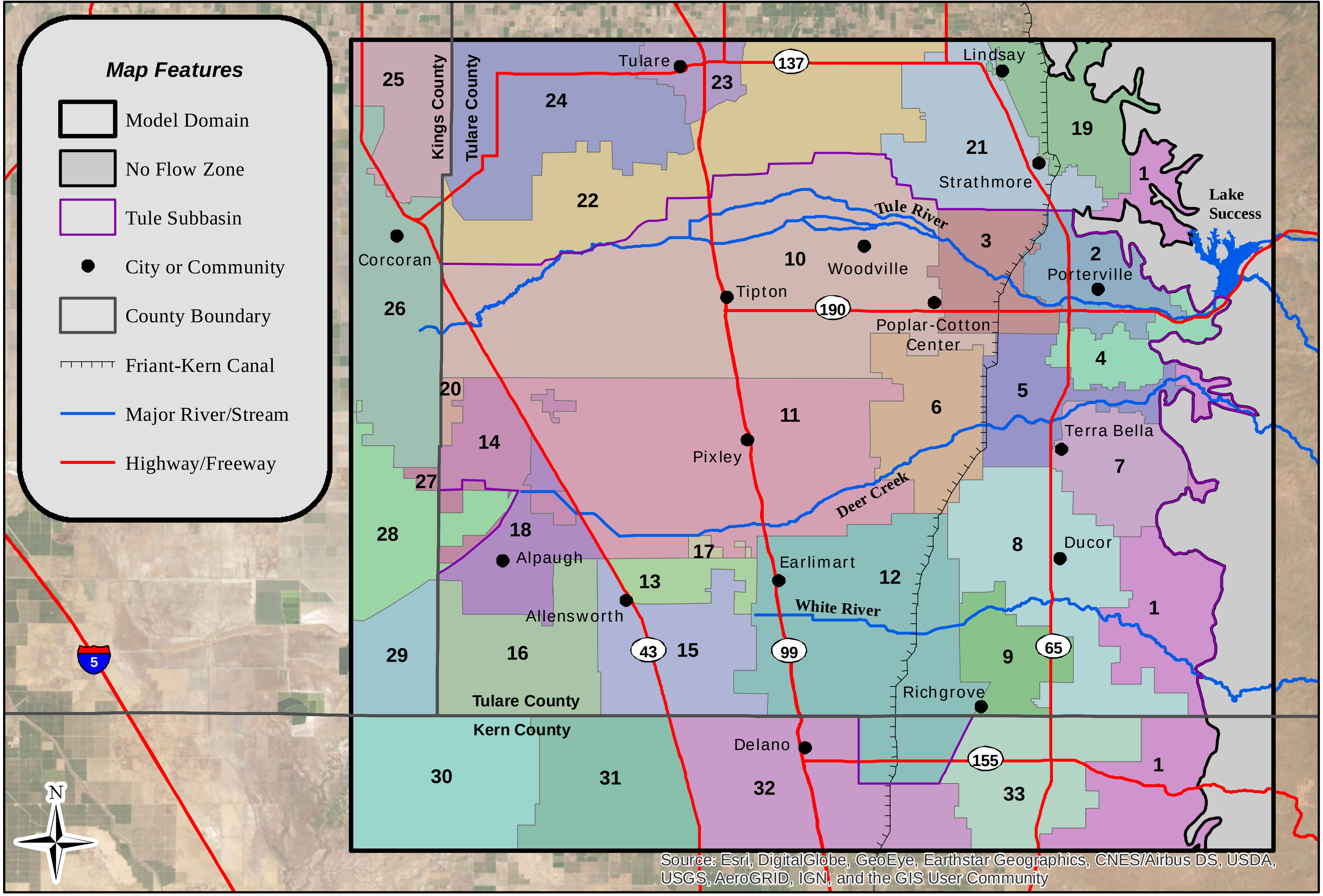
Model Domain and Boundary Conditions

Figure 15

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 2 4 8 Miles

NAD 83 State Plane Zone 4

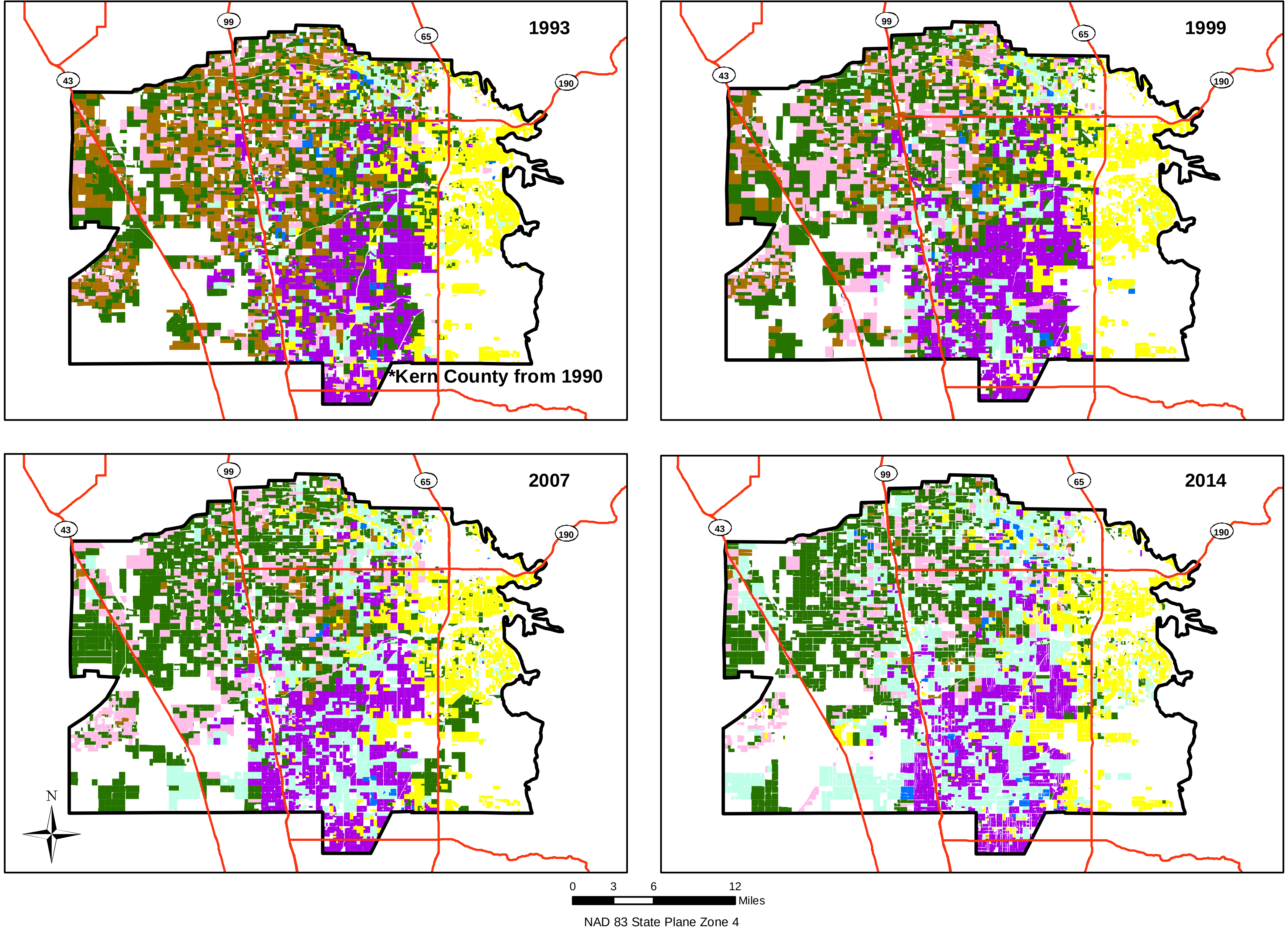
Water Budget Areas

Figure 16

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Map Features

- ☐ Tule Groundwater Subbasin
- 🟪 Alfalfa, Pasture
- 🟩 Corn, Grain, Grain Hay, and Misc. Field Crops
- 🟫 Cotton
- 🟨 Deciduous & Fruit Trees
- 🟪 Grapes
- 🟩 Nuts
- 🟦 Truck Crops
- — Major Road

Notes: Data from California Department of Water Resources and Kern County Department of Agriculture and Measurement Standards

Irrigated crops only.

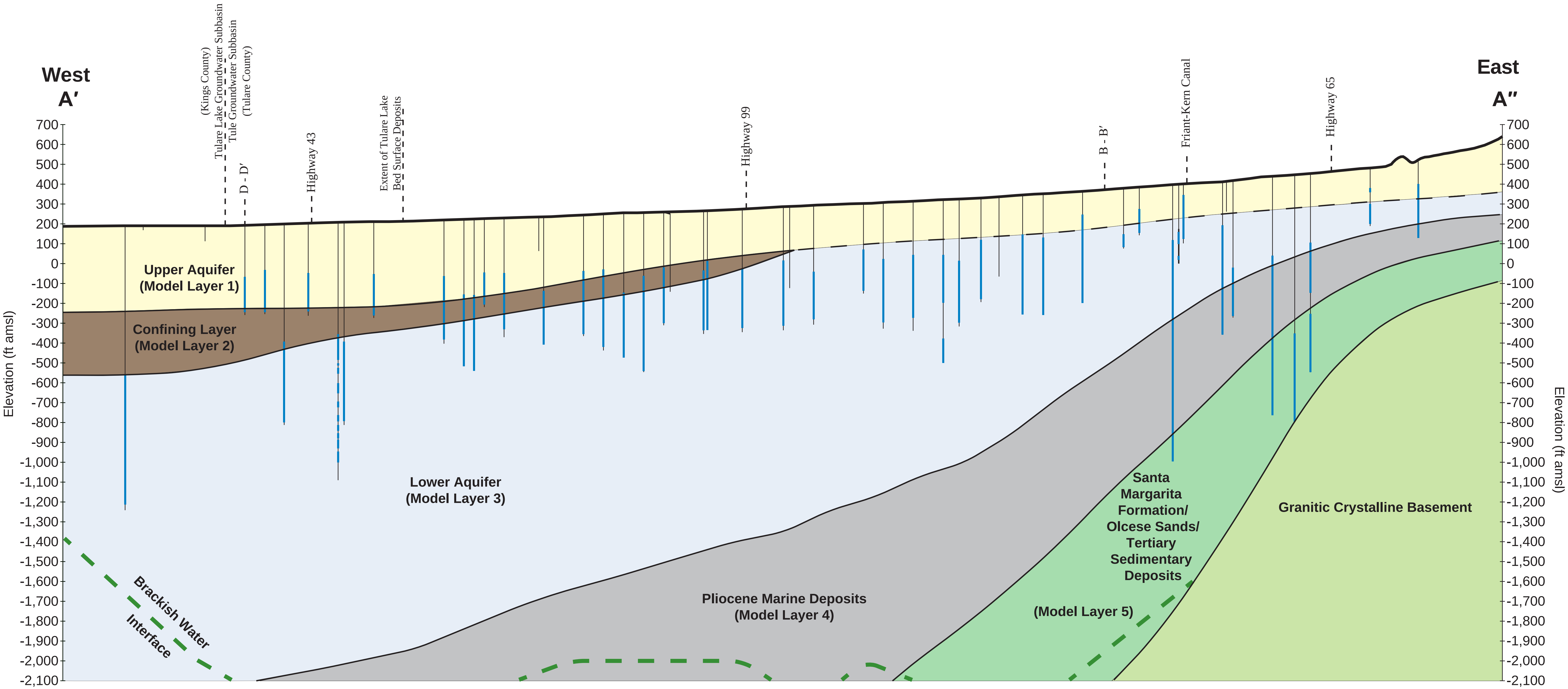
Thomas Harder & Co.
Groundwater Consulting

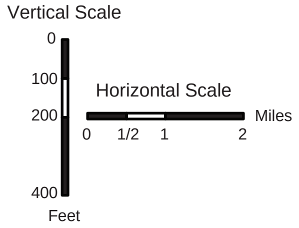
Tule Groundwater Subbasin Historical Crop Patterns

Figure 17

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin





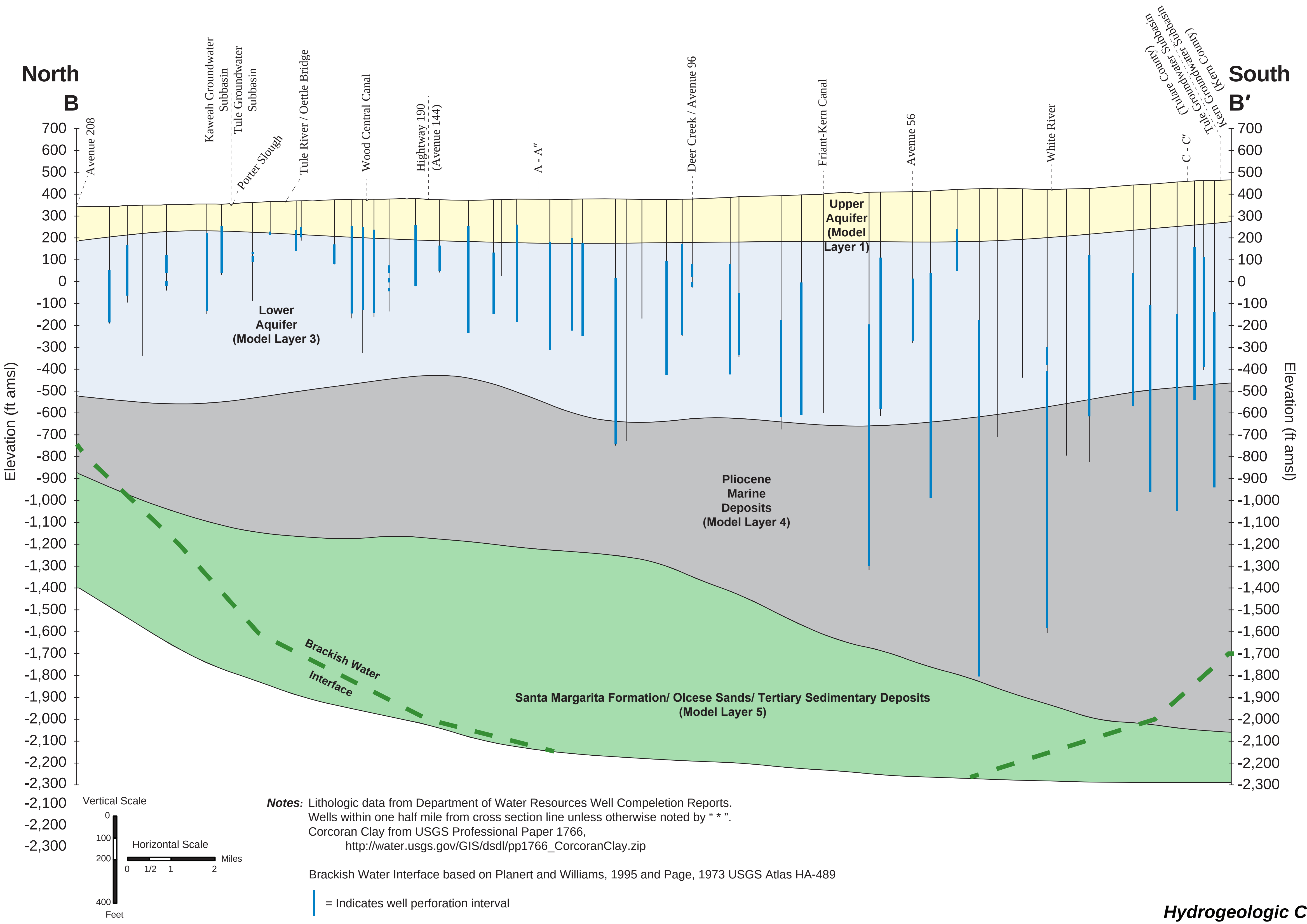
Notes: Lithologic data from Department of Water Resources Well Compeletion Reports.
Wells within one half mile from cross section line unless otherwise noted by " * ".
Corcoran Clay from USGS Professional Paper 1766,
http://water.usgs.gov/GIS/dsdl/pp1766_CorcoranClay.zip

Brackish Water Interface based on Planert and Williams, 1995 and Page, 1973 USGS Atlas HA-489

│ = Indicates well perforation interval

Thomas Harder & Co.
Groundwater Consulting

Hydrogeologic Cross Section A'-A"
Tule Groundwater Subbasin
Figure 18
January 2020



Notes: Lithologic data from Department of Water Resources Well Compeletion Reports.
Wells within one half mile from cross section line unless otherwise noted by " * ".
Corcoran Clay from USGS Professional Paper 1766,
http://water.usgs.gov/GIS/dsdl/pp1766_CorcoranClay.zip

Brackish Water Interface based on Planert and Williams, 1995 and Page, 1973 USGS Atlas HA-489

| = Indicates well perforation interval

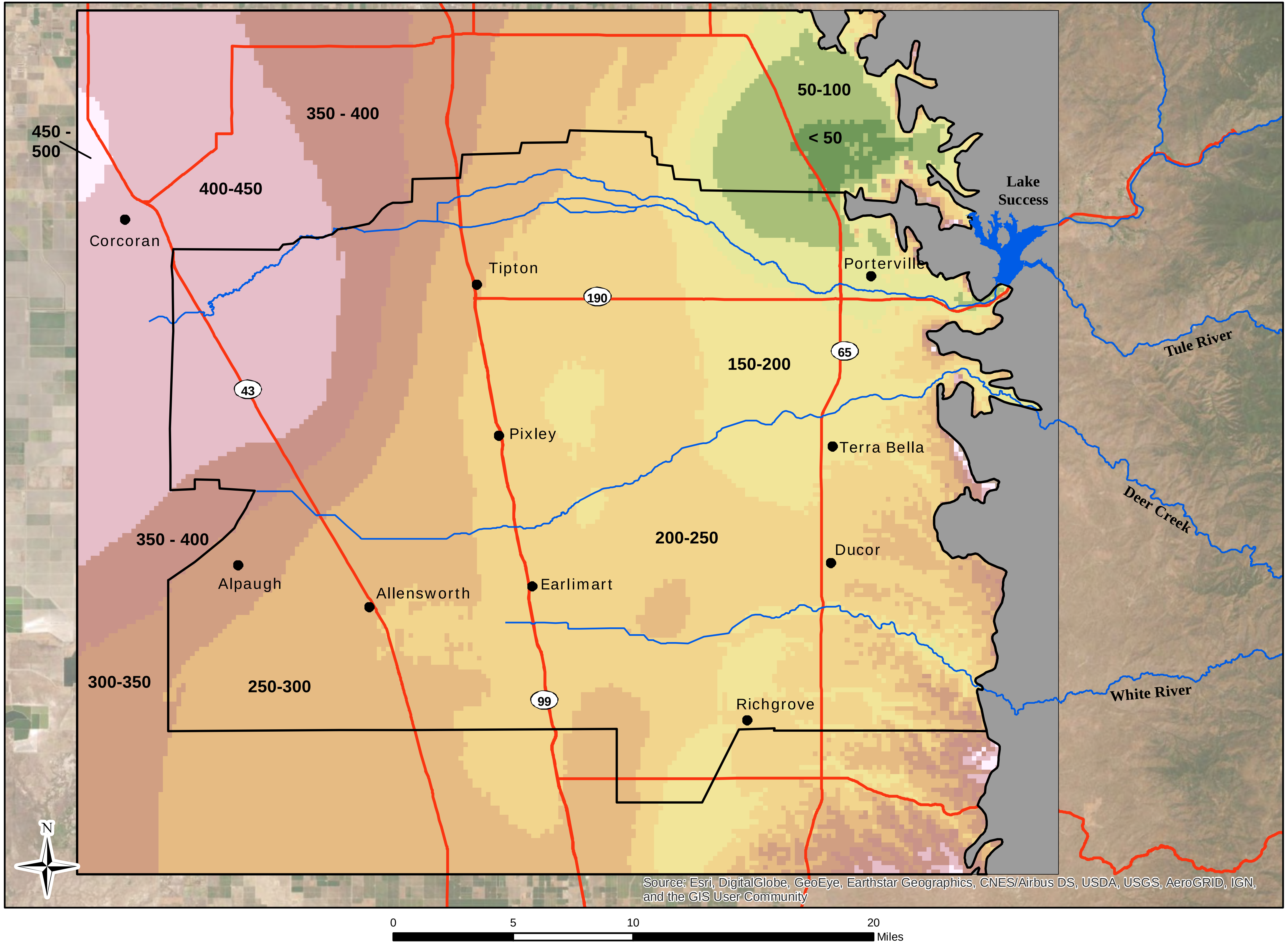
Thomas Harder & Co.
Groundwater Consulting

Hydrogeologic Cross Section B-B′
Tule Groundwater Subbasin
Figure 19
January 2020

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model of the Tule Subbasin



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Map Features

Model Layer 1 Thickness (ft)

- 🟩 < 50
- 🟩 50 - 100
- 🟨 100 - 150
- 🟨 150 - 200
- 🟧 200 - 250
- 🟧 250 - 300
- 🟫 300 - 350
- 🟫 350 - 400
- ▨ 400 - 450
- ▨ 450 - 500
- ▨ No Flow
- ☐ Model Domain
- ☐ Tule Subbasin
- ● City or Community
- — Major Hydrologic Feature
- — State Highway/Major Road

Thomas Harder & Co.
Groundwater Consulting

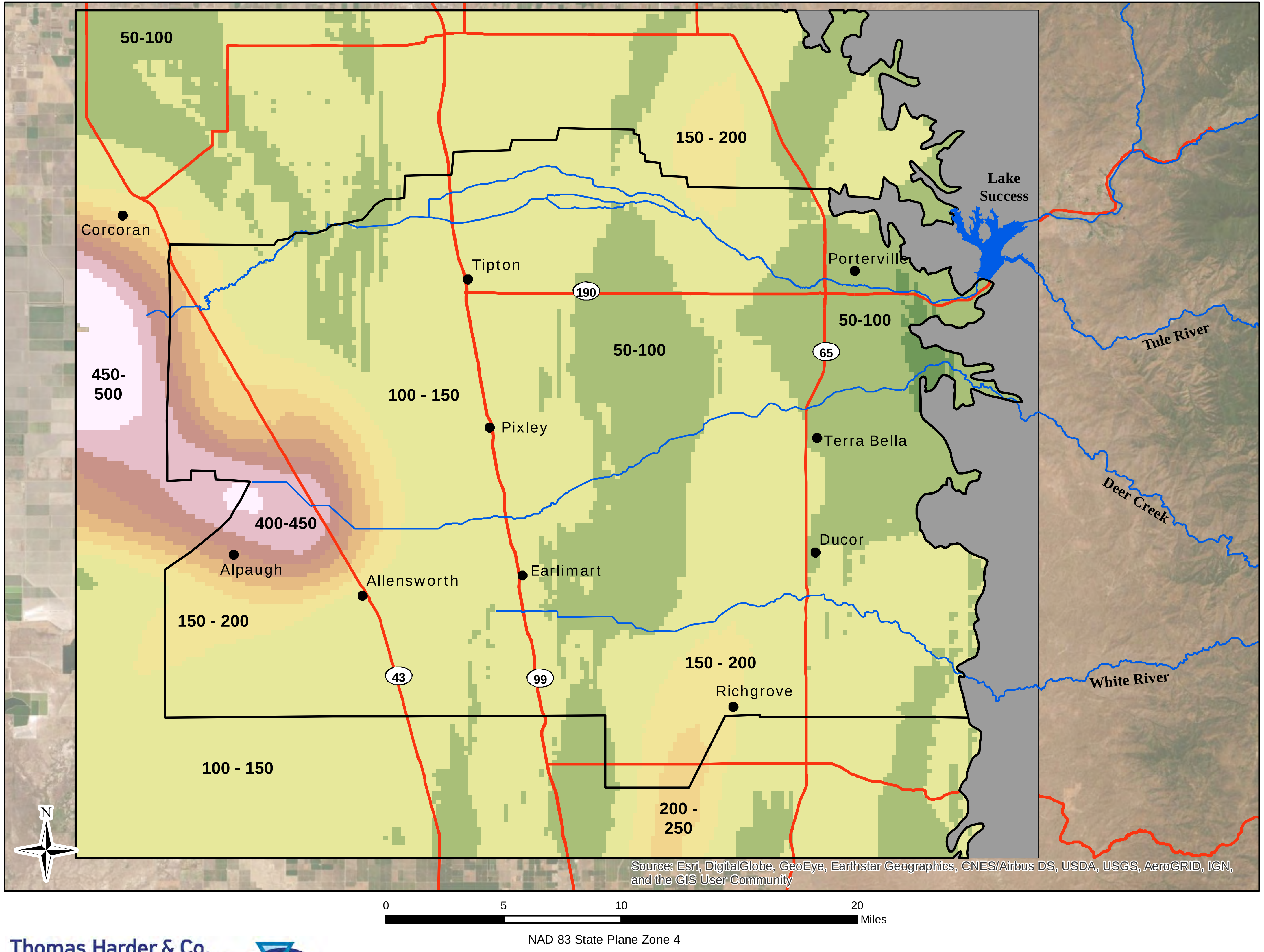
Layer 1 Thickness

Figure 20

Groundwater Flow Model of the Tule Subbasin

Tule Subbasin Technical Advisory Committee

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Map Features

Model Layer 2 Thickness (ft)

- 🟩 < 50
- 🟩 50 - 100
- 🟨 100 - 150
- 🟨 150 - 200
- 🟧 200 - 250
- 🟧 250 - 300
- 🟫 300 - 350
- 🟫 350 - 400
- 🟪 400 - 450
- ⬜ 450 - 500
- ⬛ No Flow
- ☐ Model Domain
- ☐ Tule Subbasin
- ● City or Community
- — Major Hydrologic Feature
- — State Highway/Major Road

Layer 2 Thickness

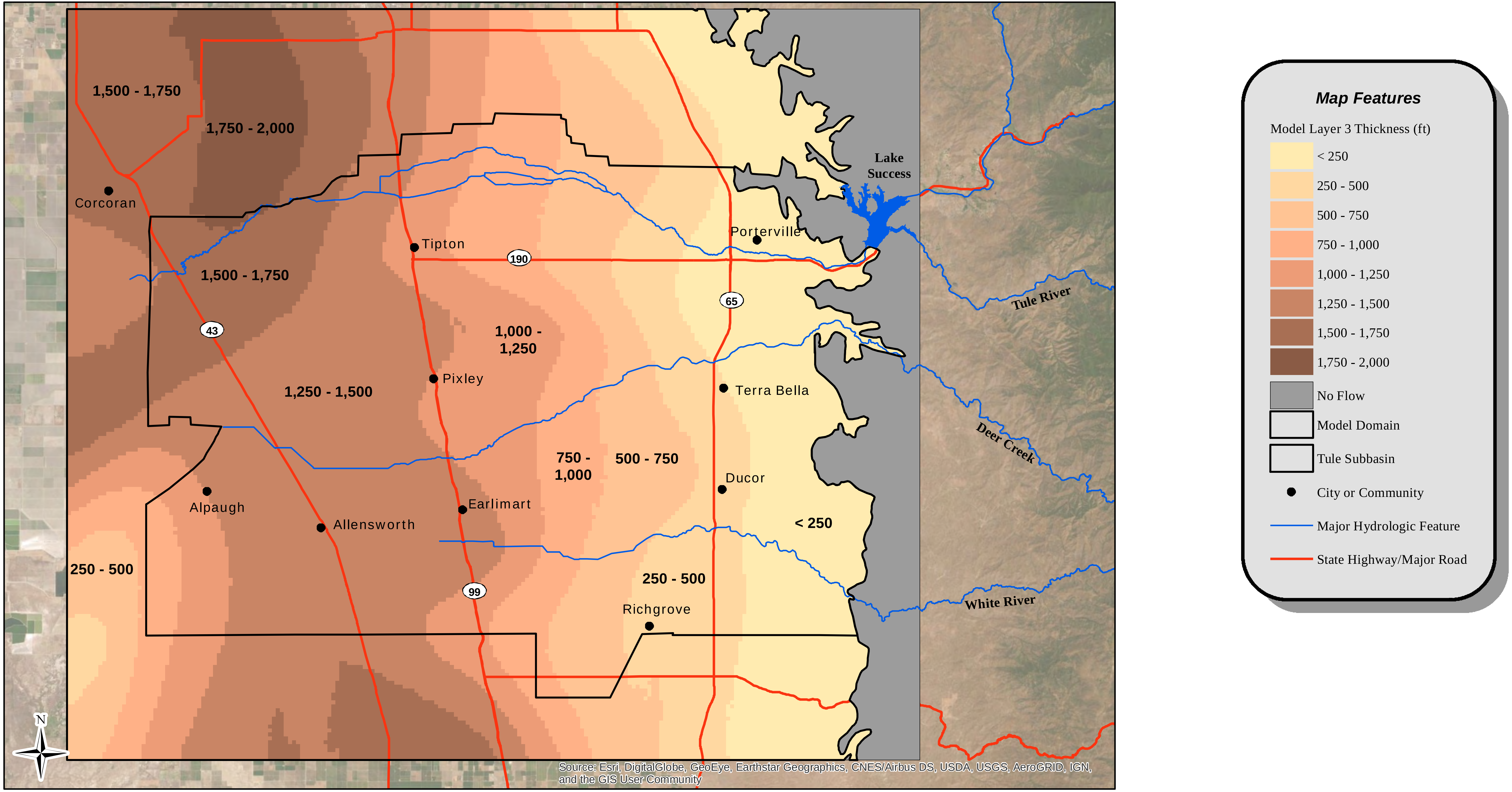
Figure 21

Thomas Harder & Co.
Groundwater Consulting

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model of the Tule Subbasin



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

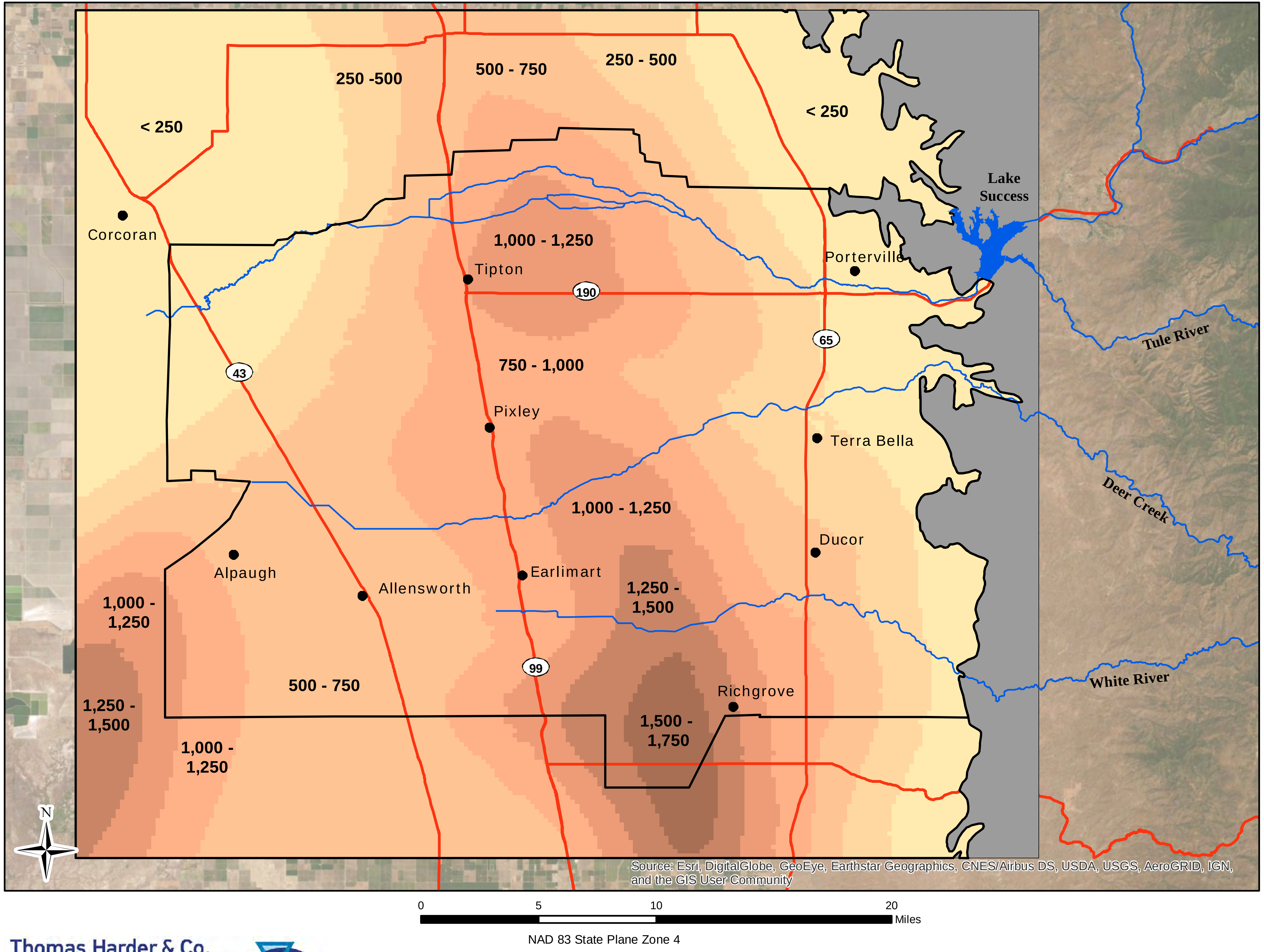
Thomas Harder & Co.
Groundwater Consulting

Layer 3 Thickness

Figure 22

Tule Subbasin Technical Advisory Committee

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

Groundwater Flow Model of the Tule Subbasin

Map Features

Model Layer 4 Thickness (ft)

- ▨ < 250
- ▨ 250 - 500
- ▨ 500 - 750
- ▨ 750 - 1,000
- ▨ 1,000 - 1,250
- ▨ 1,250 - 1,500
- ▨ 1,500 - 1,750
- ▨ 1,750 - 2,000
- ▨ No Flow
- ☐ Model Domain
- ☐ Tule Subbasin
- ● City or Community
- — Major Hydrologic Feature
- — State Highway/Major Road

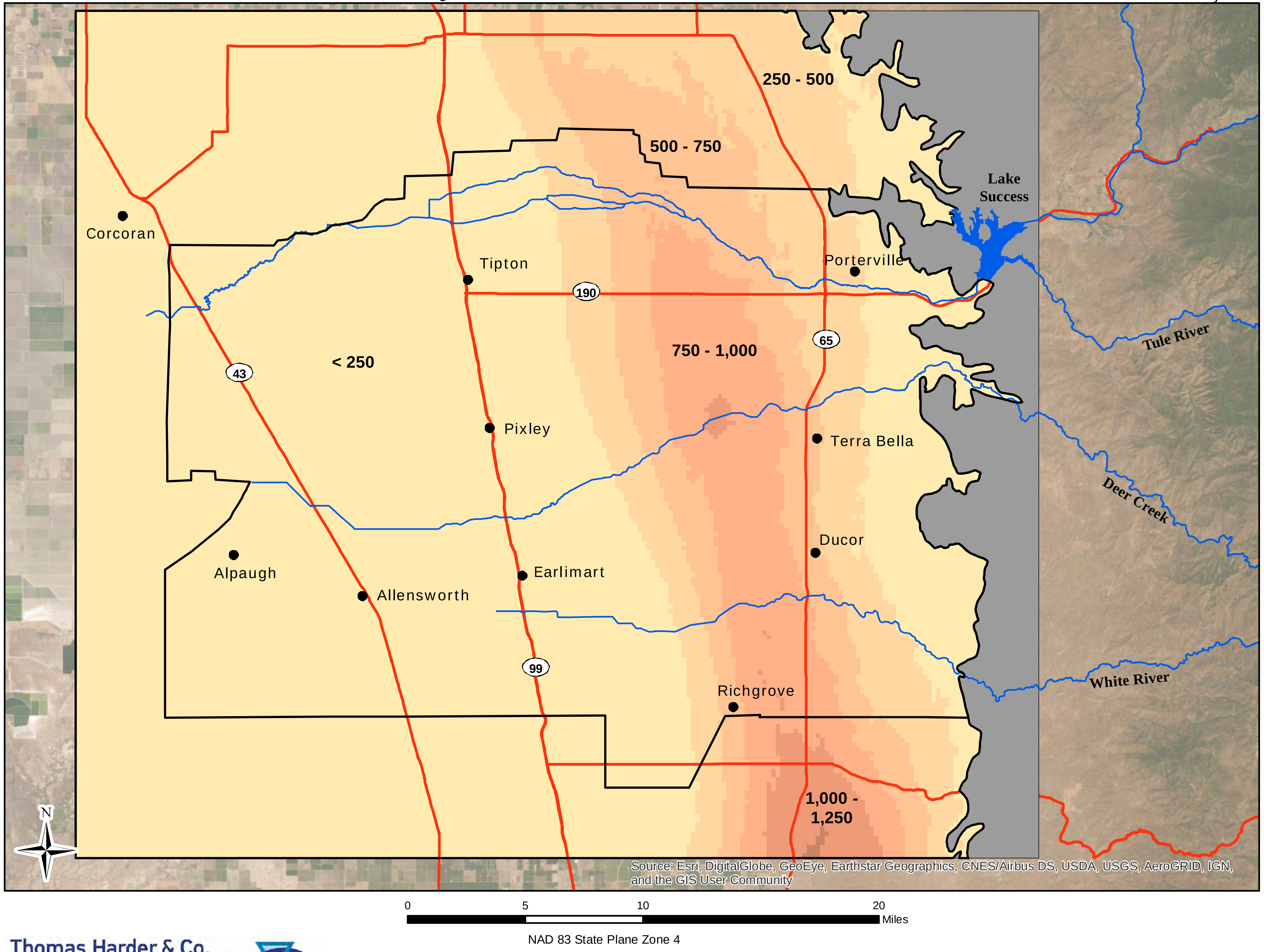
Layer 4 Thickness

Figure 23

Tule Subbasin Technical Advisory Committee

January 2020

Groundwater Flow Model of the Tule Subbasin



Map Features

Model Layer 5 Thickness (ft)

- < 250
- 250 - 500
- 500 - 750
- 750 - 1,000
- 1,000 - 1,250
- 1,250 - 1,500
- 1,500 - 1,750
- 1,750 - 2,000
- No Flow
- Model Domain
- Tule Subbasin
- ● City or Community
- Major Hydrologic Feature
- State Highway/Major Road

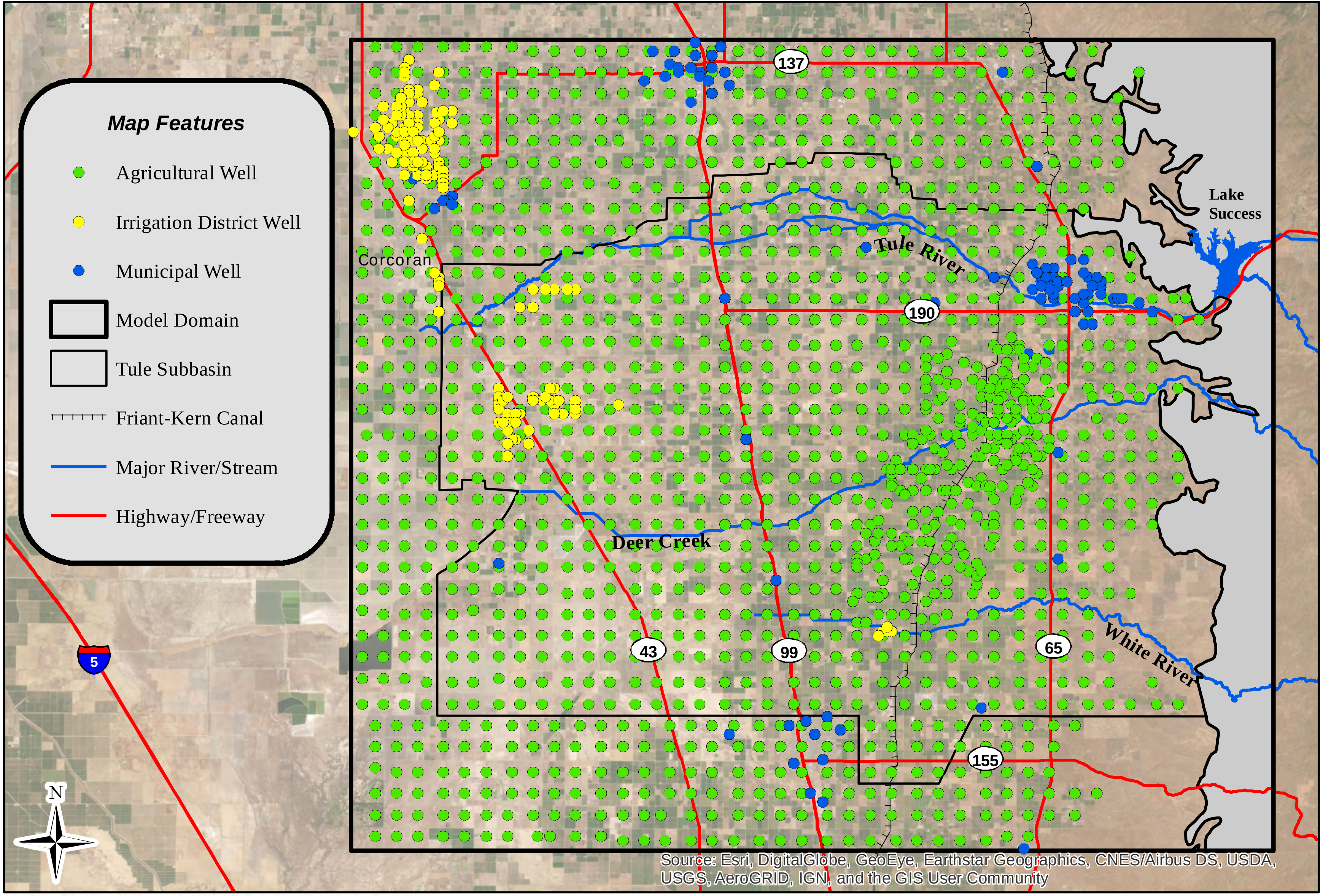
Layer 5 Thickness

Figure 24

Thomas Harder & Co.
Groundwater Consulting

Groundwater Flow Model of the Tule Subbasin
January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

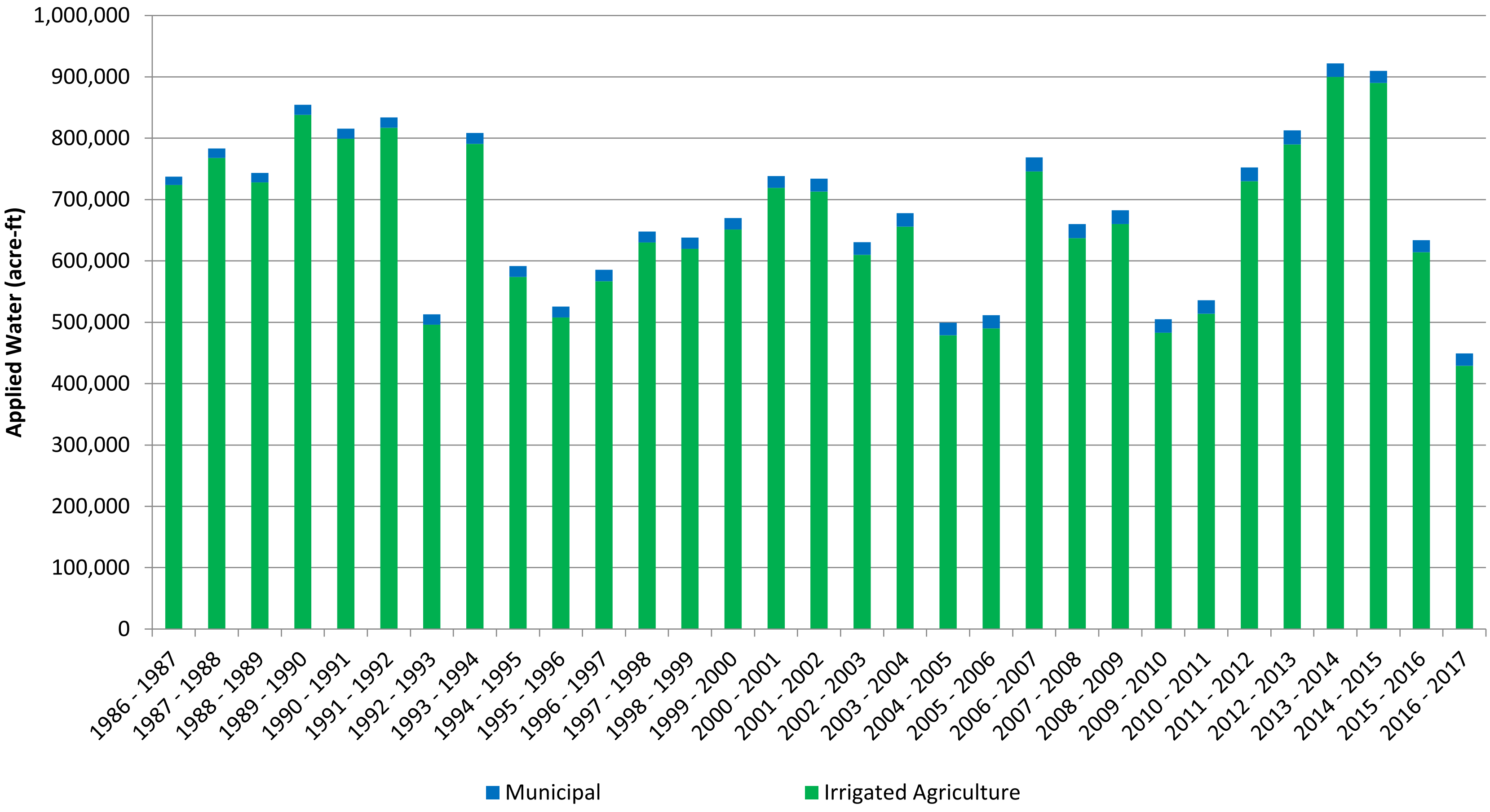
Thomas Harder & Co.
Groundwater Consulting

Wells in the Groundwater Flow Model

Figure 25

Figure 26

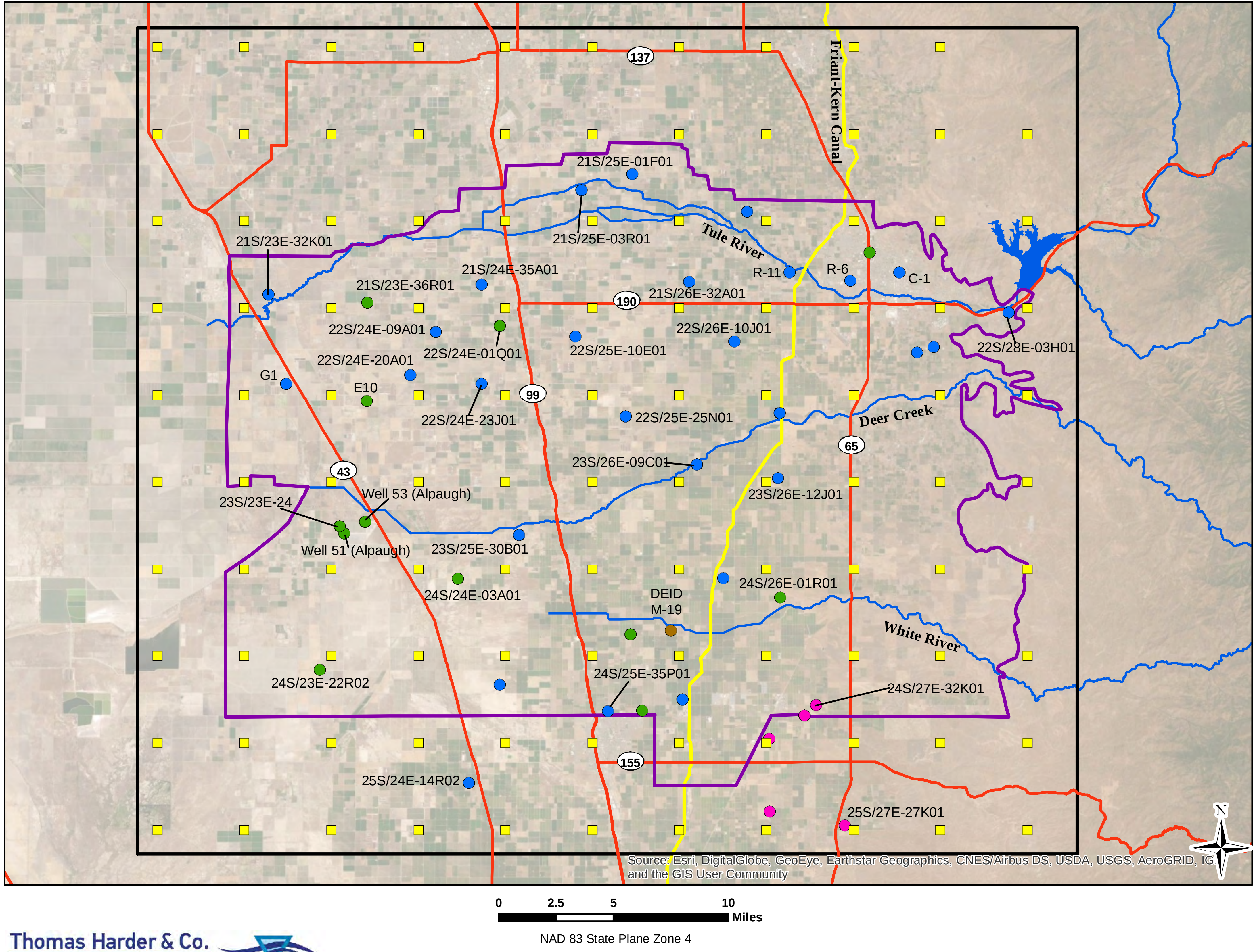
Estimated Historical Groundwater Pumping



Groundwater Flow Model of the Tule Subbasin

Tule Subbasin Technical Advisory Committee

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Map Features

- ● Layer 1 - Shallow Well
- ● Layer 3 - Deep Well
- ● Layer 4 - Deep Well
- ● DEID M-19 Nested (L1 and L3)
- ▨ Pilot Point
- — State Highway/Major Road
- — Friant-Kern Canal
- — Major Hydrologic Feature
- ☐ Tule Subbasin
- ☐ Model Domain

Thomas Harder & Co.
Groundwater Consulting

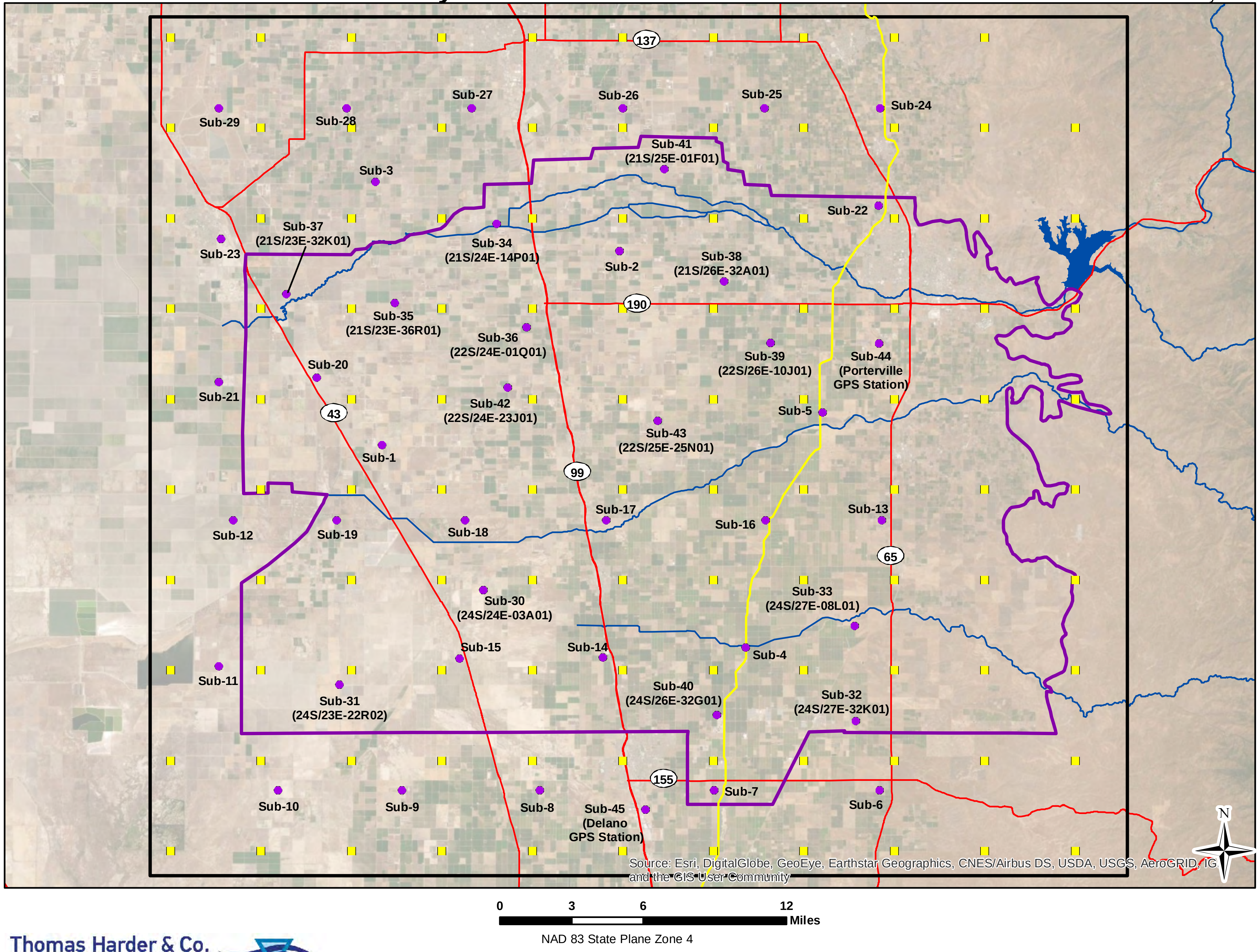
Groundwater Level Calibration Target Wells

Figure 27

Groundwater Flow Model
of the Tule Subbasin

Tule Subbasin Technical Advisory Committee

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IG
and the GIS User Community

NAD 83 State Plane Zone 4

Map Features

- ▪ Pilot Point
- ● Subsidence Target
- — Friant-Kern Canal
- — Major Hydrologic Feature
- — Major Road
- ☐ Tule Subbasin
- ☐ Model Domain

Thomas Harder & Co.
Groundwater Consulting

Subsidence Calibration Targets

Figure 28

Figure 29

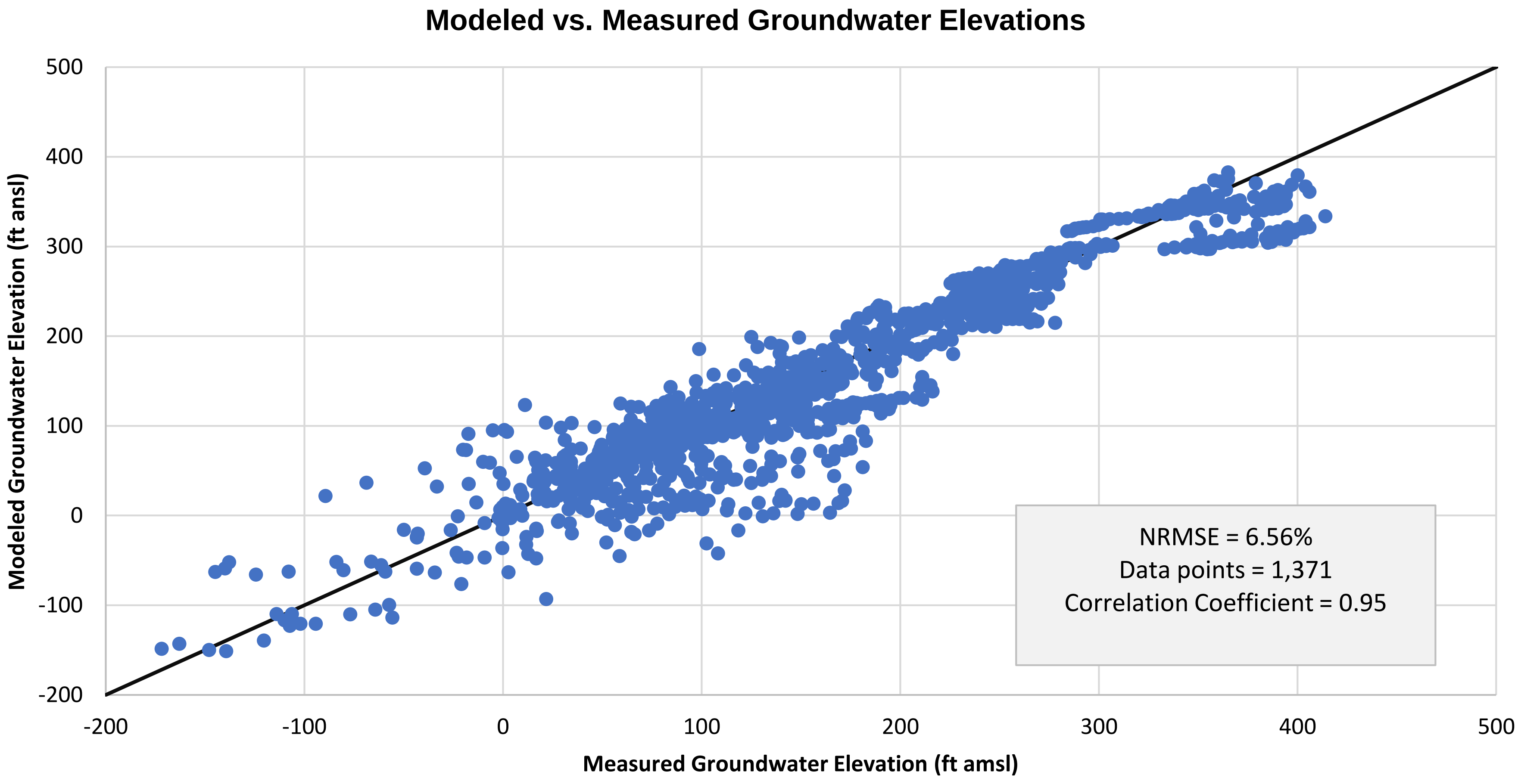

Modeled vs. Measured Groundwater Elevations

Figure 30

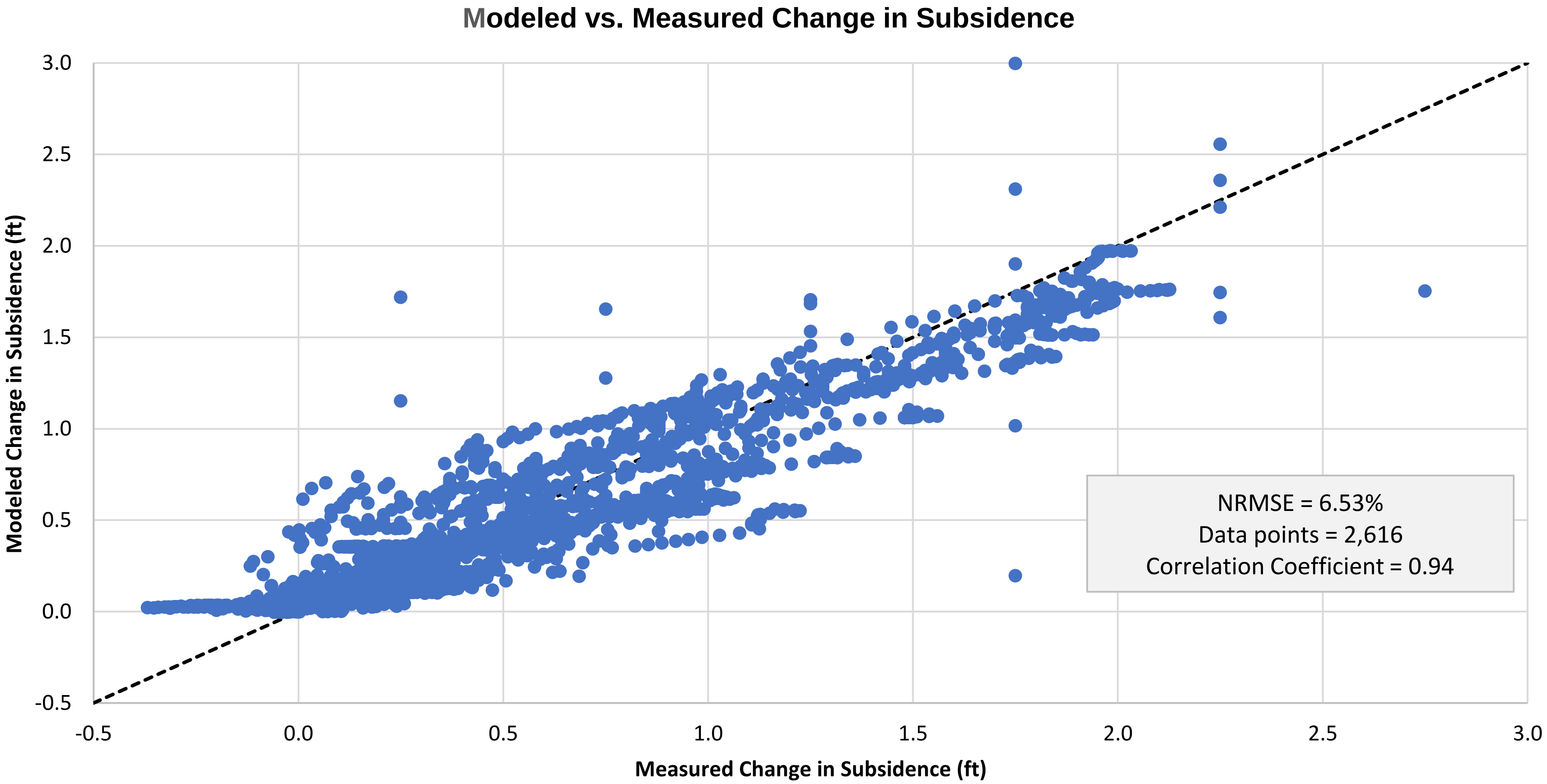
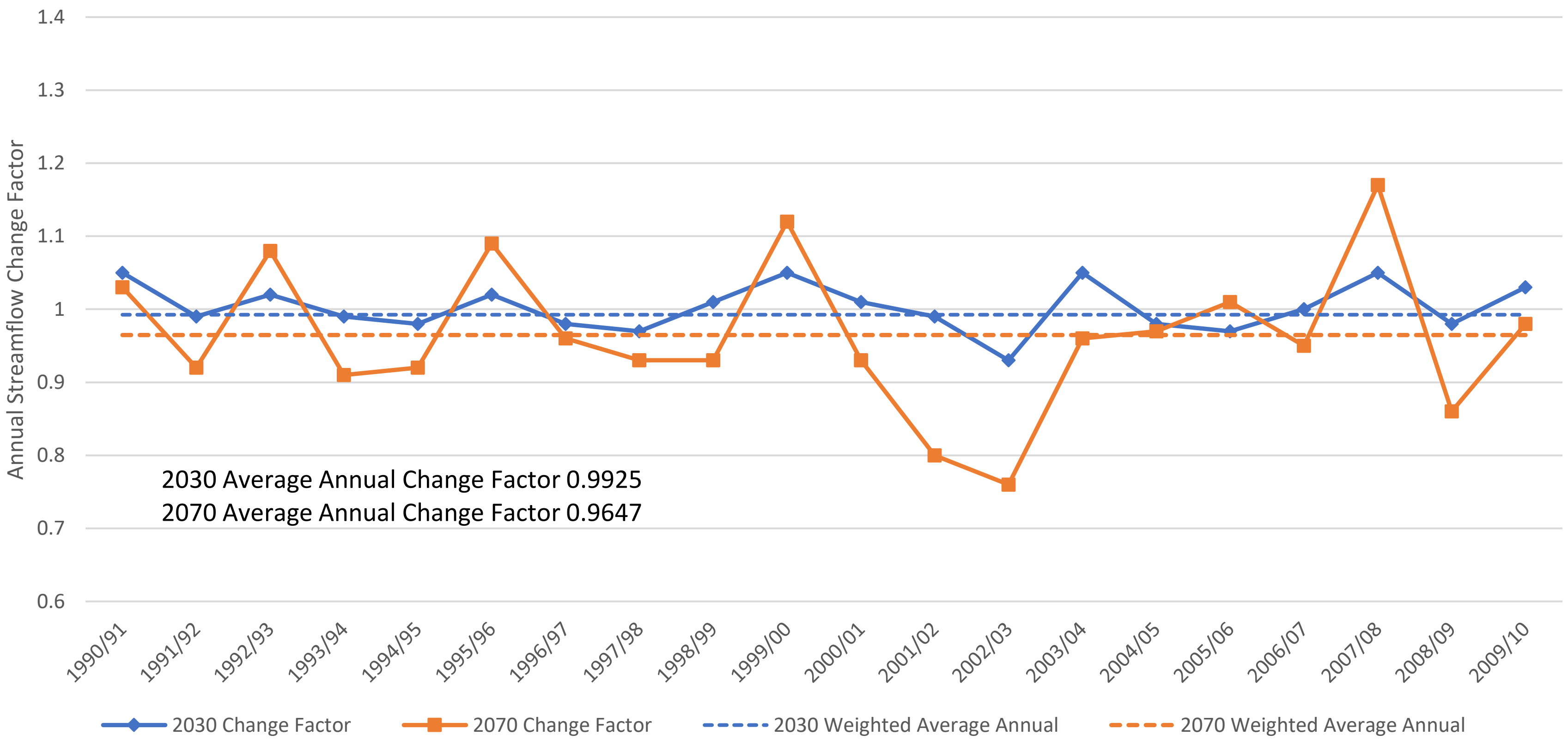

Modeled vs. Measured Change in Subsidence
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
Modeled Change in Subsidence (ft)
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Measured Change in Subsidence (ft)
NRMSE = 6.53%
Data points = 2,616
Correlation Coefficient = 0.94

Figure 31

Tule River - Inflow to Success
Future Climate Projections with Baseperiod 1990/91 through 2009/10

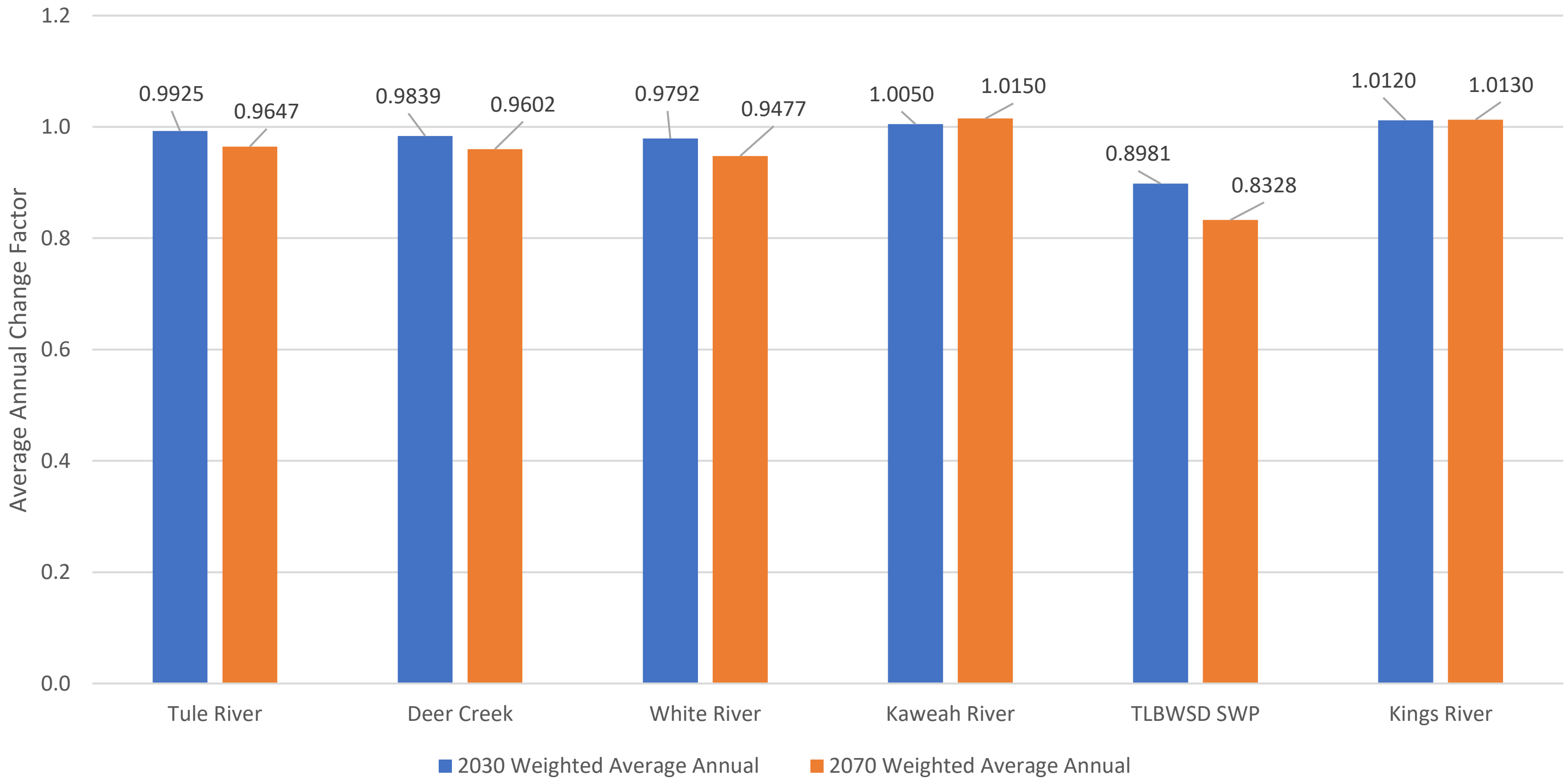


Notes:

Change factors from DWR SGMA Data Viewer, Climate Change Datasets.

2030 climate dataset used for 2017/18 through 2049/50 and 2070 climate dataset used for 2050/51 through 2069/70.

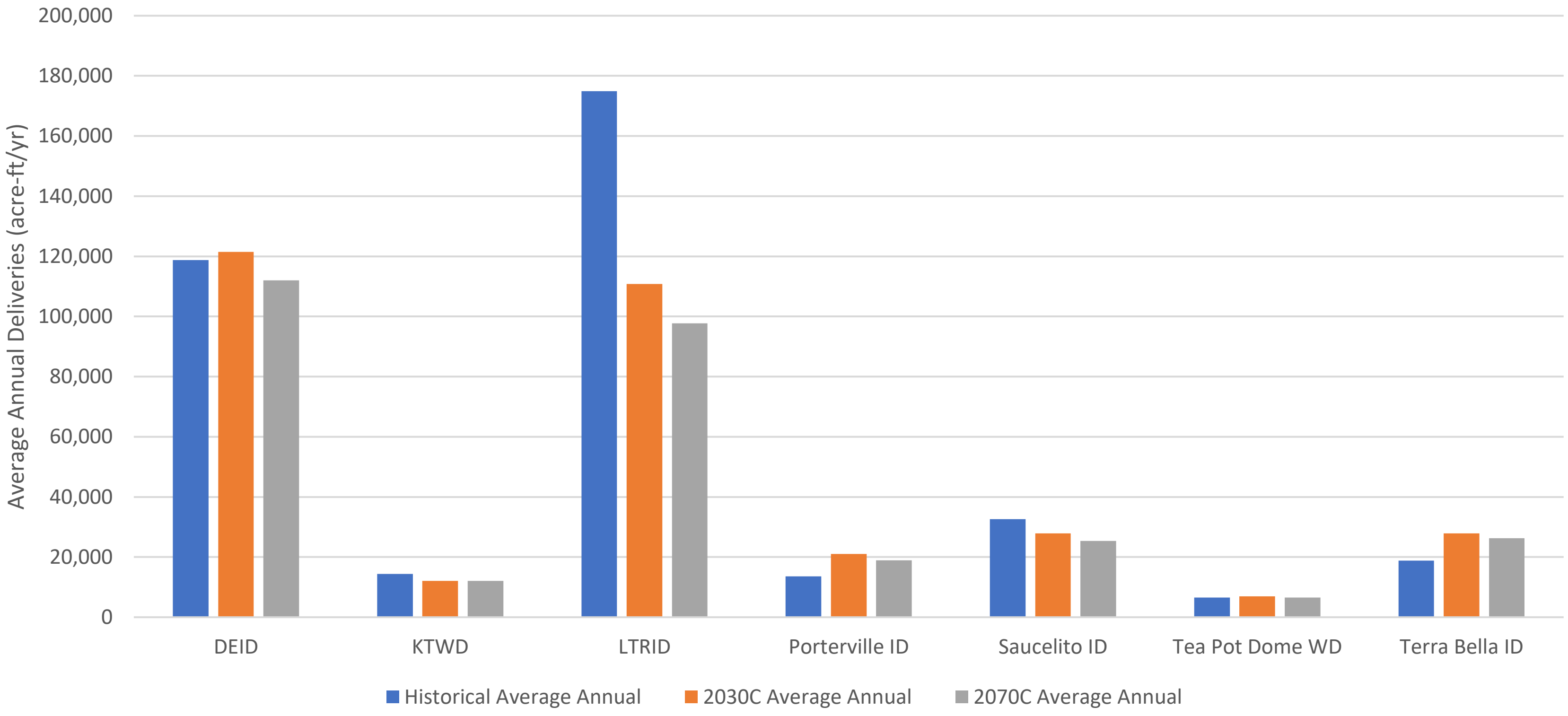
Summary of Average Annual Change Factors for Major Streams (Non Friant-Kern Canal Deliveries)



Notes:

Kaweah River, Tulare Lake Bed Water Storage District State Water Project (TLBWSD SWP), and Kings River for Angiola Water District

Historical and Future Projection Friant-Kern Canal Deliveries



Notes:

Historical average annual based on 1990/91 through 2009/10

Does not include future projects including transfers.

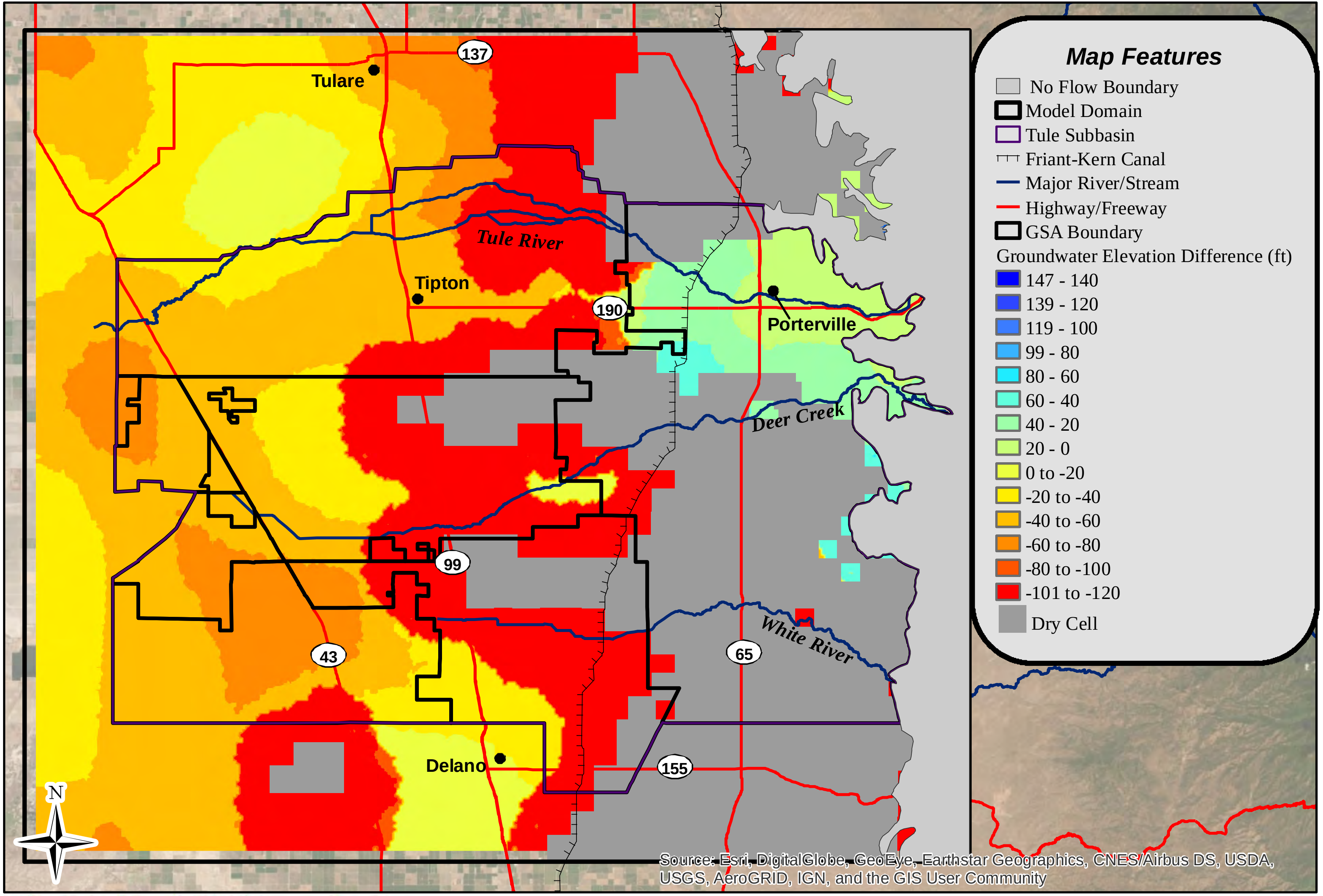
Include Class 1, Class 2/Other, 16B, and SKRRP Recapture (Class 1 and Class 2/Other)

KTWD projections provided by KTWD. KTWD deliveries within the Tule Subbasin only.

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

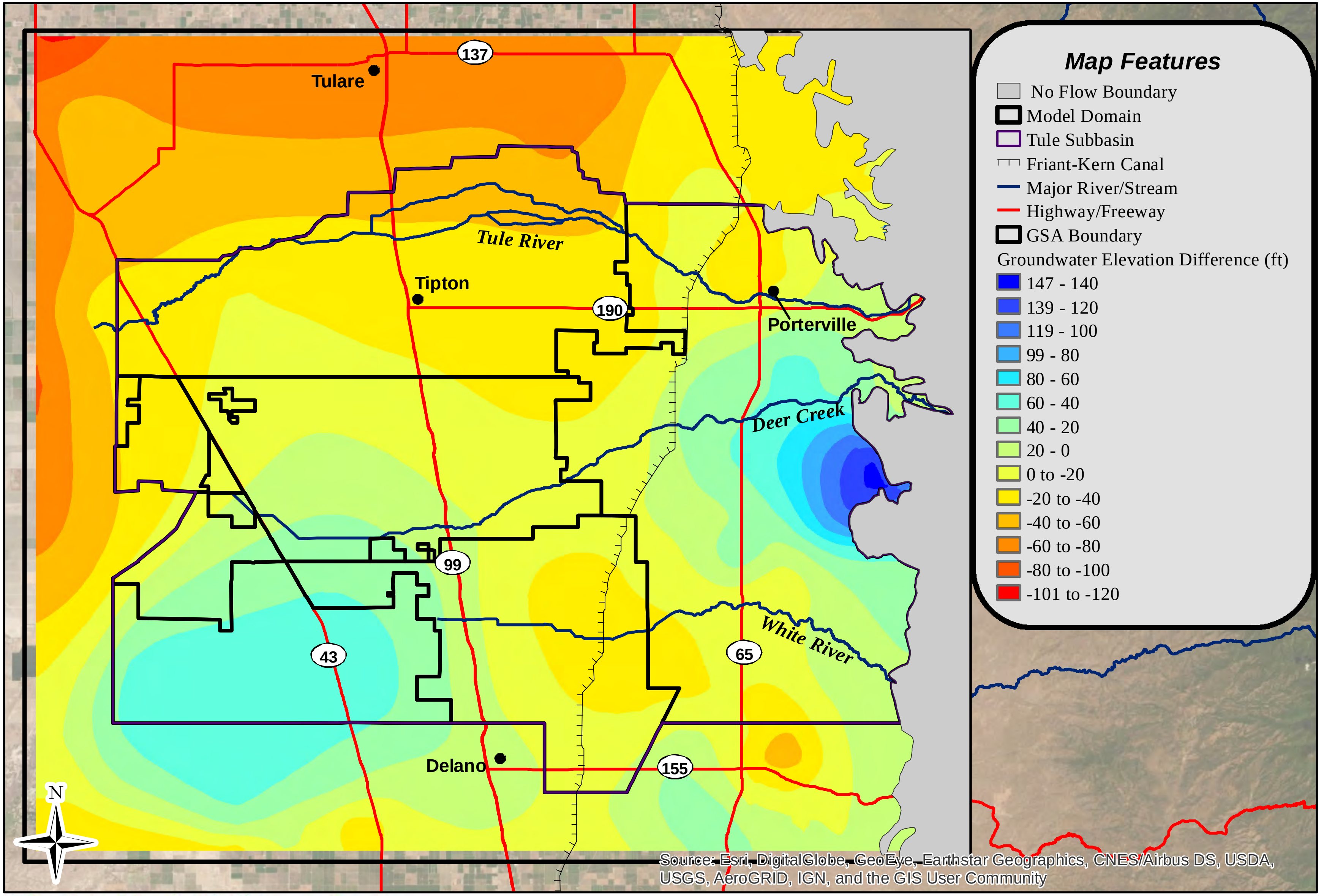
Model Simulated Change in Groundwater Level Between 2020 and 2040 (Layer 1)

Figure 34

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

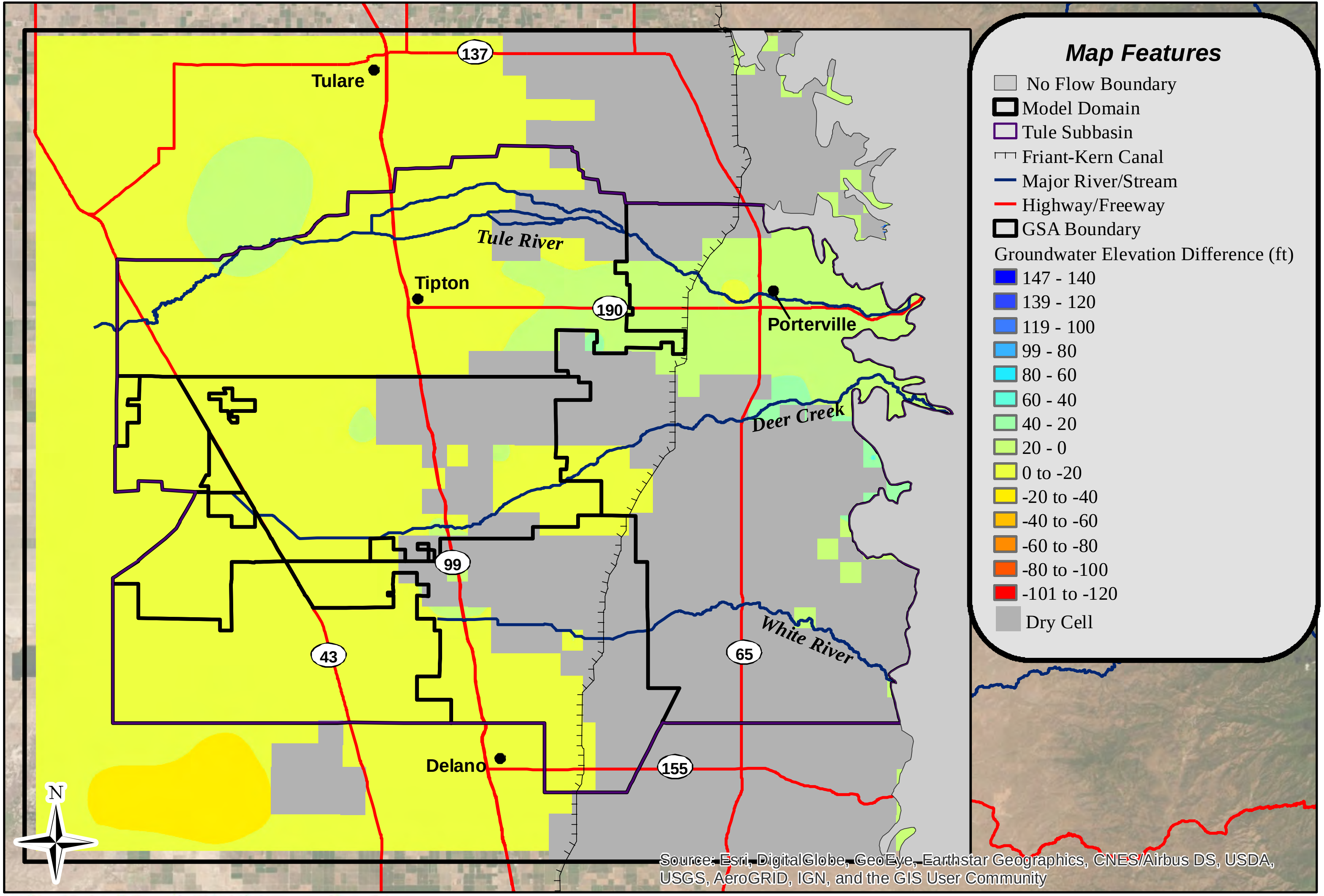
Model Simulated Change in Groundwater Level Between 2020 and 2040 (Layer 3)

Figure 35

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

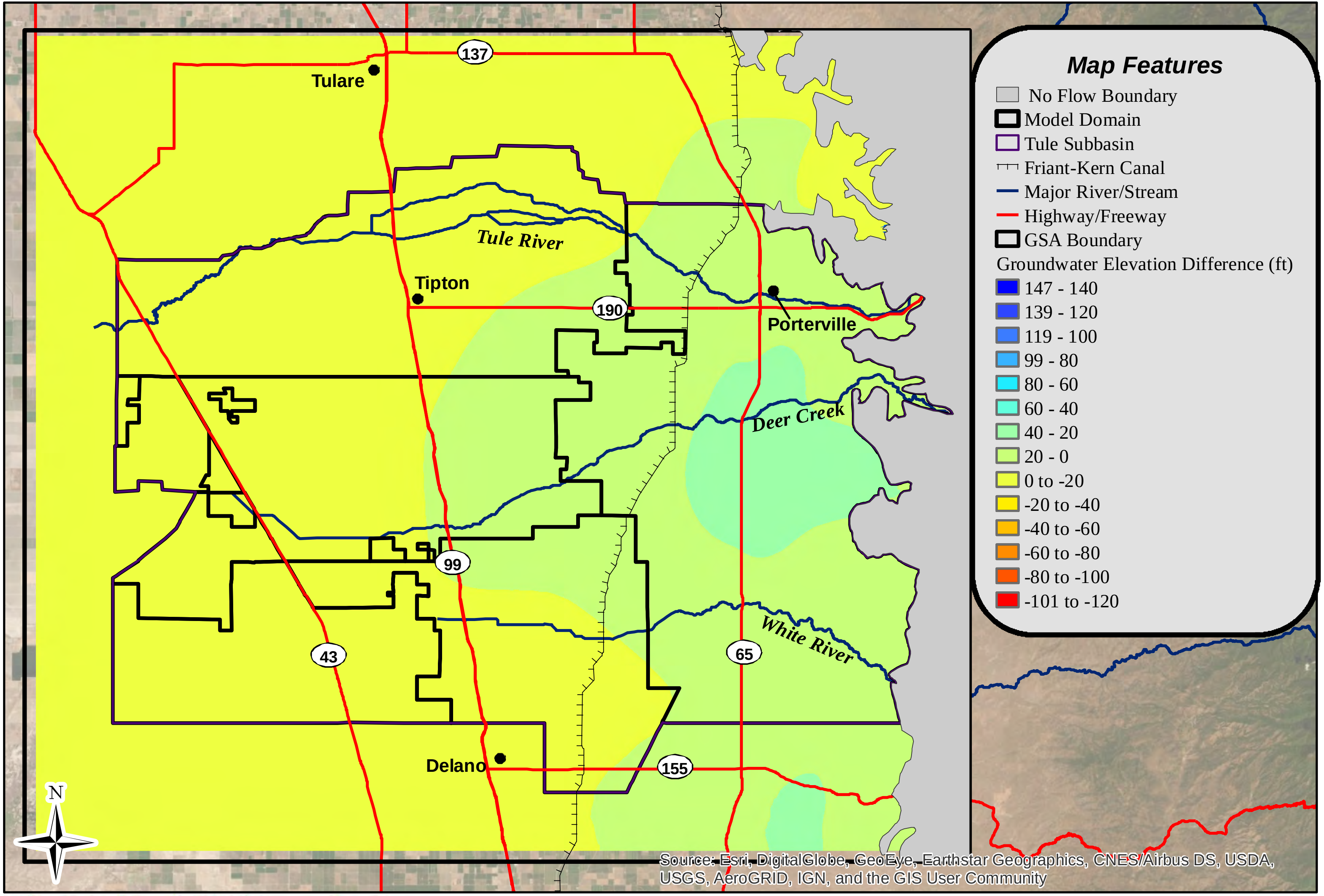
Model Simulated Change in Groundwater Level Between 2040 and 2050 (Layer 1)

Figure 36

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

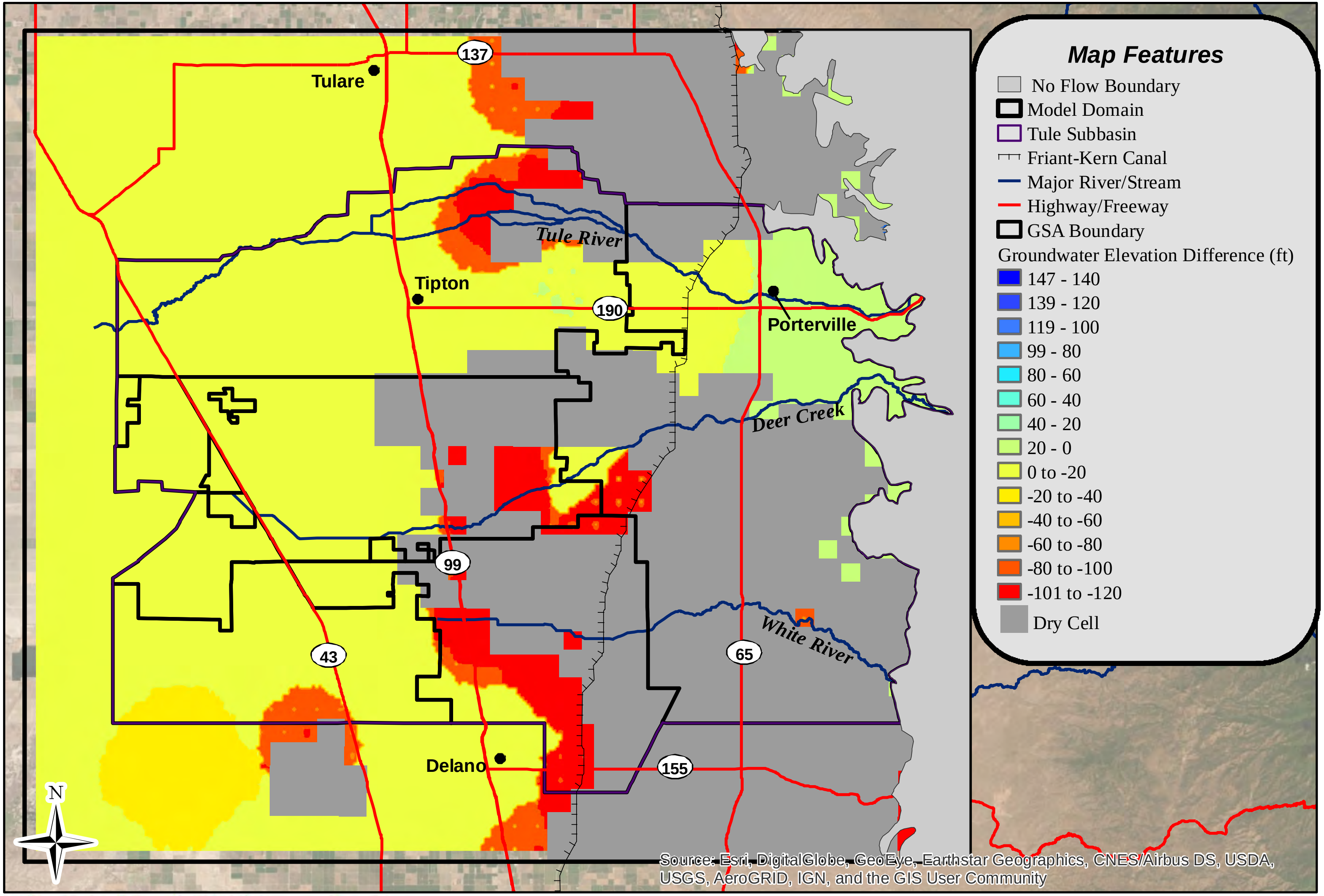
Model Simulated Change in Groundwater Level Between 2040 and 2050 (Layer 3)

Figure 37

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

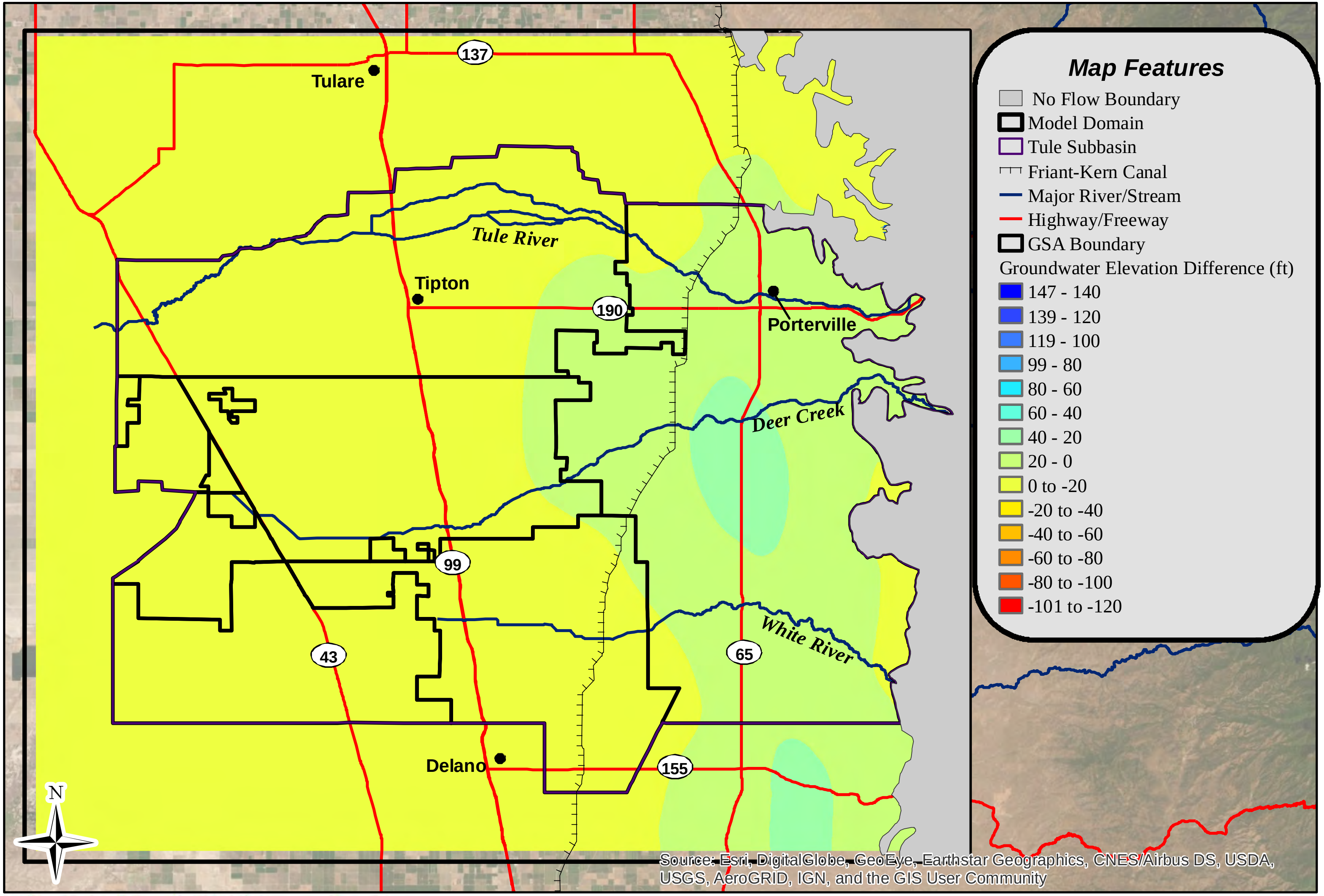
Model Simulated Change in Groundwater Level Between 2050 and 2070 (Layer 1)

Figure 38

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

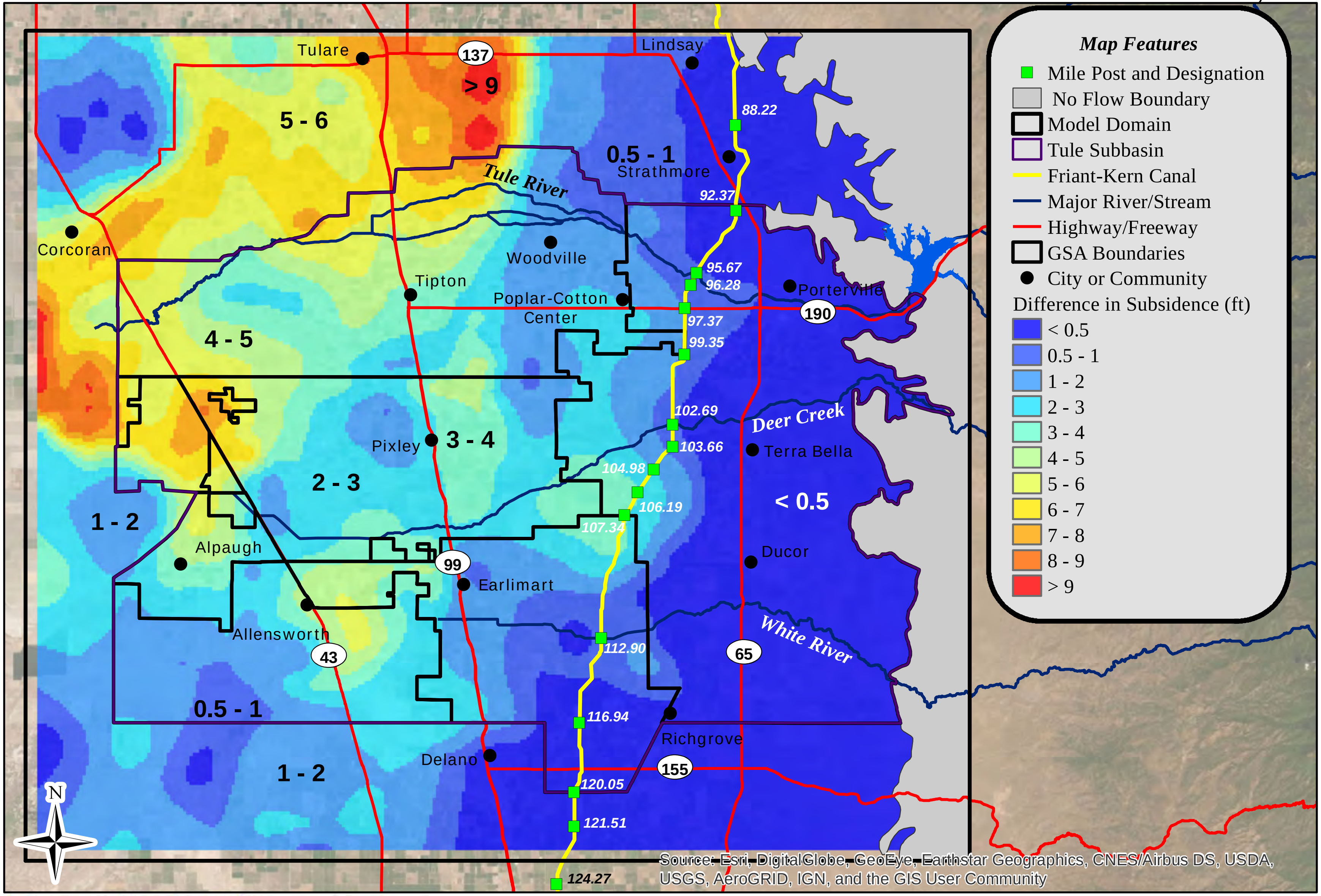
Model Simulated Change in Groundwater Level Between 2050 and 2070 (Layer 3)

Figure 39

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 2.5 5 10 Miles

NAD 83 State Plane Zone 4

Cumulative Land Subsidence in the Tule Subbasin from 2020 to 2040

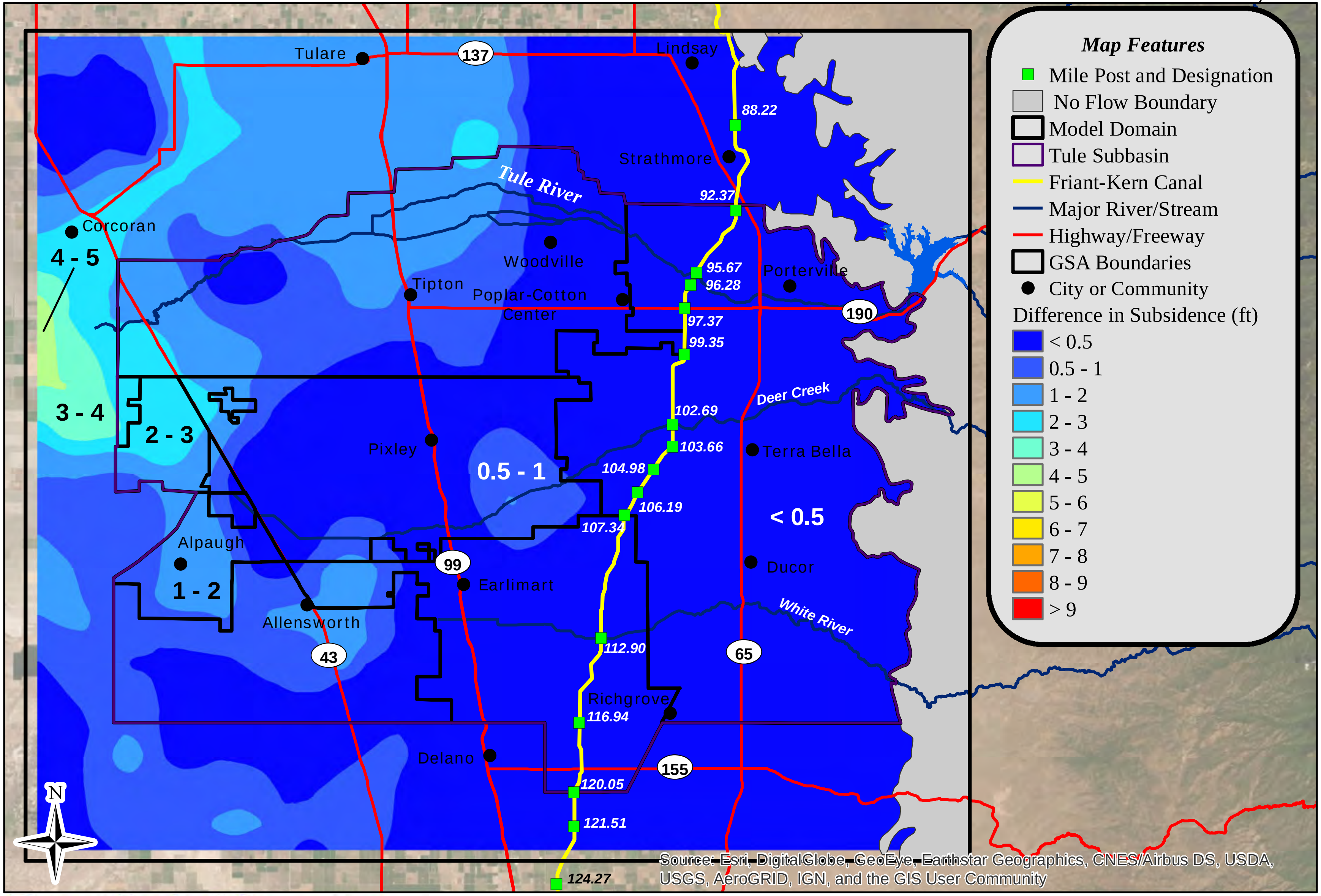
Figure 40

Note: This map shows the difference in subsidence from September 30, 2019 to September 30, 2039.

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model
of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 2.5 5 10 Miles

NAD 83 State Plane Zone 4

Cumulative Land Subsidence in the Tule Subbasin from 2040 to 2050

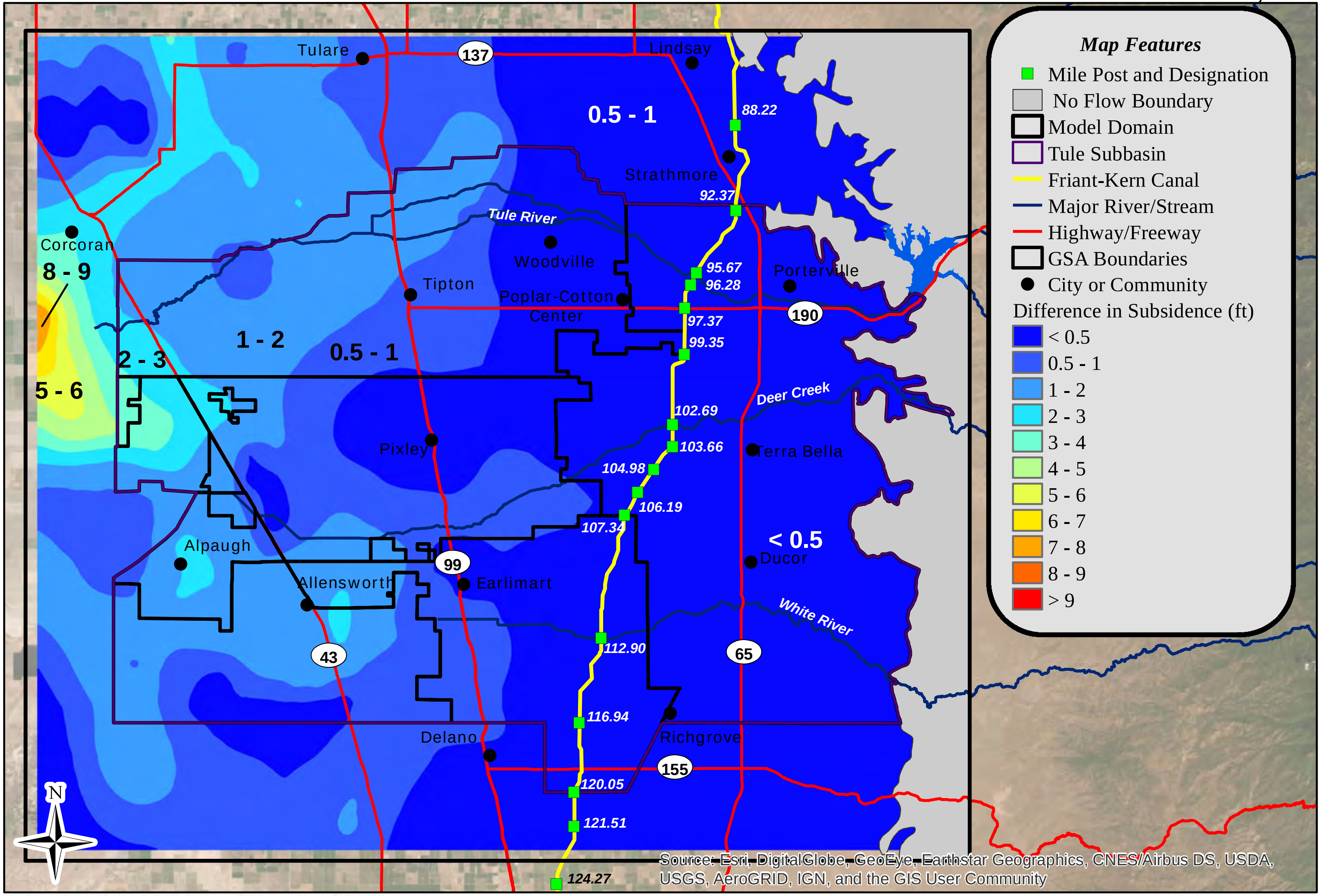
Figure 41

Note: This map shows the difference in subsidence from September 30, 2039 to September 30, 2049.

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model
of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 2.5 5 10 Miles

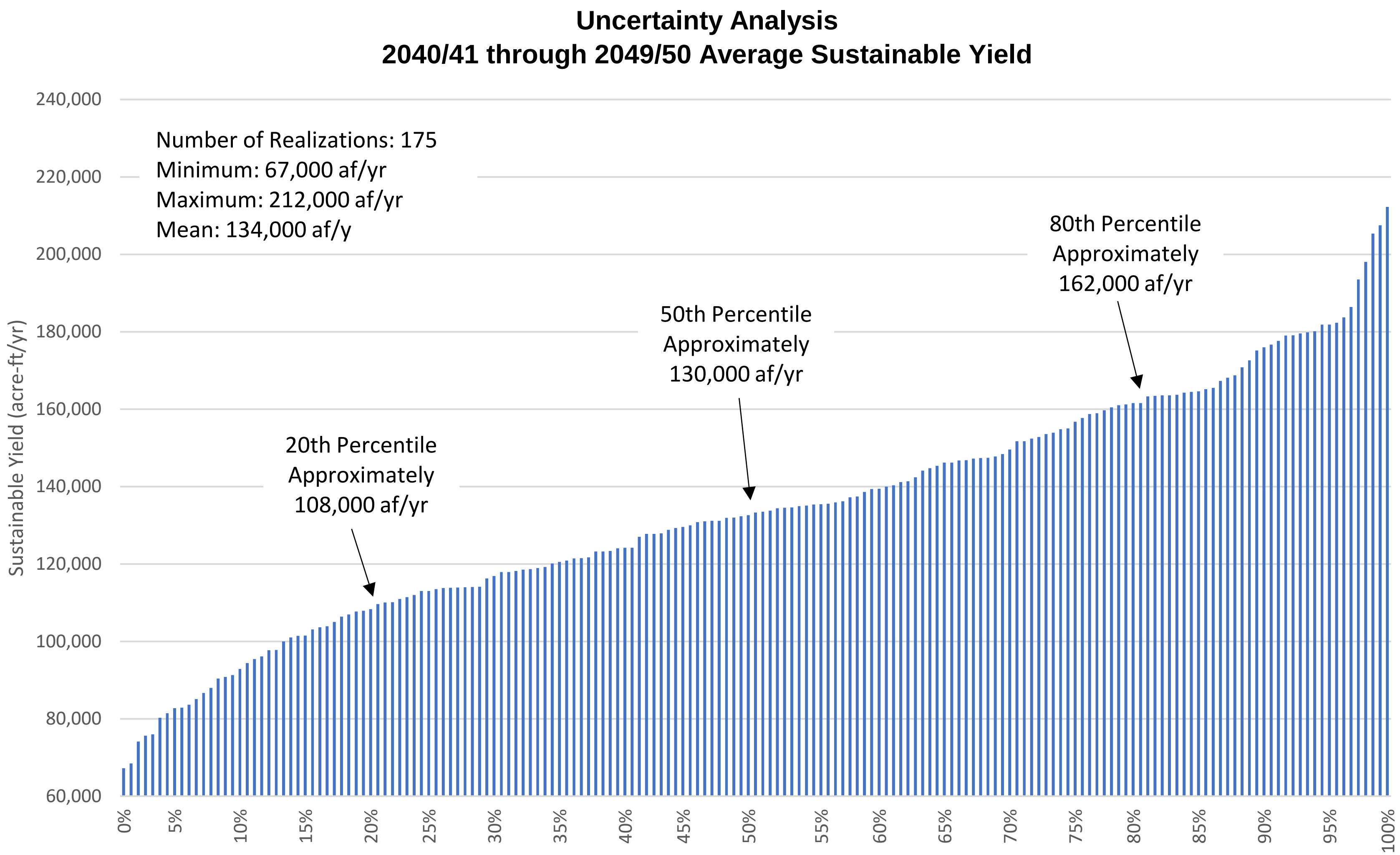
NAD 83 State Plane Zone 4

Cumulative Land Subsidence in the Tule Subbasin from 2050 to 2070

Figure 42

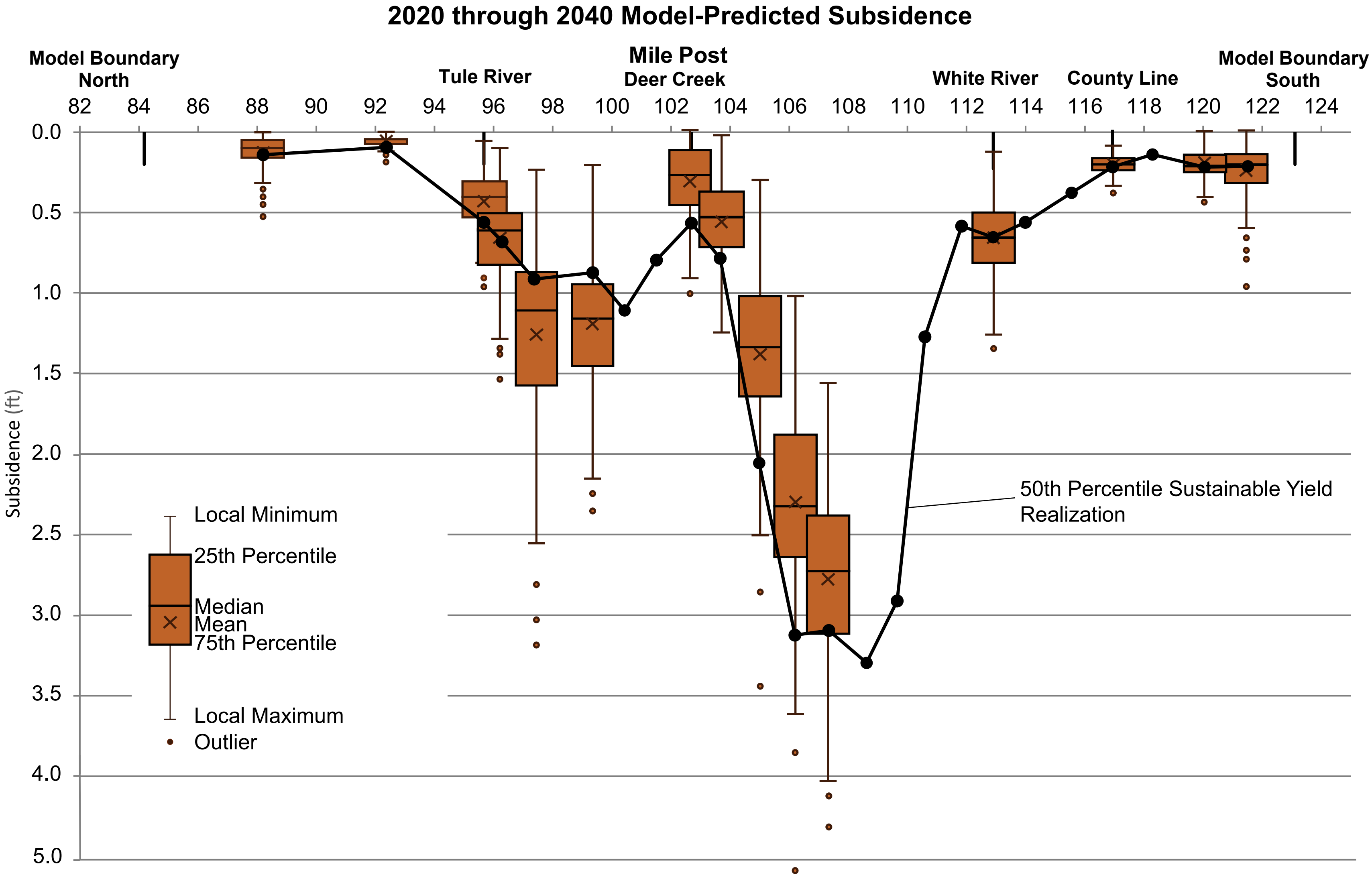
Note: This map shows the difference in subsidence from September 30, 2049 to September 30, 2069.

Figure 43



*Realizations with a storage change of -5,000 af/yr or greater

Figure 44



Thomas Harder & Co.
Groundwater Consulting

January 2020

Plates

Tule Subbasin Technical Advisory Commitee
Groundwater Flow Model of the Tule Subbasin

Notes:

Lithologic data from Department of Water Resources Well Compeletion Reports. Wells within one half mile from cross section line unless otherwise noted by " * ". Well locations are denoted as purple dots on the map. Geophysical logs show resistivity in ohm-metres. Corcoran Clay from USGS Professional Paper 1766,
http://water.usgs.gov/GIS/dsdl/pp1766_CorcoranClay.zip

Brackish Water Interface based on Planert and Williams, 1995 and Page, 1973 USGS Atlas HA-489

Thomas Harder & Co.
Groundwater Consulting

Hydrogeologic Cross Section A-A"
Tule Groundwater Subbasin

Plate 1
January 2020

Tule Subbasin Technical Advisory Committee
Groundwater Flow Model of the Tule Subbasin

Notes:

Lithologic data from Department of Water Resources Well Compeletion Reports. Wells within one half mile from cross section line unless otherwise noted by " * ". Well locations are denoted as purple dots on the map. Geophysical logs show resistivity in ohm-metres.

Legend

Label	Meaning
22S/26E-14	State Well Number (Township, Range, and Section)
Line	Land Surface
?	Unknown Lithology
C	Primarily Clay/Silt
S	Primarily Sand
S/C	Sand and Clay/Silt Mixture
T.D. 240	Total Depth of Completed Borehole (feet below land surface)
Perfs 112 - 232	Perforation Interval(s) (feet below land surface)
Bar	Perforation Interval

Brackish Water Interface based on Planert and Williams, 1995 and Page, 1973 USGS Atlas HA-489

Thomas Harder & Co.
Groundwater Consulting

Hydrogeologic Cross Section B-B'
Tule Groundwater Subbasin
Plate 2
January 2020

Tule Subbasin Technical Advisory Committee
Groundwater Flow Model of the Tule Subbasin

Notes:

Lithologic data from Department of Water Resources Well Compeletion Reports. Wells within one half mile from cross section line unless otherwise noted by " * ". Well locations are denoted as purple dots on the map. Geophysical logs show resistivity in ohm-metres.

Brackish Water Interface based on Planert and Williams, 1995 and Page, 1973 USGS Atlas HA-489

Thomas Harder & Co.
Groundwater Consulting

Hydrogeologic Cross Section C-C'
Tule Groundwater Subbasin
Plate 3
January 2020

Tule Subbasin Technical Advisory Committee
Groundwater Flow Model of the Tule Subbasin

Notes:

Lithologic data from Department of Water Resources Well Compeletion Reports. Wells within one half mile from cross section line unless otherwise noted by " * ". Well locations are denoted as purple dots on the map. Geophysical logs show resistivity in ohm-metres.

Brackish Water Interface based on Planert and Williams, 1995 and Page, 1973 USGS Atlas HA-489

Thomas Harder & Co.
Groundwater Consulting

Hydrogeologic Cross Section D-D'
Tule Groundwater Basin
Plate 4
January 2020

Tule Subbasin Technical Advisory Committee
Groundwater Flow Model of the Tule Subbasin

Notes:
Lithologic data from Department of Water Resources Well Compeletion Reports. Wells within one half mile from cross section line unless otherwise noted by " * ". Well locations are denoted as purple dots on the map. Geophysical logs show resistivity in ohm-metres.

Brackish Water Interface based on Planert and Williams, 1995 and Page, 1973 USGS Atlas HA-489

Thomas Harder & Co.
Groundwater Consulting

Hydrogeologic Cross Section E-E'
Tule Groundwater Basin
Plate 5
January 2020

Appendix A

Historical Agricultural Water Demand

Historical Agricultural Water Demand

Water Year	Total Applied Water	Total Cons. Use	Total Return Flow	Tule River			Deer Creek			Recycled Water			Imported Water			Groundwater Production		
				Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow
Subbasin-Wide																		
1986 - 1987	1,018,097	778,340	239,757	33,127	24,656	8,471	0	0	0	890	736	153	246,037	187,944	58,093	738,044	565,004	173,040
1987 - 1988	1,027,472	785,581	241,891	19,304	13,820	5,483	0	0	0	1,086	899	187	221,803	172,730	49,073	785,280	598,132	187,148
1988 - 1989	1,011,102	776,018	235,084	23,722	17,645	6,077	0	0	0	1,151	953	199	243,085	189,687	53,398	743,144	567,733	175,411
1989 - 1990	1,044,445	800,661	243,784	11,540	8,848	2,693	0	0	0	1,212	1,003	209	176,821	139,541	37,280	854,872	651,270	203,602
1990 - 1991	1,064,120	815,799	248,321	22,633	16,751	5,883	0	0	0	1,255	1,039	217	221,141	173,947	47,194	819,090	624,062	195,028
1991 - 1992	1,059,346	811,169	248,177	14,304	10,779	3,525	0	0	0	1,278	1,058	220	207,636	162,524	45,111	836,129	636,809	199,320
1992 - 1993	1,045,823	794,391	251,432	51,680	34,854	16,826	0	0	0	1,301	1,076	224	469,840	353,131	116,709	523,002	405,329	117,673
1993 - 1994	1,062,526	809,579	252,948	29,745	21,058	8,687	0	0	0	1,340	1,109	231	220,434	168,326	52,109	811,007	619,086	191,921
1994 - 1995	1,080,491	819,827	260,664	106,204	71,560	34,645	3,913	2,916	997	1,318	1,090	227	377,649	287,784	89,865	591,406	456,476	134,931
1995 - 1996	1,099,824	822,408	277,416	94,398	62,565	31,833	4,821	3,593	1,228	1,333	1,103	230	455,430	335,329	120,102	543,842	419,818	124,024
1996 - 1997	1,117,097	826,763	290,334	88,519	57,140	31,379	2,705	2,015	689	1,443	1,194	249	427,903	307,345	120,558	596,528	459,069	137,458
1997 - 1998	1,092,540	829,188	263,352	139,075	97,986	41,089	12,216	9,103	3,113	1,328	1,099	229	275,664	208,571	67,092	664,258	512,429	151,829
1998 - 1999	1,086,161	829,735	256,426	51,812	37,735	14,078	1,312	978	334	1,317	1,090	227	379,051	287,867	91,184	652,669	502,066	150,603
1999 - 2000	1,130,153	858,817	271,337	54,404	39,179	15,225	1,242	926	317	1,423	1,178	245	388,176	292,903	95,273	684,908	524,632	160,276
2000 - 2001	1,058,511	809,159	249,351	29,751	21,906	7,845	0	0	0	1,436	1,189	248	270,555	207,885	62,670	756,768	578,180	178,588
2001 - 2002	1,066,679	813,196	253,483	31,648	22,620	9,028	0	0	0	1,662	1,376	287	281,296	215,391	65,906	752,072	573,810	178,263
2002 - 2003	1,019,118	811,407	207,711	48,979	37,469	11,510	853	661	192	1,602	1,368	234	322,881	256,081	66,800	644,803	515,828	128,975
2003 - 2004	990,274	786,798	203,476	24,403	18,219	6,184	0	0	0	1,733	1,484	248	280,633	221,818	58,815	683,505	545,277	138,228
2004 - 2005	987,899	782,896	205,003	59,084	43,818	15,267	3,160	2,456	704	3,833	3,283	549	410,818	320,240	90,578	511,004	413,098	97,905
2005 - 2006	1,012,782	790,782	222,000	88,078	58,788	29,290	1,703	1,324	379	4,662	3,994	668	395,790	305,223	90,567	522,550	421,453	101,097
2006 - 2007	979,863	779,218	200,645	19,000	14,161	4,839	0	0	0	5,172	4,431	741	184,617	145,921	38,696	771,073	614,705	156,369
2007 - 2008	954,599	764,231	190,368	32,077	24,291	7,786	0	0	0	5,257	4,504	753	251,105	204,677	46,428	666,160	530,759	135,401
2008 - 2009	1,015,720	808,551	207,169	29,902	22,297	7,605	0	0	0	4,905	4,202	703	288,687	231,658	57,029	692,227	550,394	141,832
2009 - 2010	935,584	738,010	197,575	64,651	45,449	19,202	0	0	0	4,522	3,874	648	354,234	276,026	78,208	512,178	412,661	99,517
2010 - 2011	1,050,655	820,262	230,394	95,593	65,342	30,251	6,074	4,721	1,353	4,444	3,807	637	377,299	292,285	85,014	567,247	455,448	111,799
2011 - 2012	1,060,462	839,253	221,209	45,741	33,806	11,934	0	0	0	4,761	4,079	682	231,285	183,556	47,729	778,675	617,739	160,937
2012 - 2013	1,044,061	826,740	217,321	13,733	10,283	3,450	0	0	0	4,917	4,212	704	183,590	147,772	35,818	841,821	664,446	177,375
2013 - 2014	1,028,437	818,430	210,007	3,460	2,436	1,024	0	0	0	4,413	3,780	632	69,509	55,728	13,780	951,056	756,356	194,699
2014 - 2015	987,336	789,506	197,829	3,369	2,284	1,085	0	0	0	3,199	2,741	458	39,068	33,197	5,871	941,700	751,351	190,349
2015 - 2016	897,018	719,836	177,183	25,320	19,389	5,932	0	0	0	3,122	2,675	447	203,620	168,051	35,568	664,956	529,993	134,964
2016 - 2017	1,021,271	782,591	238,681	108,479	67,103	41,376	6,206	4,823	1,382	3,258	2,791	467	432,856	330,160	102,696	470,473	379,639	90,834

Historical Agricultural Water Demand

Water Year	Total Applied Water	Total Cons. Use	Total Return Flow	Tule River			Deer Creek			Recycled Water			Imported Water			Groundwater Production		
				Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow
Eastern Tule GSA																		
1986 - 1987	291,005	238,223	52,783	14,521	11,278	3,243	N/A	N/A	N/A	890	736	153	68,741	55,325	13,416	206,853	170,882	35,971
1987 - 1988	294,550	238,223	56,328	14,307	10,228	4,079	N/A	N/A	N/A	1,086	899	187	72,397	57,406	14,991	206,760	169,690	37,071
1988 - 1989	291,431	238,223	53,208	8,212	6,494	1,718	N/A	N/A	N/A	1,151	953	199	76,310	62,038	14,272	205,757	168,738	37,019
1989 - 1990	291,559	238,223	53,336	7,357	5,840	1,517	N/A	N/A	N/A	1,212	1,003	209	68,409	55,915	12,494	214,581	175,465	39,116
1990 - 1991	291,678	238,223	53,455	6,989	5,503	1,486	N/A	N/A	N/A	1,255	1,039	217	65,293	52,784	12,509	218,140	178,897	39,243
1991 - 1992	291,452	238,223	53,230	7,512	5,895	1,617	N/A	N/A	N/A	1,278	1,058	220	75,955	61,625	14,330	206,707	169,644	37,062
1992 - 1993	297,965	238,223	59,742	24,889	15,959	8,930	N/A	N/A	N/A	1,301	1,076	224	91,076	71,113	19,963	180,699	150,074	30,625
1993 - 1994	295,122	238,288	56,834	12,896	8,944	3,952	N/A	N/A	N/A	1,340	1,109	231	74,480	58,768	15,712	206,406	169,468	36,938
1994 - 1995	301,654	238,295	63,359	38,482	23,088	15,394	N/A	N/A	N/A	1,318	1,090	227	81,361	63,793	17,568	180,493	150,324	30,170
1995 - 1996	310,673	240,306	70,367	38,647	22,589	16,058	N/A	N/A	N/A	1,333	1,103	230	107,757	80,692	27,065	162,936	135,922	27,014
1996 - 1997	307,526	240,104	67,421	36,193	21,519	14,674	N/A	N/A	N/A	1,443	1,194	249	97,479	74,189	23,290	172,411	143,203	29,208
1997 - 1998	299,742	240,104	59,638	35,602	23,590	12,012	N/A	N/A	N/A	1,328	1,099	229	68,203	53,764	14,439	194,609	161,652	32,958
1998 - 1999	295,674	240,104	55,570	14,510	10,914	3,596	N/A	N/A	N/A	1,317	1,090	227	94,481	74,773	19,708	185,366	153,327	32,039
1999 - 2000	297,531	240,104	57,427	11,707	8,480	3,227	N/A	N/A	N/A	1,423	1,178	245	98,146	76,665	21,481	186,255	153,782	32,473
2000 - 2001	295,065	240,104	54,960	9,431	7,296	2,135	N/A	N/A	N/A	1,436	1,189	248	83,888	67,147	16,741	200,309	164,472	35,837
2001 - 2002	297,510	240,104	57,406	12,901	9,141	3,760	N/A	N/A	N/A	1,662	1,376	287	81,469	64,126	17,343	201,478	165,462	36,016
2002 - 2003	287,896	240,104	47,791	8,728	6,937	1,791	N/A	N/A	N/A	1,602	1,368	234	87,129	71,358	15,771	190,437	160,442	29,994
2003 - 2004	285,462	238,183	47,280	8,496	6,101	2,395	N/A	N/A	N/A	1,733	1,484	248	84,706	70,150	14,557	190,527	160,448	30,079
2004 - 2005	287,591	238,096	49,496	19,761	13,861	5,900	N/A	N/A	N/A	3,833	3,283	549	91,566	74,679	16,887	172,432	146,272	26,160
2005 - 2006	299,473	238,096	61,377	34,315	18,864	15,451	N/A	N/A	N/A	4,662	3,994	668	101,063	80,013	21,050	159,432	135,225	24,208
2006 - 2007	285,360	238,096	47,265	5,612	3,962	1,650	N/A	N/A	N/A	5,172	4,431	741	67,474	55,917	11,557	207,102	173,786	33,317
2007 - 2008	285,203	238,096	47,107	8,094	6,021	2,073	N/A	N/A	N/A	5,257	4,504	753	79,846	66,040	13,806	192,006	161,531	30,475
2008 - 2009	286,397	238,096	48,301	9,449	6,716	2,733	N/A	N/A	N/A	4,905	4,202	703	90,672	74,176	16,496	181,371	153,002	28,369
2009 - 2010	291,167	238,096	53,072	27,070	18,075	8,995	N/A	N/A	N/A	4,522	3,874	648	94,636	76,085	18,551	164,940	140,063	24,877
2010 - 2011	283,939	226,060	57,879	33,500	18,781	14,719	N/A	N/A	N/A	4,444	3,807	637	92,011	73,468	18,543	153,984	130,587	23,397
2011 - 2012	273,439	227,565	45,874	6,504	4,685	1,819	N/A	N/A	N/A	4,761	4,079	682	67,253	55,676	11,577	194,921	163,375	31,547
2012 - 2013	271,820	226,748	45,072	3,769	2,693	1,076	N/A	N/A	N/A	4,917	4,212	704	64,337	53,438	10,899	198,797	166,501	32,296
2013 - 2014	270,163	225,475	44,688	3,460	2,436	1,024	N/A	N/A	N/A	4,413	3,780	632	29,308	24,235	5,073	232,982	195,089	37,893
2014 - 2015	268,488	224,823	43,665	3,369	2,284	1,085	N/A	N/A	N/A	3,199	2,741	458	19,327	16,691	2,636	242,593	203,174	39,420
2015 - 2016	268,848	225,116	43,733	7,646	5,925	1,721	N/A	N/A	N/A	3,122	2,675	447	64,109	53,549	10,560	193,971	163,239	30,732
2016 - 2017	304,194	225,606	78,588	47,593	20,721	26,872	N/A	N/A	N/A	3,258	2,791	467	109,774	80,486	29,288	143,569	122,208	21,361

Historical Agricultural Water Demand

Water Year	Total Applied Water	Total Cons. Use	Total Return Flow	Tule River			Deer Creek			Recycled Water			Imported Water			Groundwater Production		
				Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow
Lower Tule River Irrigation District GSA																		
1986 - 1987	293,688	211,275	82,412	18,606	13,378	5,228	N/A	N/A	N/A	N/A	N/A	N/A	45,292	32,565	12,727	229,790	165,333	64,457
1987 - 1988	303,758	218,516	85,242	4,997	3,593	1,404	N/A	N/A	N/A	N/A	N/A	N/A	32,000	23,008	8,992	266,761	191,915	74,846
1988 - 1989	290,458	208,953	81,505	15,510	11,152	4,358	N/A	N/A	N/A	N/A	N/A	N/A	45,116	32,438	12,678	229,832	165,364	64,469
1989 - 1990	303,361	218,230	85,131	4,183	3,008	1,176	N/A	N/A	N/A	N/A	N/A	N/A	16,882	12,138	4,744	282,295	203,084	79,211
1990 - 1991	322,208	231,781	90,427	15,644	11,248	4,396	N/A	N/A	N/A	N/A	N/A	N/A	47,120	33,879	13,241	259,444	186,654	72,790
1991 - 1992	325,848	234,398	91,450	6,792	4,883	1,908	N/A	N/A	N/A	N/A	N/A	N/A	35,891	25,806	10,086	283,165	203,709	79,455
1992 - 1993	308,296	218,931	89,365	26,791	18,895	7,896	N/A	N/A	N/A	N/A	N/A	N/A	180,980	127,643	53,337	100,525	72,392	28,133
1993 - 1994	313,293	225,371	87,922	16,849	12,114	4,735	N/A	N/A	N/A	N/A	N/A	N/A	43,999	31,635	12,364	252,445	181,622	70,823
1994 - 1995	323,341	231,983	91,358	67,722	48,472	19,250	N/A	N/A	N/A	N/A	N/A	N/A	120,864	86,508	34,356	134,755	97,004	37,752
1995 - 1996	300,478	215,761	84,718	55,751	39,977	15,774	N/A	N/A	N/A	N/A	N/A	N/A	133,347	95,617	37,730	111,381	80,167	31,213
1996 - 1997	307,680	214,148	93,532	52,326	35,621	16,705	N/A	N/A	N/A	N/A	N/A	N/A	134,710	91,703	43,007	120,644	86,825	33,820
1997 - 1998	294,068	211,515	82,553	103,473	74,396	29,076	N/A	N/A	N/A	N/A	N/A	N/A	51,185	36,802	14,383	139,410	100,317	39,093
1998 - 1999	291,448	209,632	81,817	37,302	26,820	10,482	N/A	N/A	N/A	N/A	N/A	N/A	122,489	88,069	34,420	131,657	94,743	36,914
1999 - 2000	322,165	231,717	90,448	42,697	30,699	11,998	N/A	N/A	N/A	N/A	N/A	N/A	117,256	84,306	32,950	162,212	116,711	45,500
2000 - 2001	276,273	198,721	77,552	20,320	14,610	5,710	N/A	N/A	N/A	N/A	N/A	N/A	55,432	39,855	15,577	200,521	144,256	56,266
2001 - 2002	287,661	206,908	80,752	18,747	13,479	5,268	N/A	N/A	N/A	N/A	N/A	N/A	57,673	41,467	16,206	211,241	151,963	59,278
2002 - 2003	272,579	206,819	65,760	40,251	30,532	9,718	N/A	N/A	N/A	N/A	N/A	N/A	85,429	64,803	20,627	146,899	111,484	35,415
2003 - 2004	276,611	210,749	65,862	15,907	12,118	3,789	N/A	N/A	N/A	N/A	N/A	N/A	54,868	41,798	13,070	205,836	156,833	49,003
2004 - 2005	276,208	210,440	65,768	39,323	29,956	9,367	N/A	N/A	N/A	N/A	N/A	N/A	138,498	105,507	32,991	98,387	74,977	23,410
2005 - 2006	263,486	197,520	65,966	53,763	39,925	13,838	N/A	N/A	N/A	N/A	N/A	N/A	114,482	85,015	29,467	95,241	72,580	22,661
2006 - 2007	267,230	203,600	63,630	13,388	10,199	3,189	N/A	N/A	N/A	N/A	N/A	N/A	20,443	15,573	4,870	233,399	177,828	55,571
2007 - 2008	261,534	199,261	62,273	23,983	18,270	5,713	N/A	N/A	N/A	N/A	N/A	N/A	53,024	40,393	12,631	184,527	140,598	43,929
2008 - 2009	295,571	225,190	70,381	20,453	15,581	4,872	N/A	N/A	N/A	N/A	N/A	N/A	73,446	55,951	17,495	201,672	153,659	48,013
2009 - 2010	236,426	174,762	61,664	37,581	27,374	10,207	N/A	N/A	N/A	N/A	N/A	N/A	123,325	89,831	33,494	75,520	57,557	17,963
2010 - 2011	302,825	228,543	74,282	62,093	46,561	15,532	N/A	N/A	N/A	N/A	N/A	N/A	121,727	91,278	30,449	119,005	90,703	28,302
2011 - 2012	312,980	236,874	76,106	39,237	29,121	10,115	N/A	N/A	N/A	N/A	N/A	N/A	42,291	31,389	10,903	231,452	176,364	55,088
2012 - 2013	294,561	224,440	70,121	9,964	7,590	2,373	N/A	N/A	N/A	N/A	N/A	N/A	25,716	19,590	6,126	258,881	197,260	61,621
2013 - 2014	283,682	216,153	67,529	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	283,682	216,153	67,529
2014 - 2015	246,677	187,963	58,714	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	246,677	187,963	58,714
2015 - 2016	219,092	166,949	52,143	17,674	13,464	4,210	N/A	N/A	N/A	N/A	N/A	N/A	46,013	35,052	10,961	155,405	118,433	36,973
2016 - 2017	272,226	206,838	65,388	60,886	46,382	14,503	N/A	N/A	N/A	N/A	N/A	N/A	126,021	95,606	30,415	85,319	65,041	20,278

Historical Agricultural Water Demand

Water Year	Total Applied Water	Total Cons. Use	Total Return Flow	Tule River			Deer Creek			Recycled Water			Imported Water			Groundwater Production		
				Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow
Pixley Irrigation District GSA																		
1986 - 1987	153,767	114,587	39,180	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	1,151	858	293	152,616	113,729	38,887
1987 - 1988	153,767	114,587	39,180	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	0	0	0	153,767	114,587	39,180
1988 - 1989	153,767	114,587	39,180	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	3,627	2,702	924	150,141	111,884	38,256
1989 - 1990	174,387	129,953	44,434	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	0	0	0	174,387	129,953	44,434
1990 - 1991	176,516	131,539	44,977	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	0	0	0	176,516	131,539	44,977
1991 - 1992	166,792	124,293	42,499	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	0	0	0	166,792	124,293	42,499
1992 - 1993	165,032	122,982	42,051	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	53,530	39,890	13,639	111,503	83,091	28,411
1993 - 1994	177,163	132,021	45,141	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	0	0	0	177,163	132,021	45,141
1994 - 1995	182,108	135,706	46,401	N/A	N/A	N/A	3,913	2,916	997	N/A	N/A	N/A	29,783	22,194	7,589	148,411	110,596	37,816
1995 - 1996	163,604	121,918	41,687	N/A	N/A	N/A	4,821	3,593	1,228	N/A	N/A	N/A	38,375	28,597	9,778	120,408	89,728	30,680
1996 - 1997	168,324	125,435	42,889	N/A	N/A	N/A	2,705	2,015	689	N/A	N/A	N/A	22,254	16,584	5,670	143,365	106,835	36,530
1997 - 1998	175,112	130,493	44,619	N/A	N/A	N/A	12,216	9,103	3,113	N/A	N/A	N/A	24,467	18,233	6,234	138,430	103,157	35,272
1998 - 1999	178,373	132,923	45,450	N/A	N/A	N/A	1,312	978	334	N/A	N/A	N/A	21,160	15,769	5,392	155,900	116,176	39,724
1999 - 2000	187,825	139,967	47,858	N/A	N/A	N/A	1,242	926	317	N/A	N/A	N/A	26,366	19,648	6,718	160,217	119,394	40,824
2000 - 2001	165,472	123,309	42,163	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	6,410	4,777	1,633	159,062	118,532	40,529
2001 - 2002	159,902	119,159	40,743	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	9,550	7,117	2,433	150,352	112,042	38,310
2002 - 2003	151,591	117,459	34,132	N/A	N/A	N/A	853	661	192	N/A	N/A	N/A	19,578	15,170	4,408	131,160	101,628	29,532
2003 - 2004	143,885	111,838	32,047	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	6,828	5,307	1,521	137,057	106,531	30,526
2004 - 2005	143,267	111,358	31,909	N/A	N/A	N/A	3,160	2,456	704	N/A	N/A	N/A	35,846	27,862	7,984	104,261	81,039	23,222
2005 - 2006	170,036	132,164	37,871	N/A	N/A	N/A	1,703	1,324	379	N/A	N/A	N/A	36,731	28,550	8,181	131,602	102,291	29,311
2006 - 2007	147,335	114,519	32,815	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	4,449	3,458	991	142,886	111,061	31,824
2007 - 2008	133,635	103,871	29,764	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	7,434	5,778	1,656	126,201	98,093	28,108
2008 - 2009	157,297	122,263	35,034	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	14,865	11,554	3,311	142,432	110,709	31,723
2009 - 2010	131,420	102,149	29,271	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	16,593	12,897	3,696	114,827	89,252	25,575
2010 - 2011	169,047	131,396	37,651	N/A	N/A	N/A	6,074	4,721	1,353	N/A	N/A	N/A	31,321	24,345	6,976	131,652	102,330	29,322
2011 - 2012	181,603	141,156	40,448	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	2,291	1,781	510	179,312	139,375	39,937
2012 - 2013	182,553	141,894	40,659	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	3,251	2,527	724	179,302	139,367	39,935
2013 - 2014	184,161	143,144	41,017	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	0	0	0	184,161	143,144	41,017
2014 - 2015	184,057	143,063	40,994	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	0	0	0	184,057	143,063	40,994
2015 - 2016	121,082	94,114	26,968	N/A	N/A	N/A	0	0	0	N/A	N/A	N/A	2,164	1,682	482	118,918	92,432	26,486
2016 - 2017	149,868	116,489	33,379	N/A	N/A	N/A	6,206	4,823	1,382	N/A	N/A	N/A	51,171	39,774	11,397	92,492	71,891	20,600

Historical Agricultural Water Demand

Water Year	Total Applied Water	Total Cons. Use	Total Return Flow	Tule River			Deer Creek			Recycled Water			Imported Water			Groundwater Production		
				Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow
Delano-Earlimart Irrigation District GSA																		
1986 - 1987	165,921	128,557	37,363	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	114,782	87,645	27,138	51,138	40,912	10,226
1987 - 1988	162,123	128,557	33,566	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	110,345	87,125	23,221	51,778	41,432	10,345
1988 - 1989	162,104	128,557	33,547	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	105,980	83,591	22,390	56,124	44,966	11,157
1989 - 1990	161,755	128,557	33,198	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	83,837	65,868	17,969	77,918	62,689	15,229
1990 - 1991	160,014	128,557	31,457	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	106,877	86,019	20,858	53,137	42,538	10,599
1991 - 1992	162,084	128,557	33,527	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	92,567	72,699	19,868	69,517	55,858	13,659
1992 - 1993	160,750	128,557	32,193	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	127,775	102,414	25,360	32,976	26,143	6,833
1993 - 1994	163,728	128,160	35,568	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	91,696	70,257	21,439	72,032	57,903	14,129
1994 - 1995	159,899	128,101	31,798	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	119,936	96,276	23,659	39,963	31,825	8,138
1995 - 1996	177,394	132,583	44,811	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	142,817	105,755	37,061	34,577	26,827	7,749
1996 - 1997	182,282	132,512	49,770	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	148,693	106,548	42,145	33,589	25,964	7,625
1997 - 1998	172,420	132,512	39,907	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	116,888	88,704	28,184	55,532	43,808	11,724
1998 - 1999	169,495	132,512	36,983	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	121,365	94,723	26,642	48,130	37,789	10,341
1999 - 2000	171,523	132,512	39,011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	129,847	99,972	29,875	41,676	32,541	9,135
2000 - 2001	170,597	132,512	38,085	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	117,178	90,422	26,756	53,419	42,090	11,329
2001 - 2002	170,441	132,512	37,929	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	126,740	98,325	28,415	43,702	34,188	9,514
2002 - 2003	163,870	132,512	31,357	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	121,277	97,456	23,820	42,593	35,056	7,537
2003 - 2004	162,319	128,366	33,953	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	127,364	99,687	27,677	34,955	28,679	6,276
2004 - 2005	158,692	128,185	30,506	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	119,767	96,113	23,654	38,925	32,072	6,852
2005 - 2006	158,146	128,185	29,961	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	119,850	96,651	23,200	38,296	31,535	6,761
2006 - 2007	156,416	128,185	28,231	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	78,970	63,155	15,815	77,446	65,030	12,416
2007 - 2008	152,562	128,185	24,376	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	106,470	89,981	16,489	46,092	38,205	7,887
2008 - 2009	155,593	128,185	27,408	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	109,078	89,619	19,459	46,515	38,567	7,948
2009 - 2010	155,866	128,185	27,681	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	112,888	92,645	20,243	42,978	35,540	7,438
2010 - 2011	153,971	124,818	29,153	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	118,032	95,977	22,055	35,939	29,599	6,341
2011 - 2012	152,311	124,812	27,499	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	113,031	92,032	20,998	39,281	32,458	6,823
2012 - 2013	151,444	124,812	26,632	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	87,302	70,960	16,342	64,143	53,729	10,414
2013 - 2014	148,827	124,812	24,015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38,106	31,039	7,067	110,722	93,580	17,142
2014 - 2015	147,227	124,812	22,414	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18,591	15,905	2,685	128,636	108,907	19,729
2015 - 2016	147,227	124,812	22,414	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	90,160	77,138	13,023	57,066	47,675	9,392
2016 - 2017	155,082	124,812	30,270	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	121,326	98,215	23,111	33,756	27,731	6,025

Historical Agricultural Water Demand

Water Year	Total Applied Water	Total Cons. Use	Total Return Flow	Tule River			Deer Creek			Recycled Water			Imported Water			Groundwater Production		
				Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow
Tri-County Water Authority GSA																		
1986 - 1987	56,858	42,849	14,009	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8,035	5,776	2,260	48,823	37,074	11,750
1987 - 1988	56,637	42,849	13,788	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,530	2,596	935	53,107	40,254	12,853
1988 - 1989	56,671	42,849	13,822	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6,026	4,459	1,567	50,645	38,390	12,255
1989 - 1990	56,692	42,849	13,843	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,847	2,810	1,037	52,845	40,039	12,806
1990 - 1991	56,852	42,849	14,003	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	925	632	293	55,926	42,217	13,710
1991 - 1992	56,585	42,849	13,736	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,611	1,197	414	54,974	41,652	13,322
1992 - 1993	56,890	42,849	14,041	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8,240	6,035	2,205	48,650	36,814	11,836
1993 - 1994	56,610	42,869	13,742	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5,130	3,833	1,297	51,481	39,036	12,445
1994 - 1995	56,744	42,870	13,874	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12,853	9,506	3,347	43,891	33,364	10,528
1995 - 1996	73,837	55,920	17,917	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16,567	12,333	4,234	57,270	43,587	13,683
1996 - 1997	75,642	57,282	18,361	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12,383	9,161	3,223	63,259	48,121	15,138
1997 - 1998	75,599	57,282	18,318	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7,460	5,534	1,926	68,139	51,748	16,391
1998 - 1999	75,585	57,282	18,304	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9,778	7,267	2,511	65,807	50,015	15,793
1999 - 2000	75,554	57,258	18,296	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8,281	6,156	2,124	67,274	51,102	16,172
2000 - 2001	75,552	57,256	18,296	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,824	2,842	982	71,728	54,415	17,314
2001 - 2002	75,582	57,256	18,326	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,932	2,179	754	72,650	55,078	17,572
2002 - 2003	71,592	57,256	14,335	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,734	3,647	1,087	66,858	53,609	13,249
2003 - 2004	60,999	48,831	12,167	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,434	2,438	995	57,565	46,393	11,172
2004 - 2005	61,070	47,408	13,662	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12,571	8,040	4,531	48,499	39,369	9,131
2005 - 2006	60,821	47,408	13,413	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11,831	7,497	4,335	48,990	39,912	9,078
2006 - 2007	61,761	47,408	14,352	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6,641	3,909	2,732	55,120	43,500	11,620
2007 - 2008	60,832	47,408	13,424	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,165	1,242	923	58,667	46,166	12,500
2008 - 2009	60,431	47,408	13,023	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	313	179	133	60,118	47,229	12,889
2009 - 2010	60,353	47,408	12,944	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,396	2,284	1,112	56,957	45,125	11,832
2010 - 2011	70,437	54,723	15,714	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7,104	3,608	3,495	63,333	51,114	12,219
2011 - 2012	70,064	54,423	15,641	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3,210	1,339	1,870	66,854	53,083	13,771
2012 - 2013	71,841	54,423	17,418	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,492	628	864	70,349	53,795	16,555
2013 - 2014	70,802	54,423	16,379	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,048	227	820	69,754	54,195	15,559
2014 - 2015	70,443	54,423	16,021	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	575	300	275	69,868	54,122	15,746
2015 - 2016	70,385	54,423	15,962	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	587	316	271	69,798	54,107	15,691
2016 - 2017	69,951	54,423	15,528	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12,281	8,039	4,242	57,669	46,384	11,286

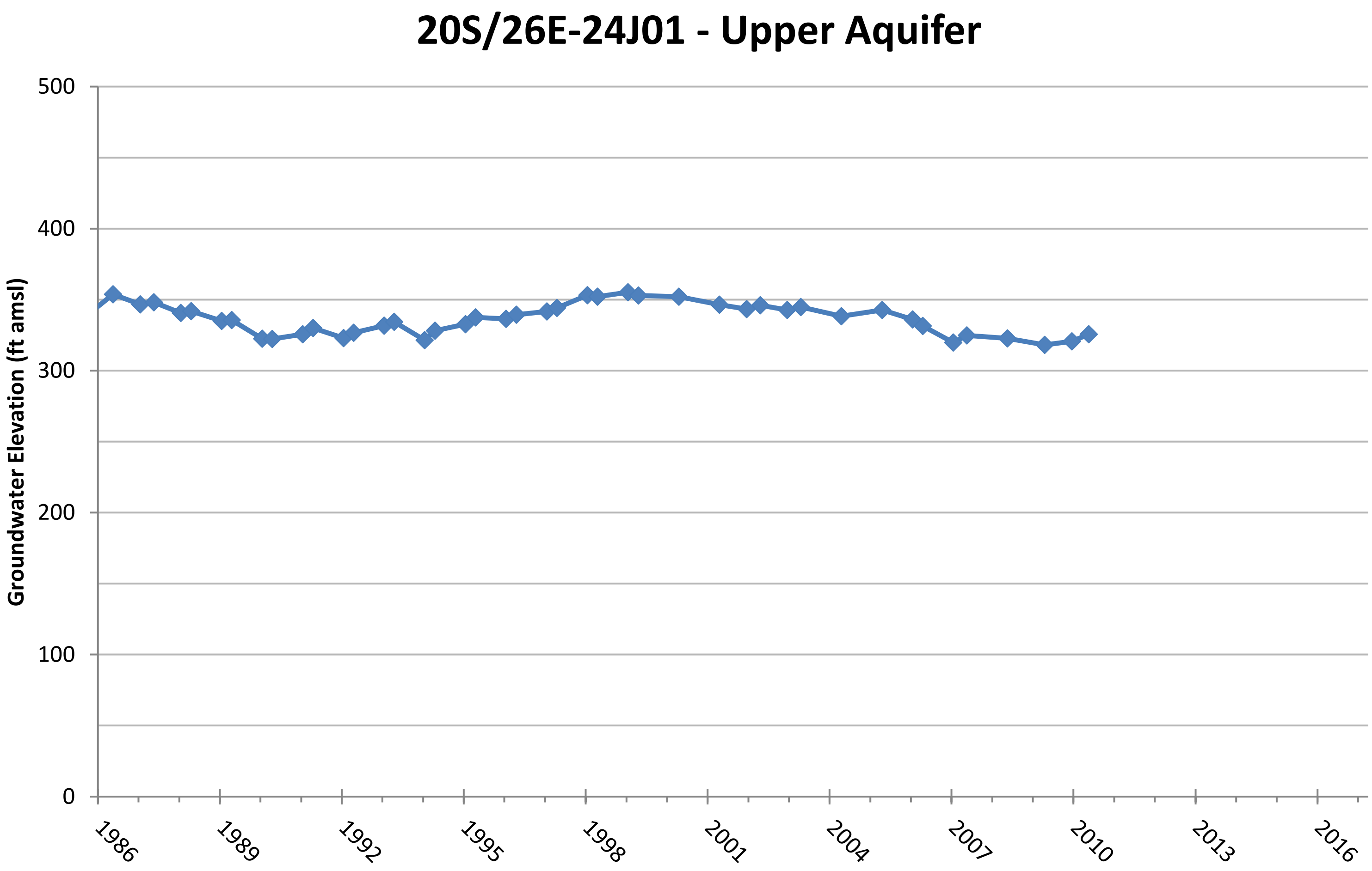
Historical Agricultural Water Demand

Water Year	Total Applied Water	Total Cons. Use	Total Return Flow	Tule River			Deer Creek			Recycled Water			Imported Water			Groundwater Production		
				Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow	Applied	Cons. Use	Return Flow
Alpaugh GSA																		
1986 - 1987	35,769	26,833	8,936	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,145	859	286	34,624	25,974	8,650
1987 - 1988	35,769	26,833	8,936	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	35,769	26,833	8,936
1988 - 1989	35,769	26,833	8,936	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	35,769	26,833	8,936
1989 - 1990	35,769	26,833	8,936	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	35,769	26,833	8,936
1990 - 1991	35,769	26,833	8,936	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	35,769	26,833	8,936
1991 - 1992	35,769	26,833	8,936	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	35,769	26,833	8,936
1992 - 1993	35,769	26,833	8,936	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13,821	10,368	3,453	21,948	16,465	5,483
1993 - 1994	35,779	26,841	8,939	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4,115	3,087	1,028	31,664	23,754	7,910
1994 - 1995	35,780	26,841	8,939	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9,723	7,294	2,429	26,057	19,547	6,510
1995 - 1996	33,699	25,280	8,419	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12,381	9,288	3,093	21,318	15,992	5,326
1996 - 1997	33,482	25,118	8,365	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	33,482	25,118	8,365
1997 - 1998	33,482	25,118	8,365	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	33,482	25,118	8,365
1998 - 1999	33,482	25,118	8,365	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	33,482	25,118	8,365
1999 - 2000	33,472	25,110	8,362	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	91	68	23	33,381	25,042	8,339
2000 - 2001	33,471	25,109	8,362	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	33,471	25,109	8,362
2001 - 2002	33,471	25,109	8,362	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	33,471	25,109	8,362
2002 - 2003	32,637	25,109	7,528	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	98	75	23	32,540	25,034	7,506
2003 - 2004	30,217	23,308	6,909	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	30,217	23,308	6,909
2004 - 2005	30,556	23,017	7,539	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13,660	9,985	3,675	16,896	13,032	3,863
2005 - 2006	31,475	23,017	8,458	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15,189	10,454	4,734	16,287	12,563	3,724
2006 - 2007	29,840	23,017	6,823	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	29,840	23,017	6,823
2007 - 2008	29,840	23,017	6,823	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	29,840	23,017	6,823
2008 - 2009	29,840	23,017	6,823	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,009	1,550	459	27,831	21,467	6,364
2009 - 2010	29,840	23,017	6,823	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,518	1,943	576	27,322	21,075	6,247
2010 - 2011	20,679	15,175	5,504	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10,324	7,188	3,137	10,355	7,987	2,368
2011 - 2012	18,791	14,321	4,470	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	889	513	377	17,902	13,808	4,093
2012 - 2013	18,566	14,321	4,245	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	18,566	14,321	4,245
2013 - 2014	18,566	14,321	4,245	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	18,566	14,321	4,245
2014 - 2015	18,566	14,321	4,245	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	18,566	14,321	4,245
2015 - 2016	18,566	14,321	4,245	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	18,566	14,321	4,245
2016 - 2017	18,566	14,321	4,245	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,232	1,721	510	16,335	12,600	3,735

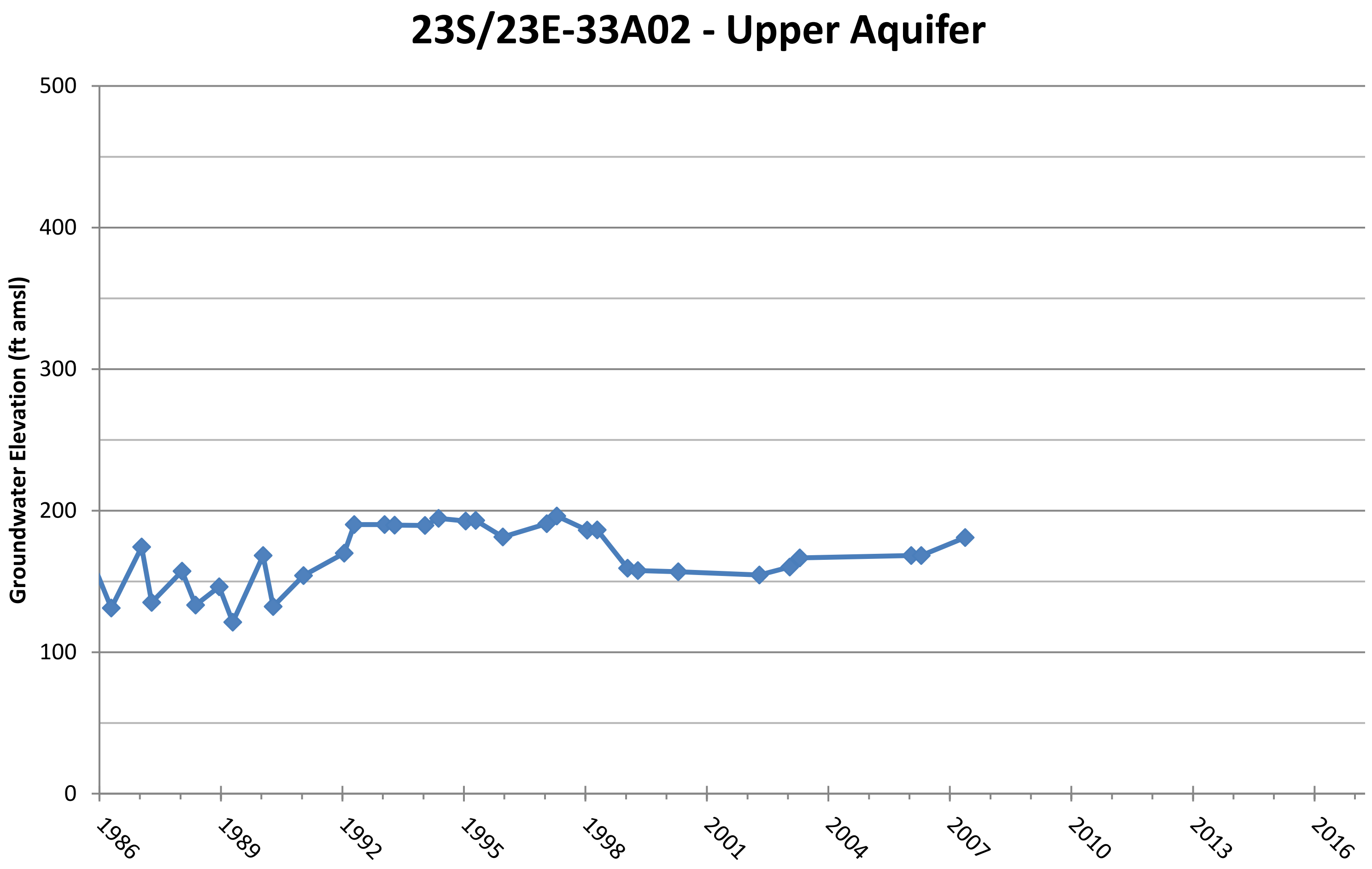
Appendix B

Hydrographs for Boundary Wells

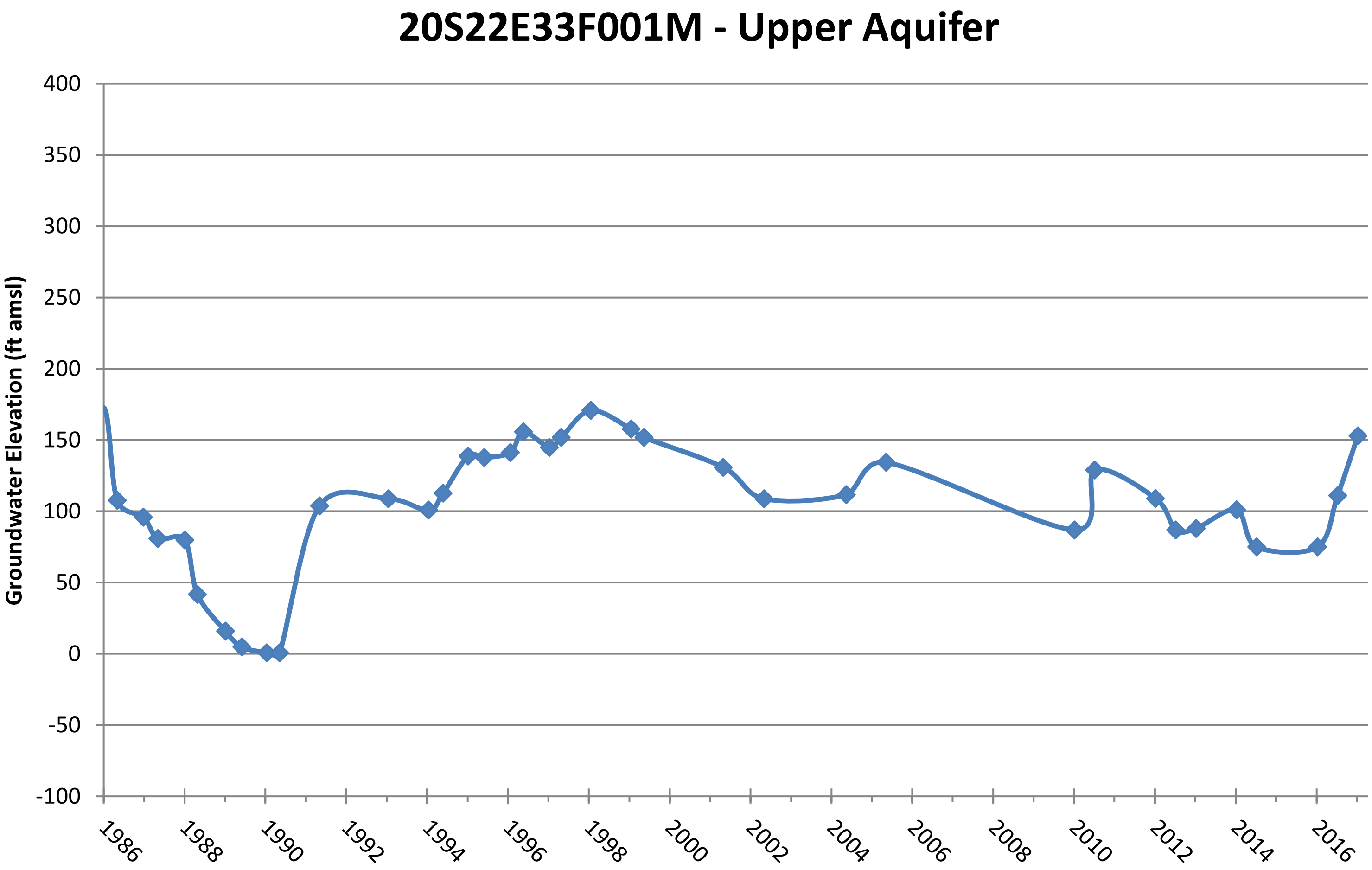
Boundary Condition Well Hydrograph



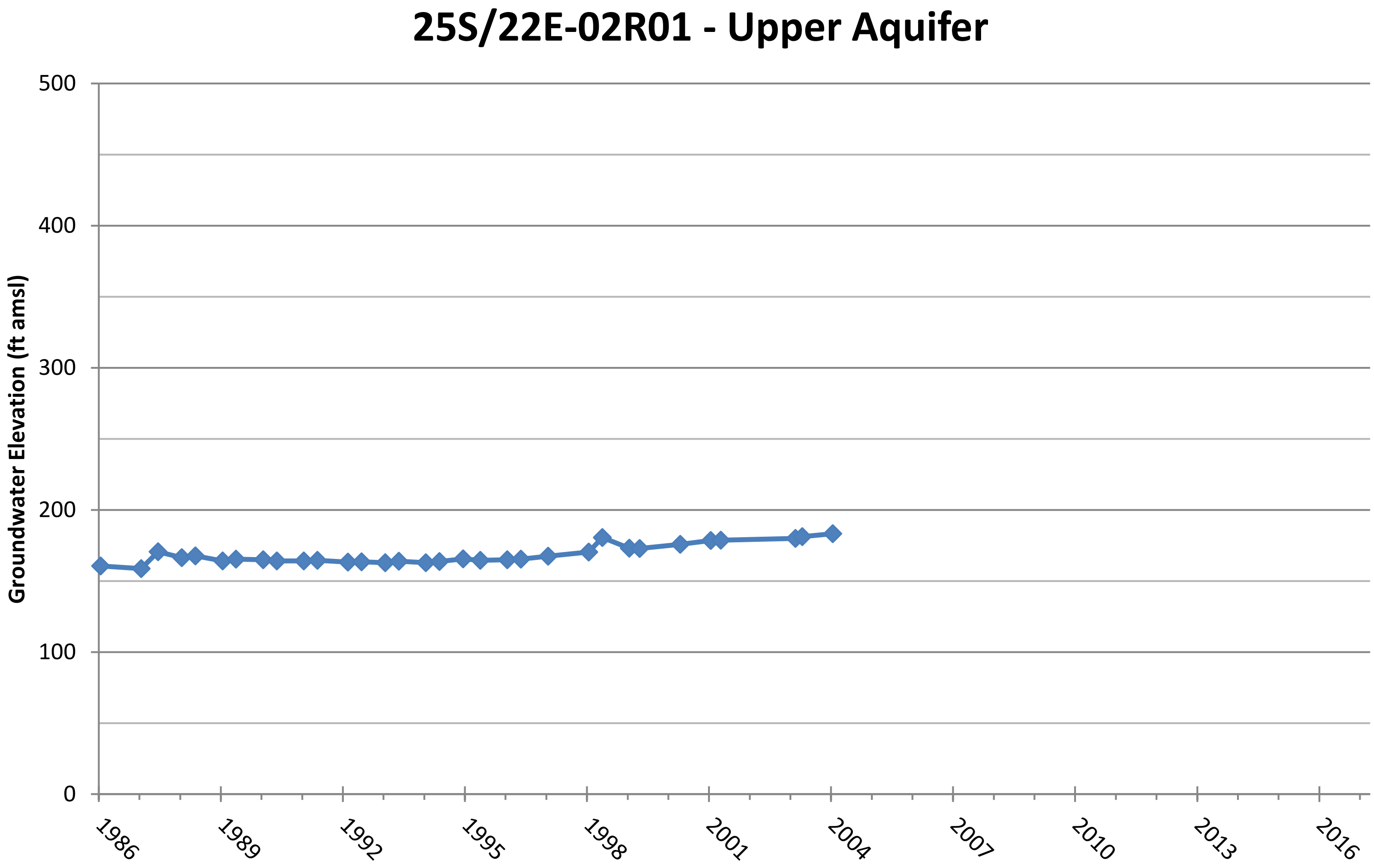
Boundary Condition Well Hydrograph



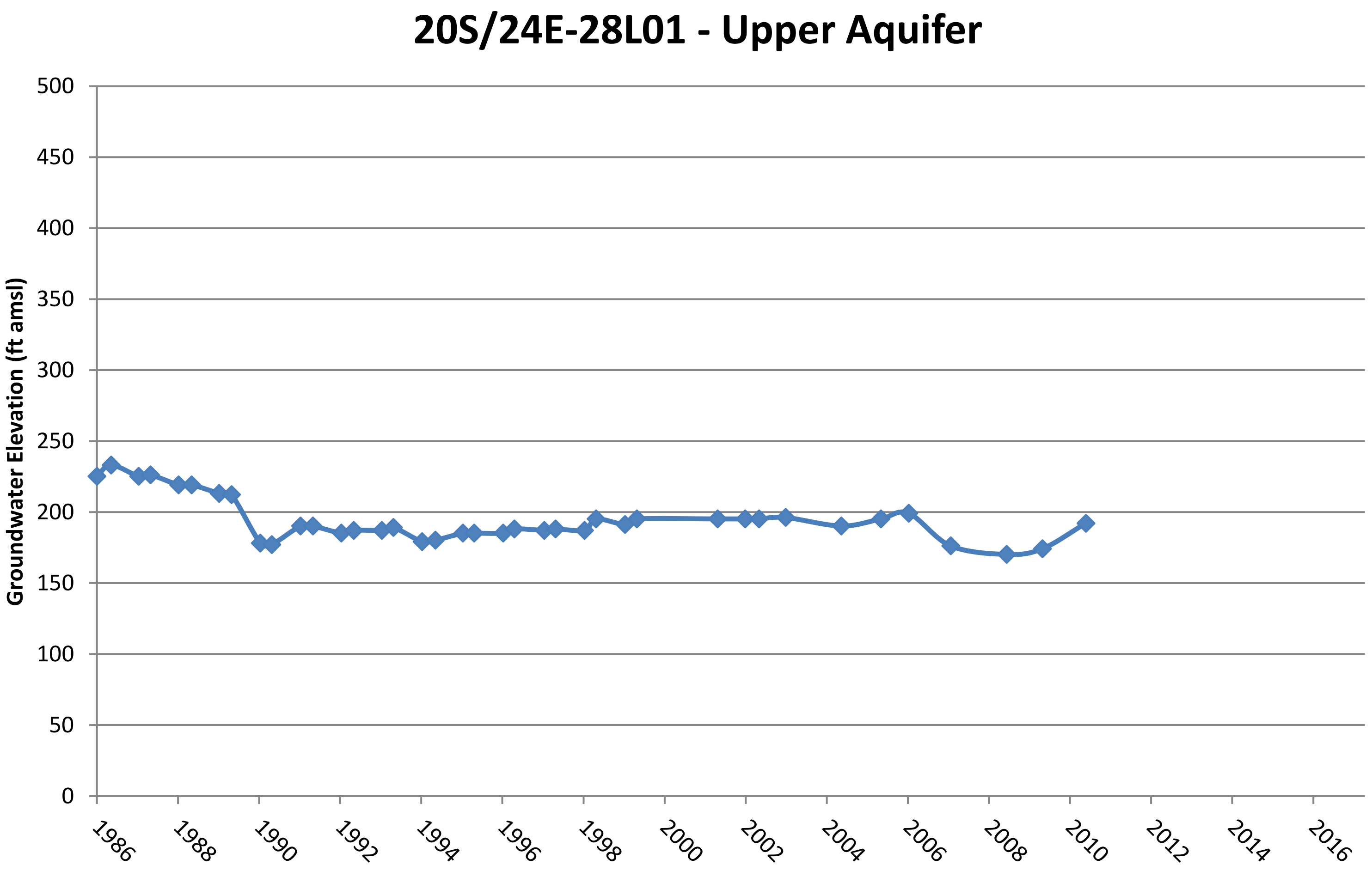
Boundary Condition Well Hydrograph



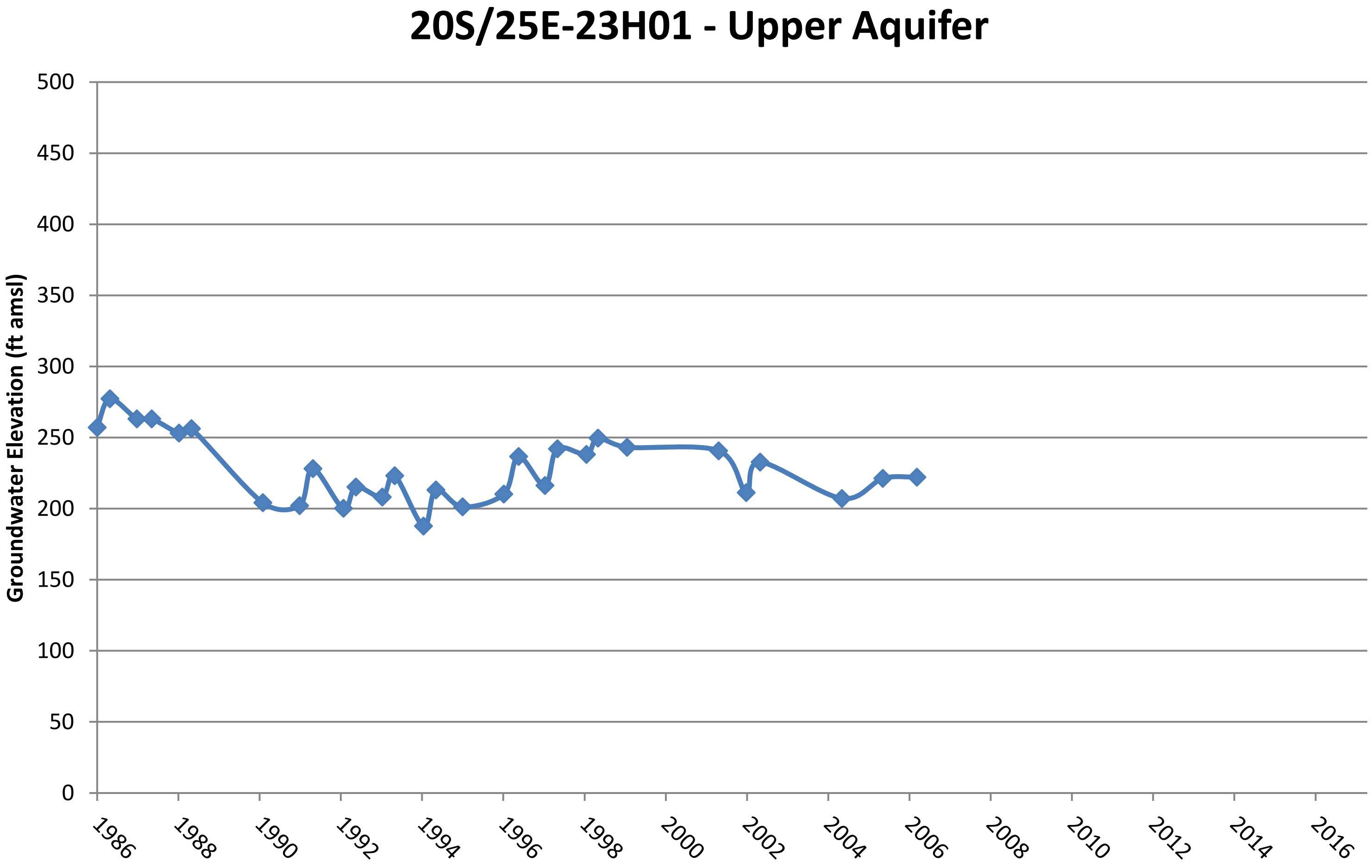
Boundary Condition Well Hydrograph



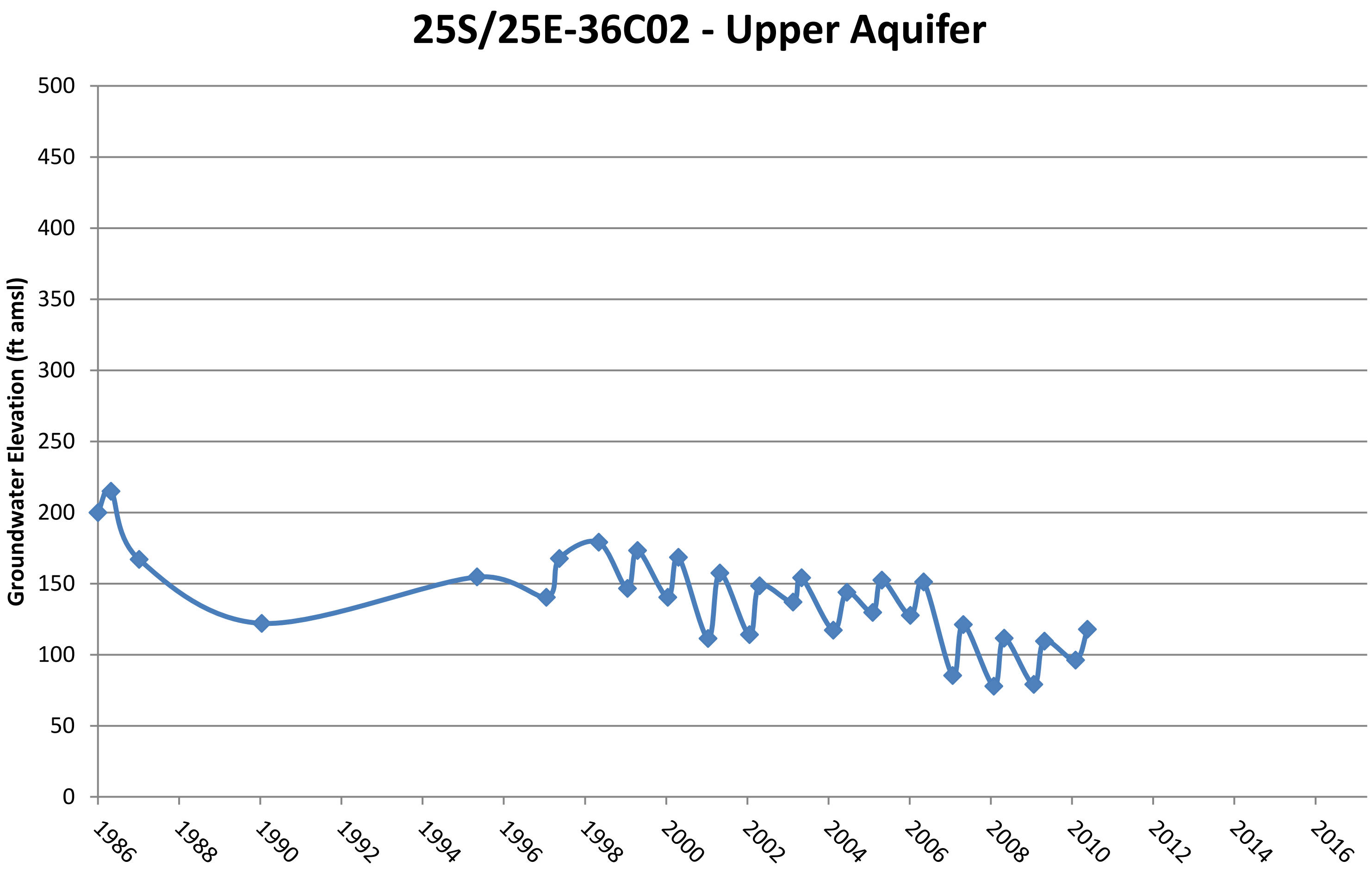
Boundary Condition Well Hydrograph



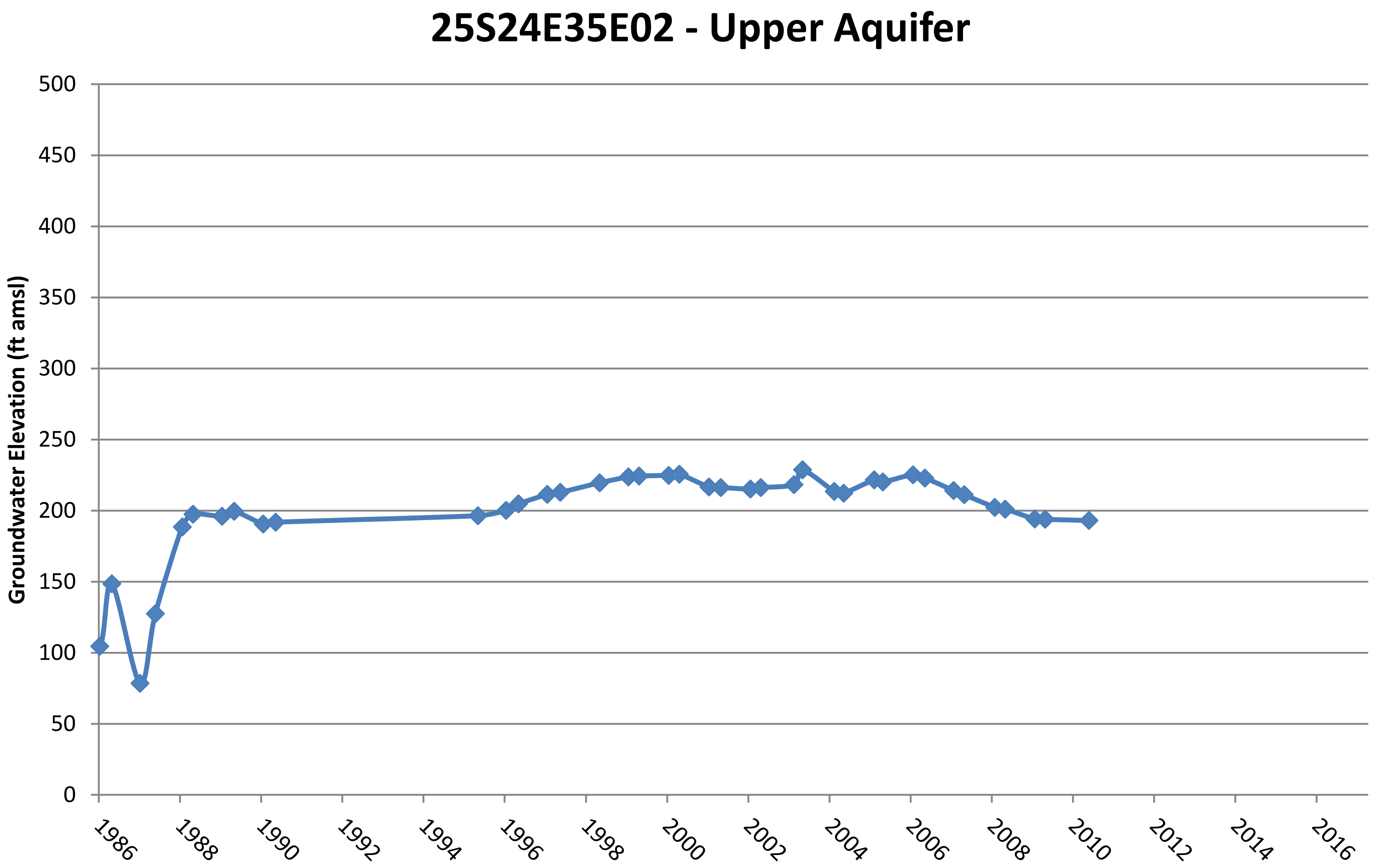
Boundary Condition Well Hydrograph



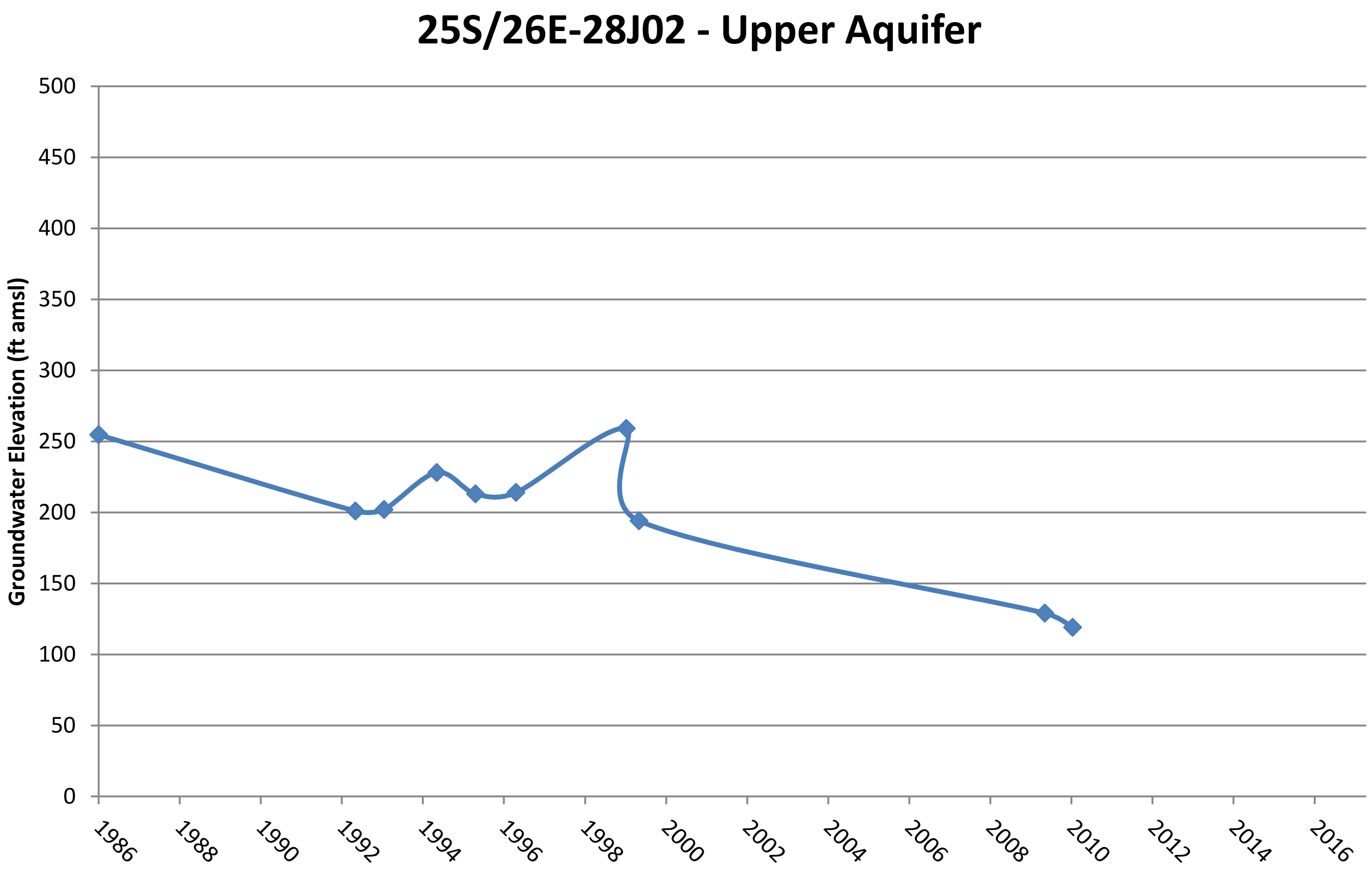
Boundary Condition Well Hydrograph



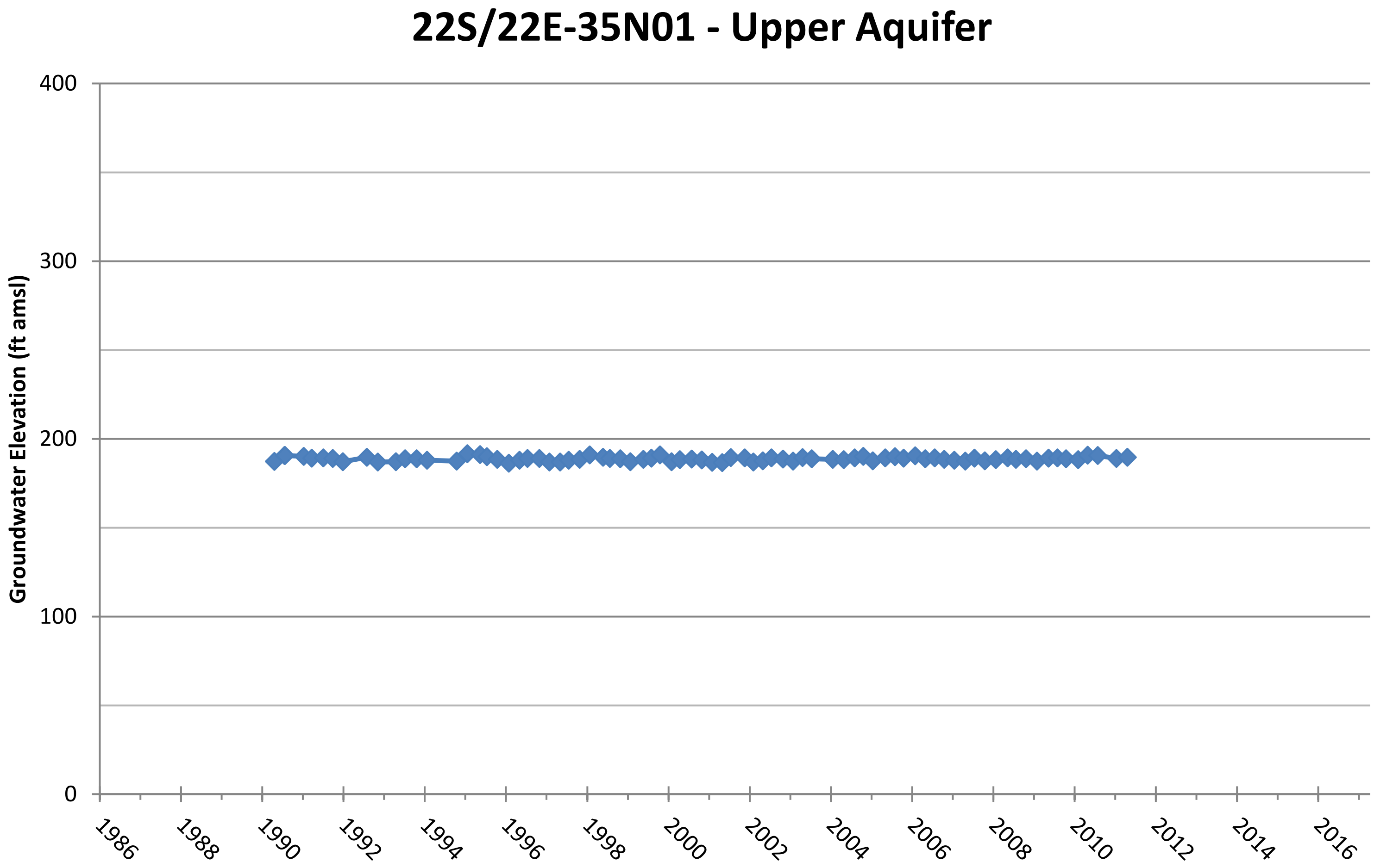
Boundary Condition Well Hydrograph



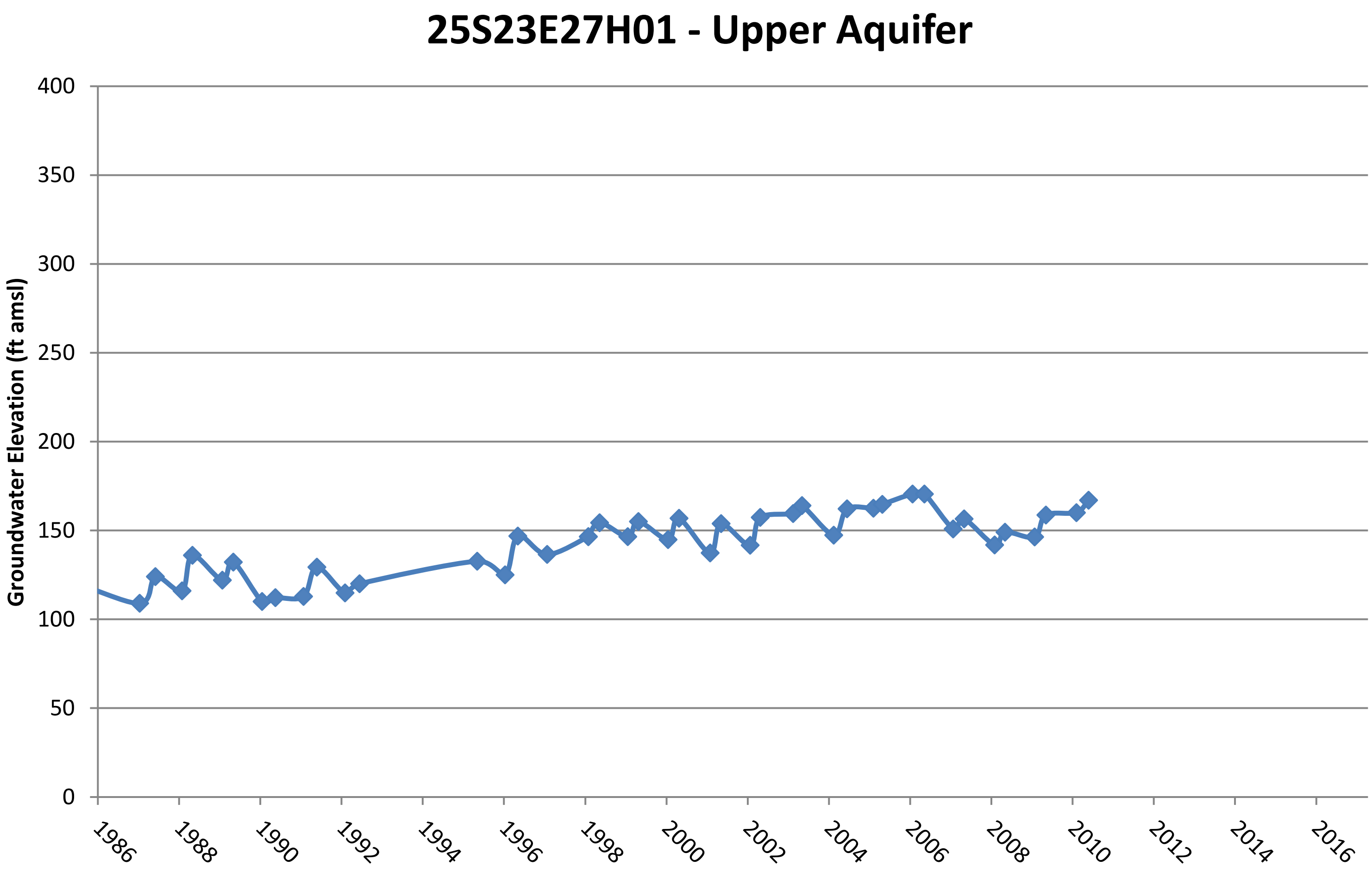
Boundary Condition Well Hydrograph



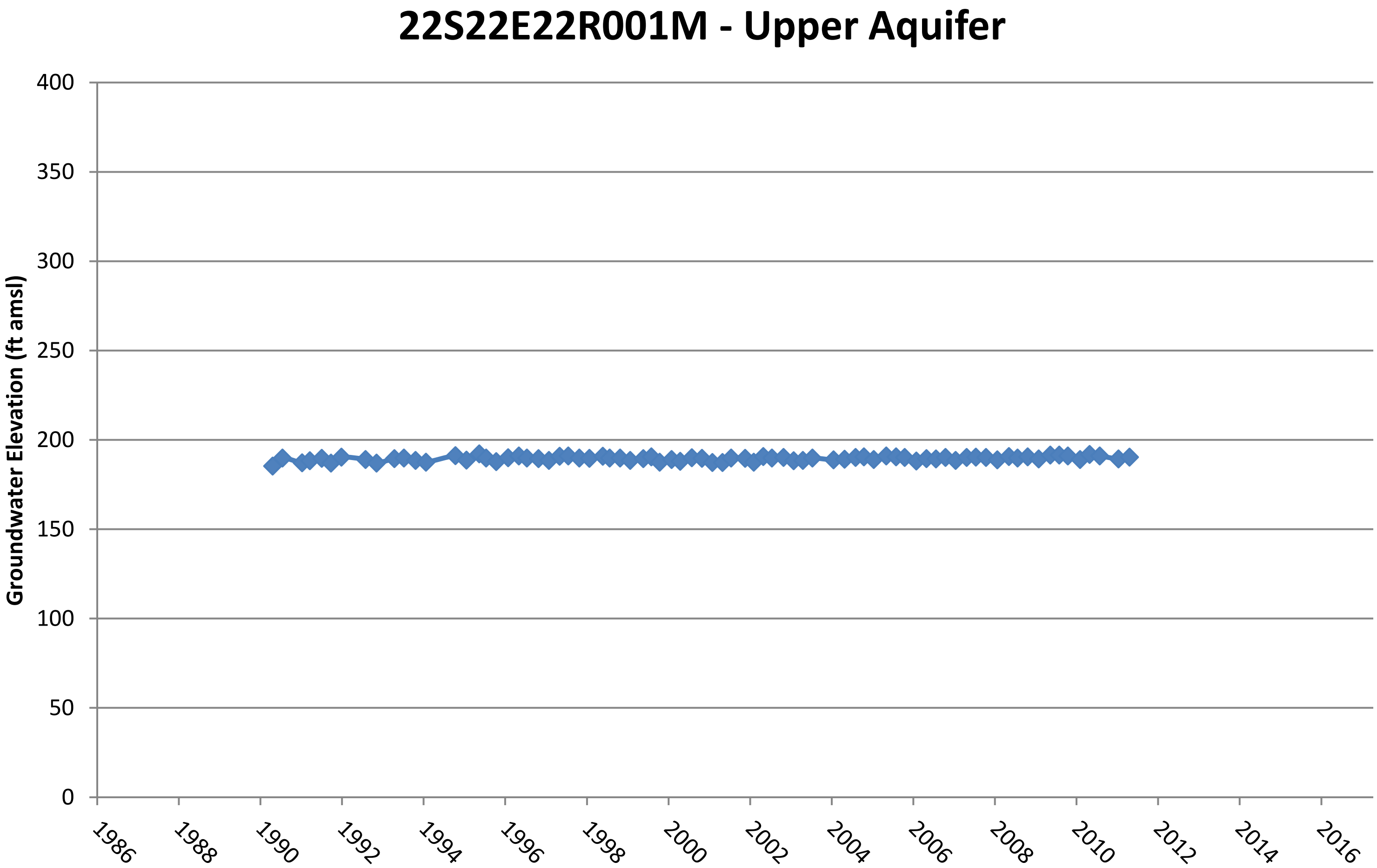
Boundary Condition Well Hydrograph



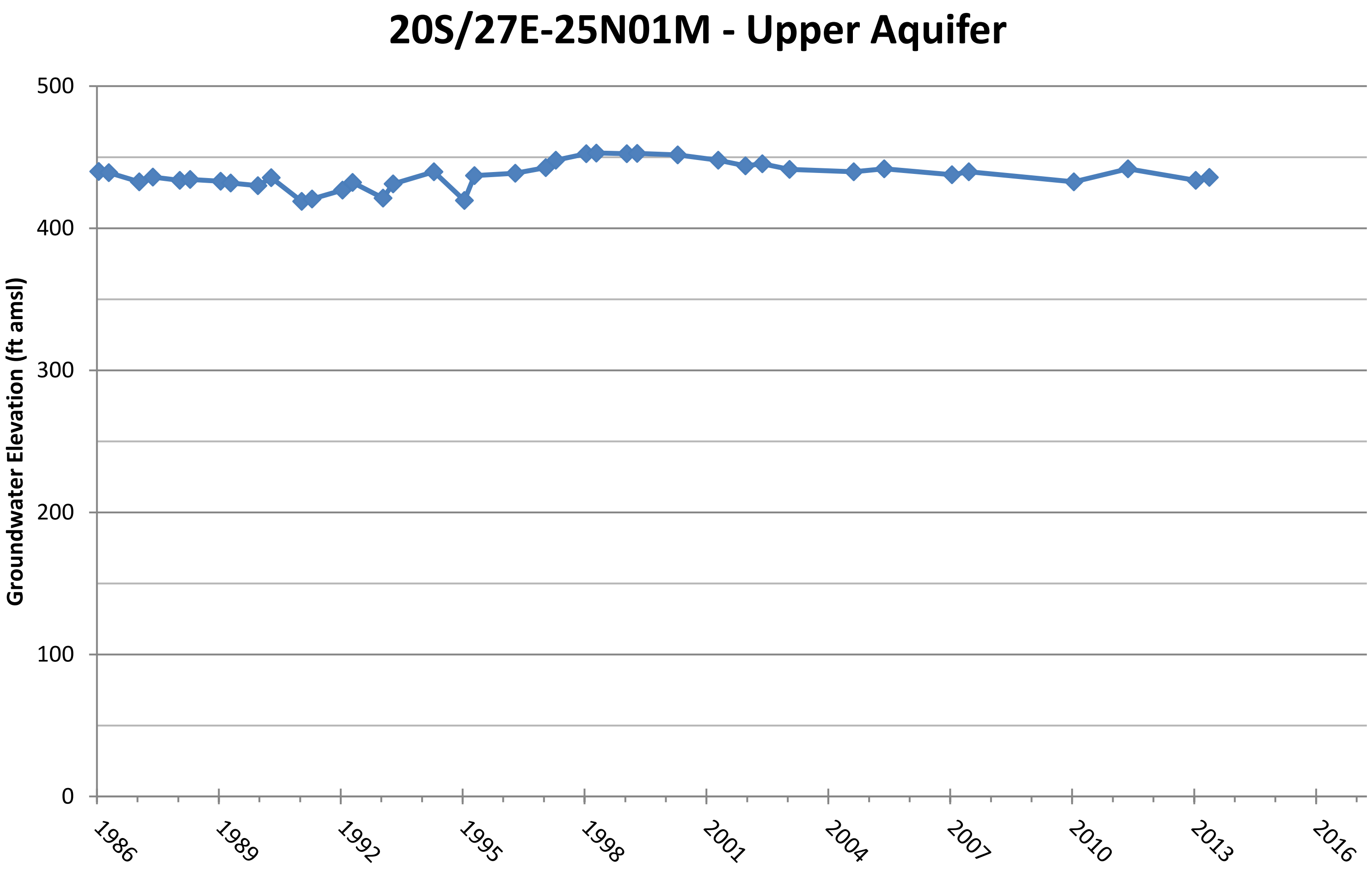
Boundary Condition Well Hydrograph



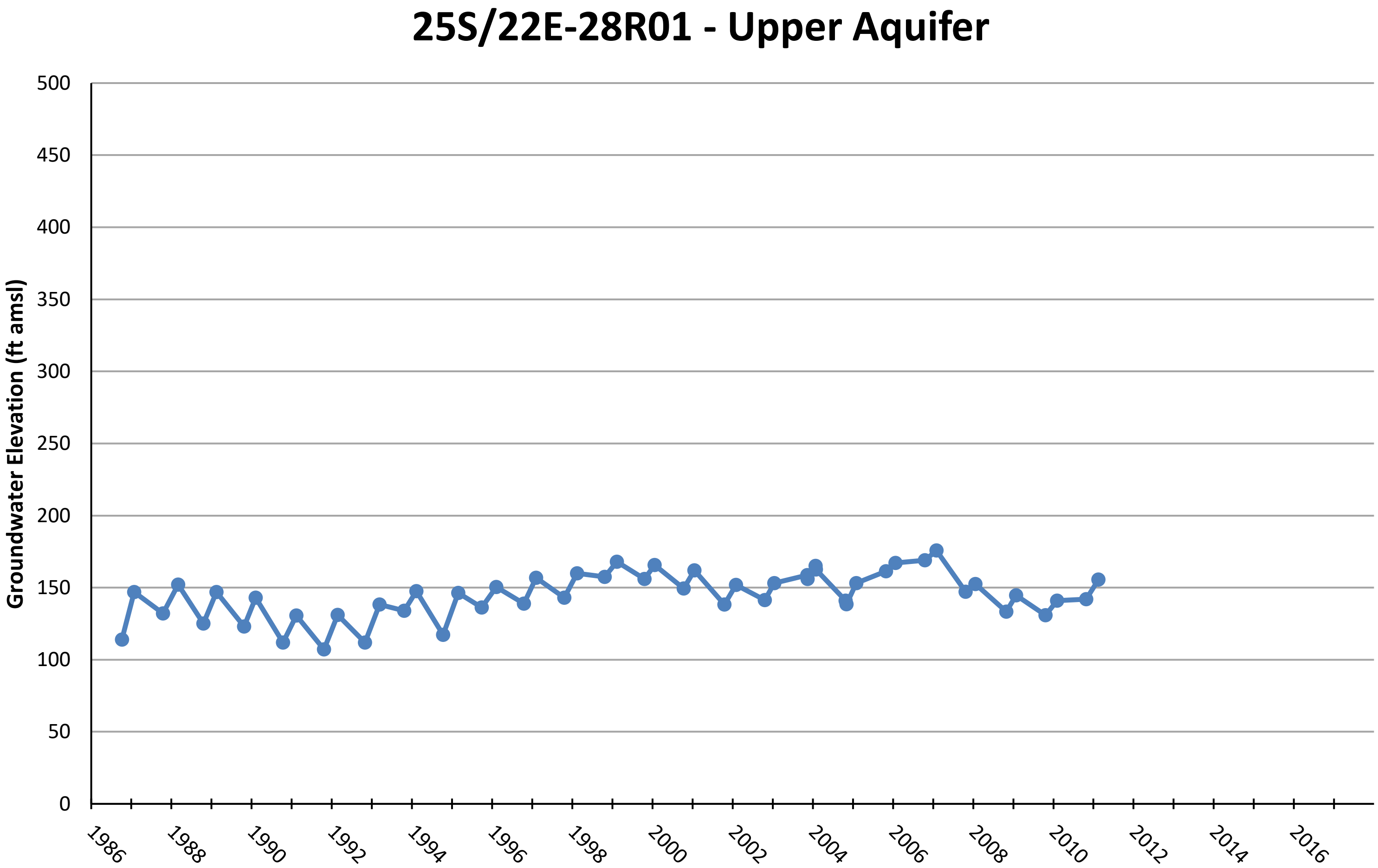
Boundary Condition Well Hydrograph



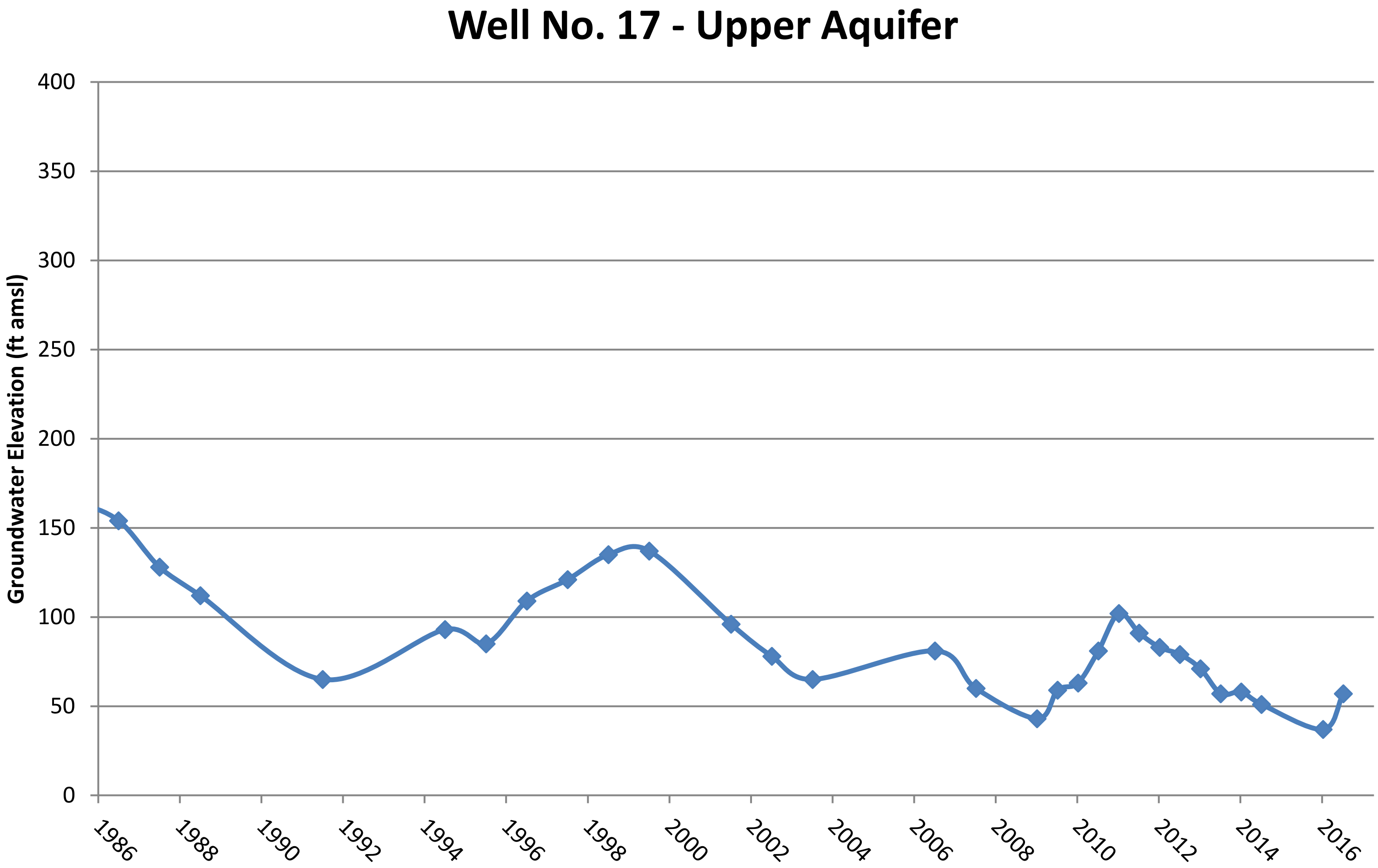
Boundary Condition Well Hydrograph



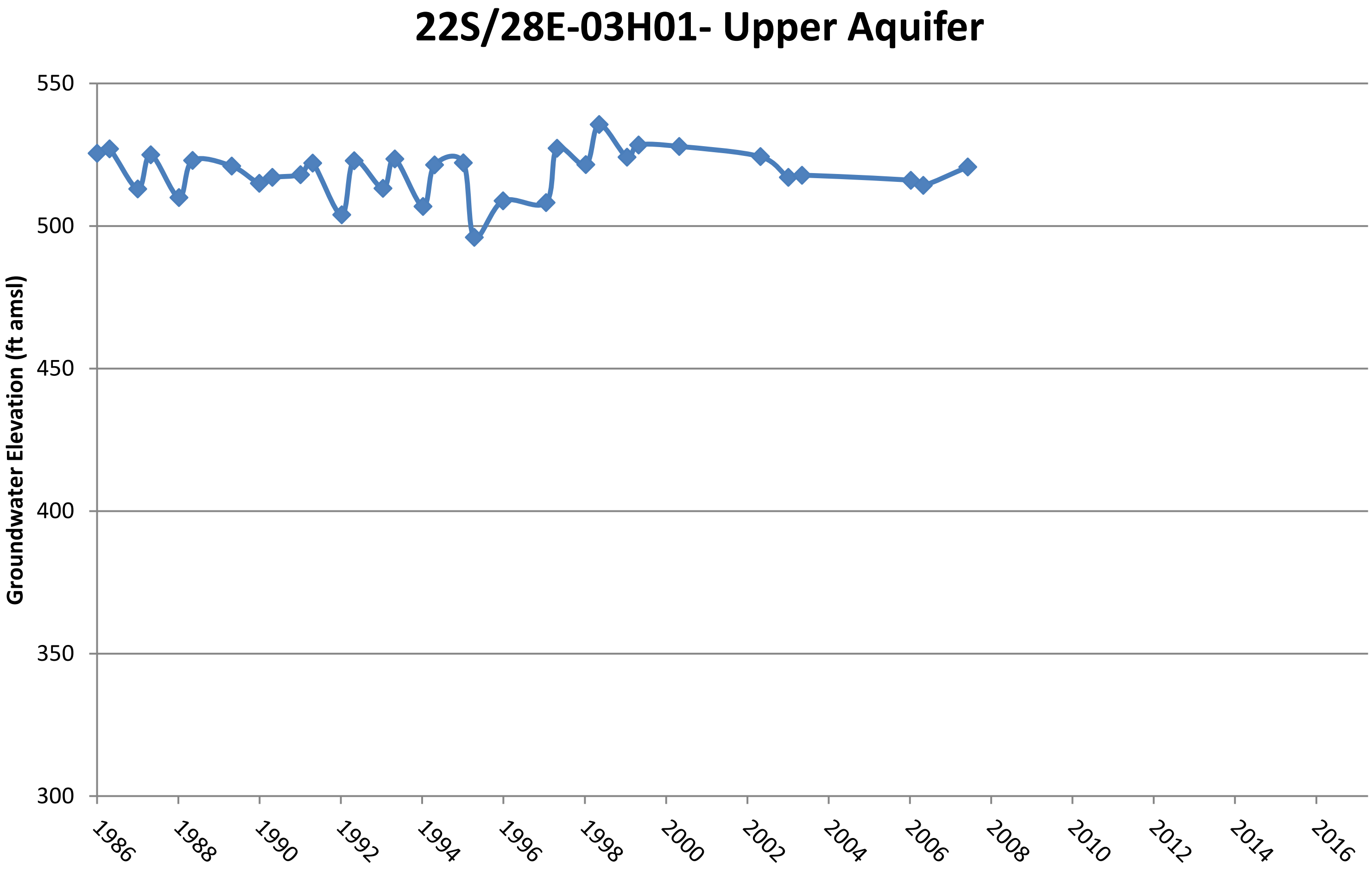
Boundary Condition Well Hydrograph



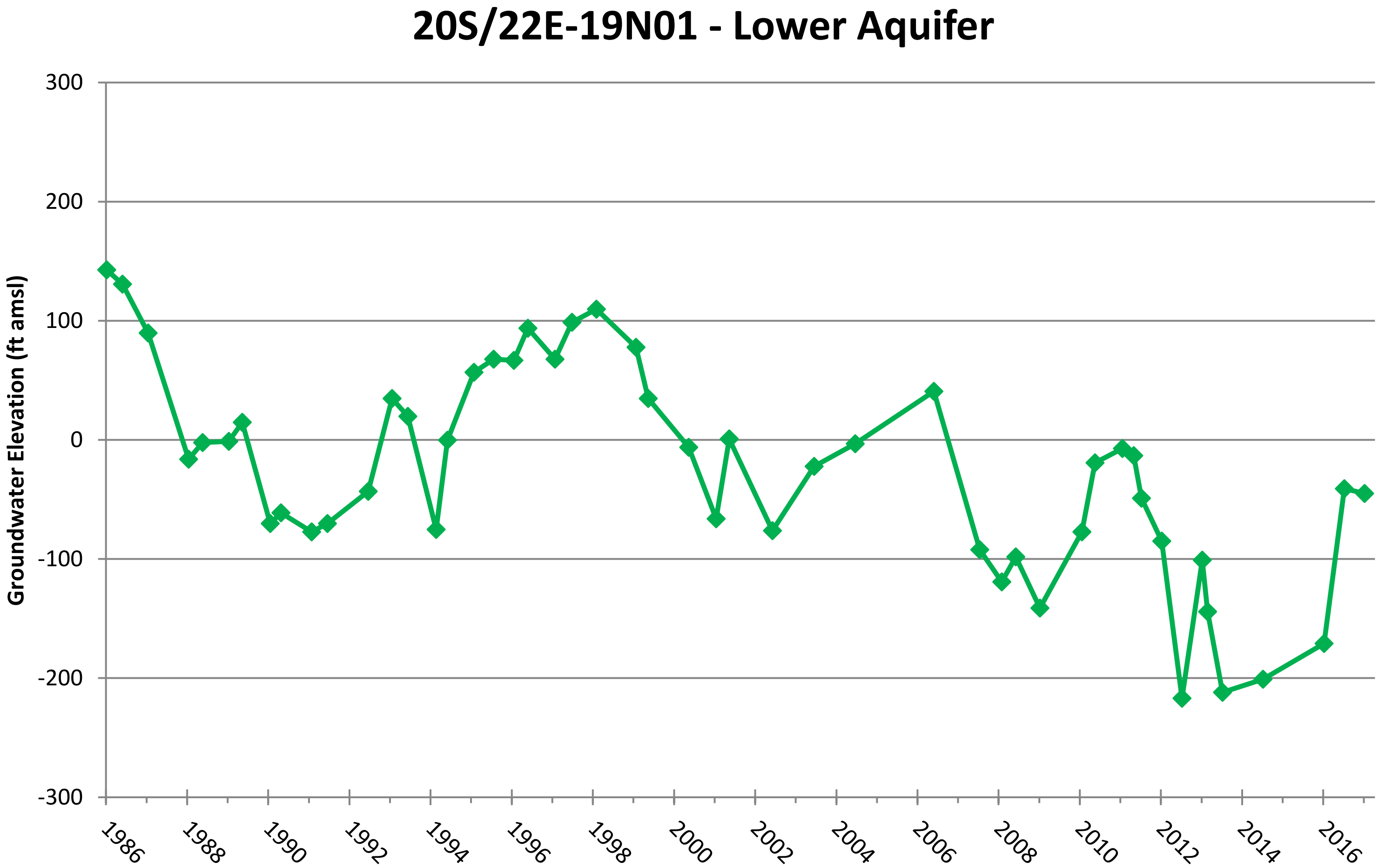
Boundary Condition Well Hydrograph



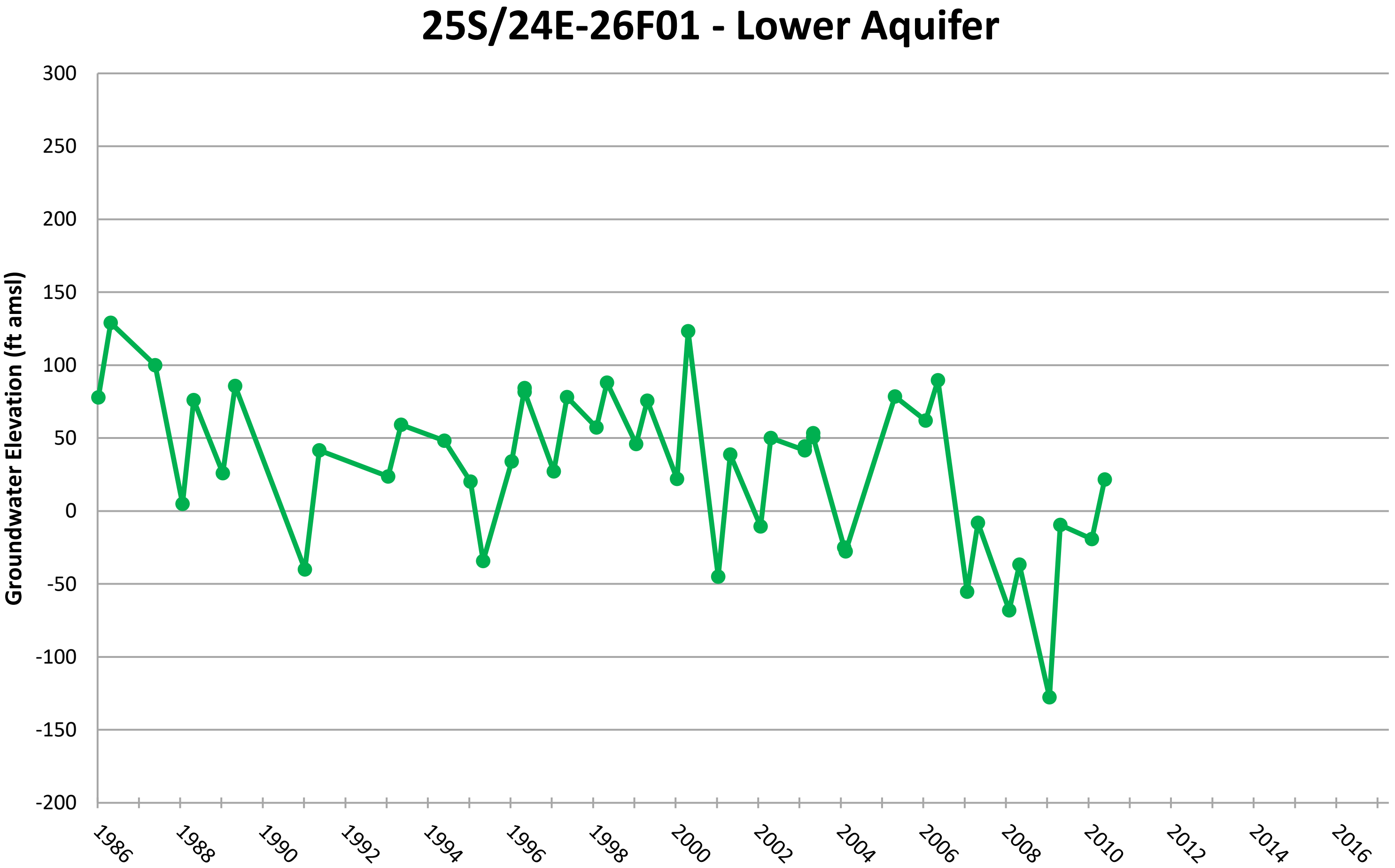
Boundary Condition Well Hydrograph



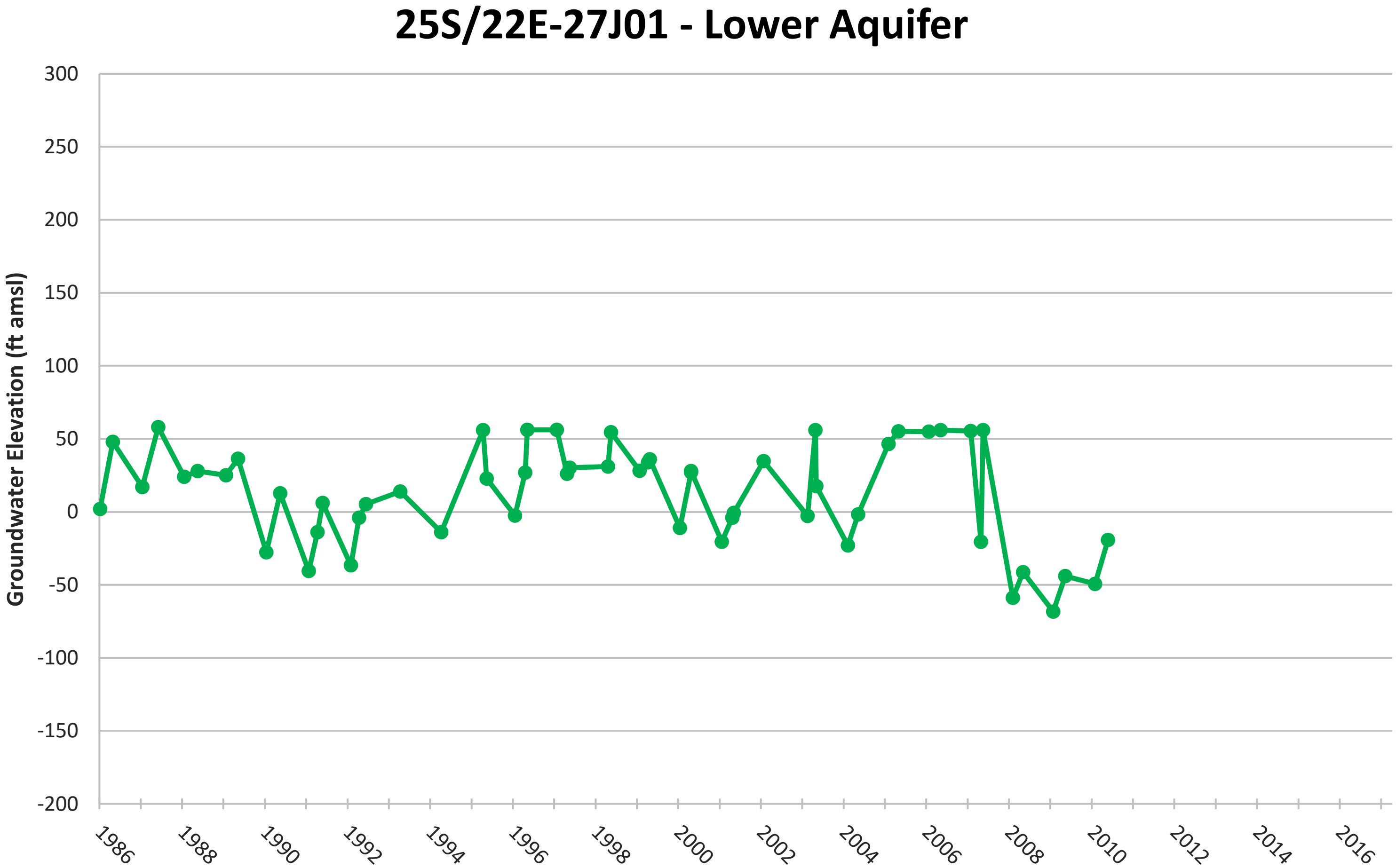
Boundary Condition Well Hydrograph



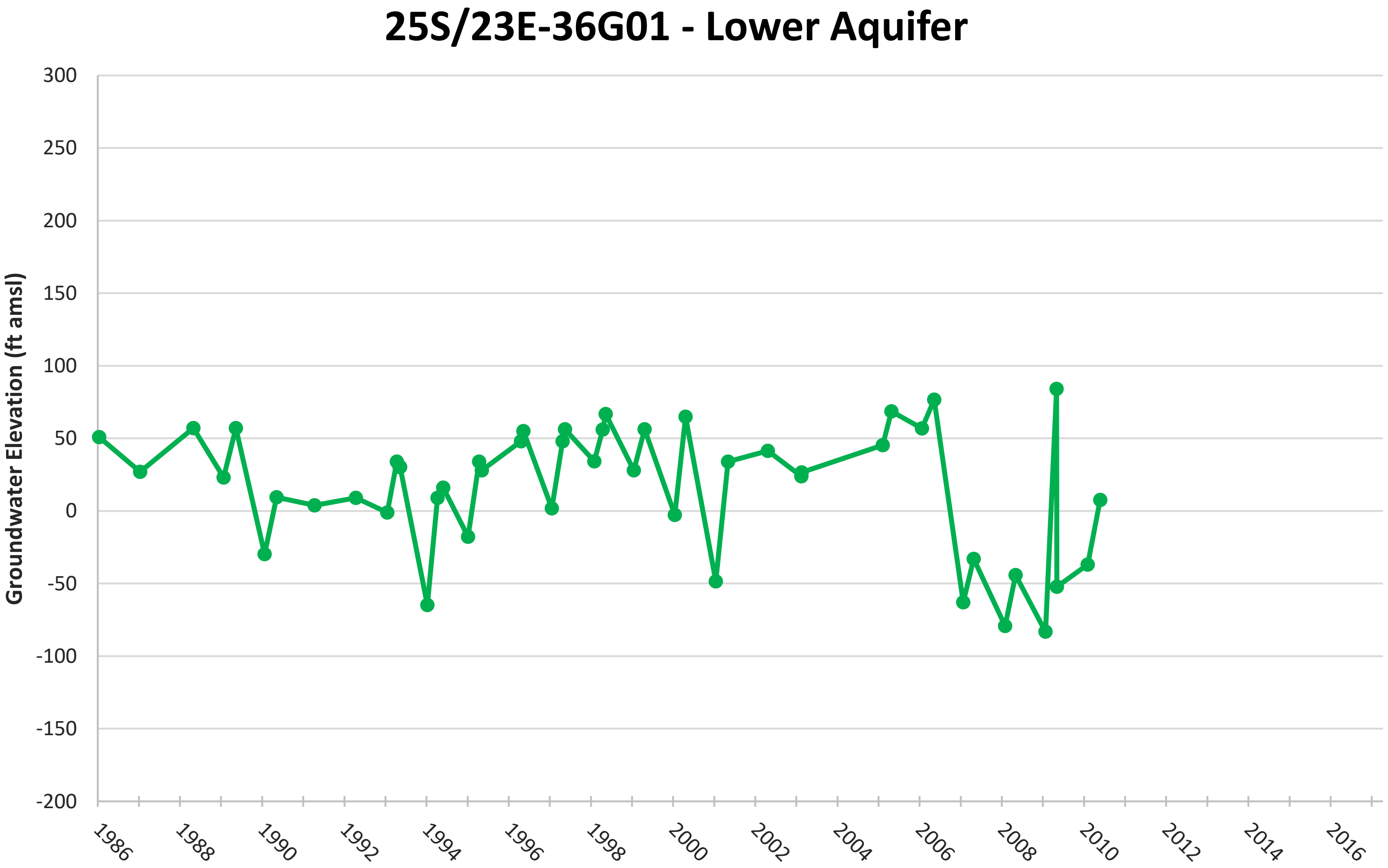
Boundary Condition Well Hydrograph



Boundary Condition Well Hydrograph

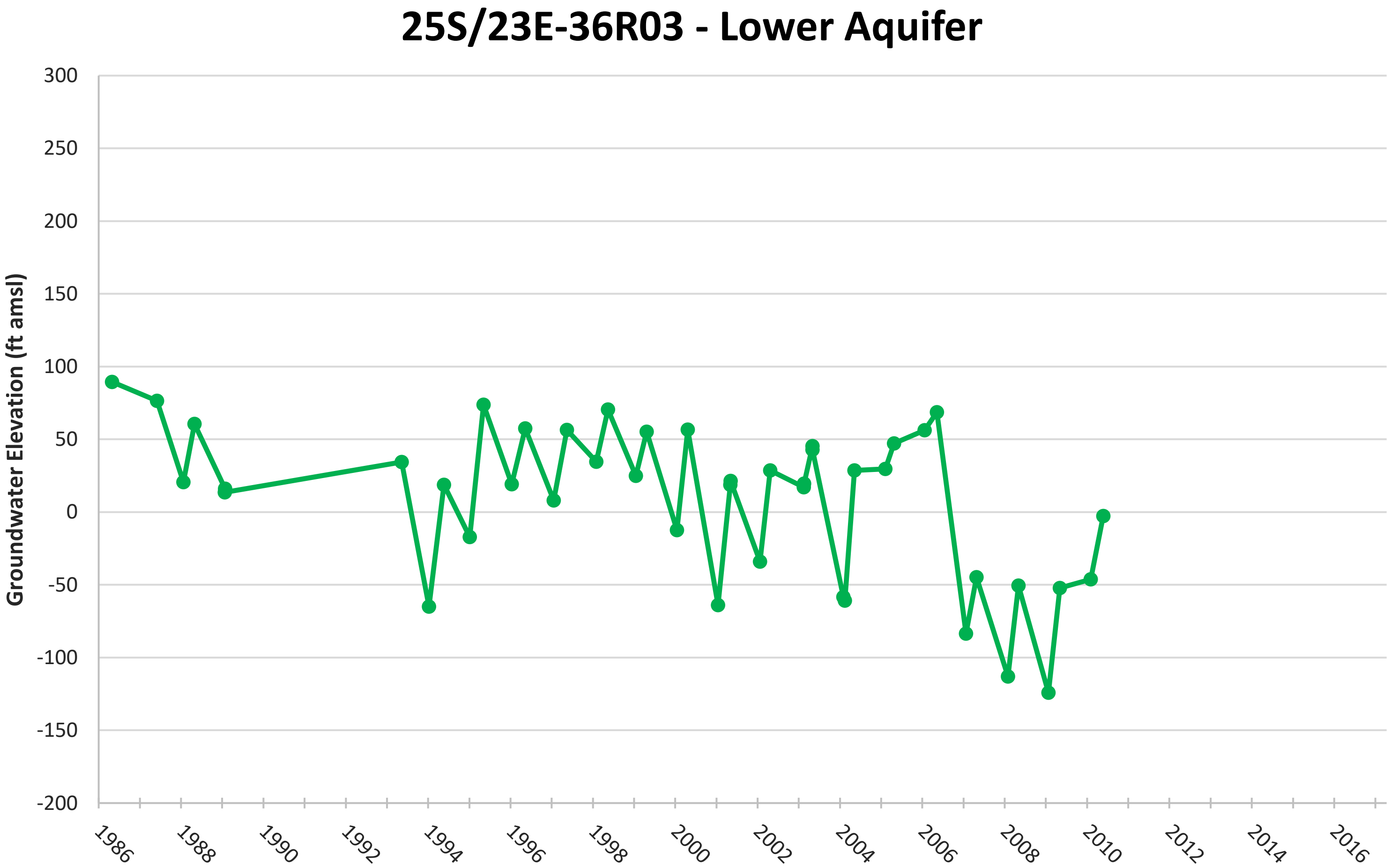


Boundary Condition Well Hydrograph

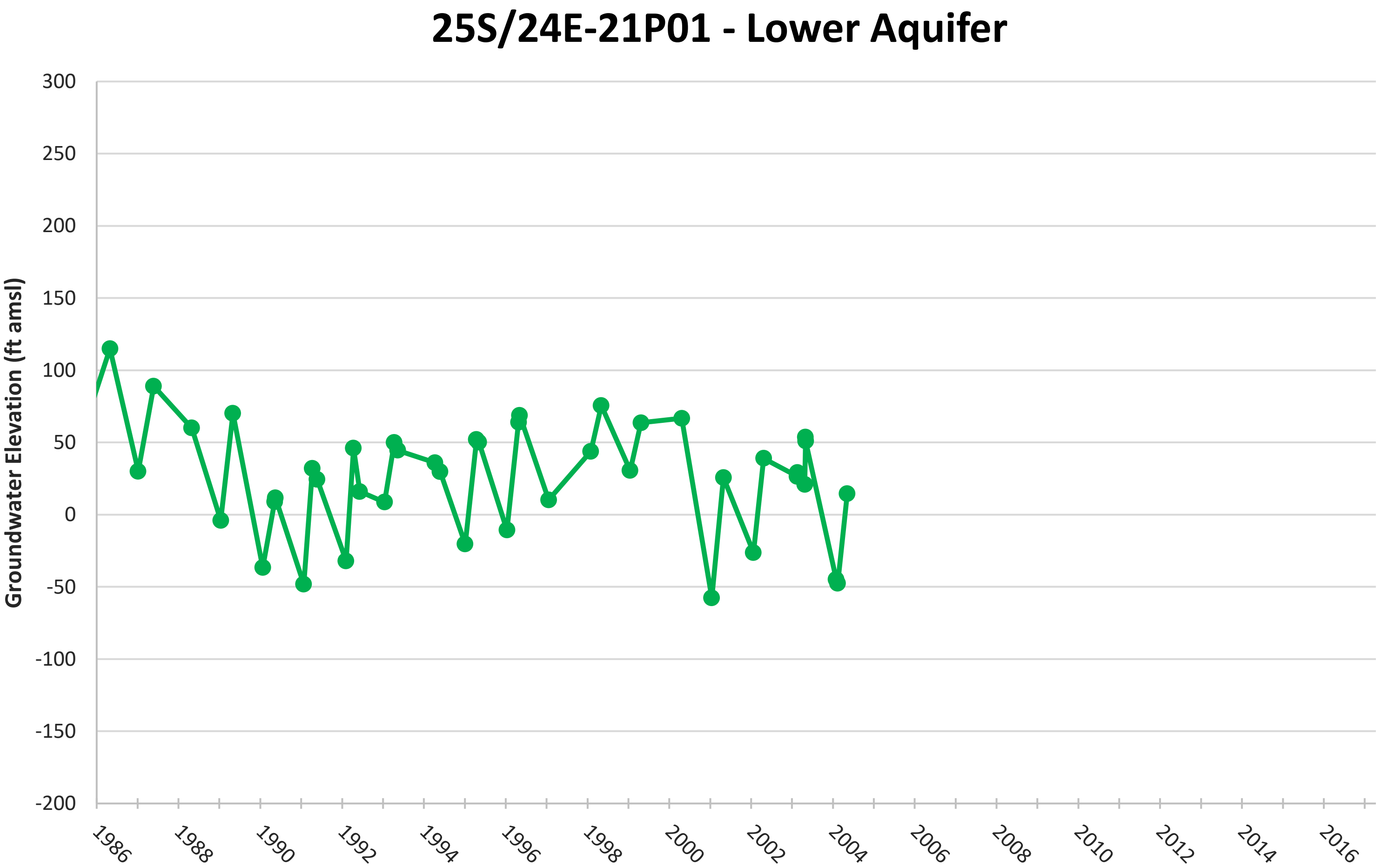


Thomas Harder & Co.
Groundwater Consulting

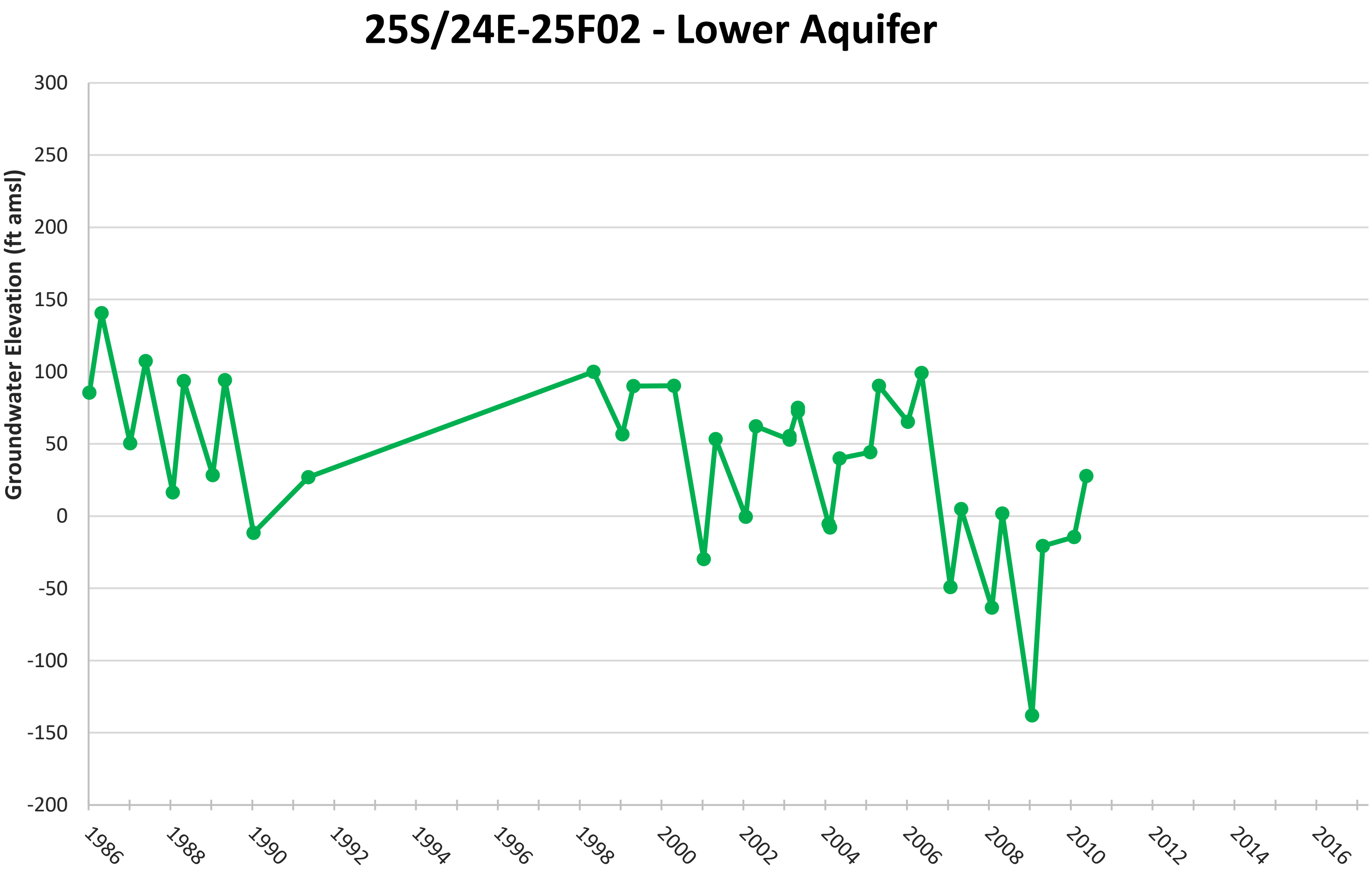
Boundary Condition Well Hydrograph



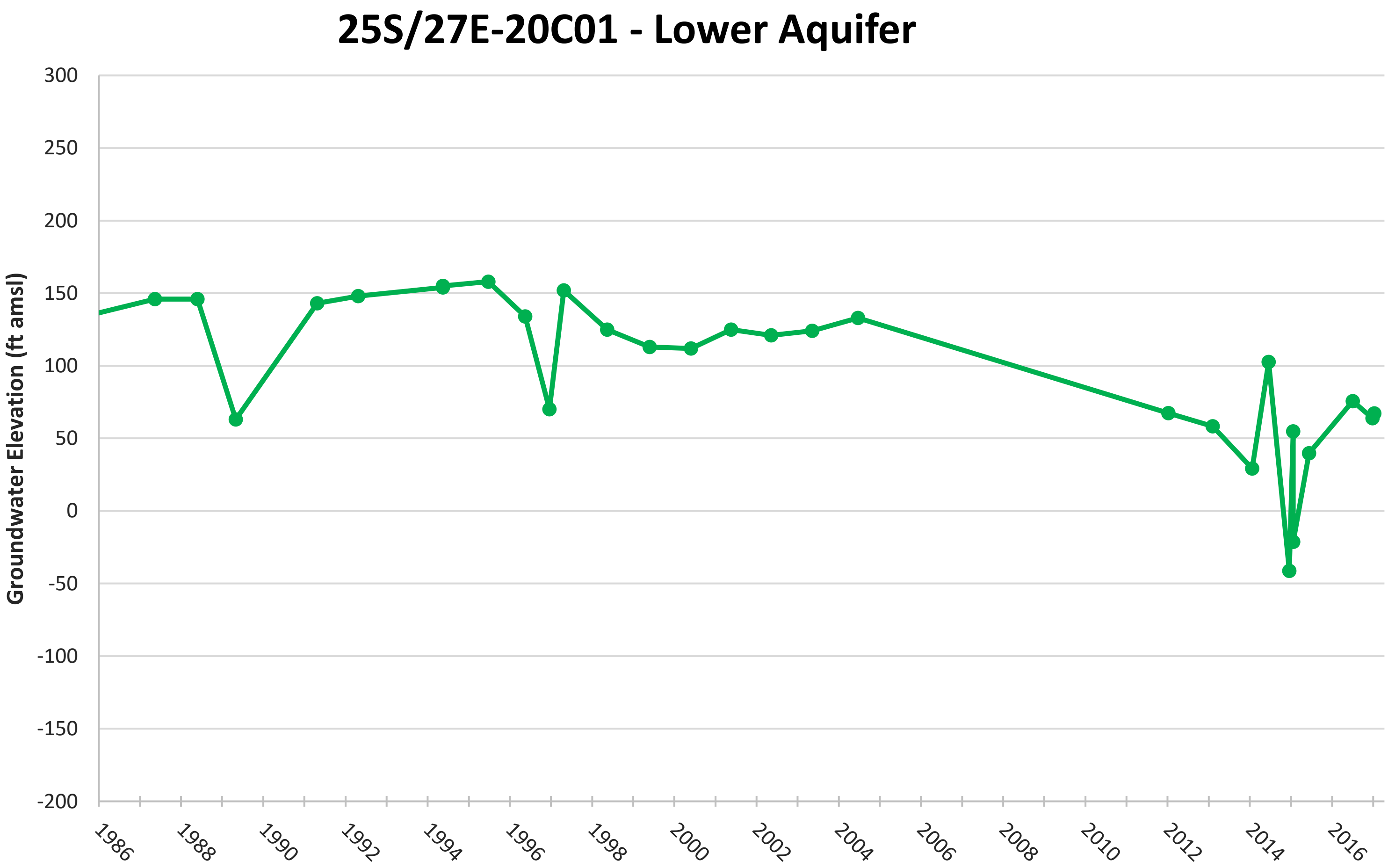
Boundary Condition Well Hydrograph



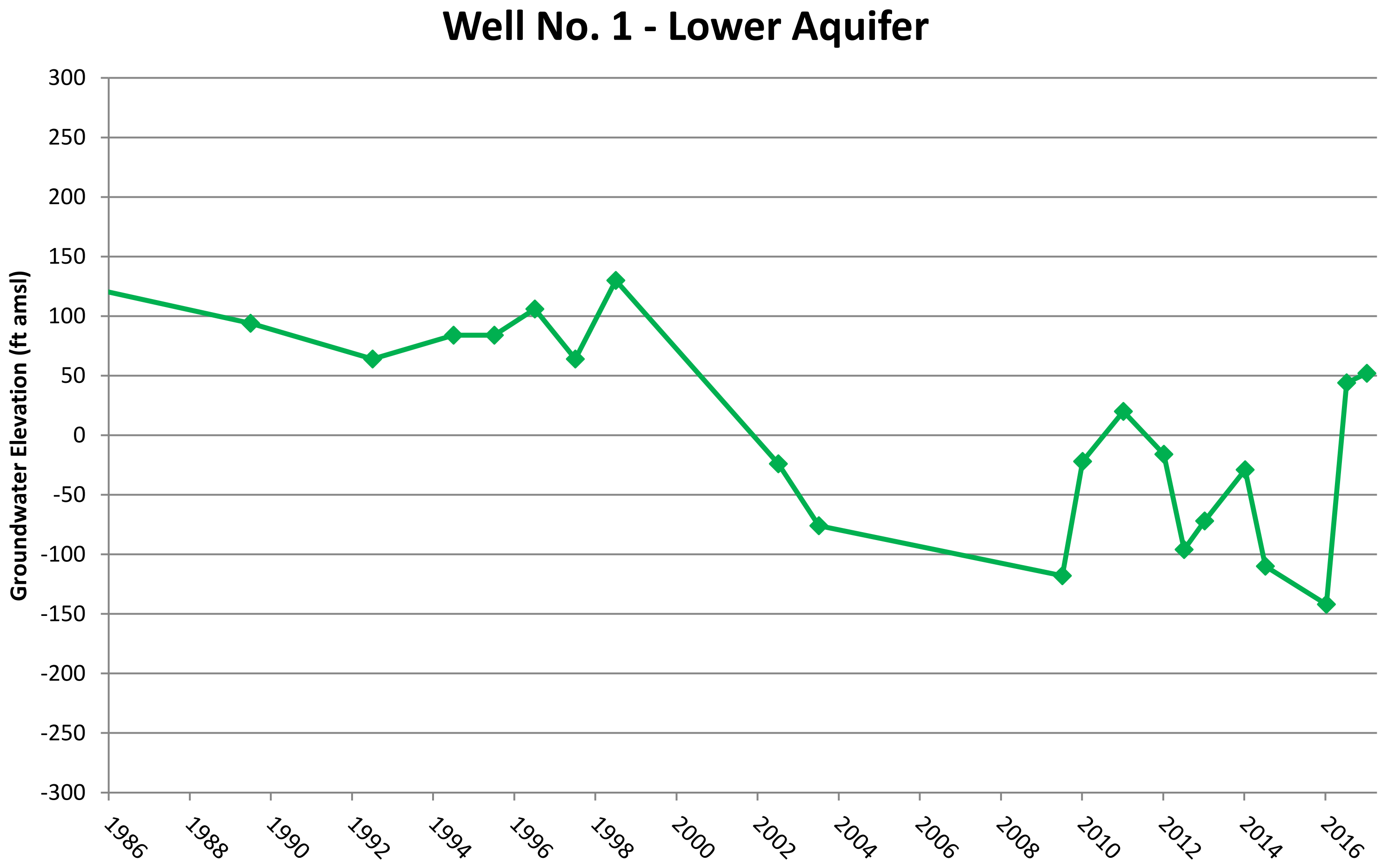
Boundary Condition Well Hydrograph



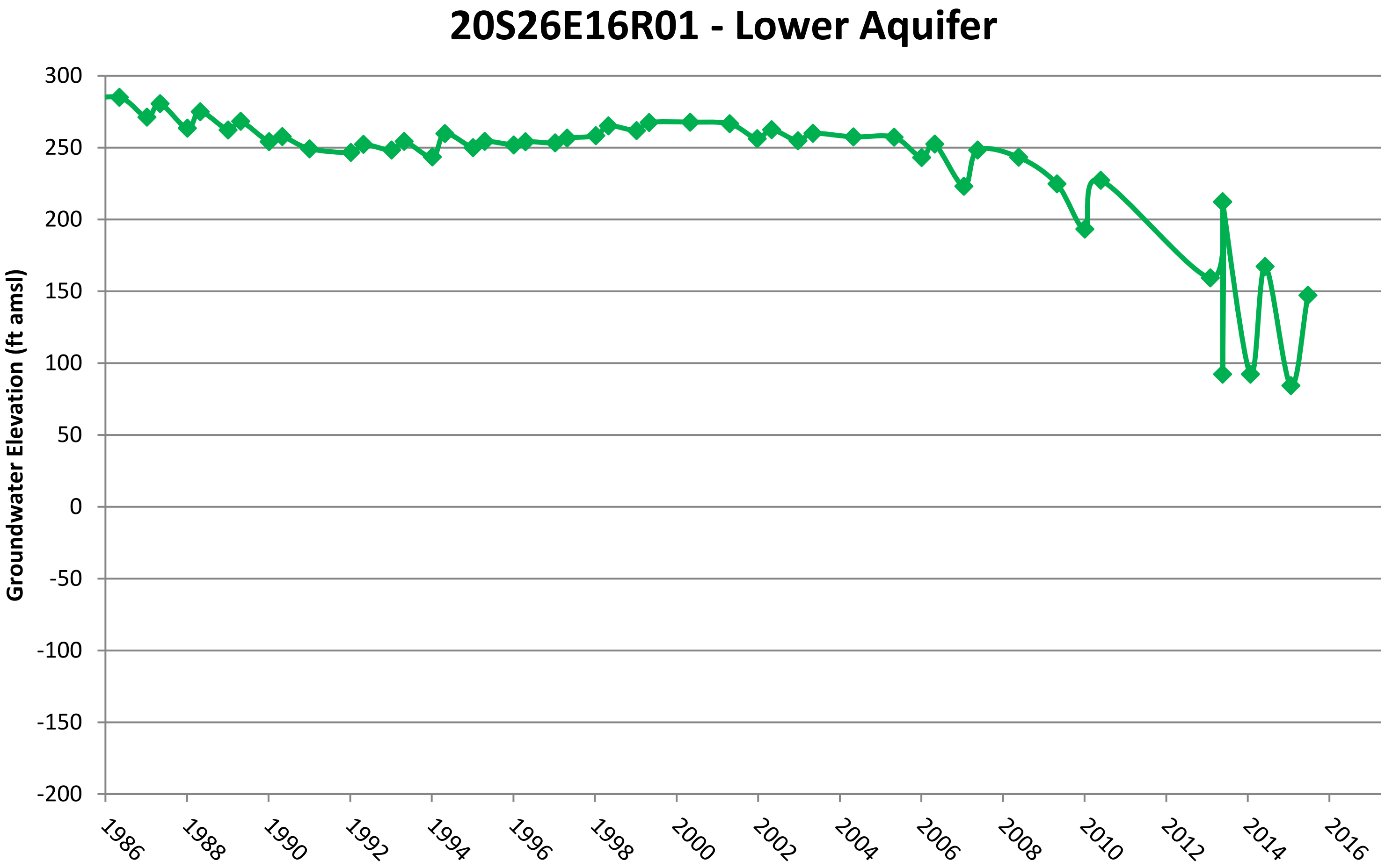
Boundary Condition Well Hydrograph



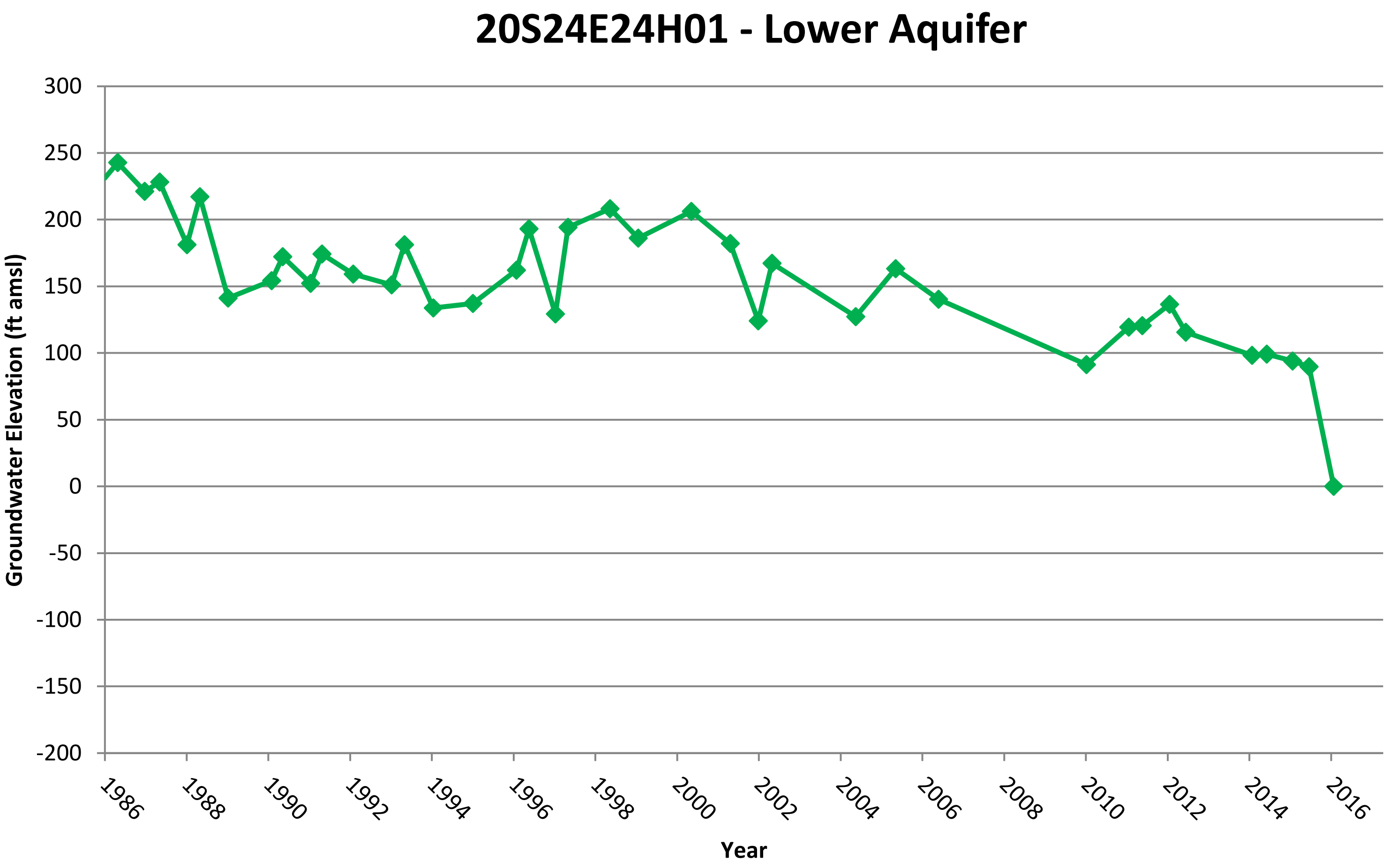
Boundary Condition Well Hydrograph



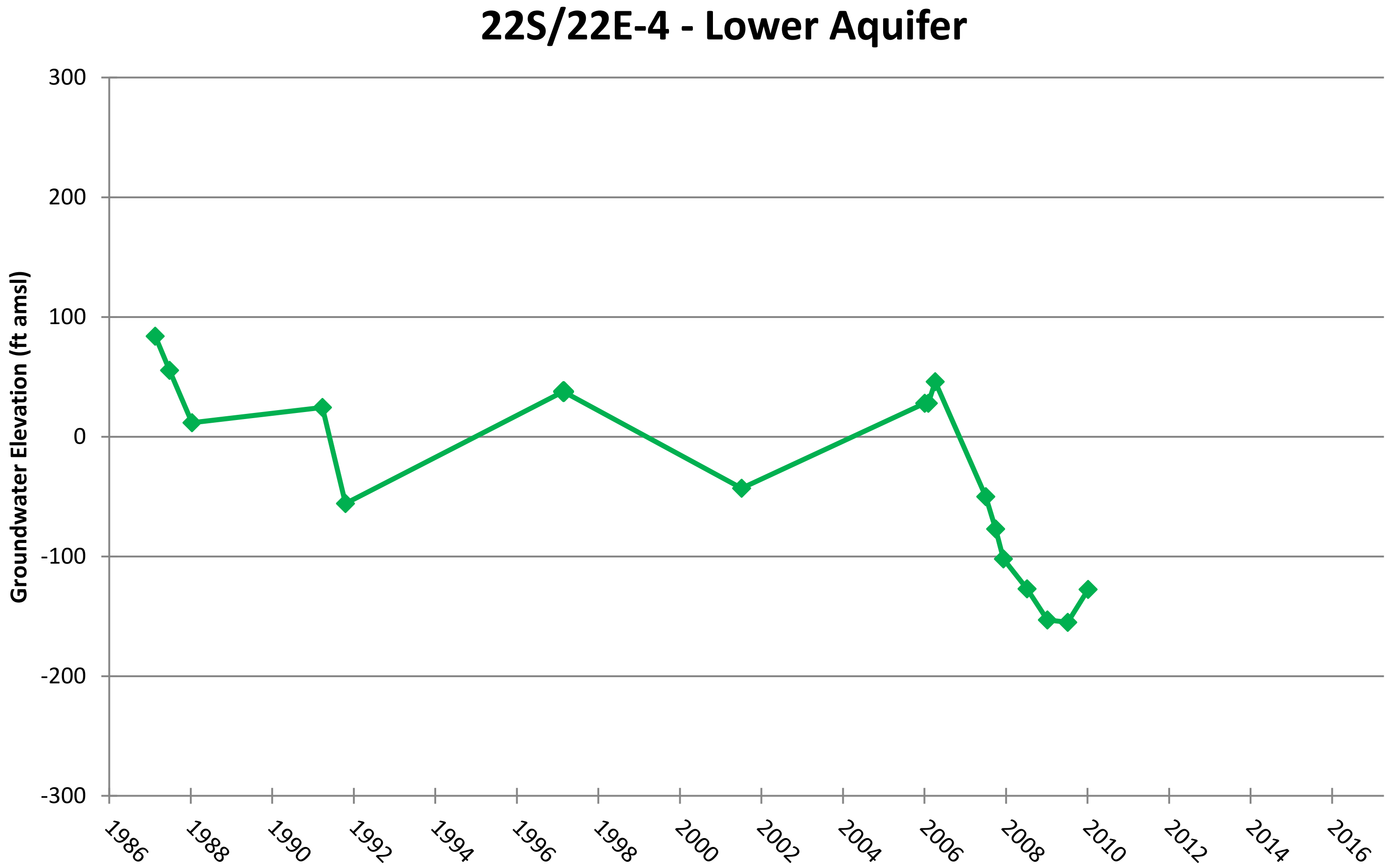
Boundary Condition Well Hydrograph



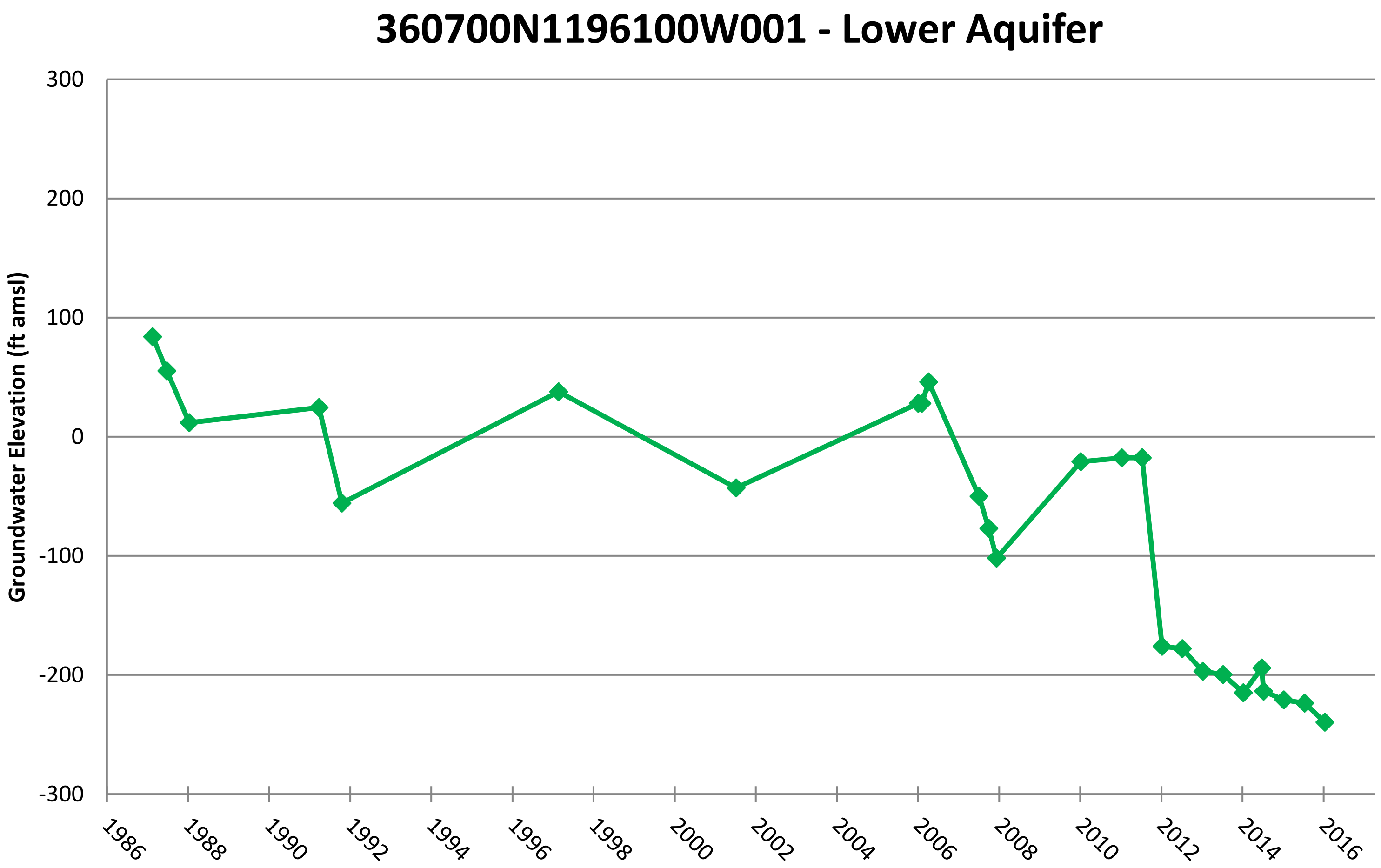
Boundary Condition Well Hydrograph



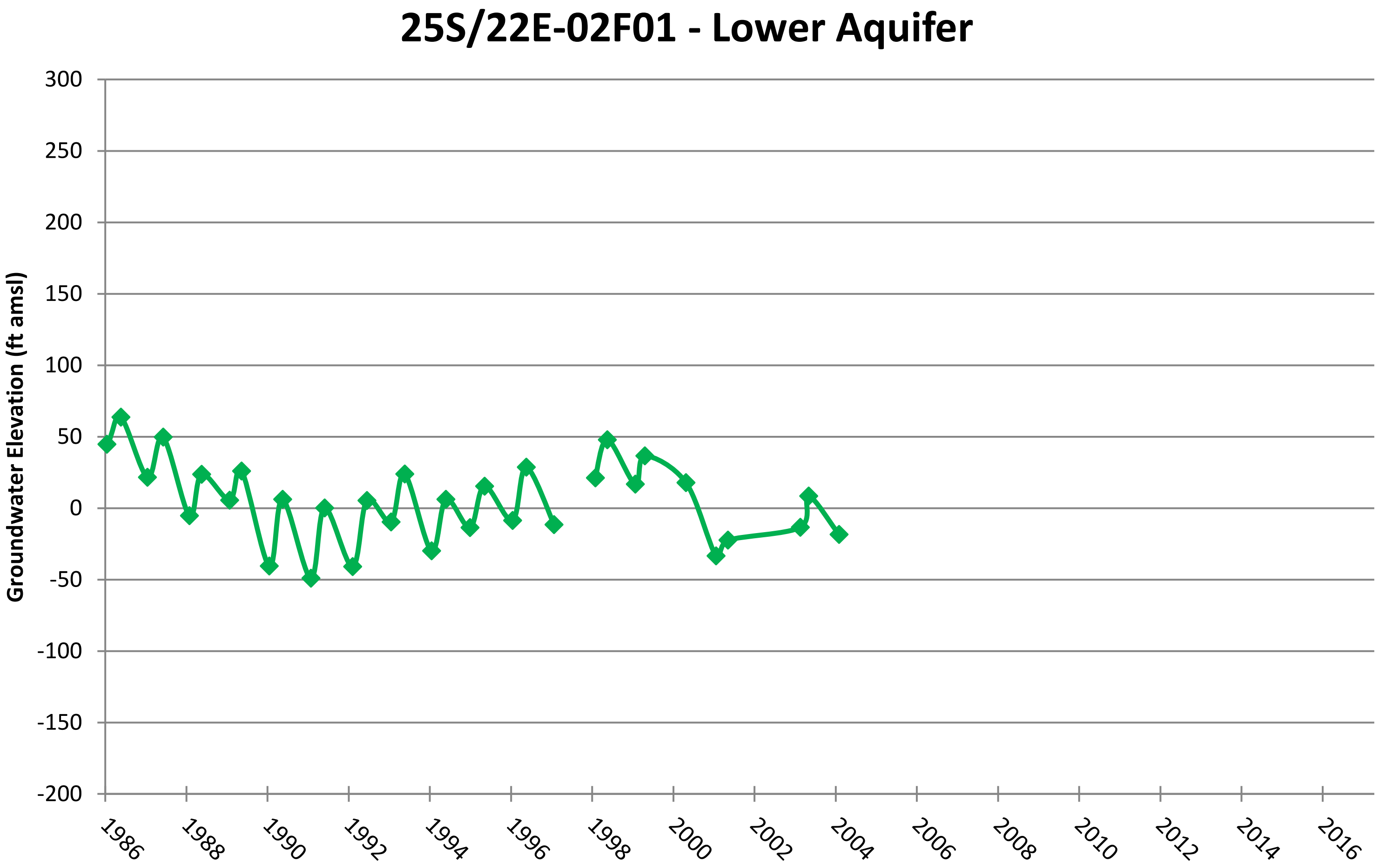
Boundary Condition Well Hydrograph



Boundary Condition Well Hydrograph



Boundary Condition Well Hydrograph



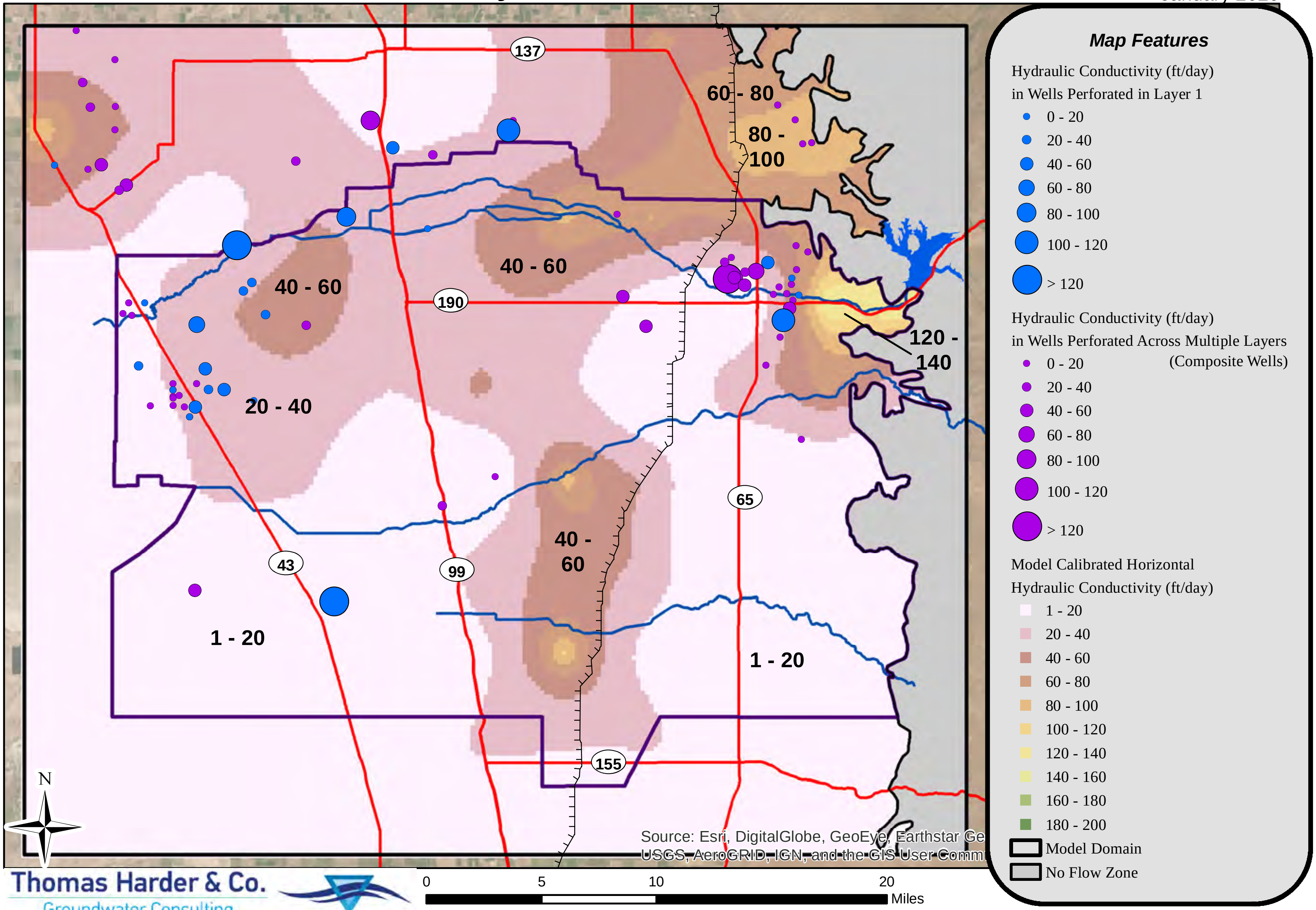
Appendix C

Calibration Parameters

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Ge
USGS, AeroGRID, IGN, and the GIS User Comm

Thomas Harder & Co.
Groundwater Consulting

NAD 83 State Plane Zone 4

Note: Blue and purple dots indicate Hydraulic Conductivity values derived from controlled pumping tests (see Table 3).

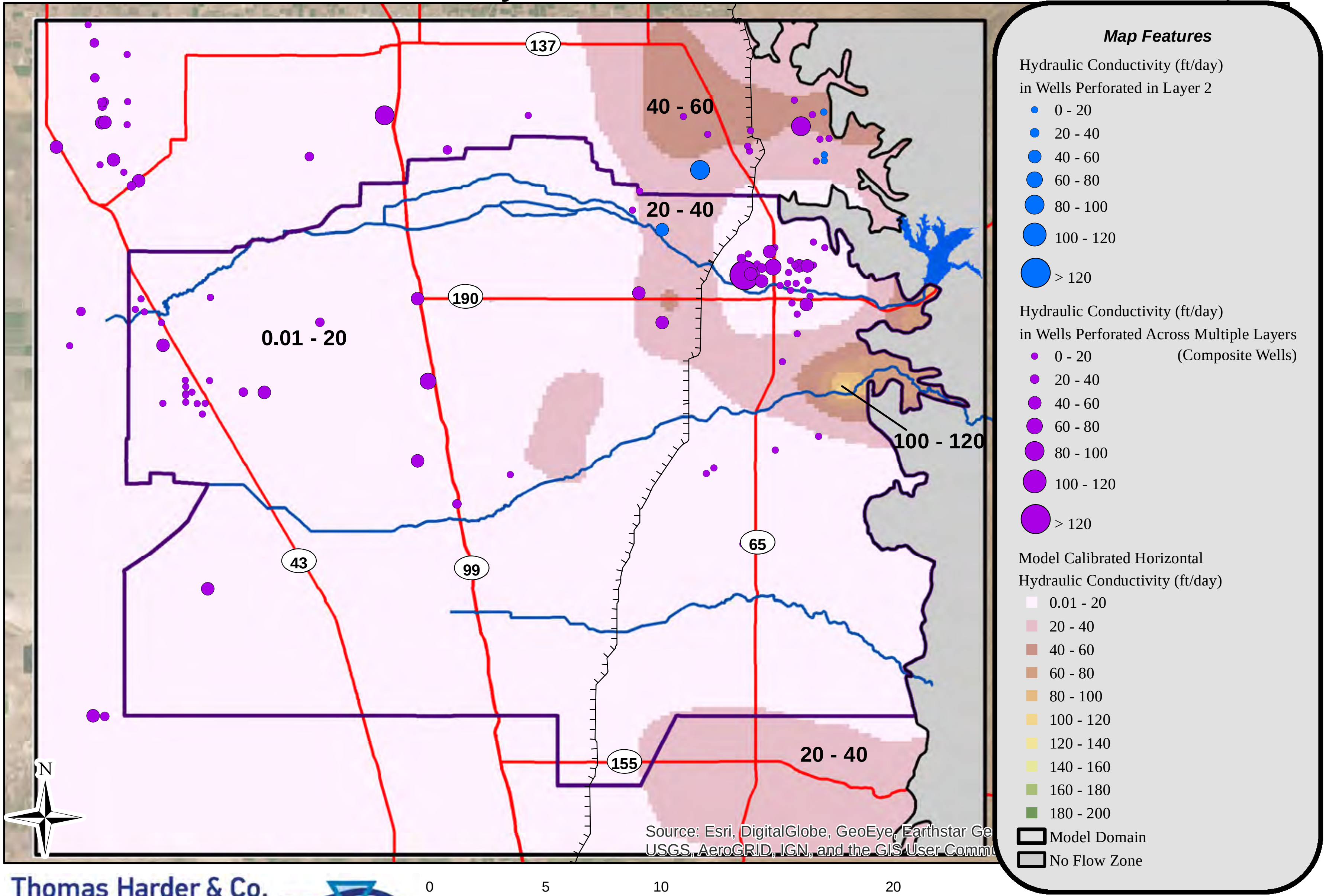
Layer 1 Horizontal Hydraulic Conductivity

Appendix C-1

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Thomas Harder & Co.
Groundwater Consulting

NAD 83 State Plane Zone 4

Note: Blue and purple dots indicate Hydraulic Conductivity values derived from controlled pumping tests (see Table 3).

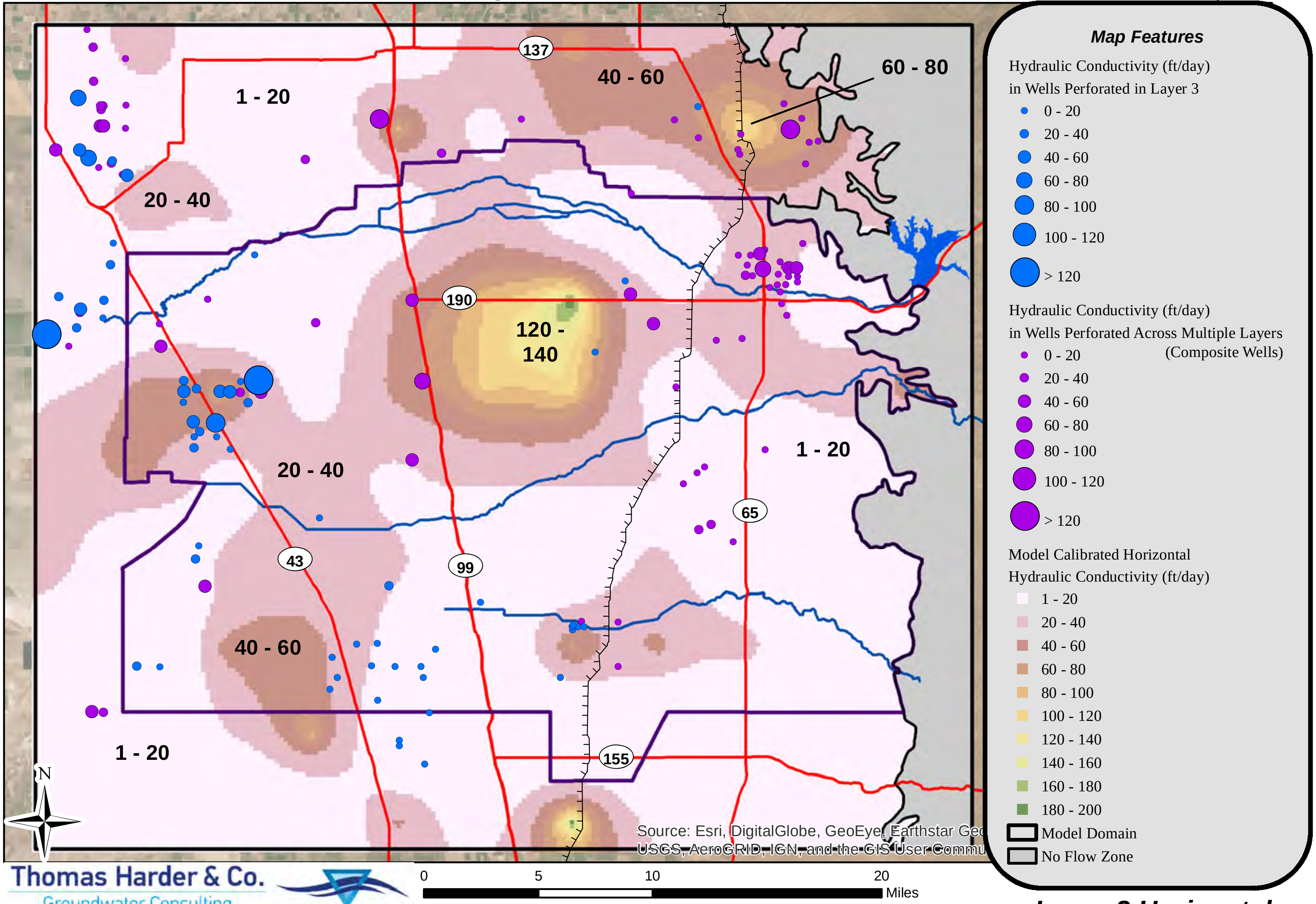
Layer 2 Horizontal Hydraulic Conductivity

Appendix C-2

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geo
USGS, AeroGRID, IGN, and the GIS User Commu

Thomas Harder & Co.
Groundwater Consulting

NAD 83 State Plane Zone 4

Note: Blue and purple dots indicate Hydraulic Conductivity values derived from controlled pumping tests (see Table 3).

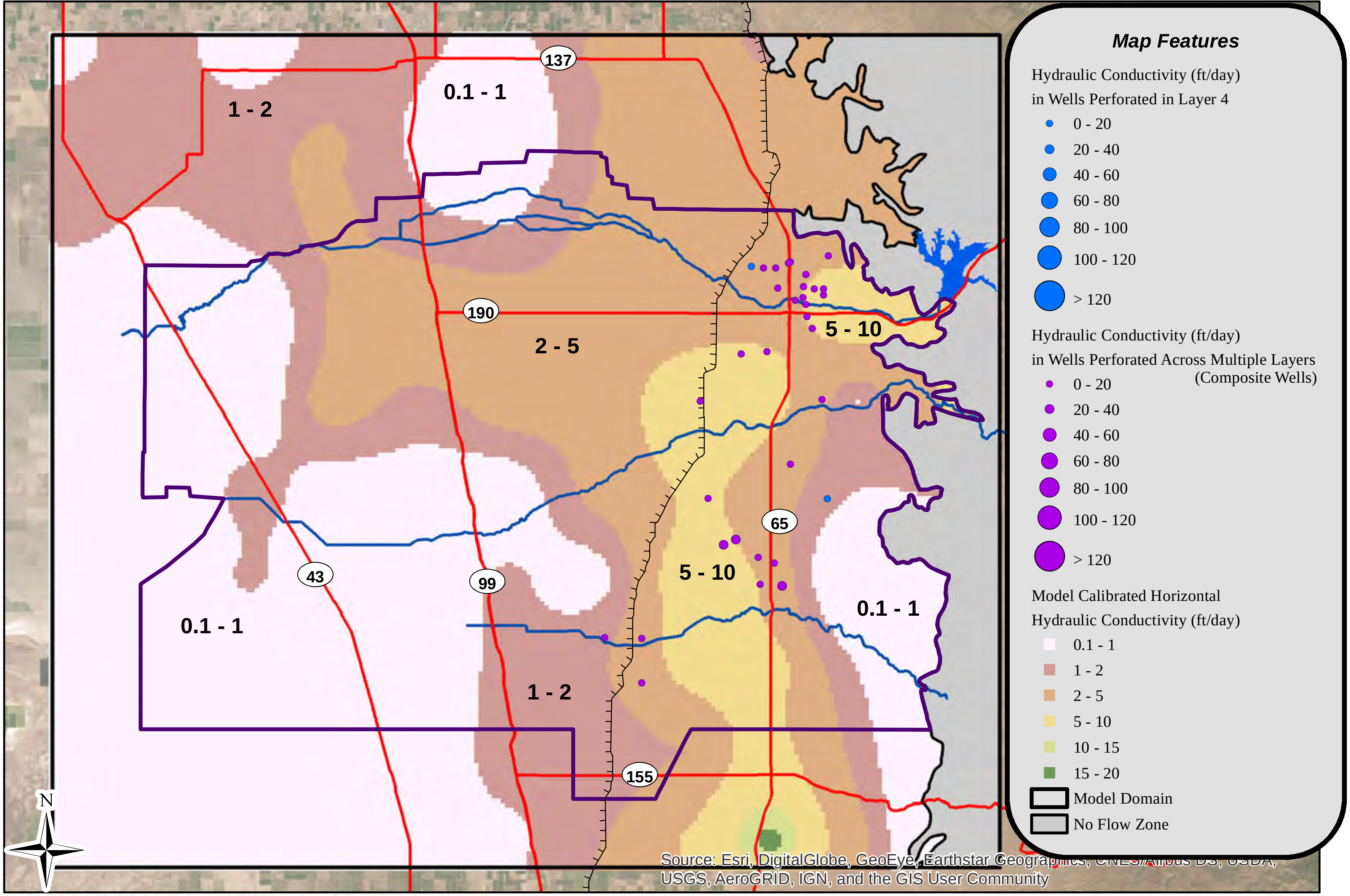
Layer 3 Horizontal Hydraulic Conductivity

Appendix C-3

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20
Miles

NAD 83 State Plane Zone 4

Note: Blue and purple dots indicate Hydraulic Conductivity values derived from controlled pumping tests (see Table 3).

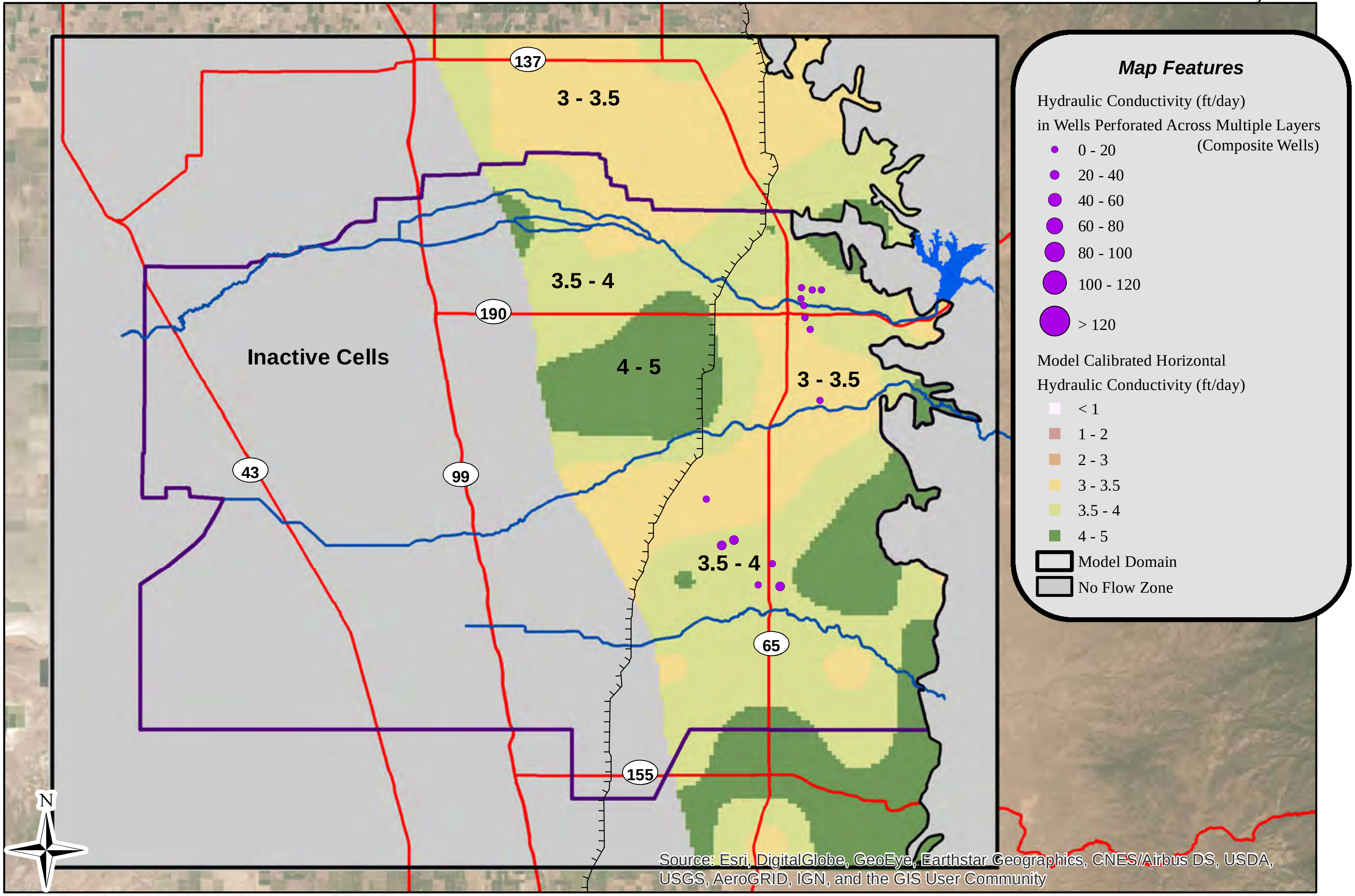
Layer 4 Horizontal Hydraulic Conductivity

Appendix C-4

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20 Miles

NAD 83 State Plane Zone 4

Note: Purple dots indicate Hydraulic Conductivity values derived from controlled pumping tests (see Table 3).

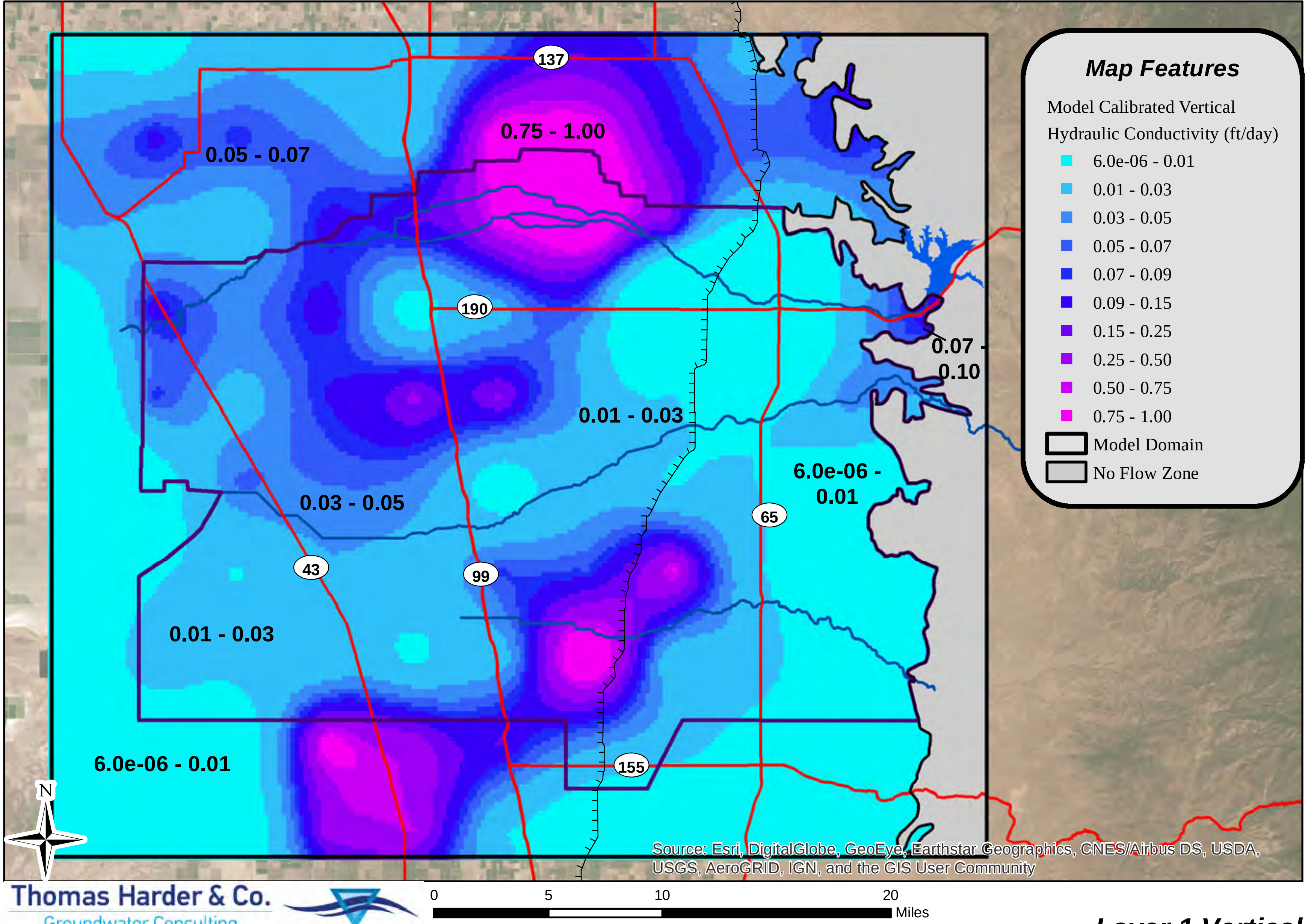
Layer 5 Horizontal Hydraulic Conductivity

Appendix C-5

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

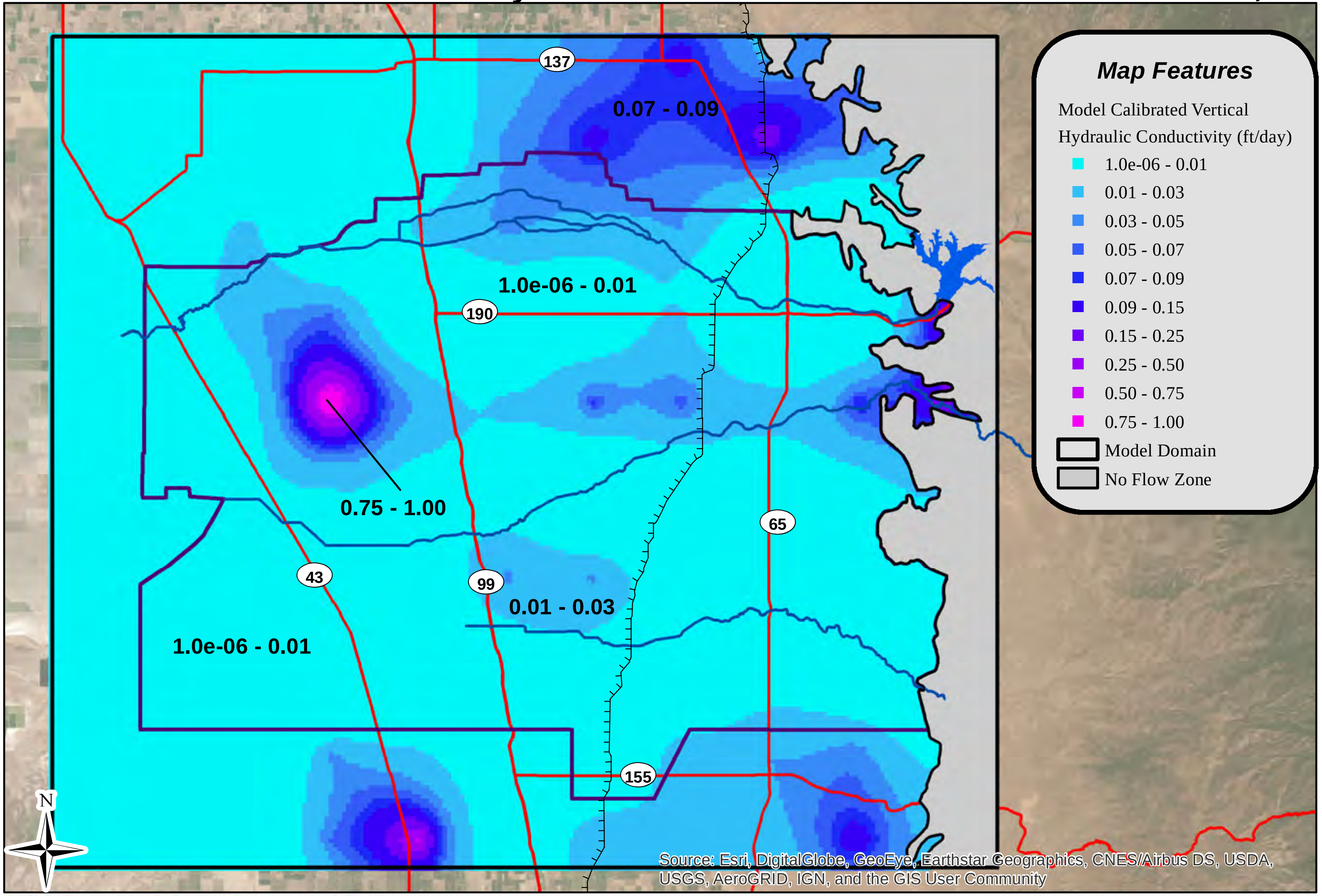
Layer 1 Vertical Hydraulic Conductivity

Appendix C-6

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20
Miles

NAD 83 State Plane Zone 4

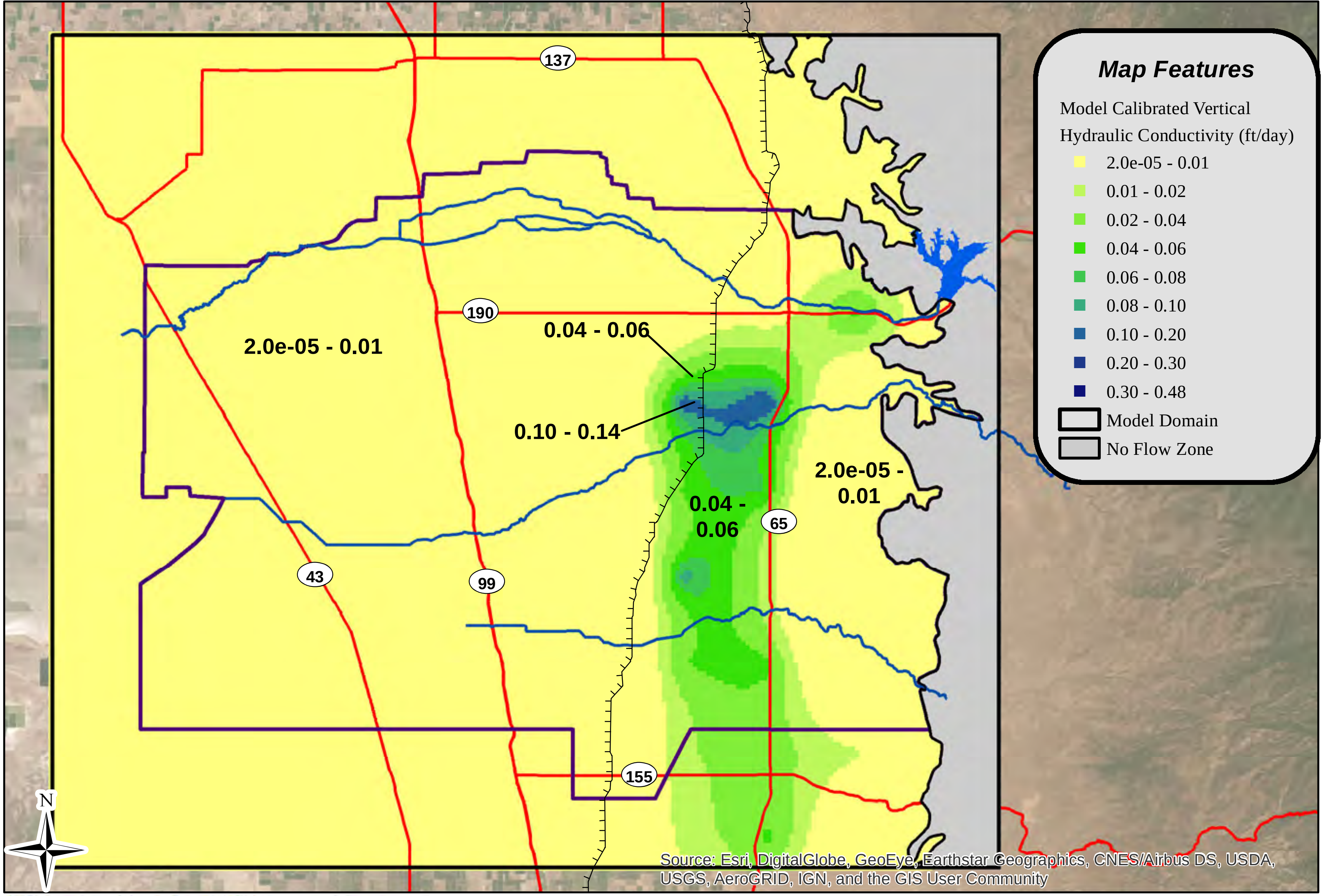
Layer 2 Vertical Hydraulic Conductivity

Appendix C-7

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20 Miles

NAD 83 State Plane Zone 4

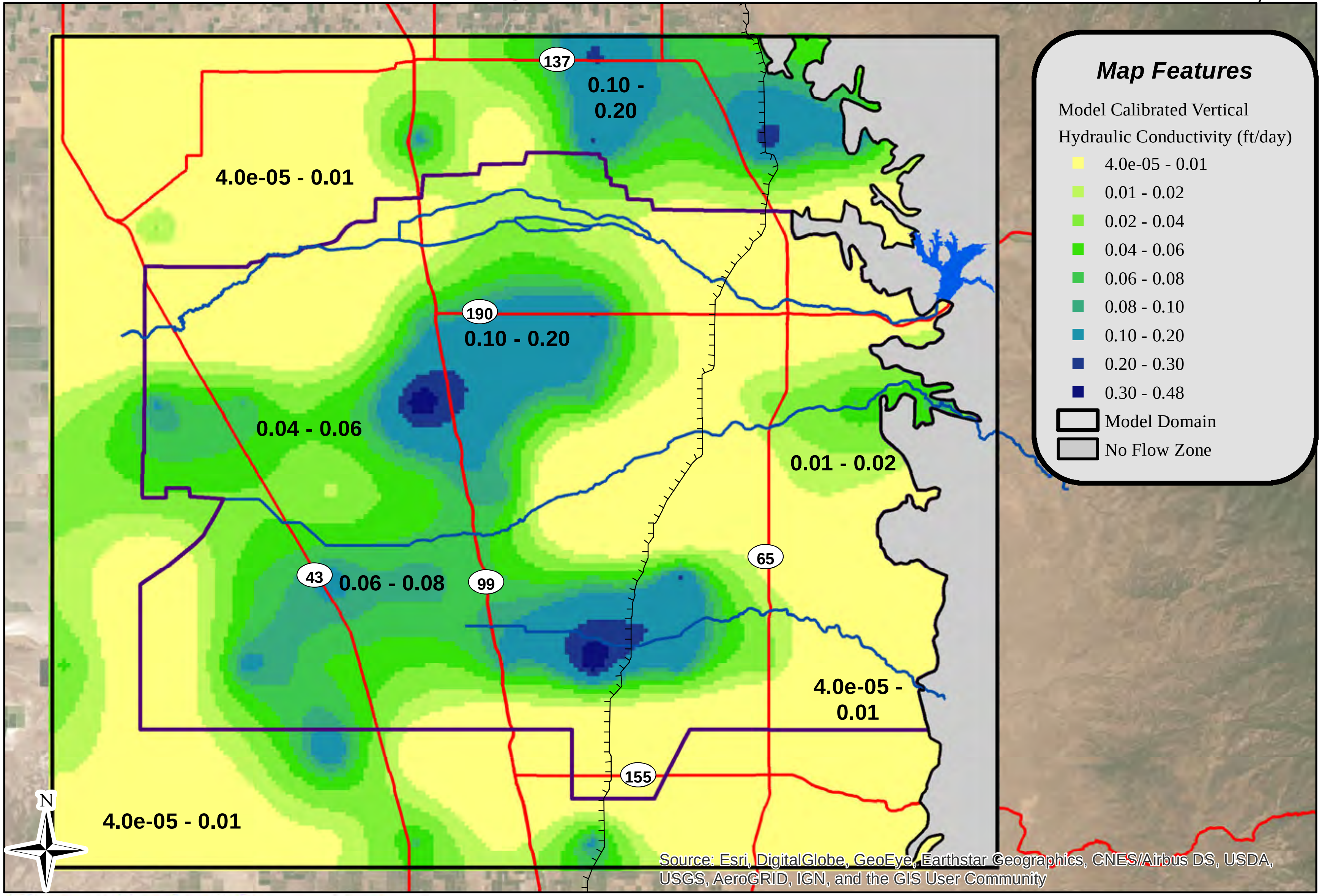
Layer 4 Vertical Hydraulic Conductivity

Appendix C-8

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20 Miles

NAD 83 State Plane Zone 4

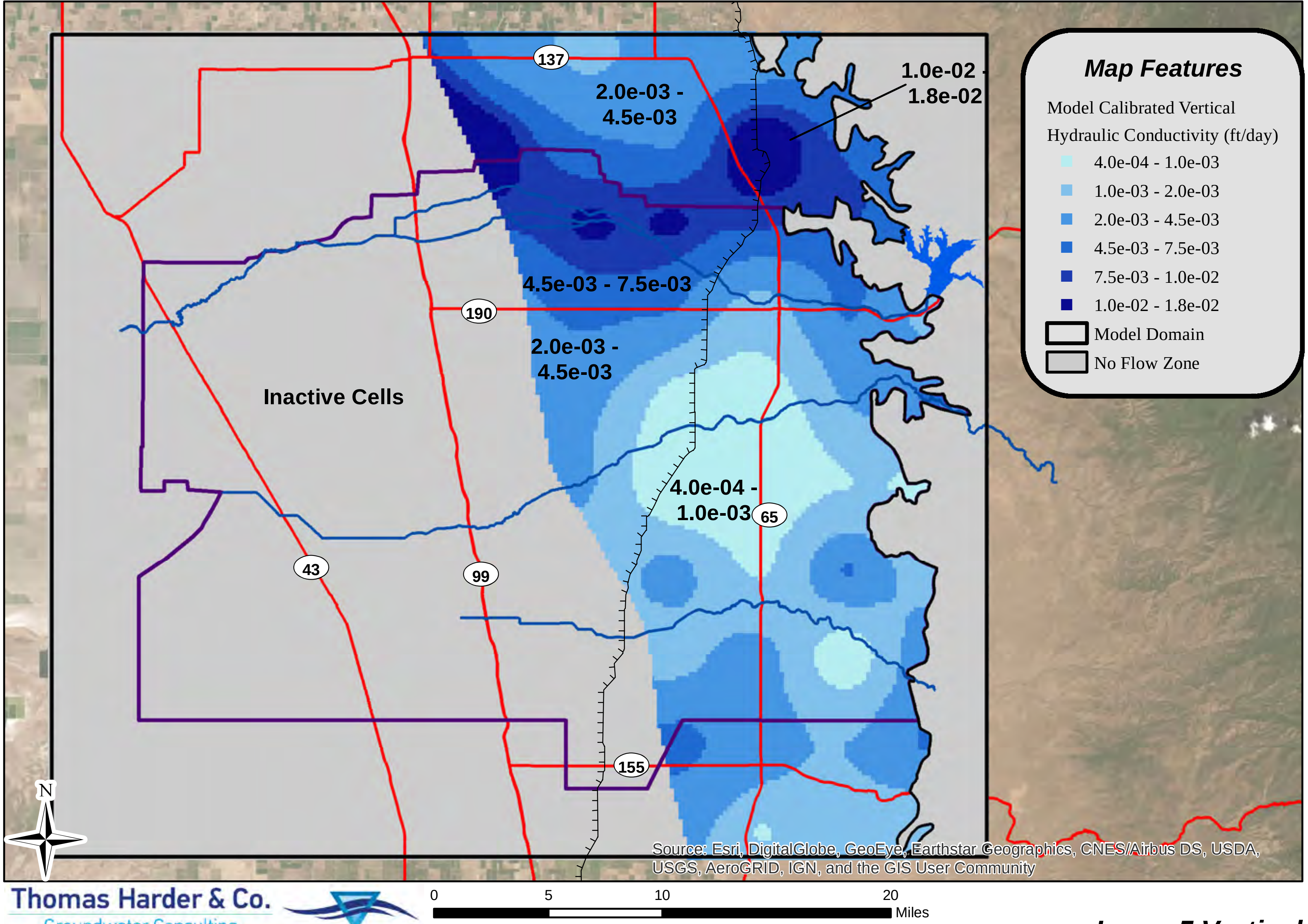
Layer 3 Vertical Hydraulic Conductivity

Appendix C-9

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

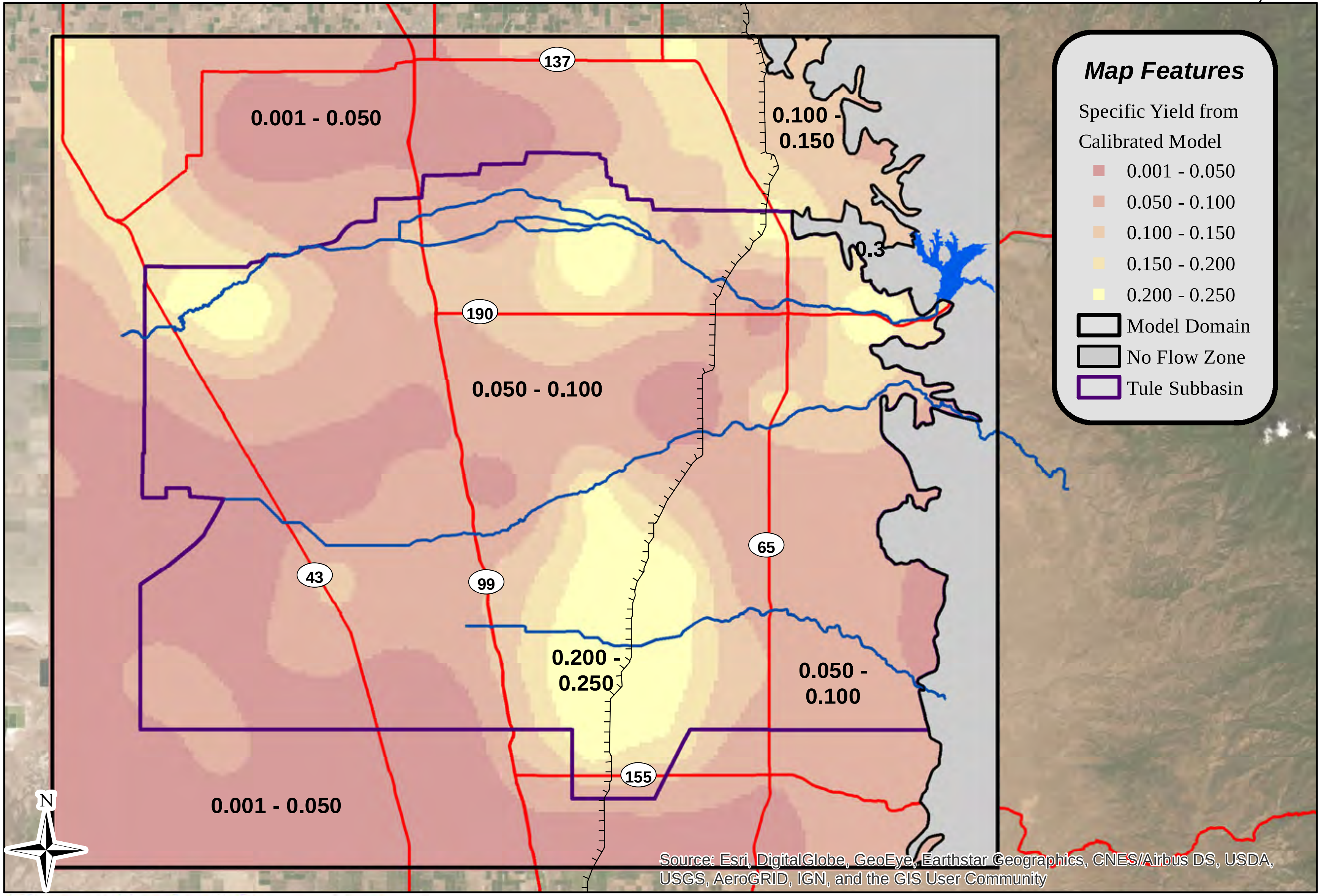
Layer 5 Vertical Hydraulic Conductivity

Appendix C-10

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

NAD 83 State Plane Zone 4

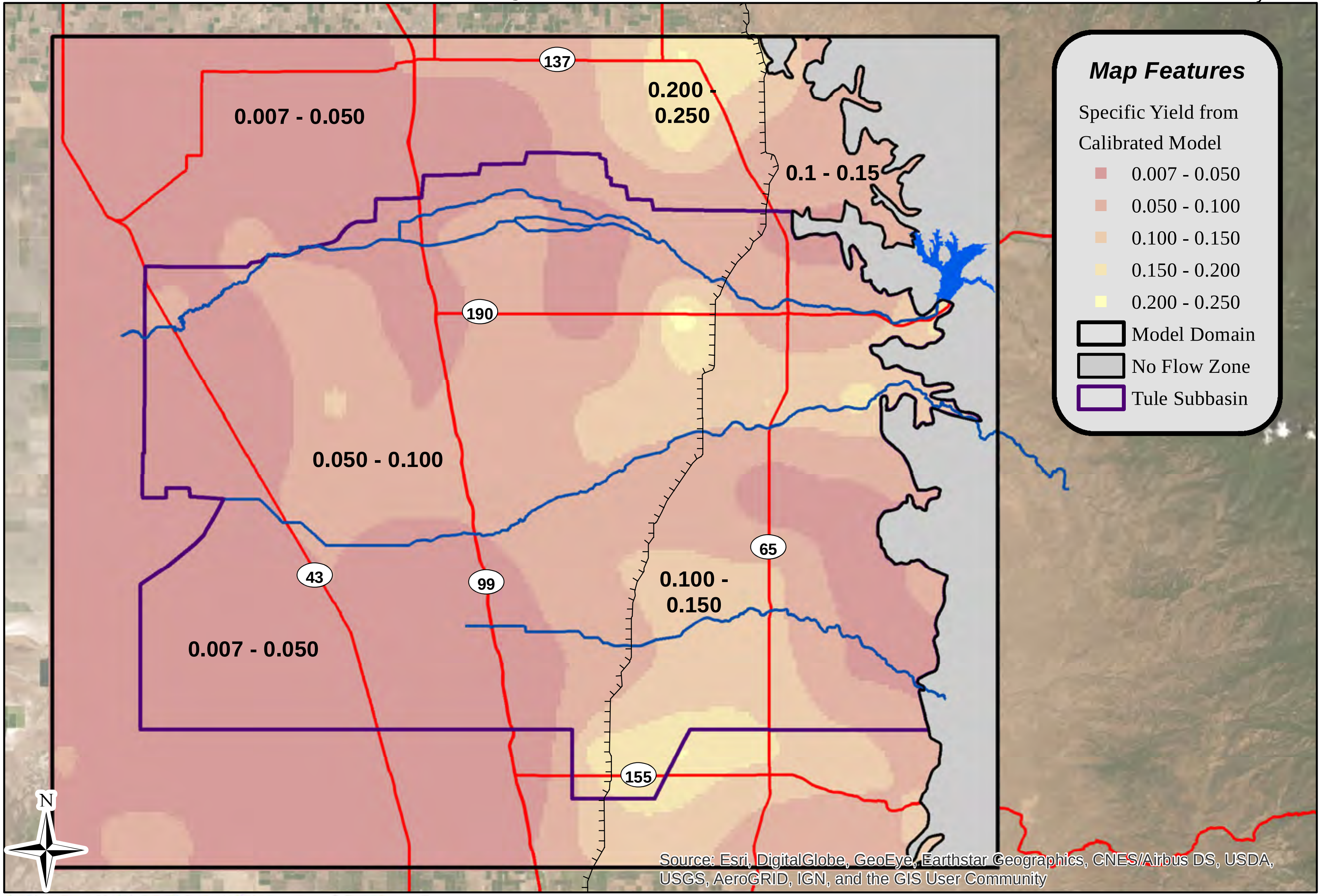
Layer 1 Specific Yield

Appendix C-11

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20
Miles

NAD 83 State Plane Zone 4

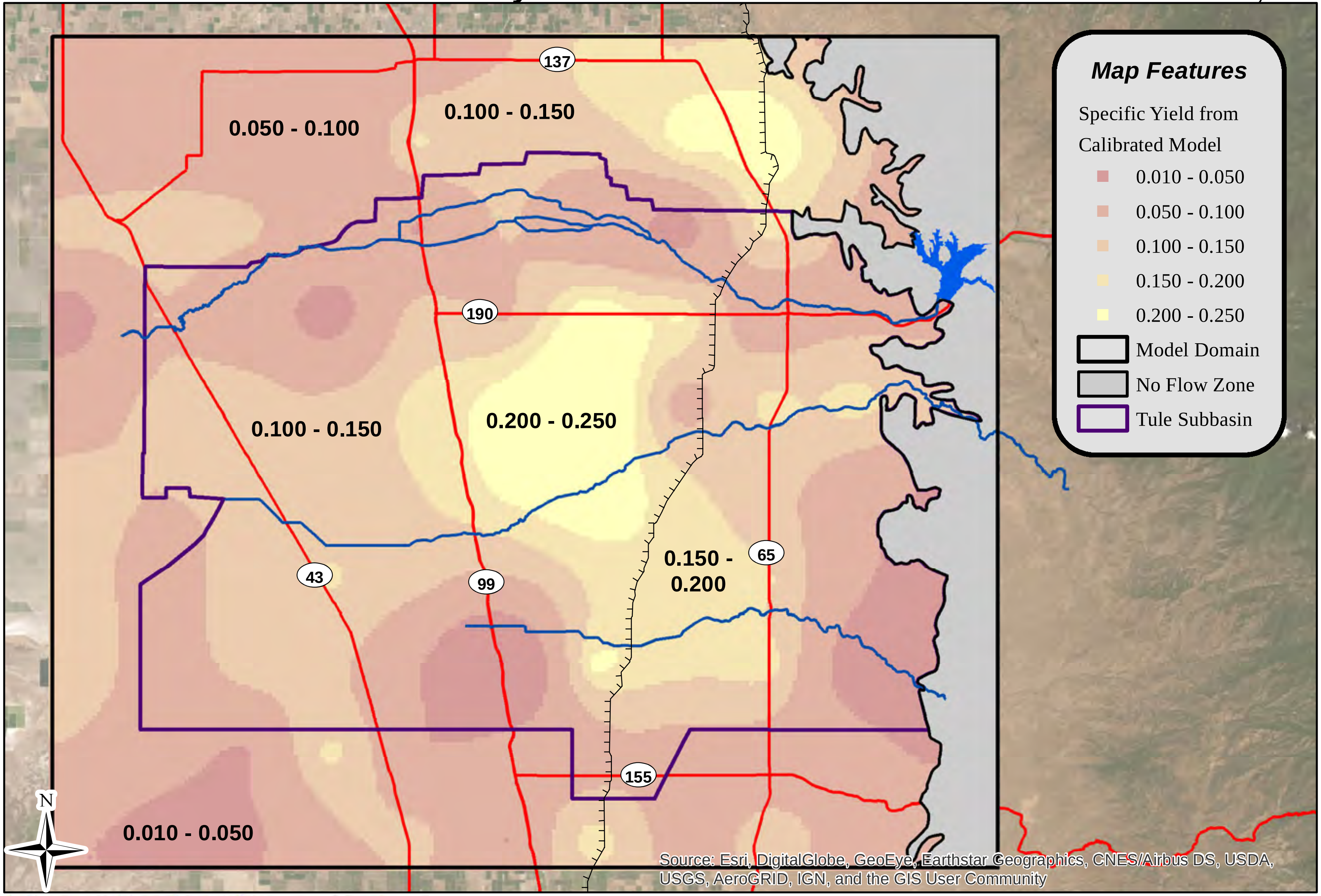
Layer 2 Specific Yield

Appendix C-12

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

NAD 83 State Plane Zone 4

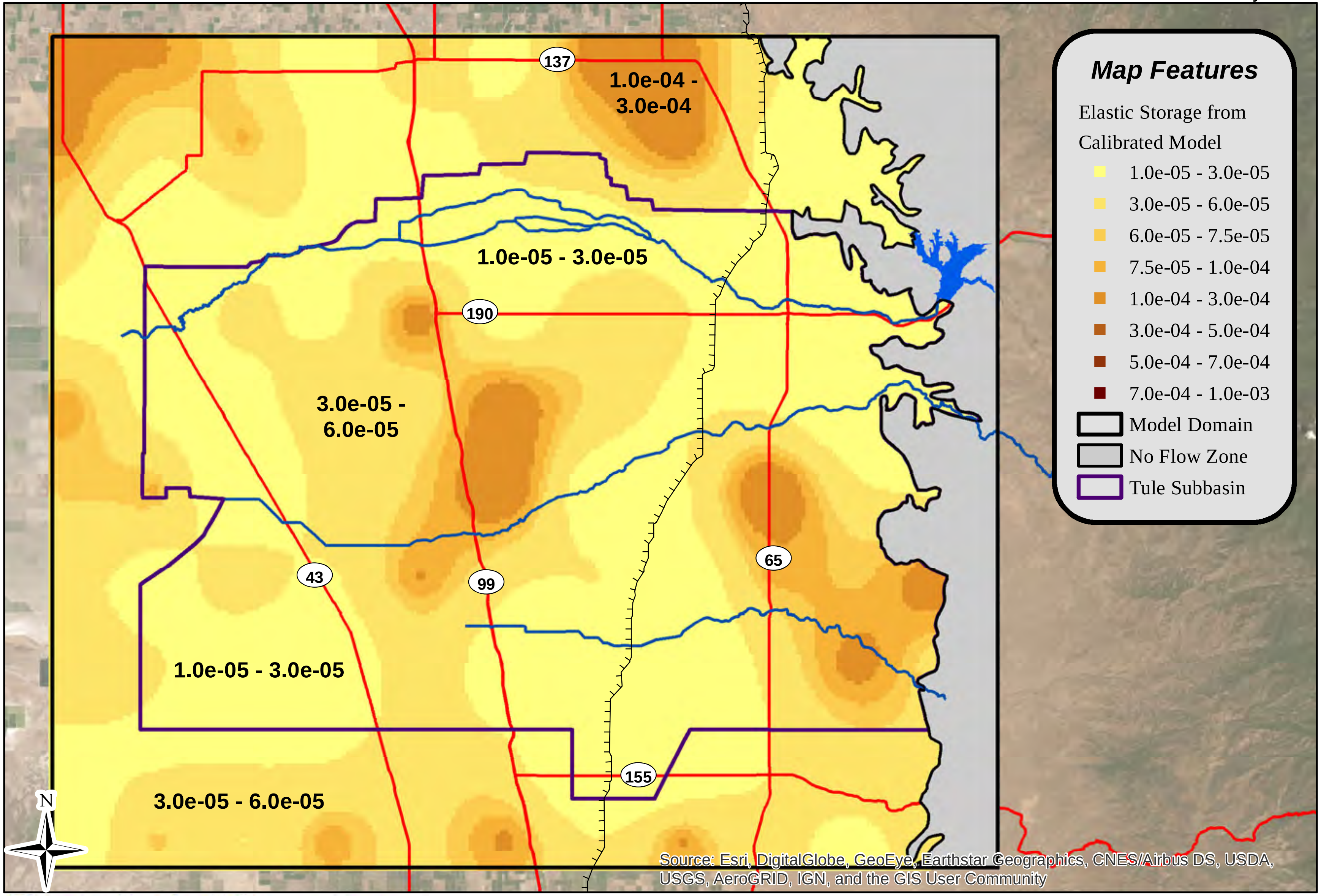
Layer 3 Specific Yield

Appendix C-13

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20 Miles

NAD 83 State Plane Zone 4

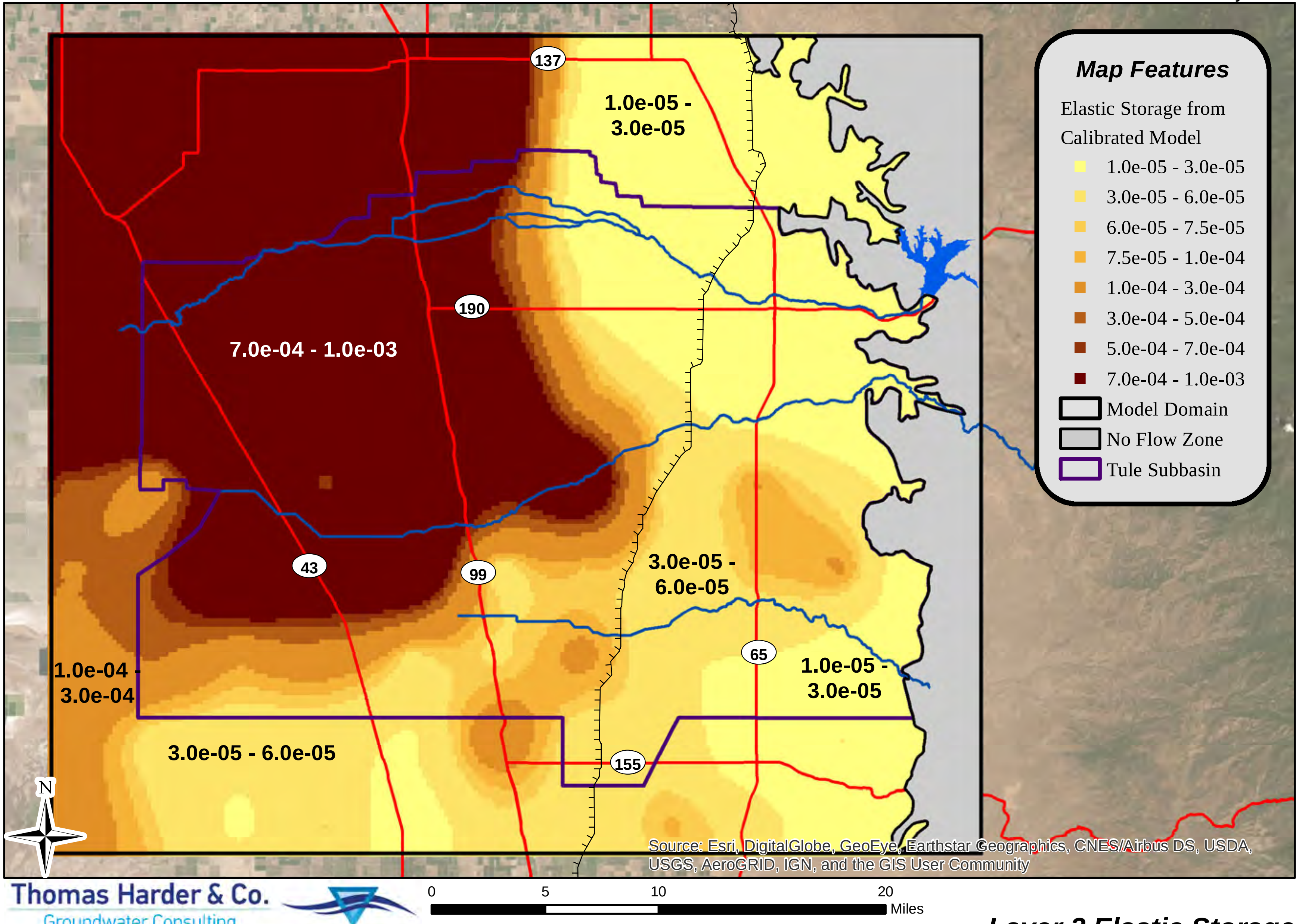
Layer 1 Elastic Storage

Appendix C-14

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

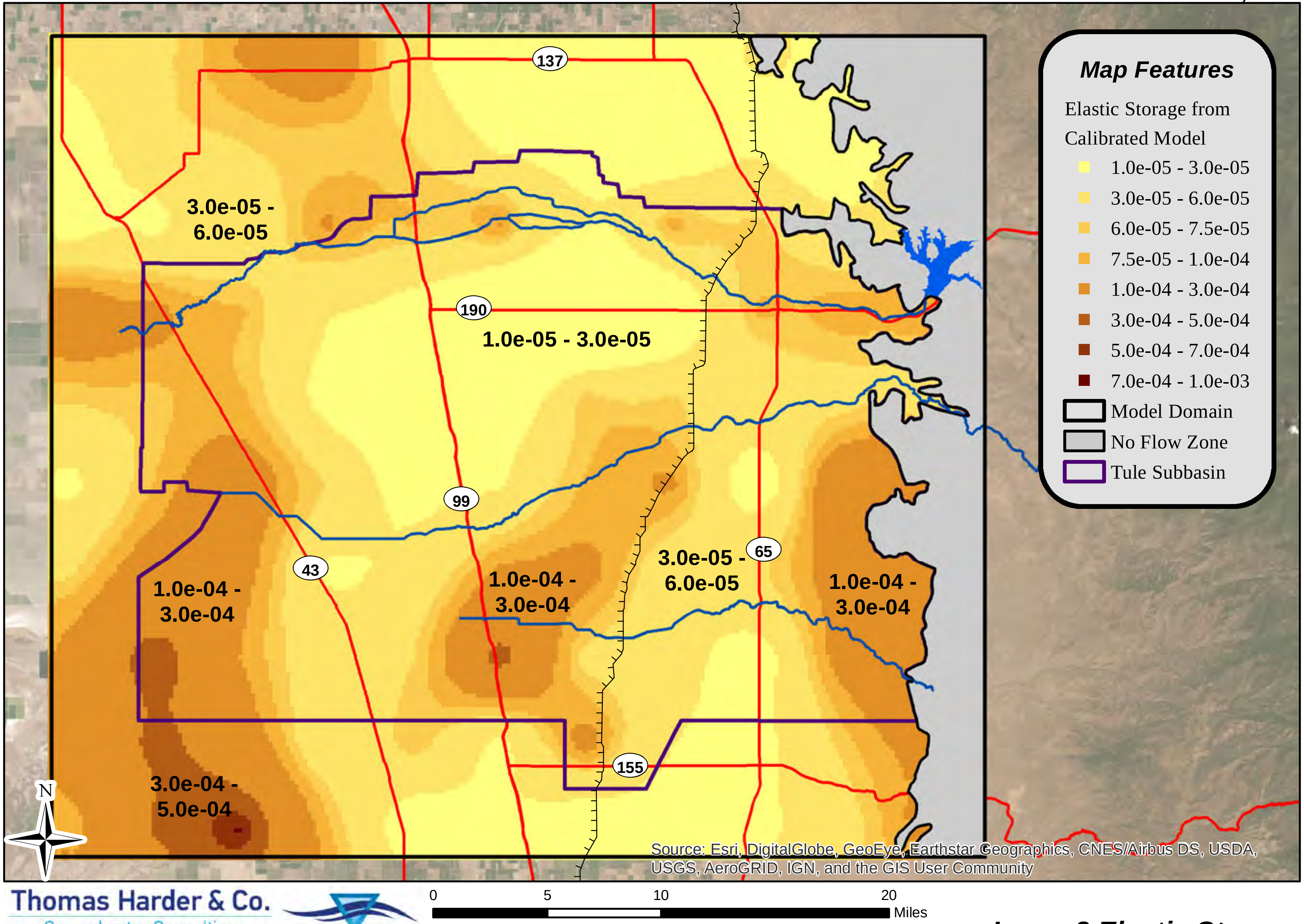
Layer 2 Elastic Storage

Appendix C-15

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

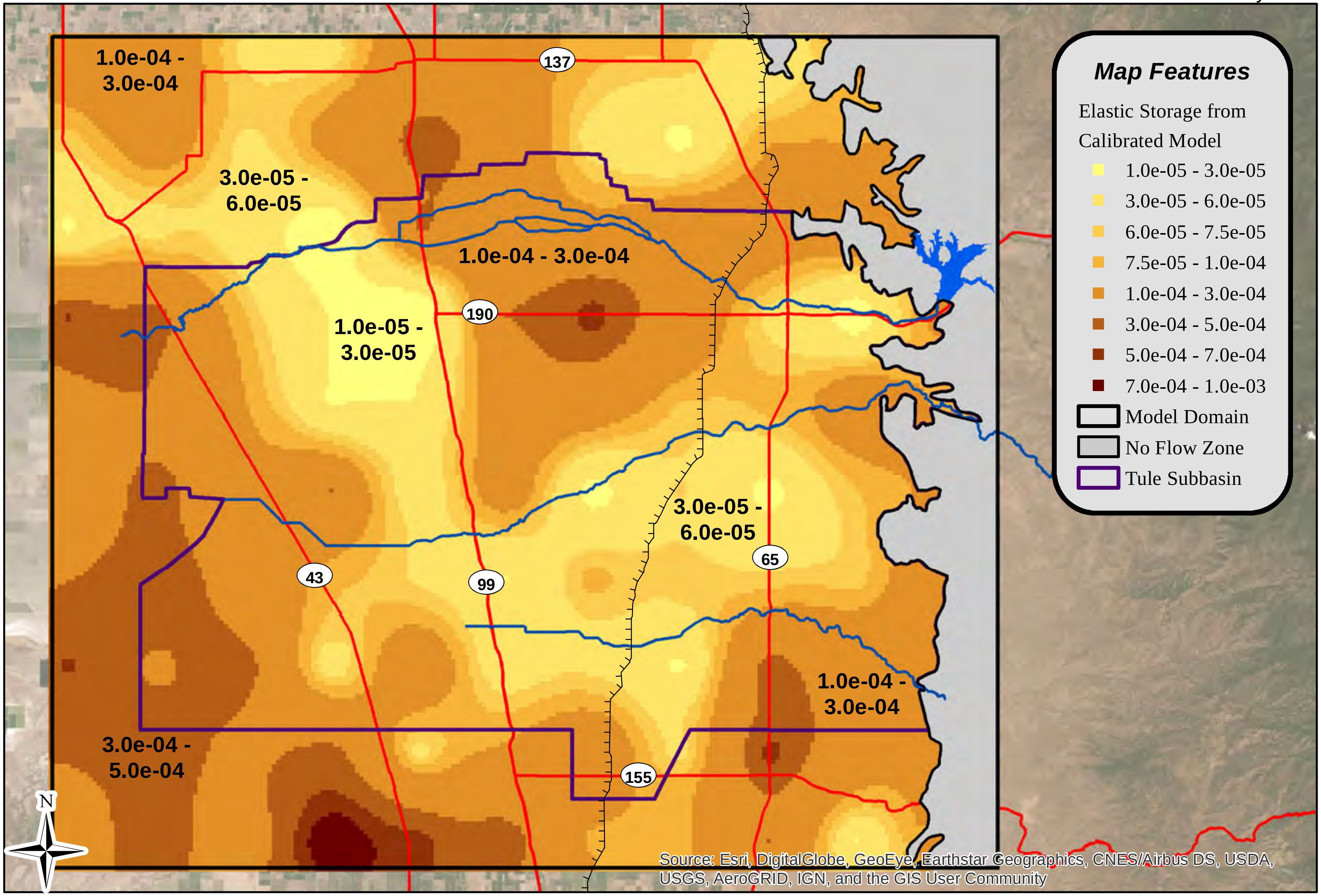
Layer 3 Elastic Storage

Appendix C-16

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20 Miles

NAD 83 State Plane Zone 4

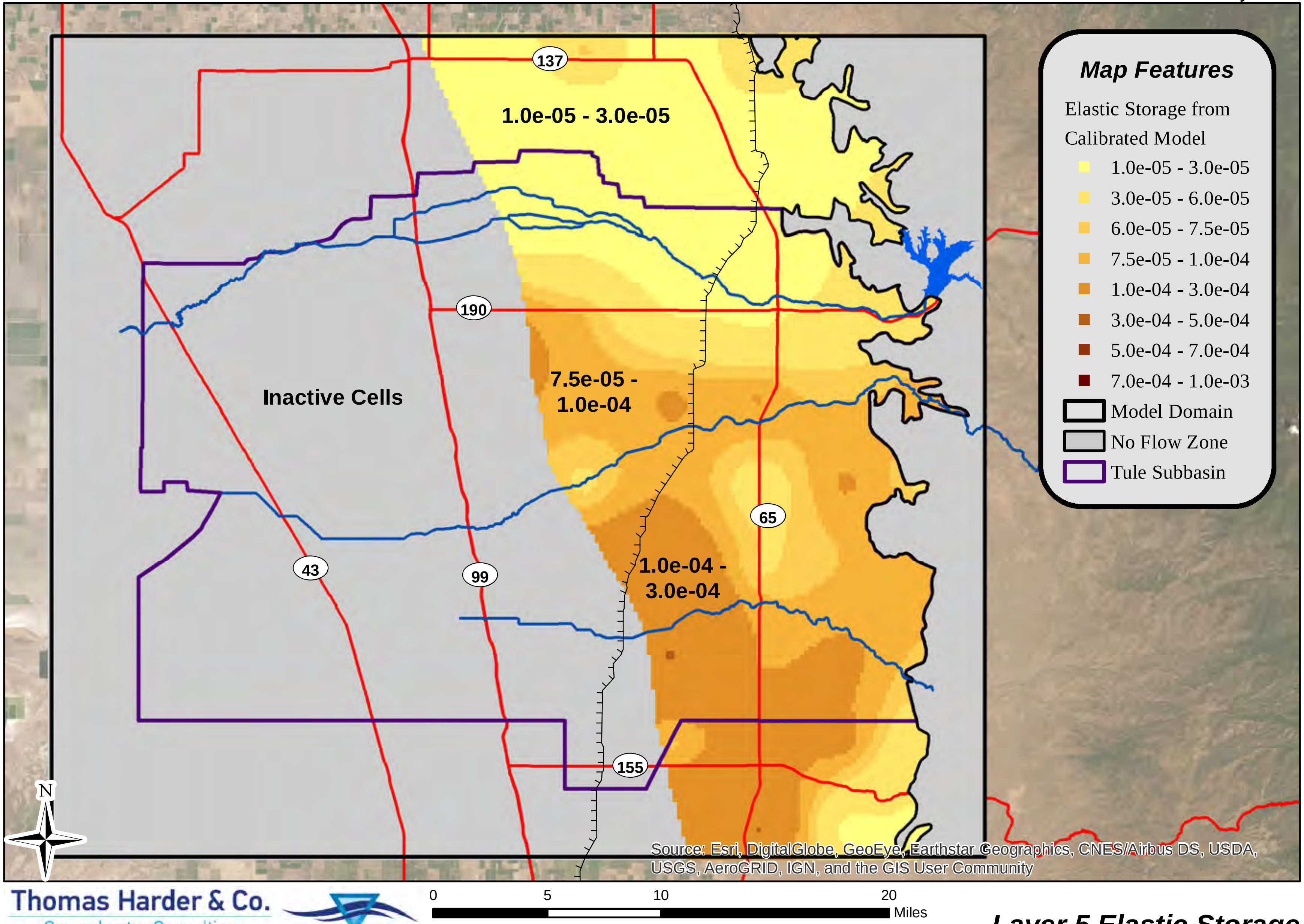
Layer 4 Elastic Storage

Appendix C-17

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

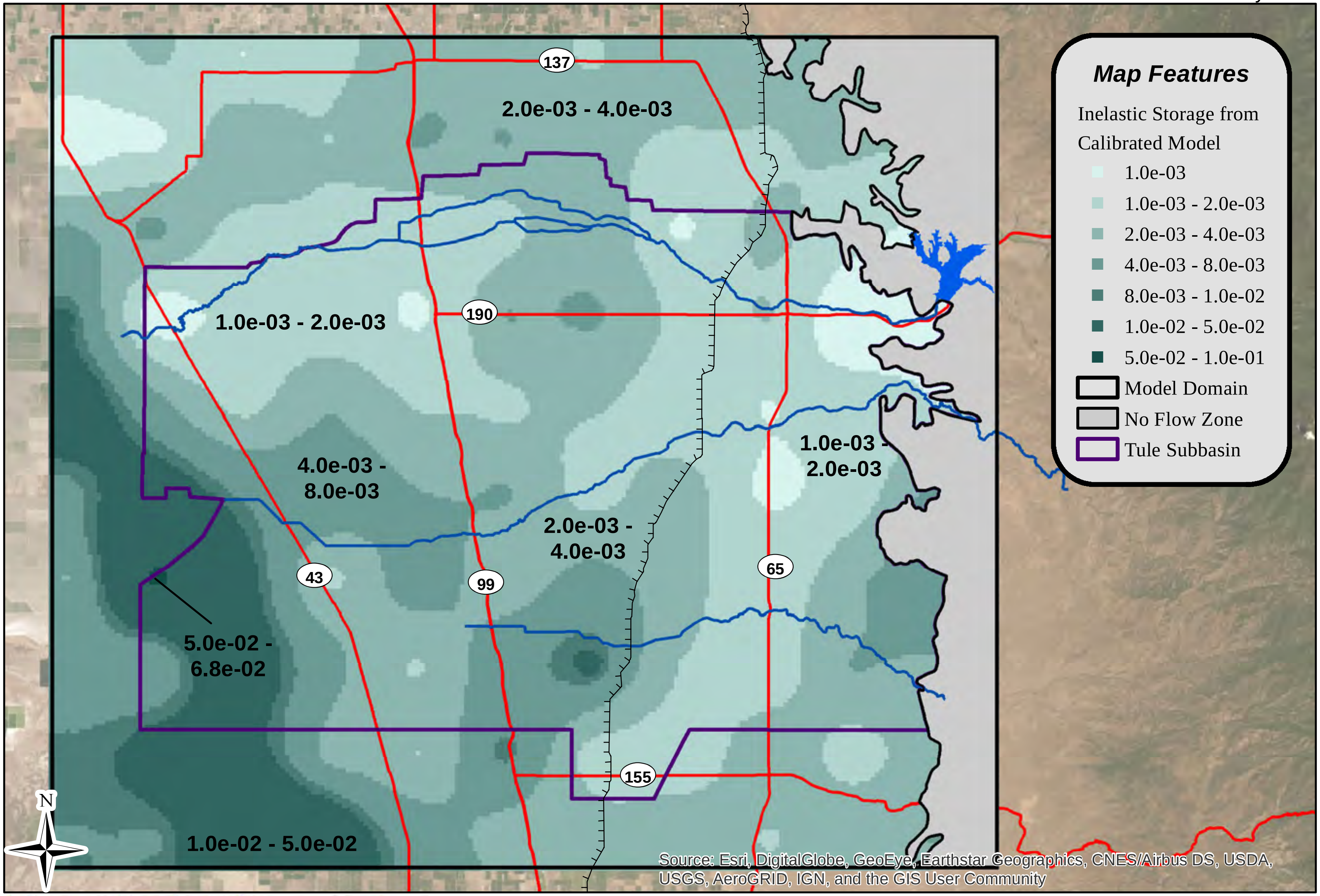
Layer 5 Elastic Storage

Appendix C-18

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



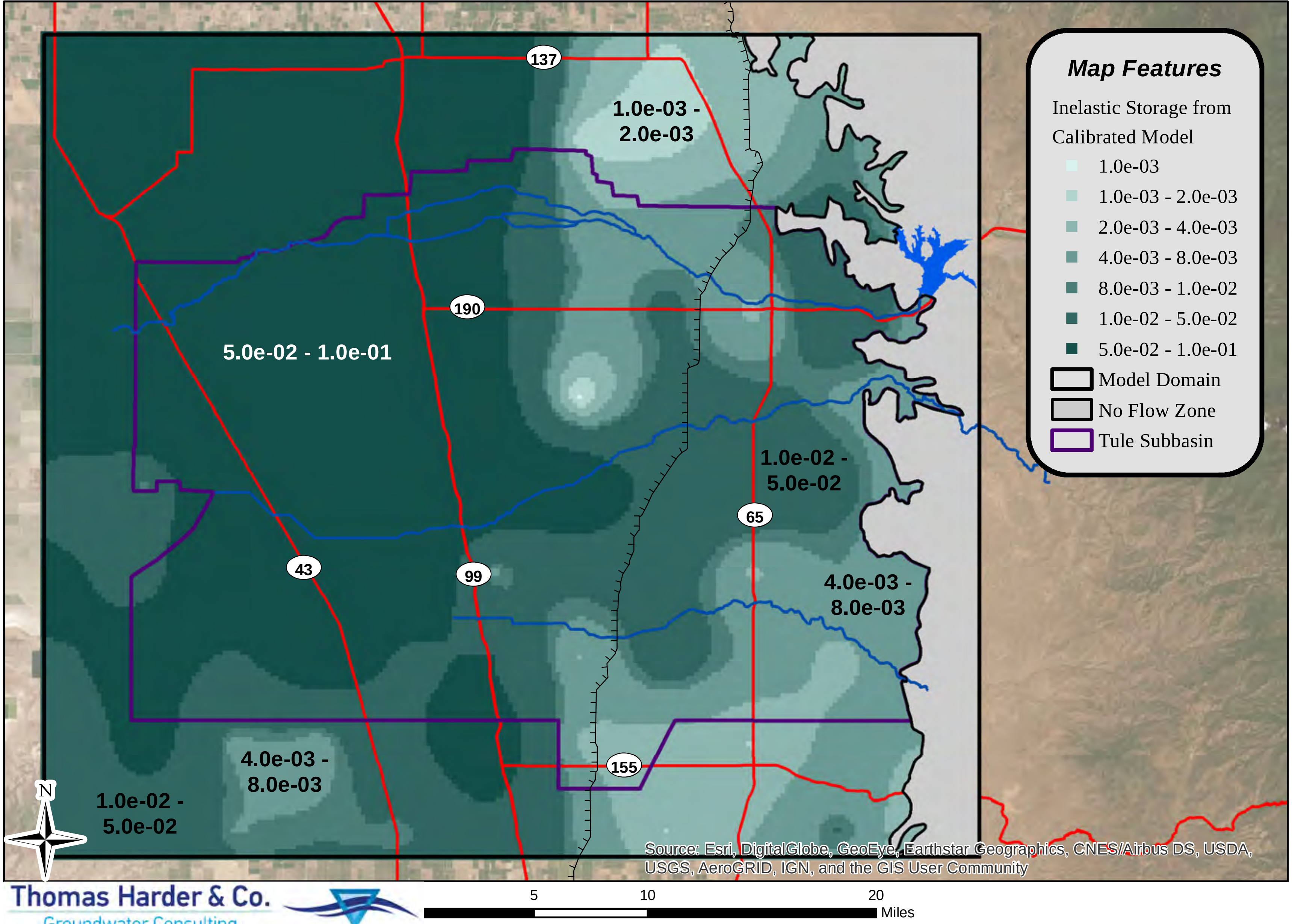
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20
Miles

NAD 83 State Plane Zone 4

Layer 1
Inelastic Storage
Appendix C-19



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

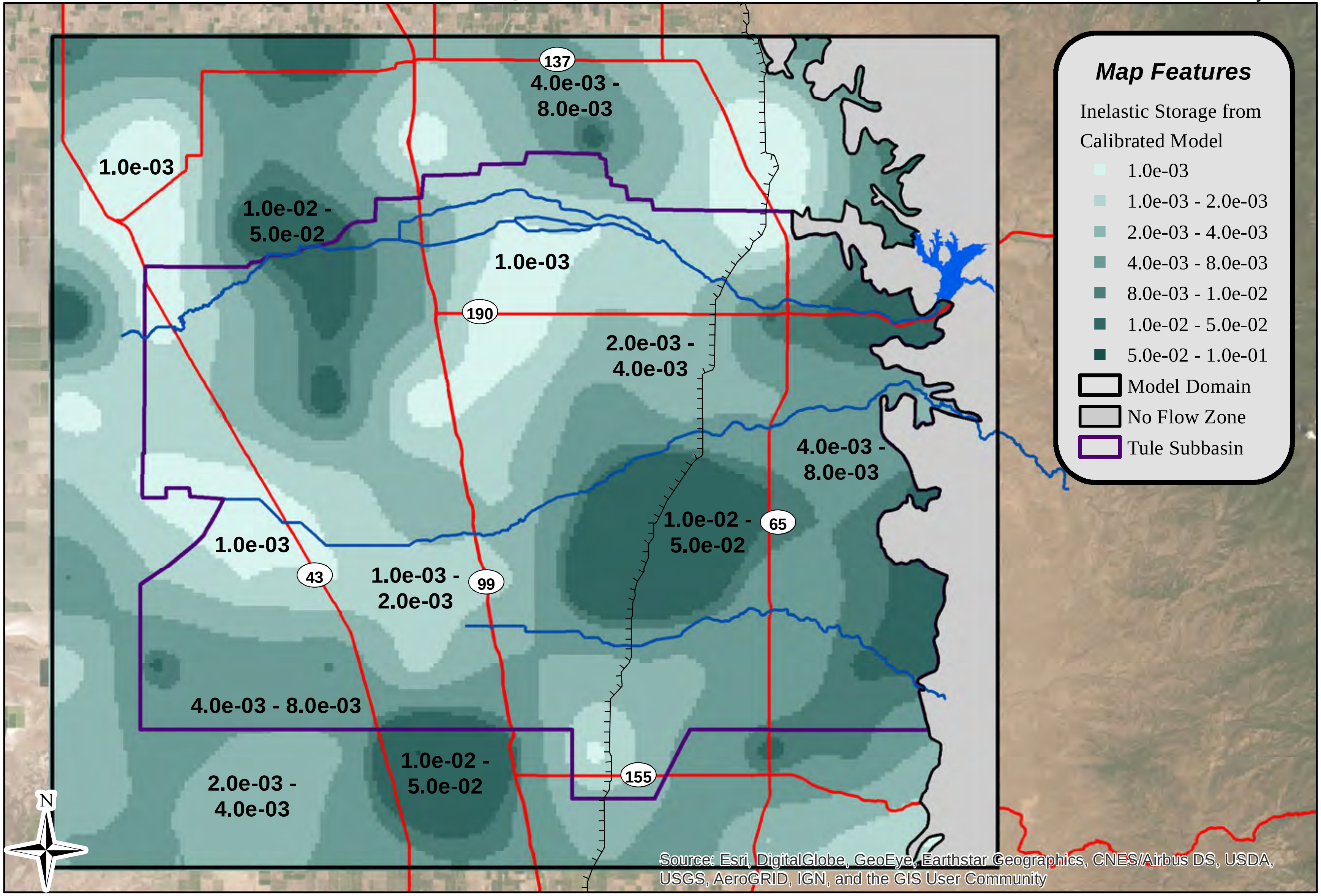
NAD 83 State Plane Zone 4

Layer 2
Inelastic Storage
Appendix C-20

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

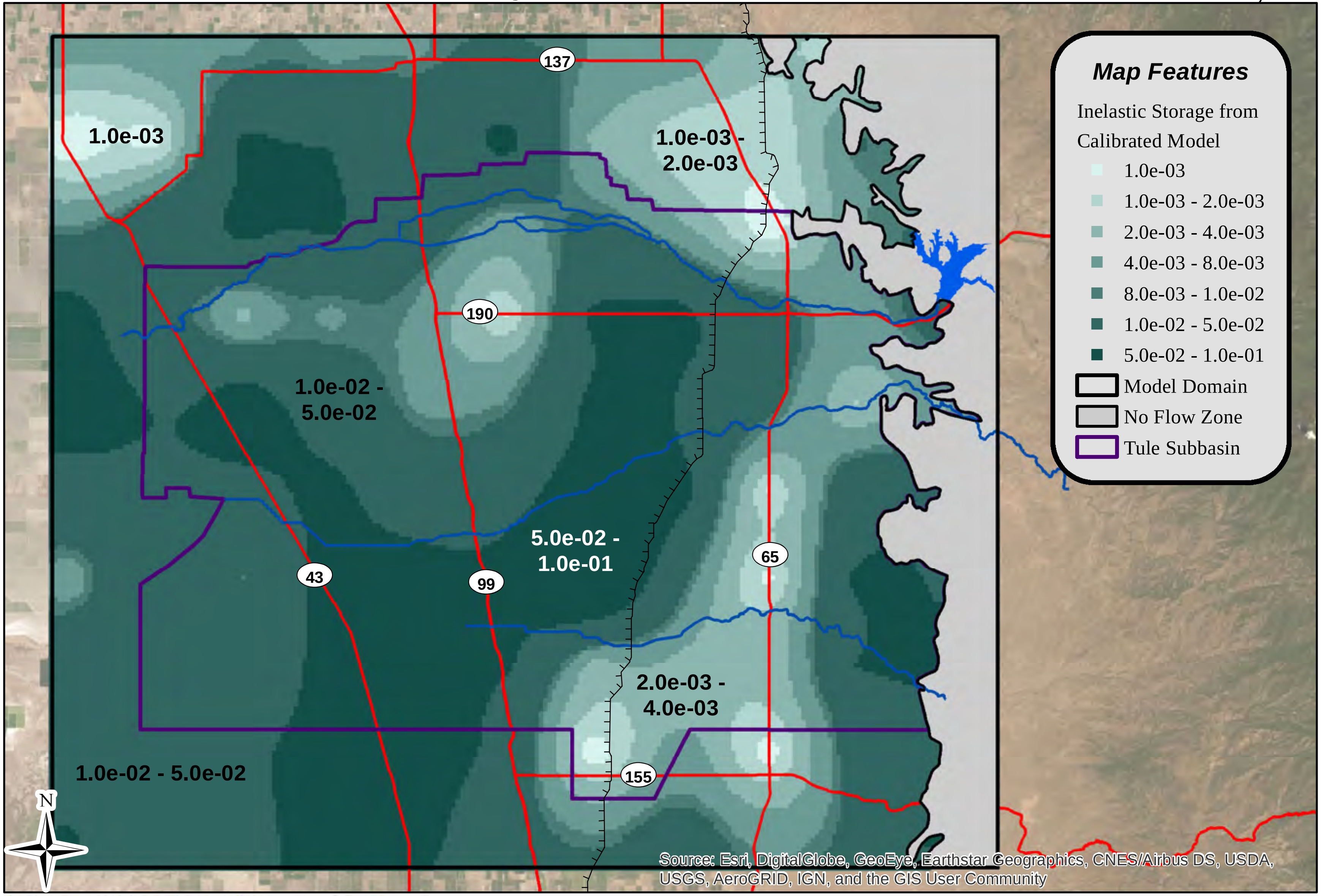
Layer 3 Inelastic Storage

Appendix C-21

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

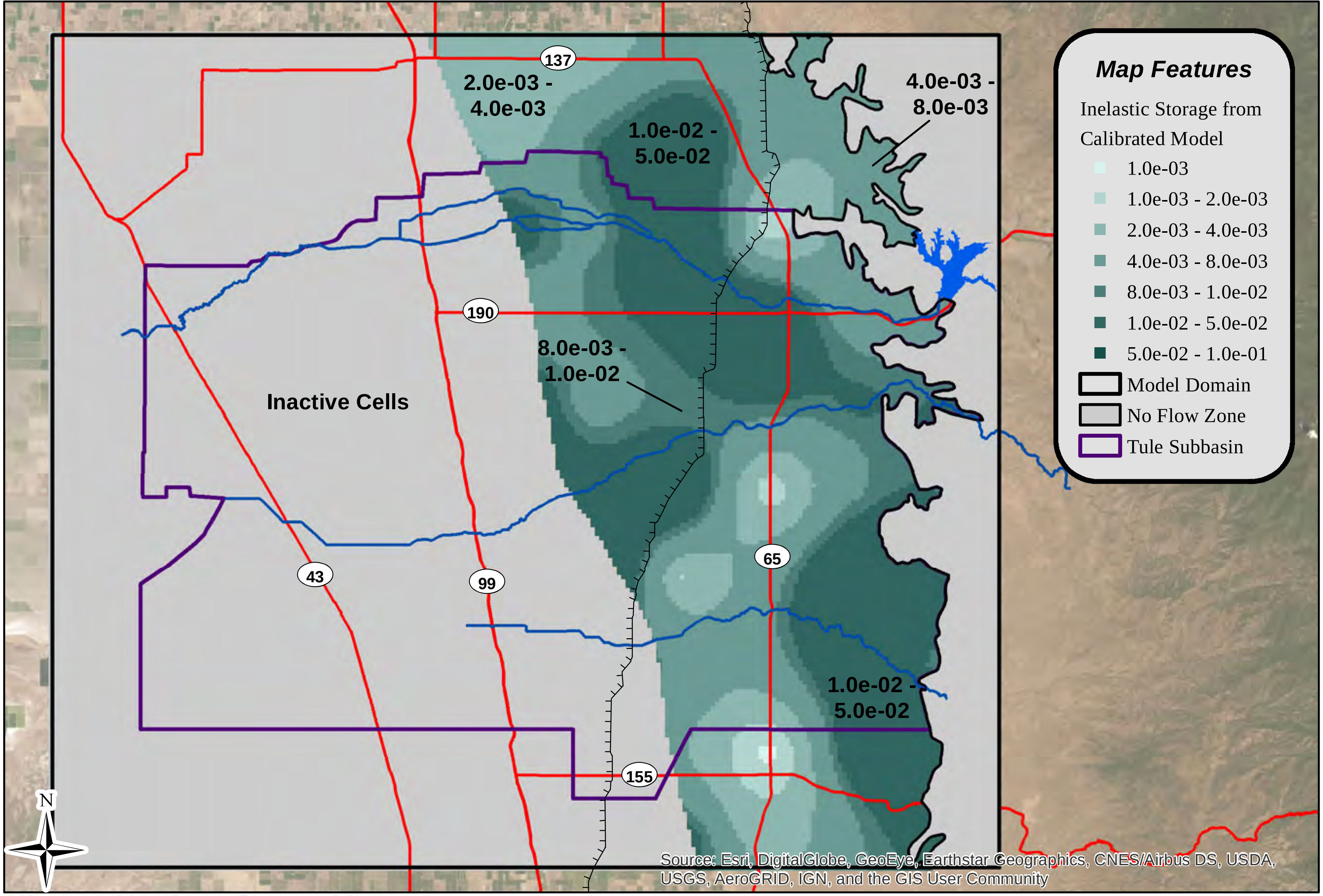
NAD 83 State Plane Zone 4

Layer 4
Inelastic Storage
Appendix C-22

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Map Features

Inelastic Storage from Calibrated Model

- ▨ 1.0e-03
- ▨ 1.0e-03 - 2.0e-03
- ▨ 2.0e-03 - 4.0e-03
- ▨ 4.0e-03 - 8.0e-03
- ▨ 8.0e-03 - 1.0e-02
- ▨ 1.0e-02 - 5.0e-02
- ▨ 5.0e-02 - 1.0e-01
- ☐ Model Domain
- ▨ No Flow Zone
- ☐ Tule Subbasin

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20 Miles

NAD 83 State Plane Zone 4

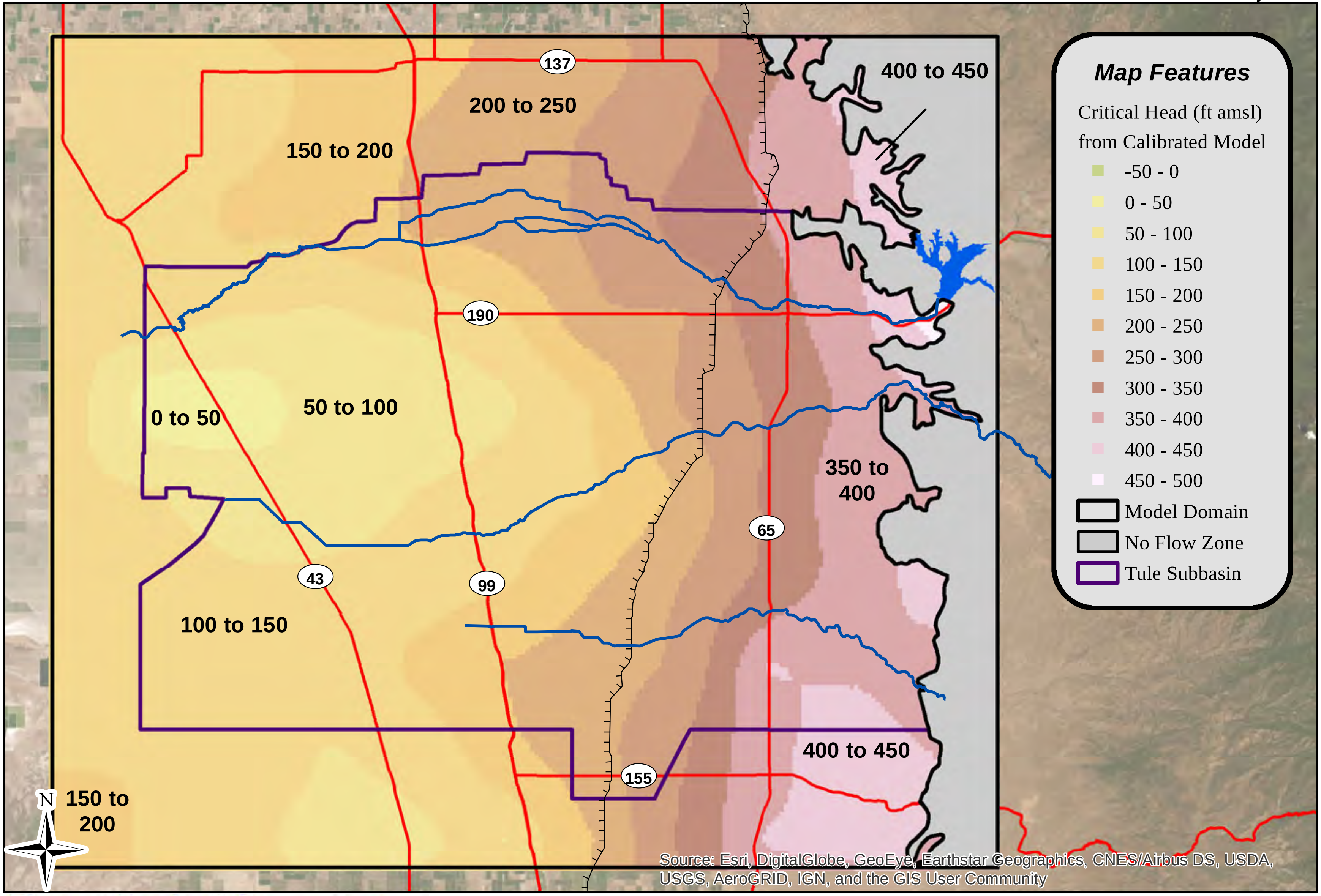
Layer 5 Inelastic Storage

Appendix C-23

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20
Miles

NAD 83 State Plane Zone 4

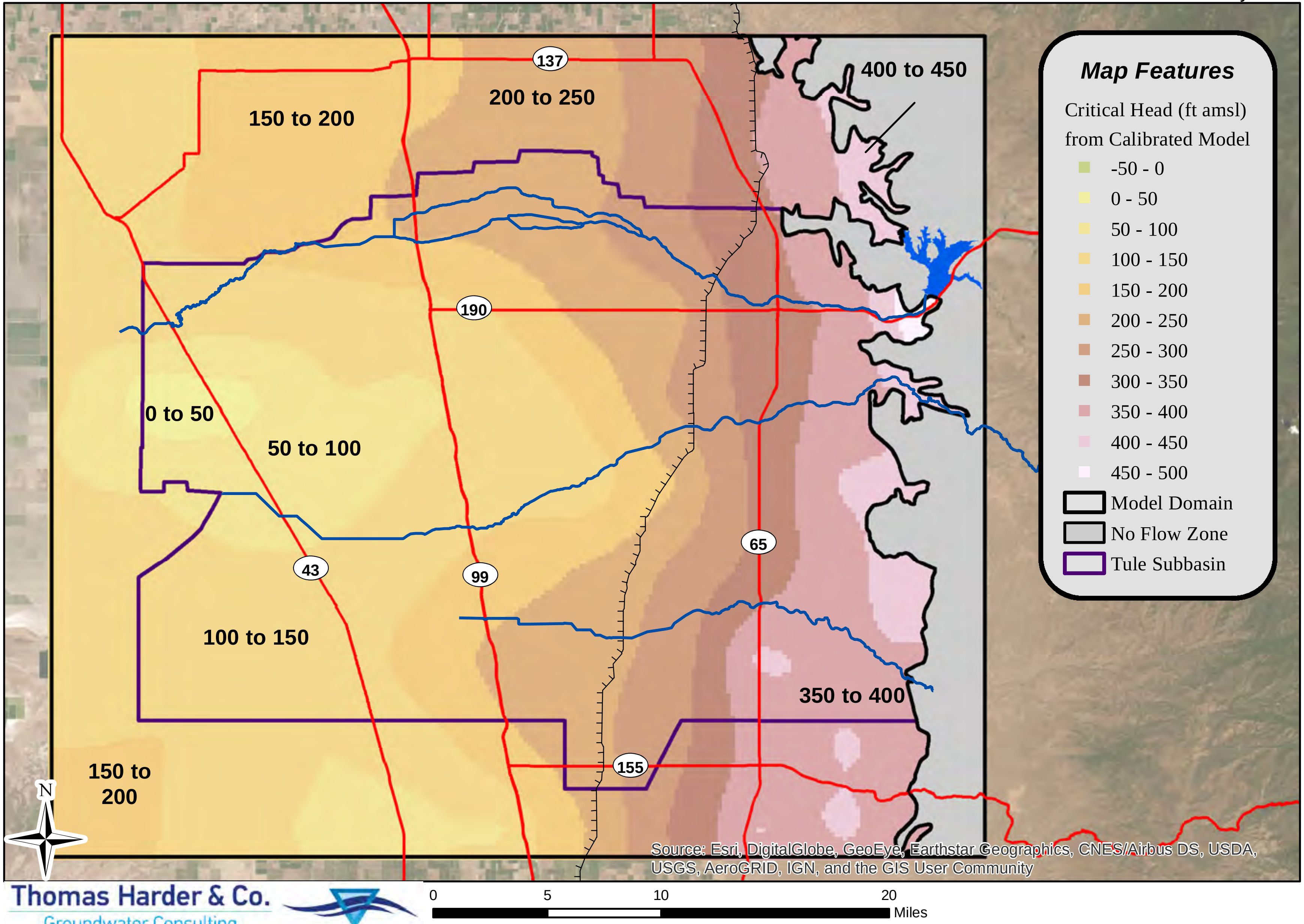
Layer 1 Critical Heads

Appendix C-24

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

NAD 83 State Plane Zone 4

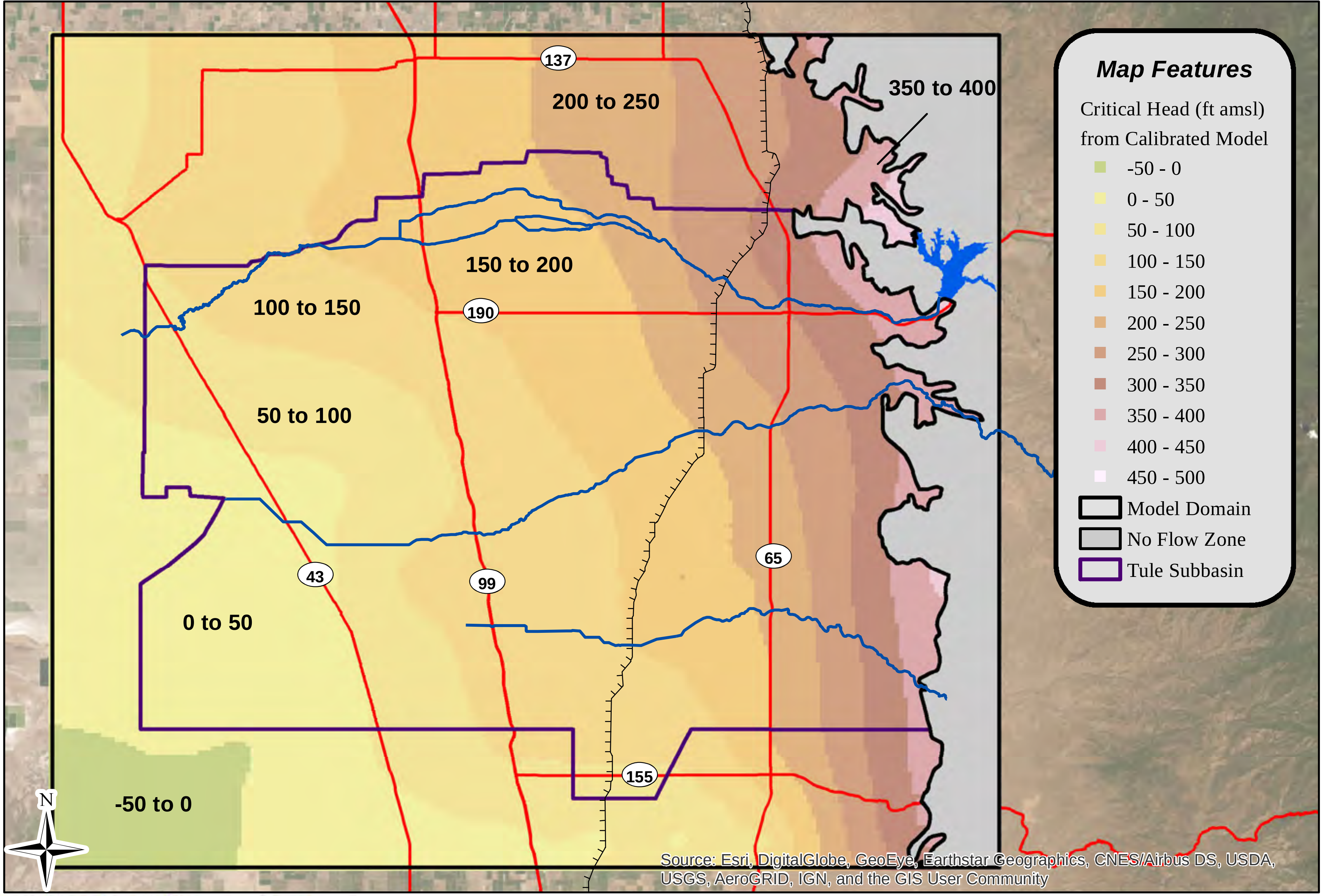
Layer 2 Critical Heads

Appendix C-25

Tule Subbasin Technical Advisory Committee

Groundwater Flow Model of the Tule Subbasin

January 2020



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 5 10 20 Miles

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

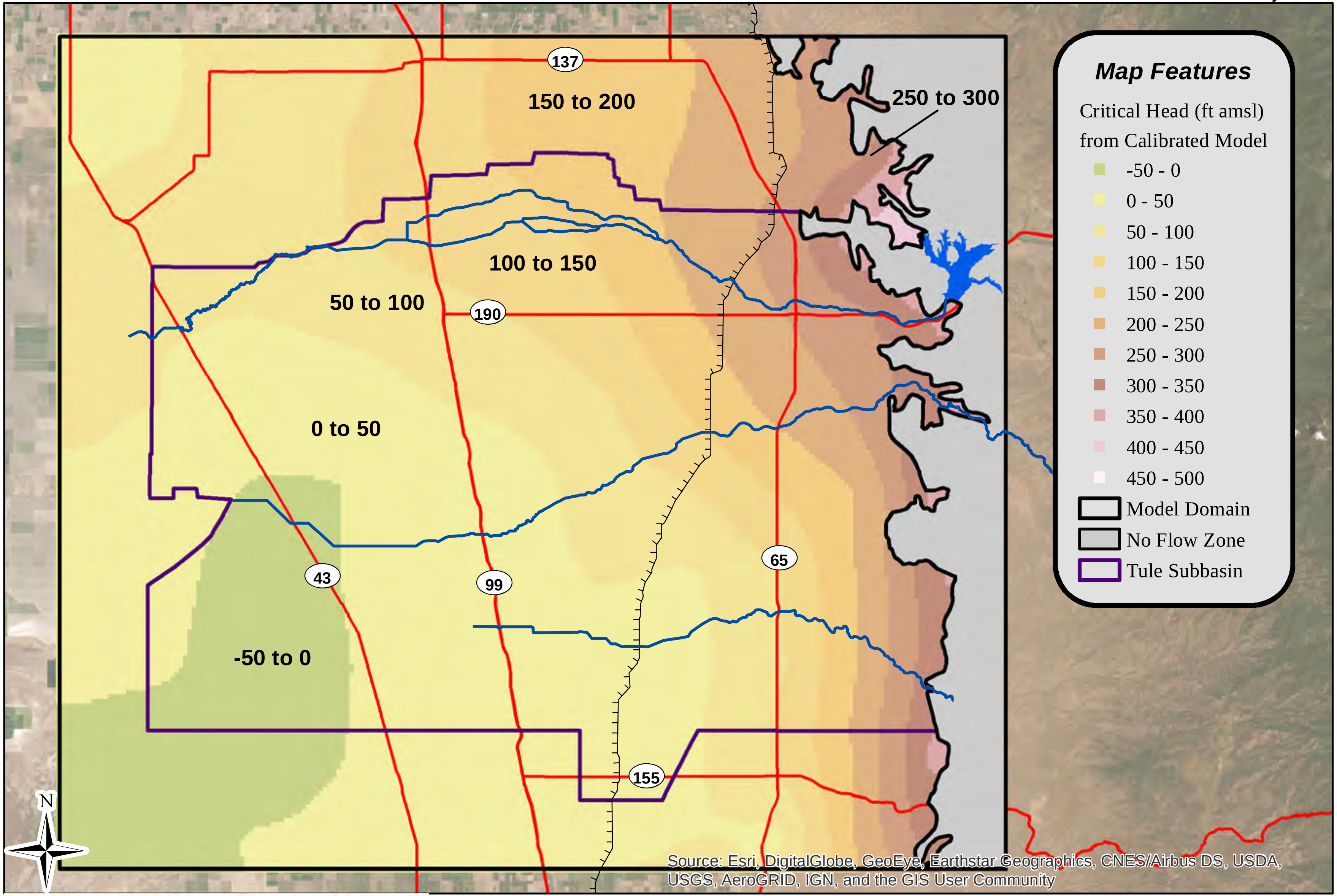
Layer 3 Critical Heads

Appendix C-26

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Thomas Harder & Co.
Groundwater Consulting

0 5 10 20 Miles

NAD 83 State Plane Zone 4

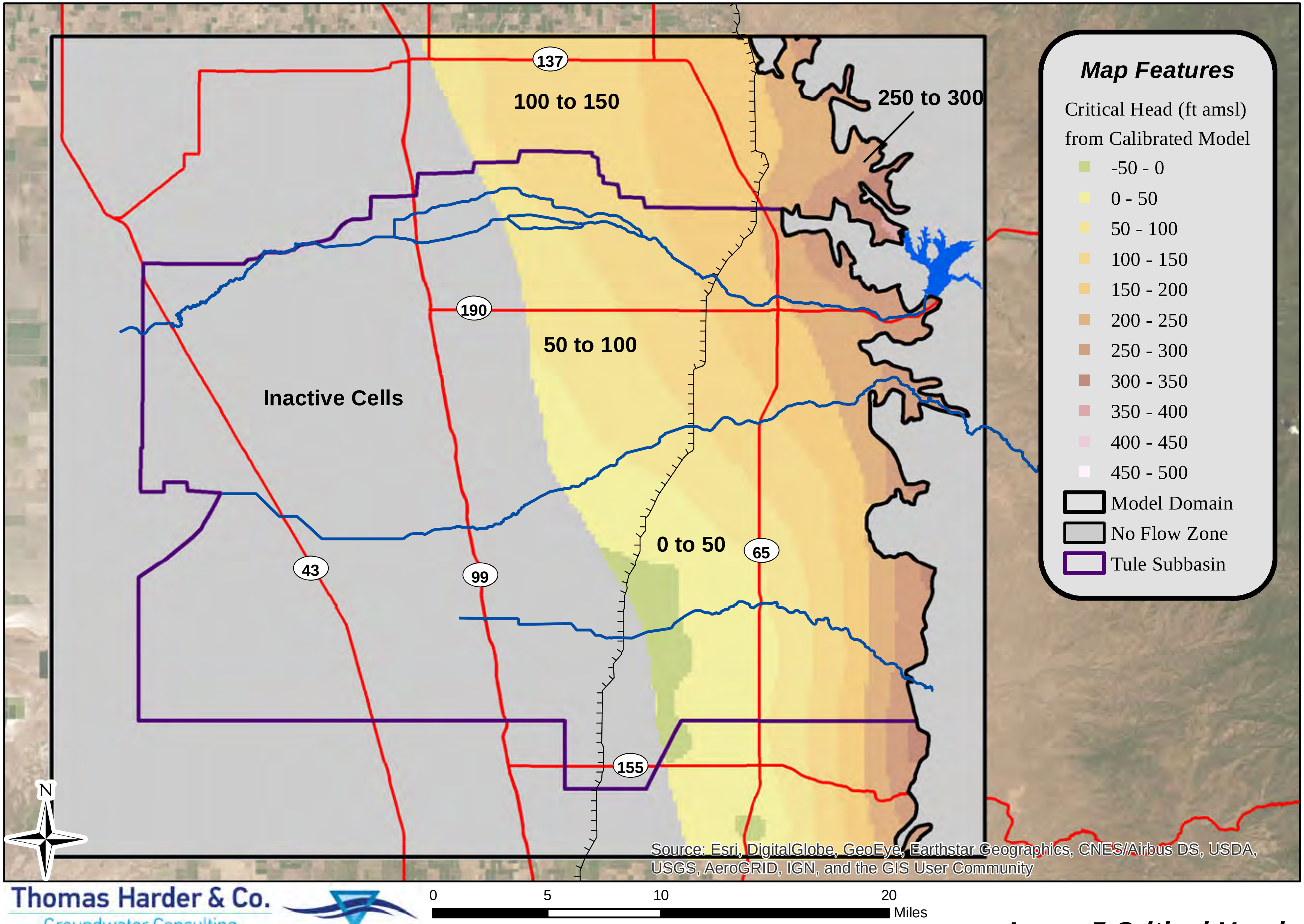
Layer 4 Critical Heads

Appendix C-27

Groundwater Flow Model of the Tule Subbasin

January 2020

Tule Subbasin Technical Advisory Committee



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

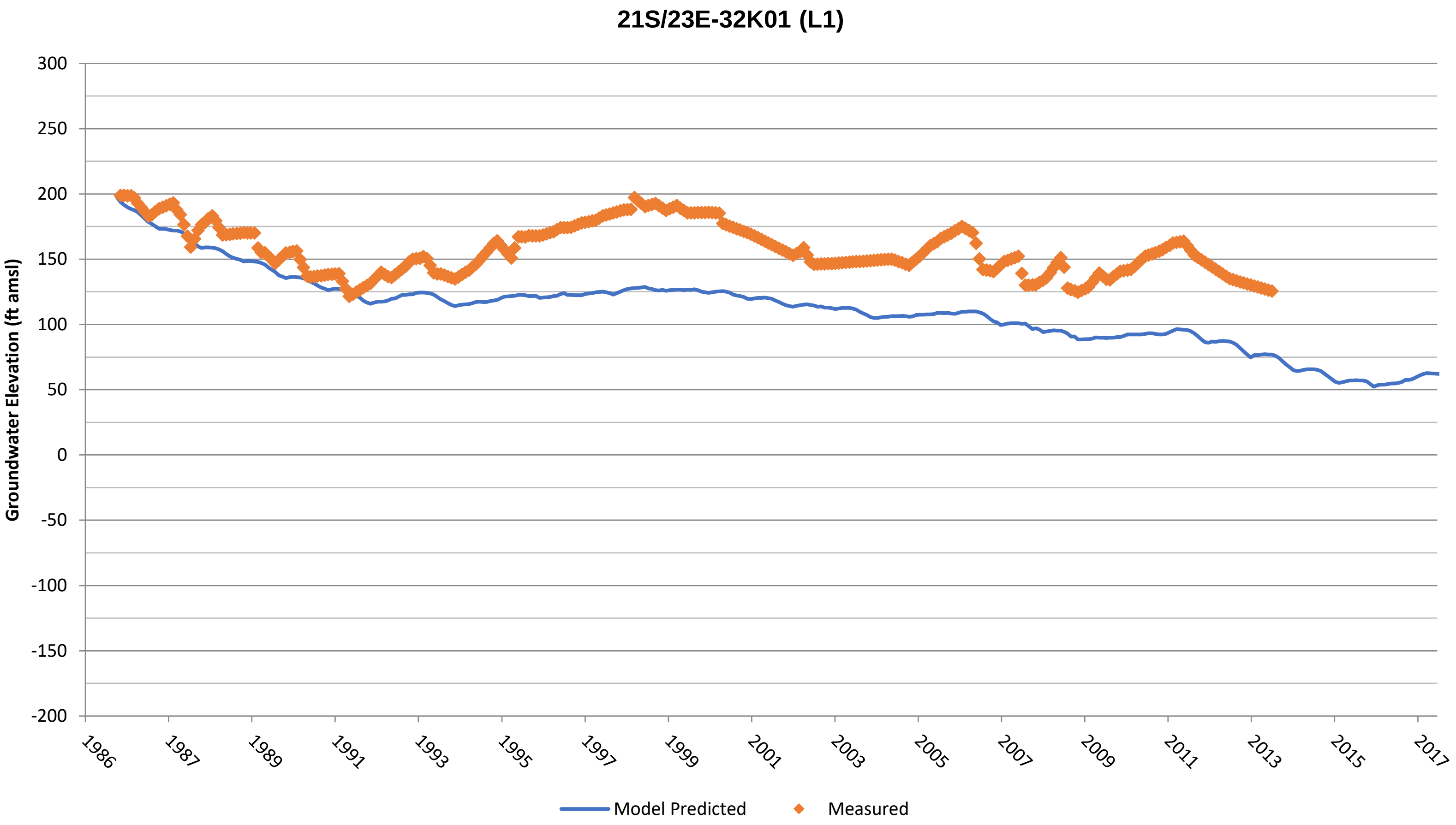
Layer 5 Critical Heads

Appendix C-28

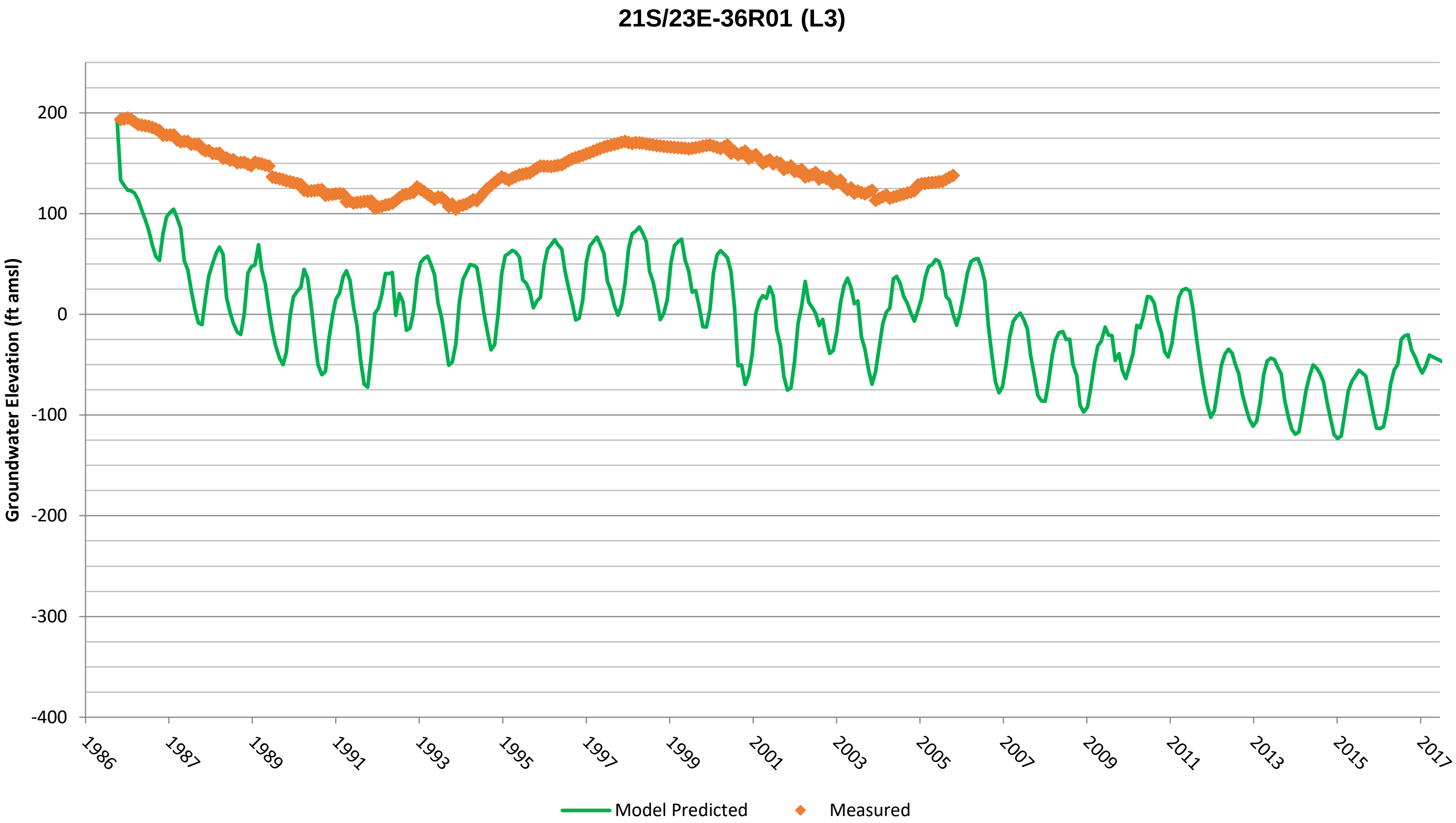
Appendix D

Model Calibration Hydrographs

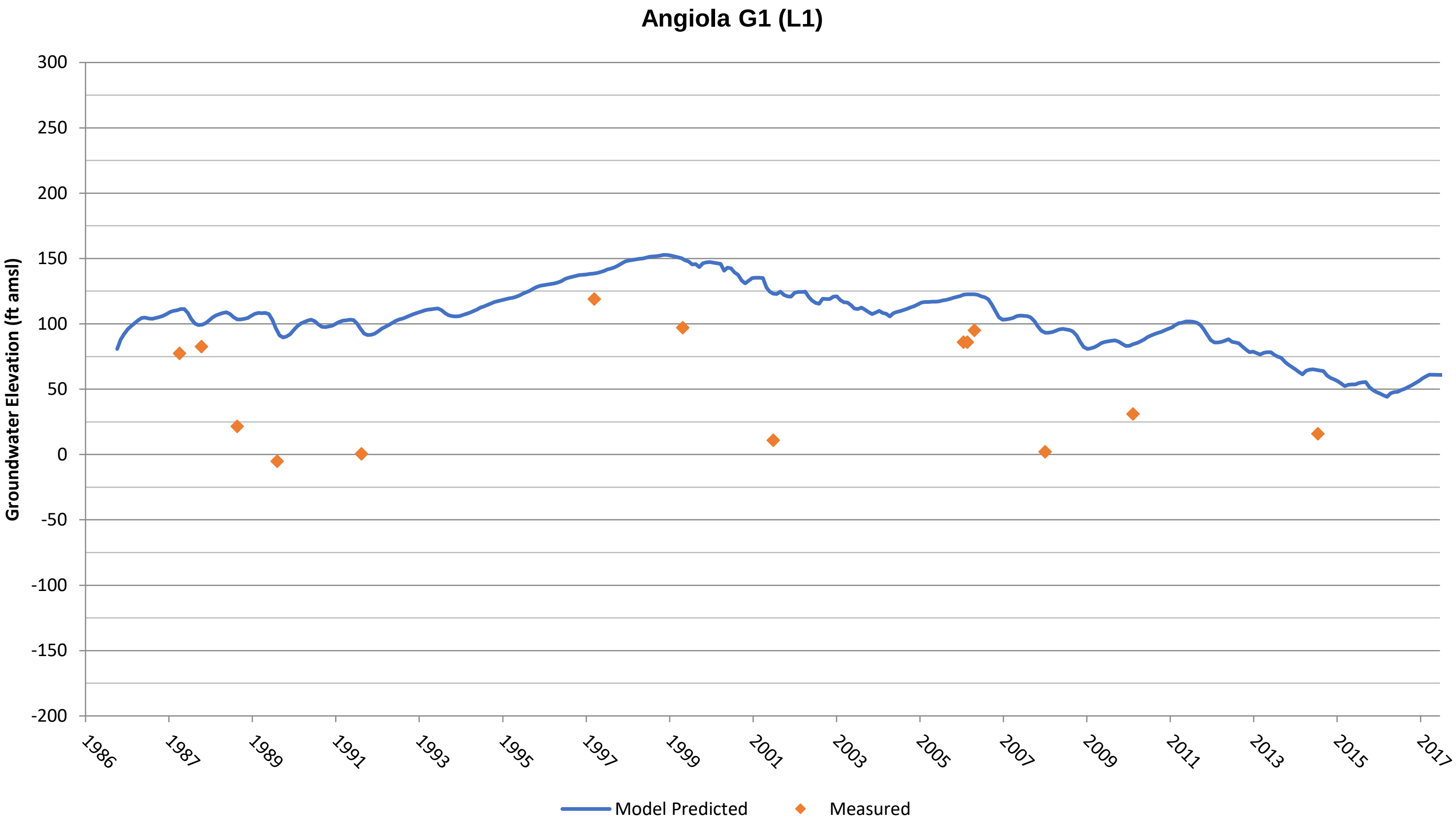
Model Calibration Hydrographs



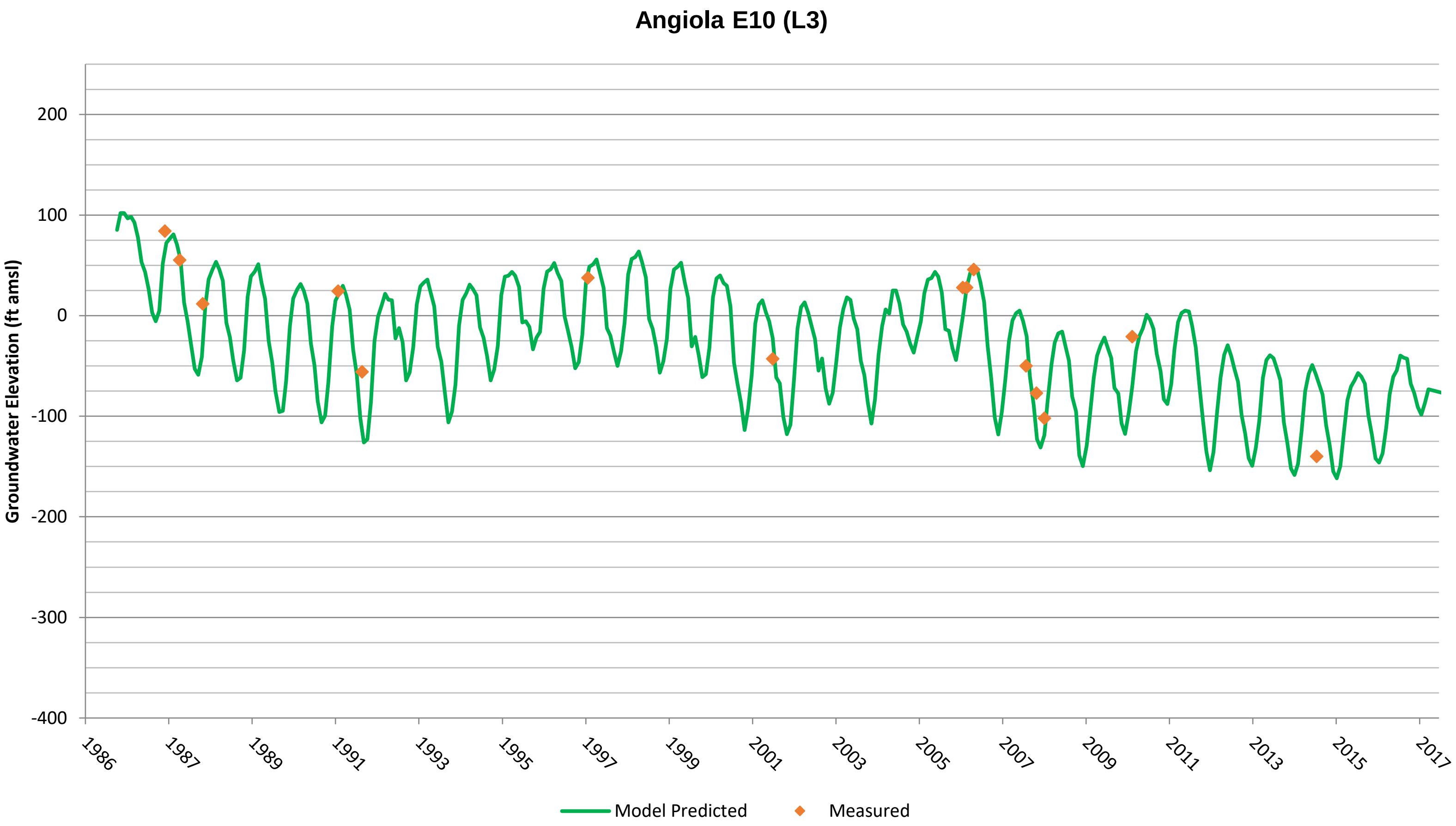
Model Calibration Hydrographs



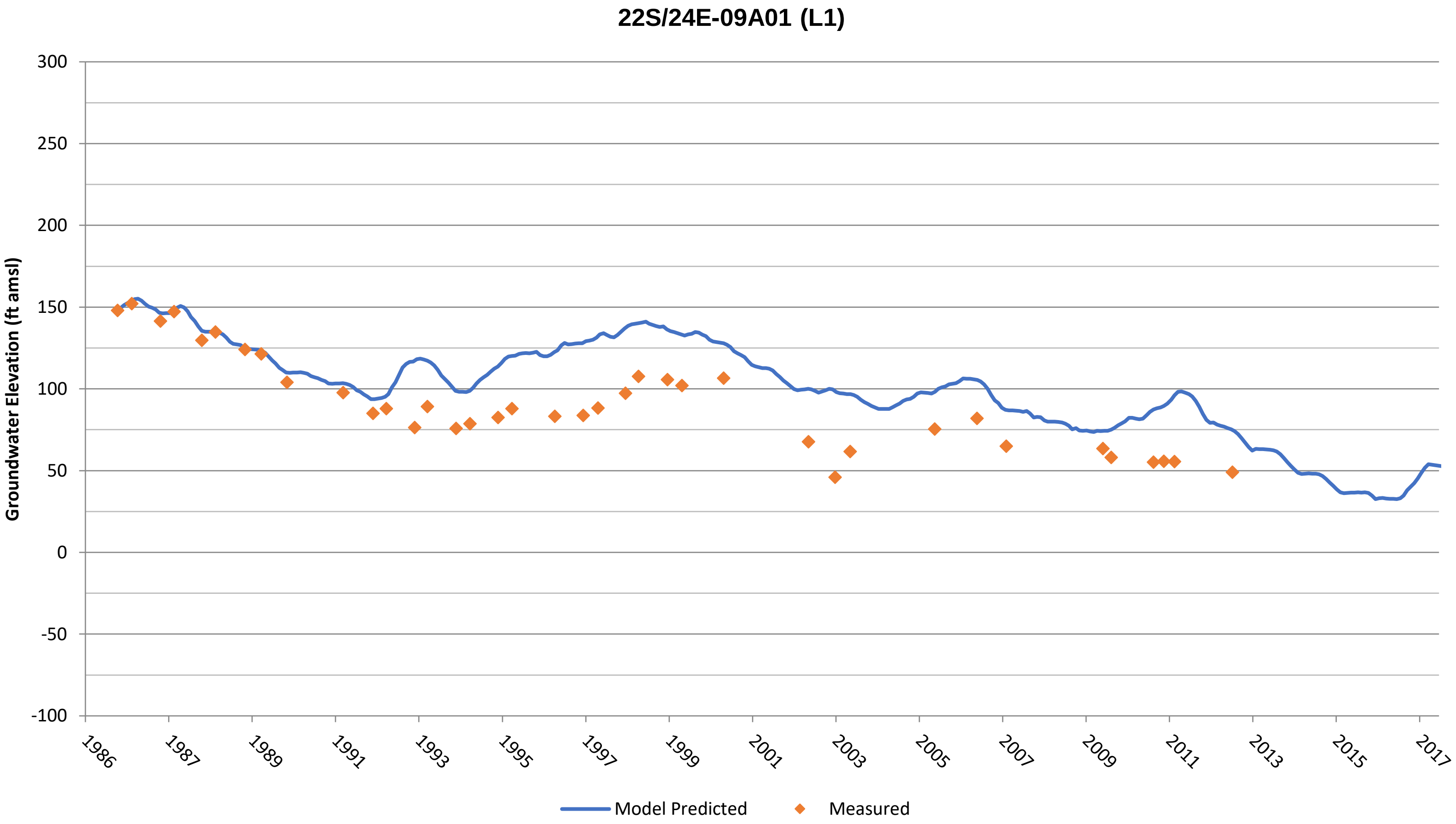
Model Calibration Hydrographs



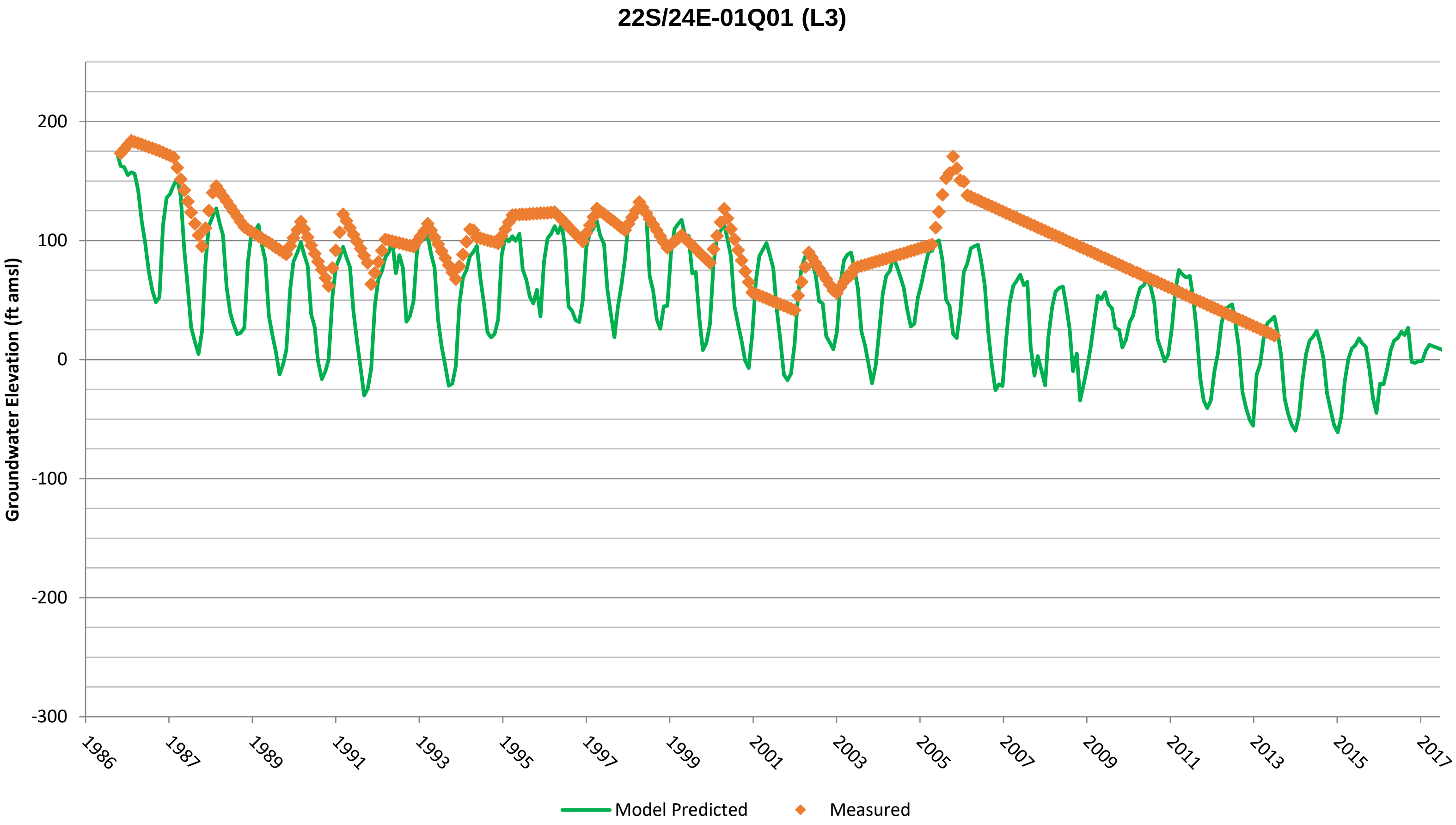
Model Calibration Hydrographs



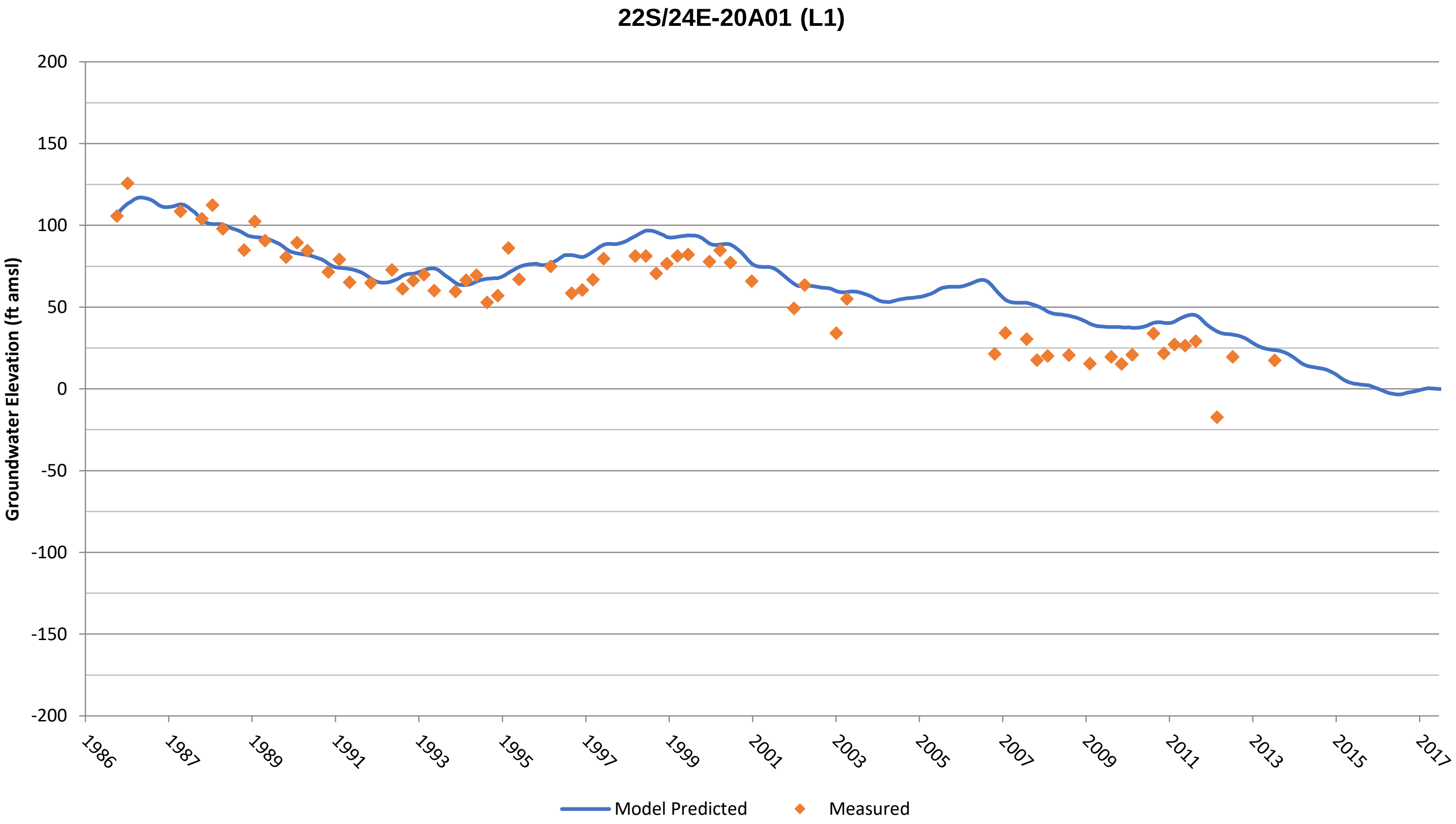
Model Calibration Hydrographs



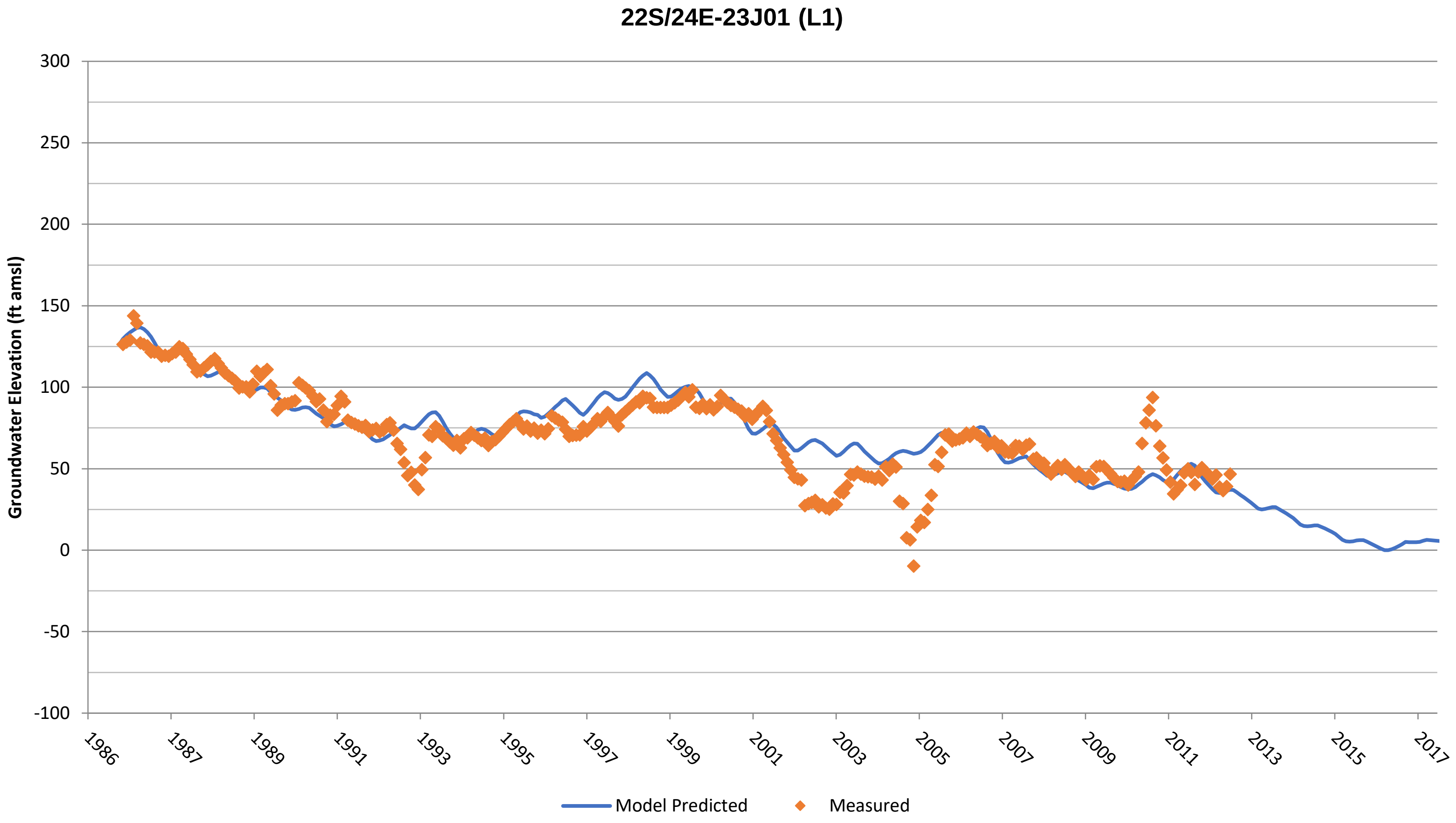
Model Calibration Hydrographs



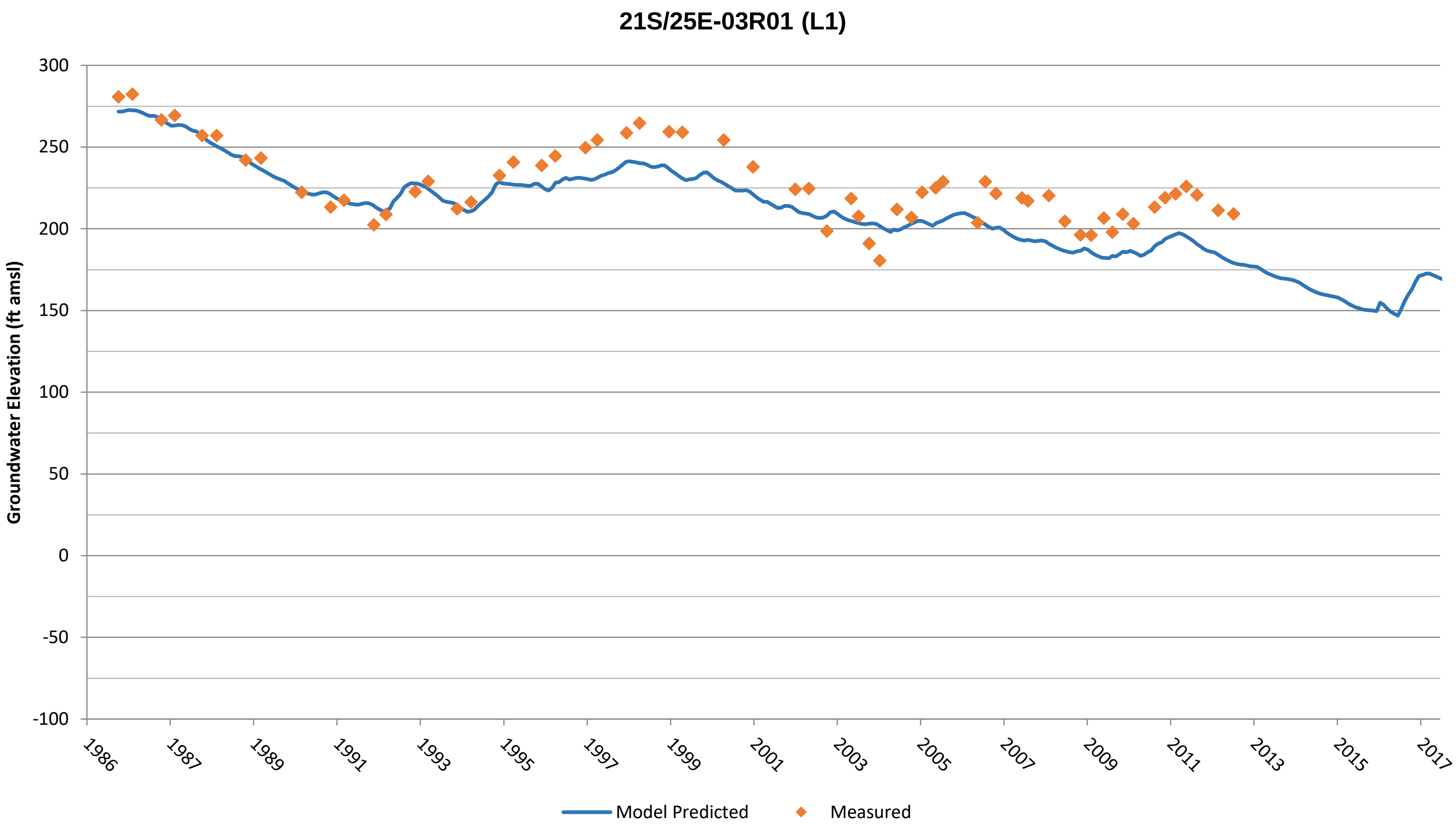
Model Calibration Hydrographs



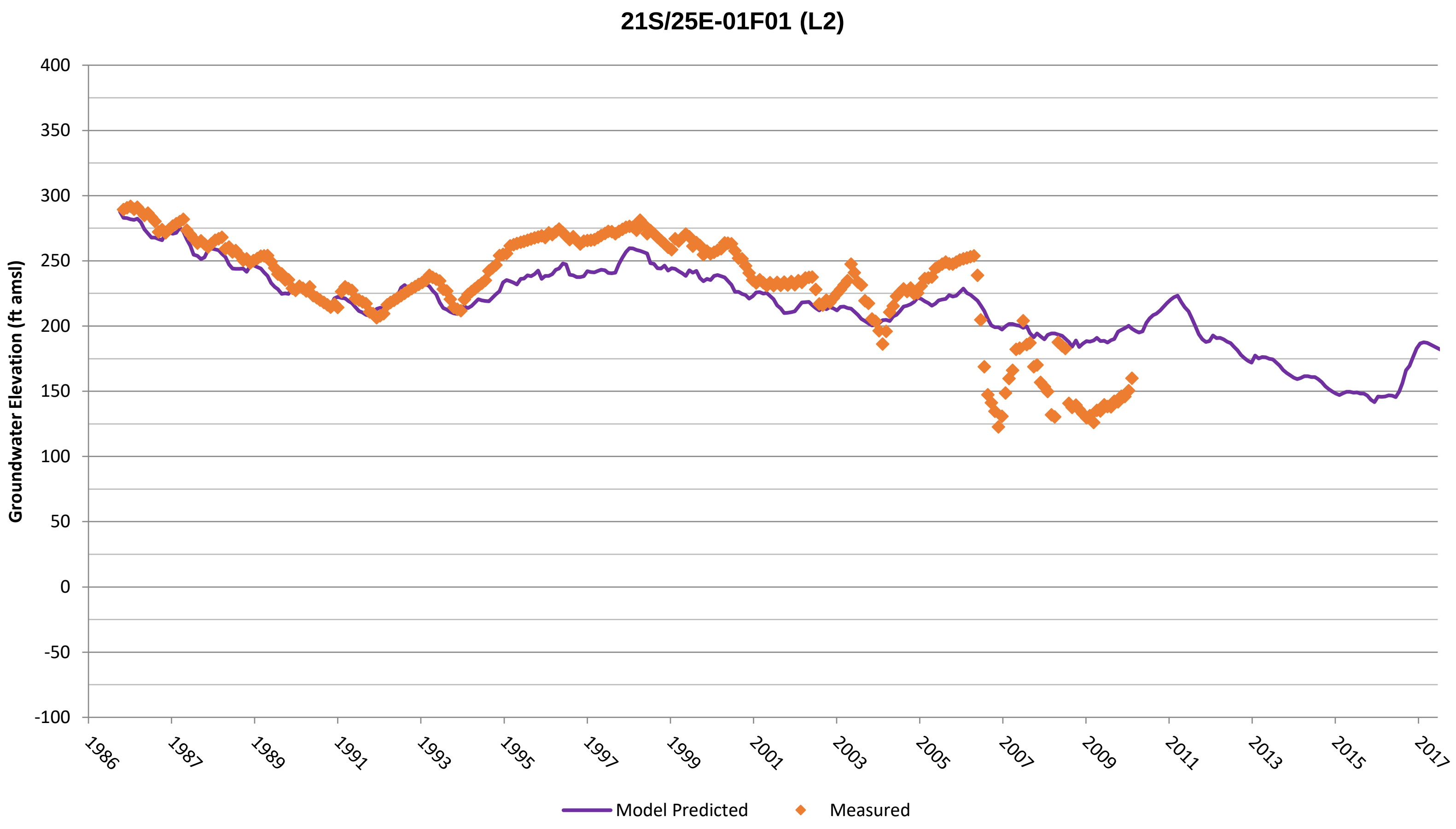
Model Calibration Hydrographs



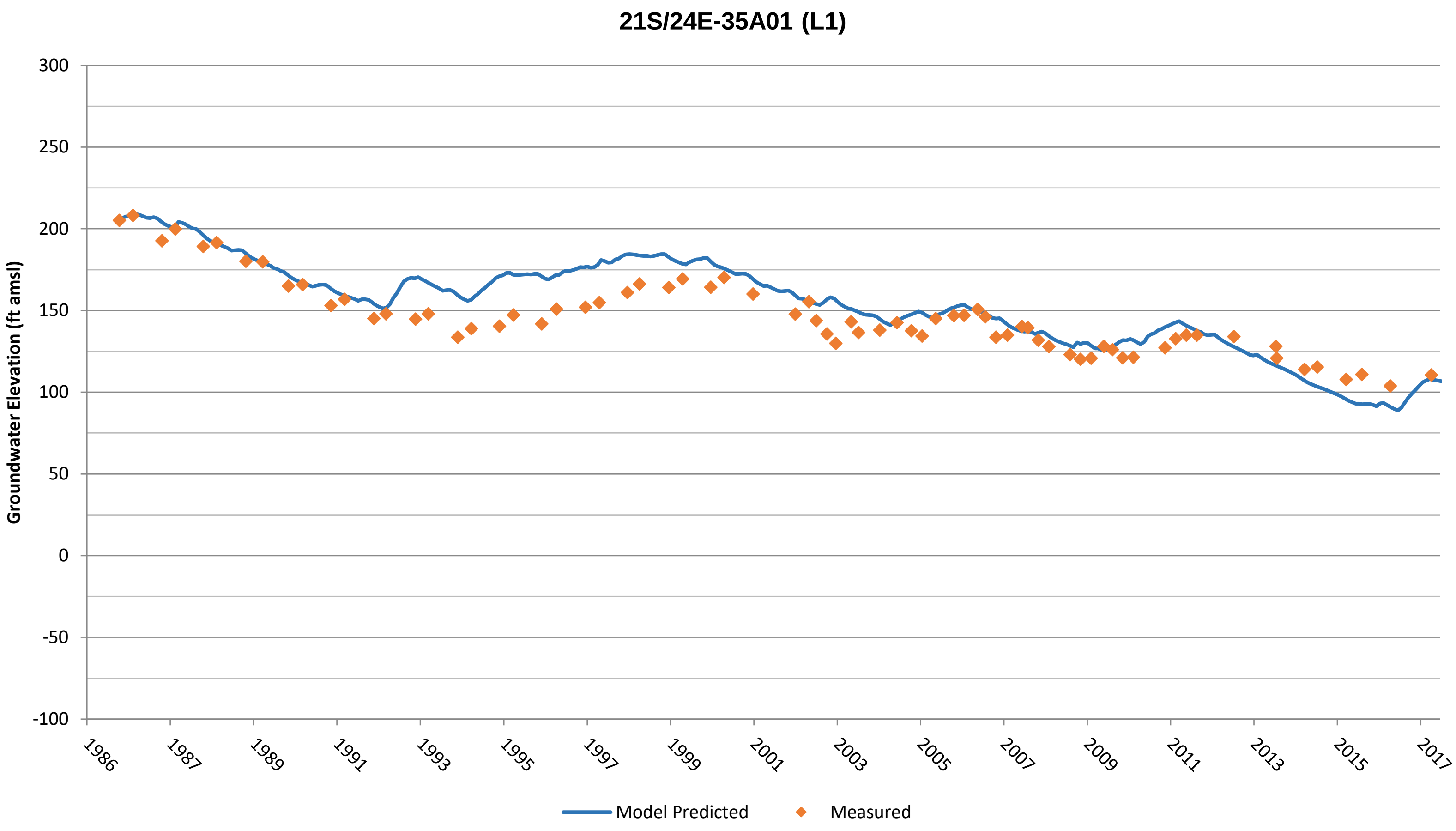
Model Calibration Hydrographs



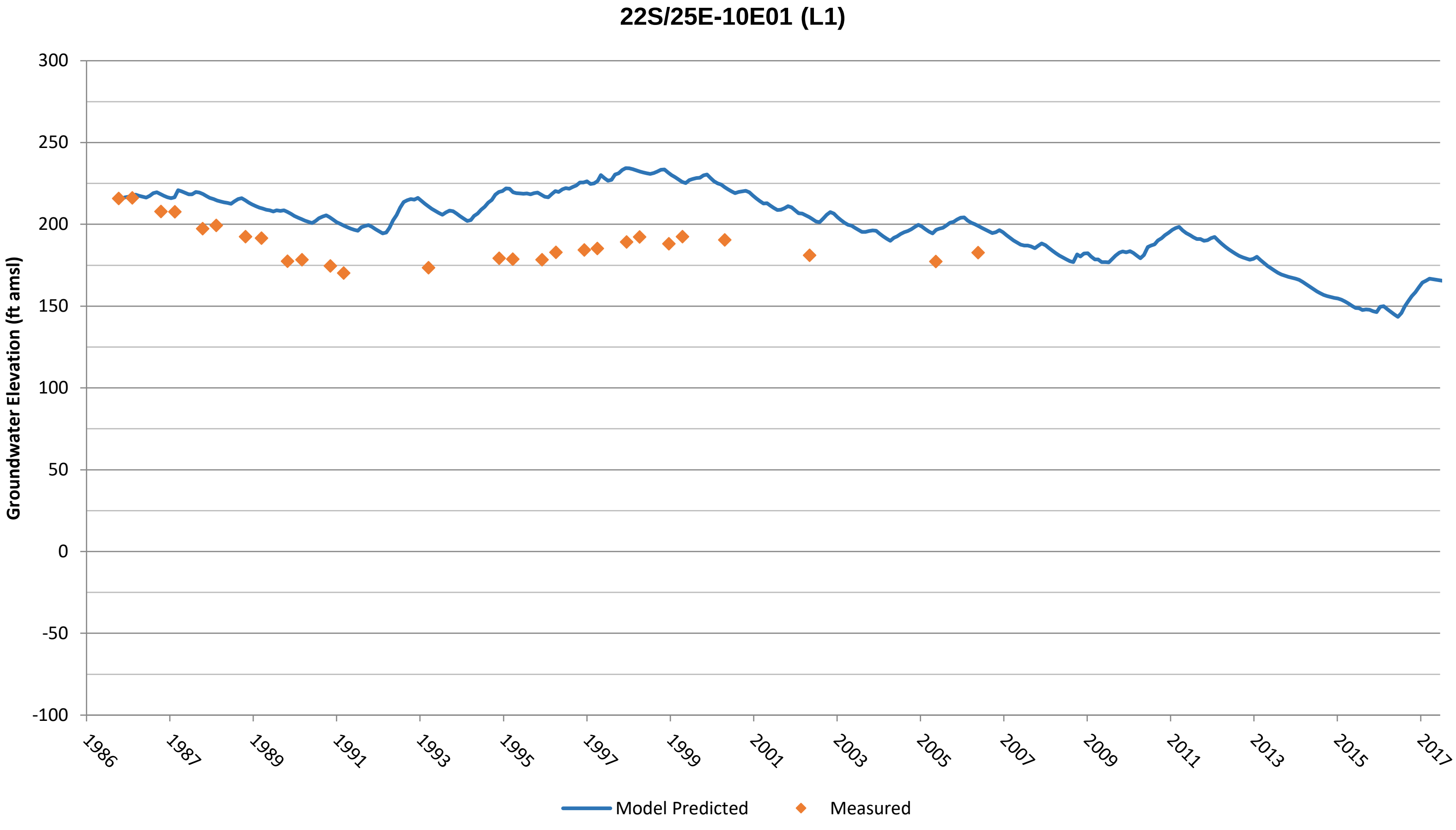
Model Calibration Hydrographs



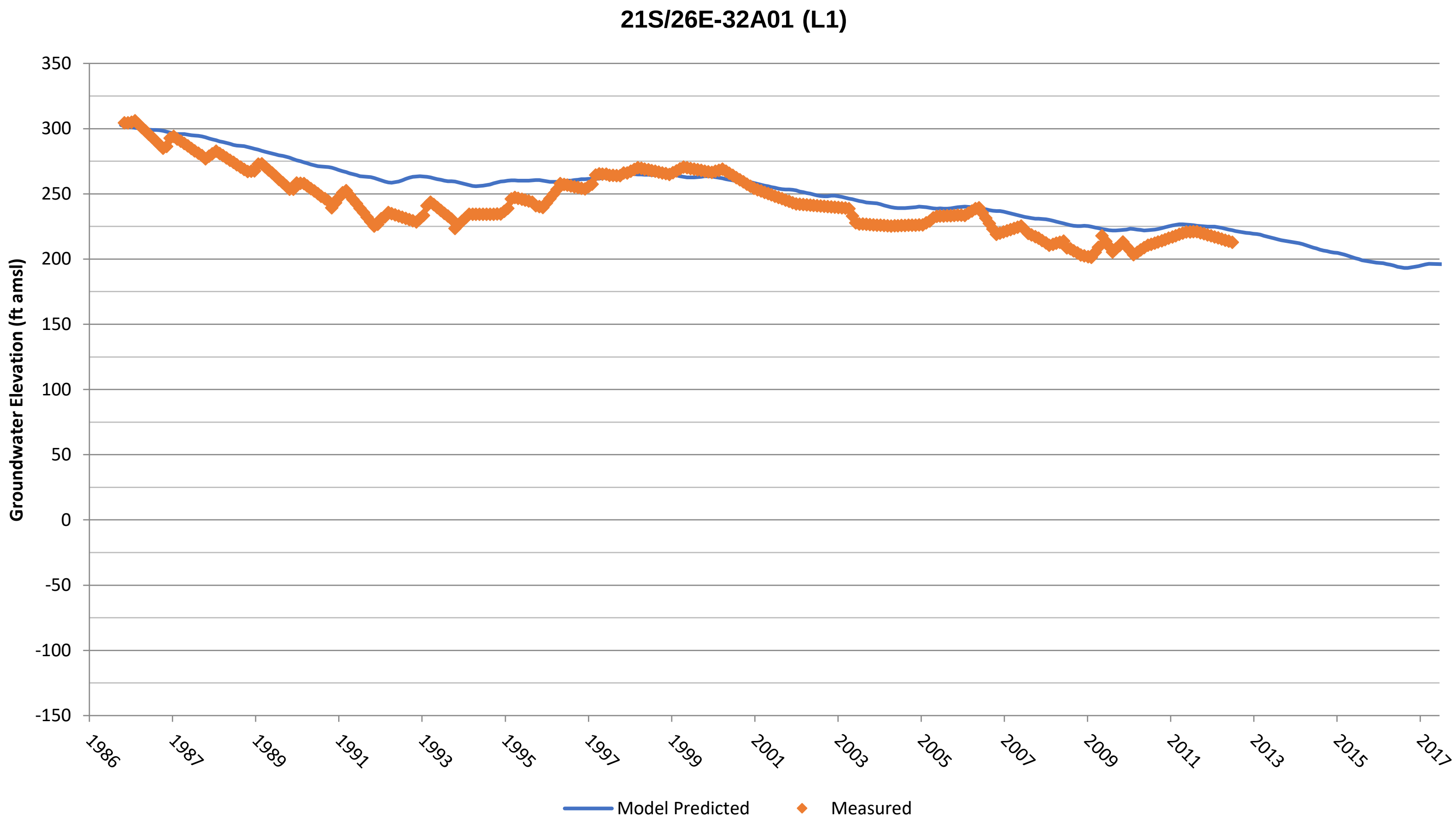
Model Calibration Hydrographs



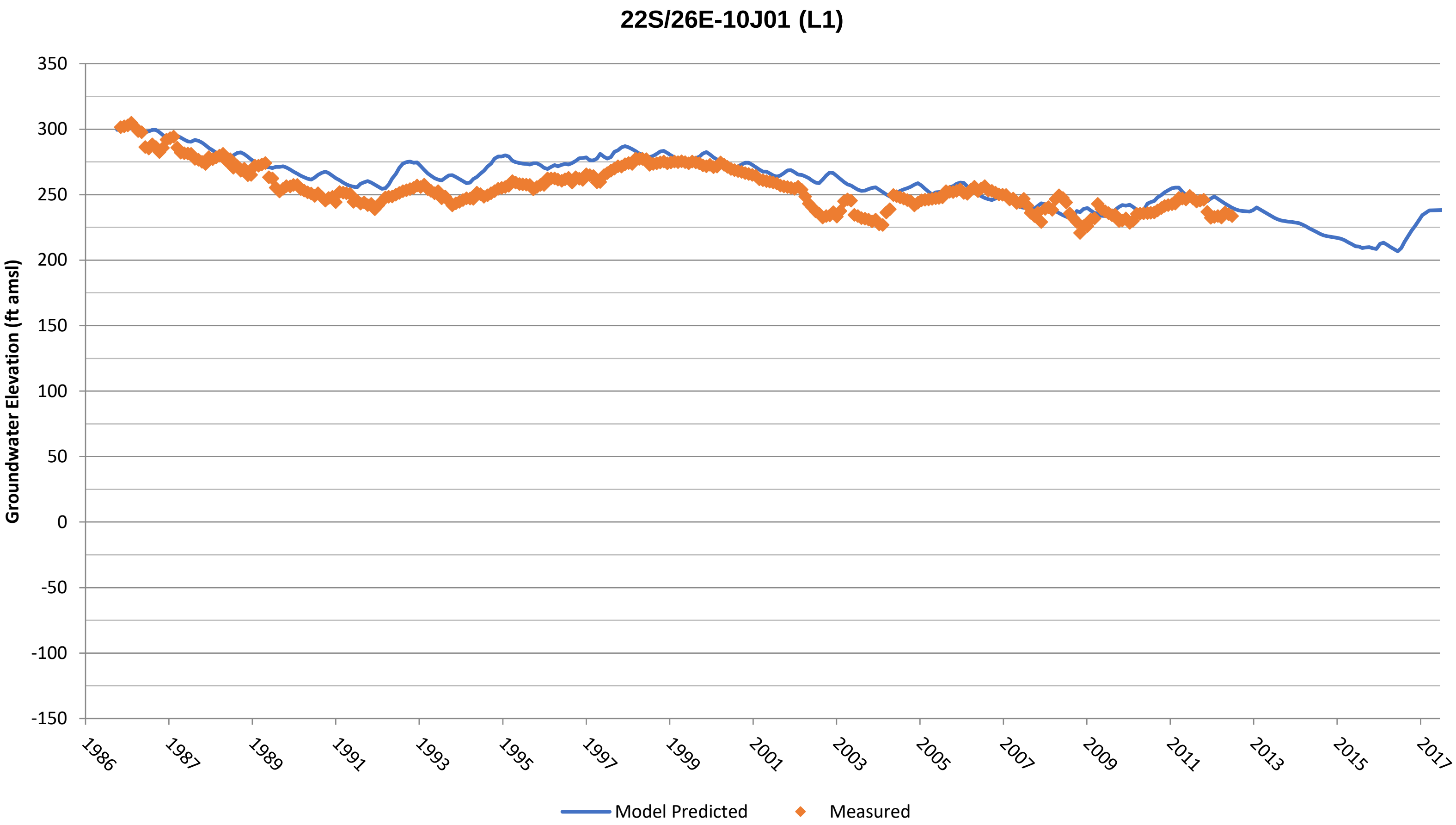
Model Calibration Hydrographs



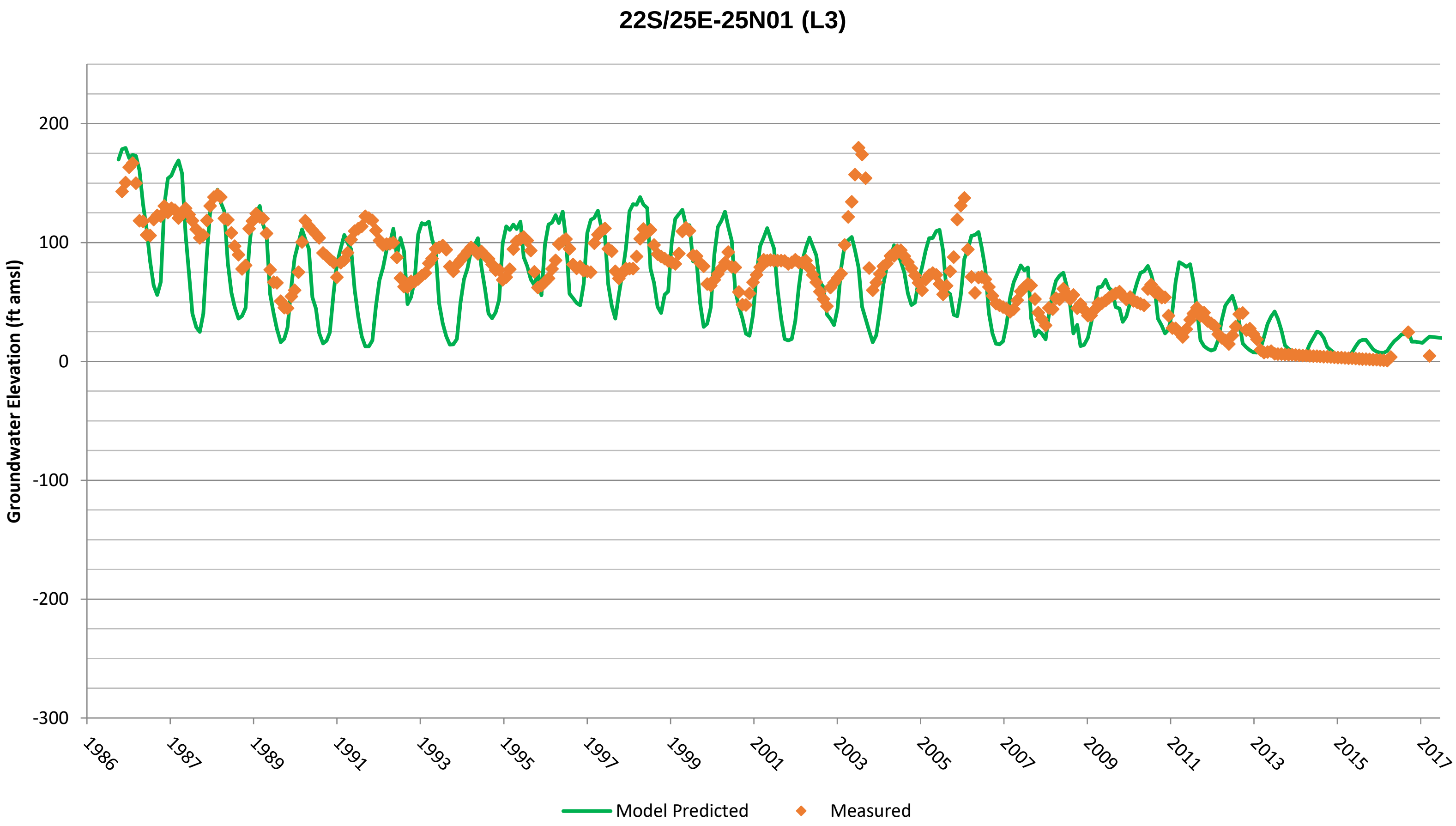
Model Calibration Hydrographs



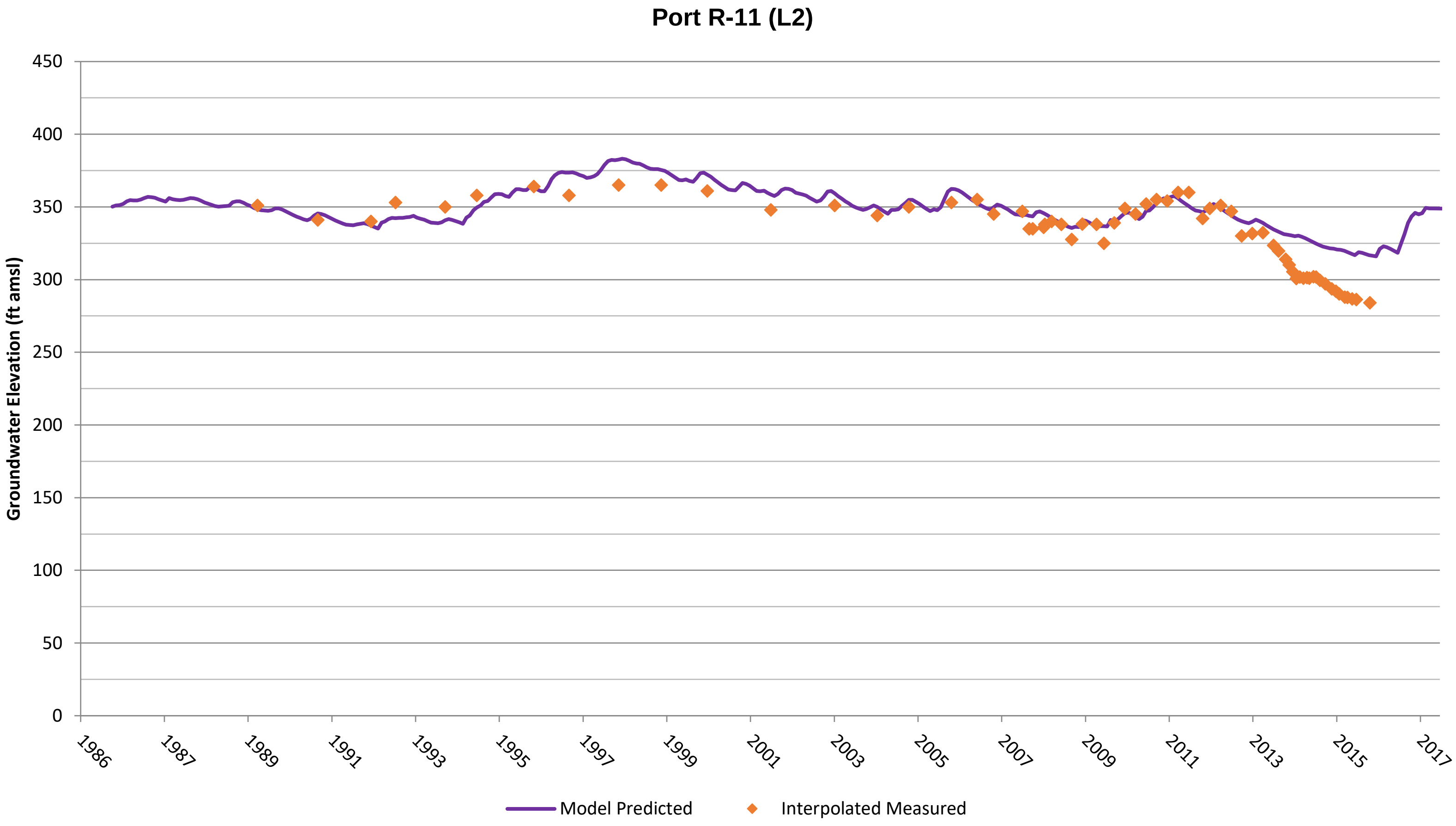
Model Calibration Hydrographs



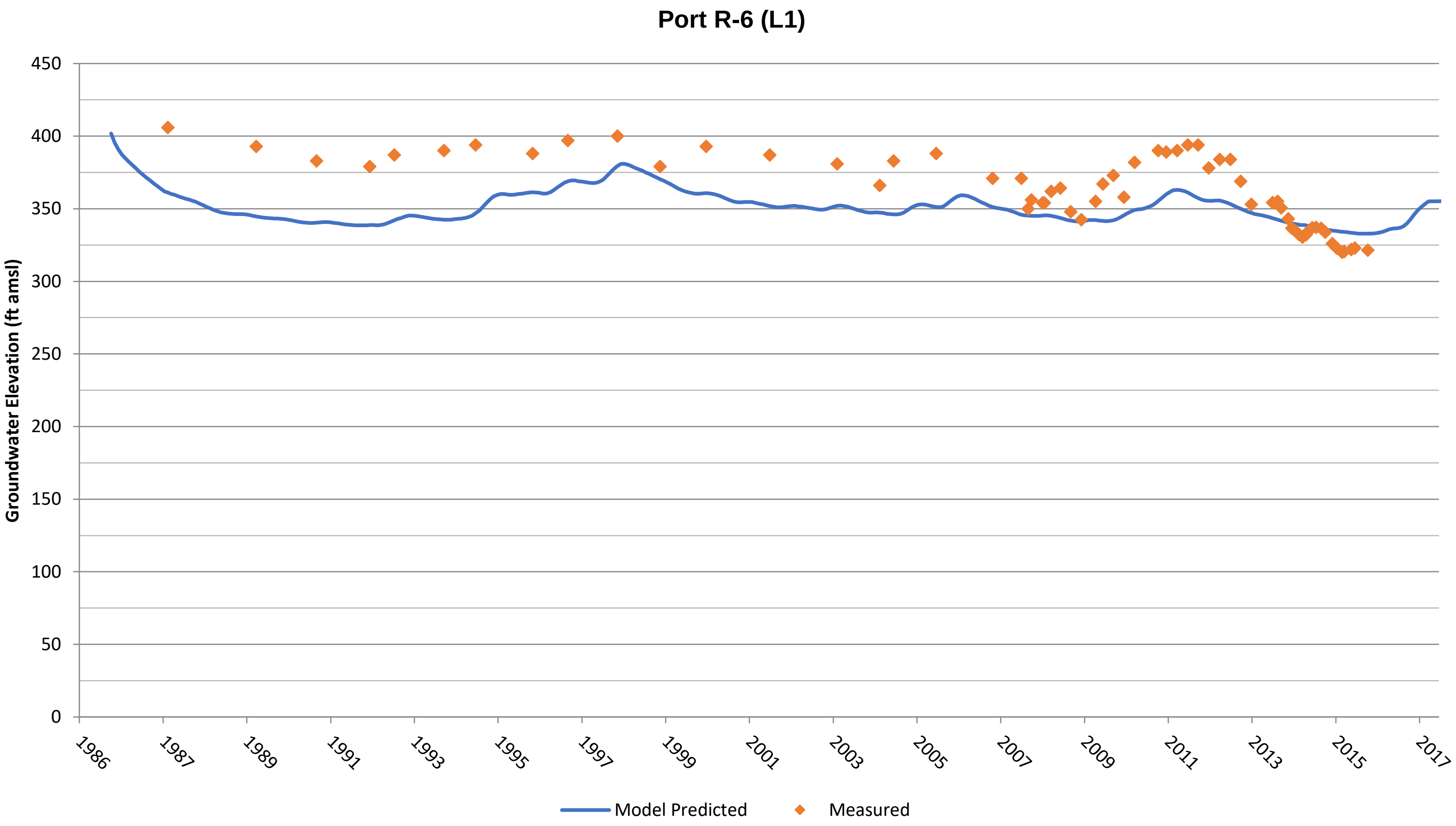
Model Calibration Hydrographs



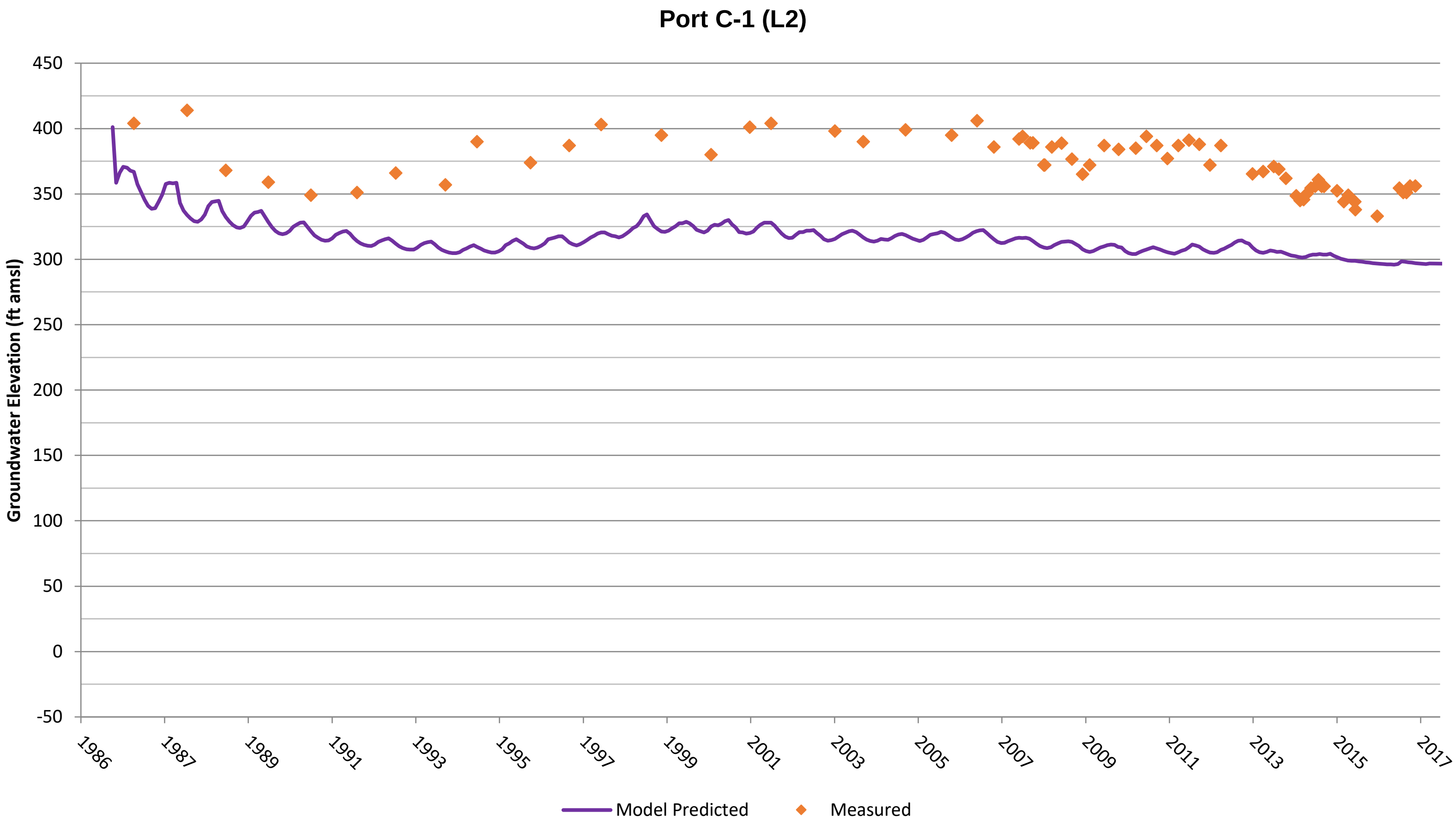
Model Calibration Hydrographs



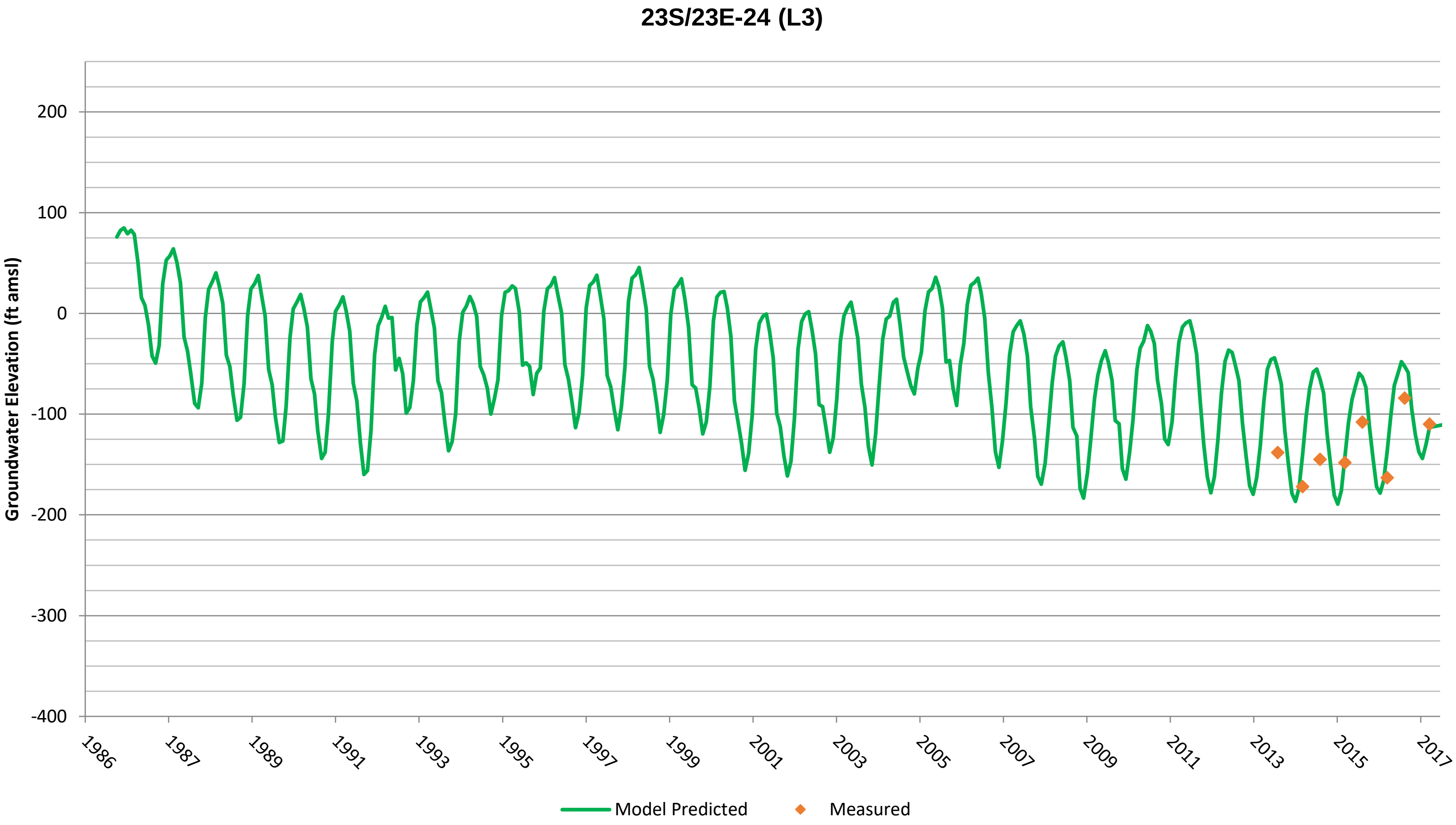
Model Calibration Hydrographs



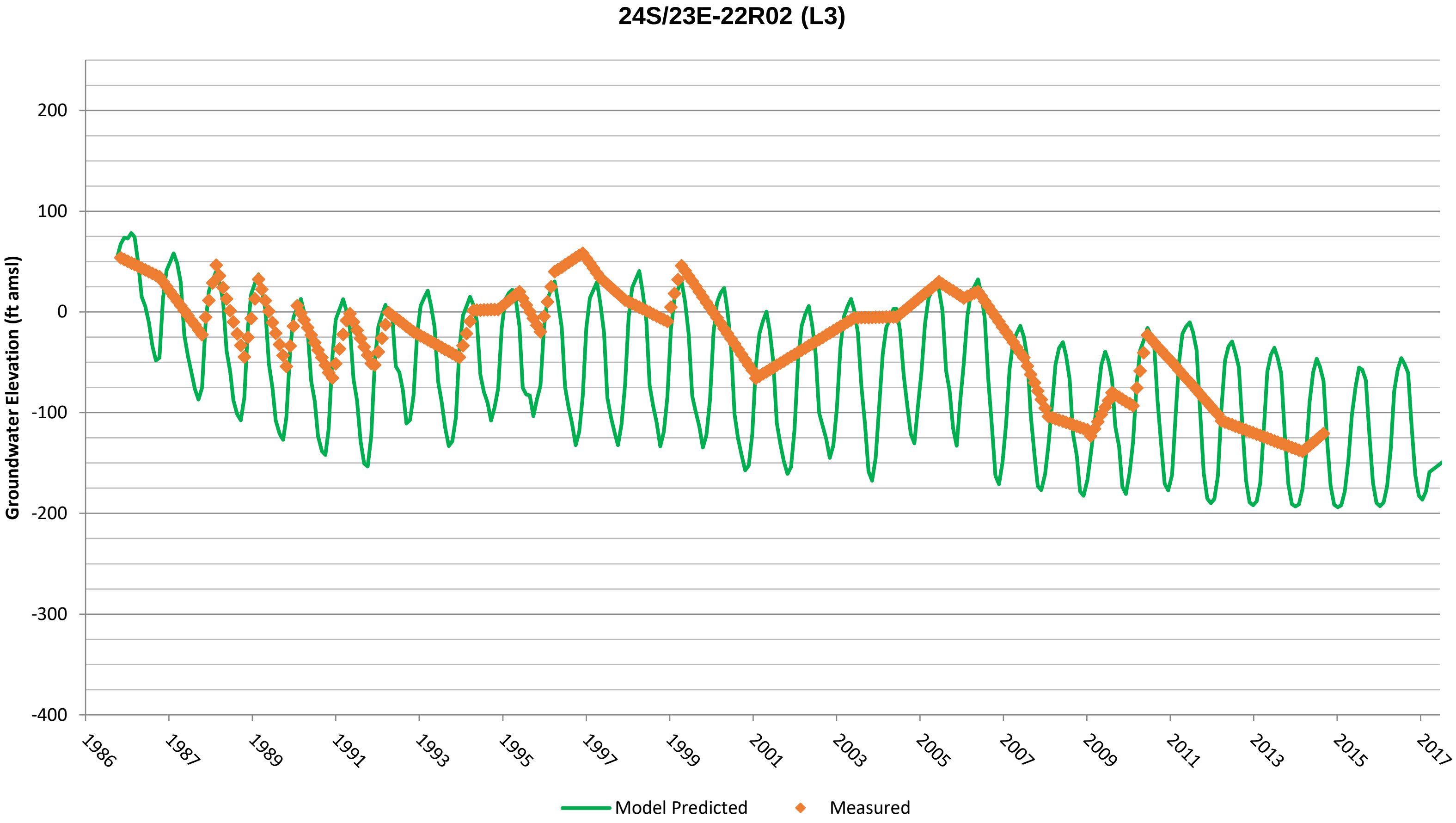
Model Calibration Hydrographs



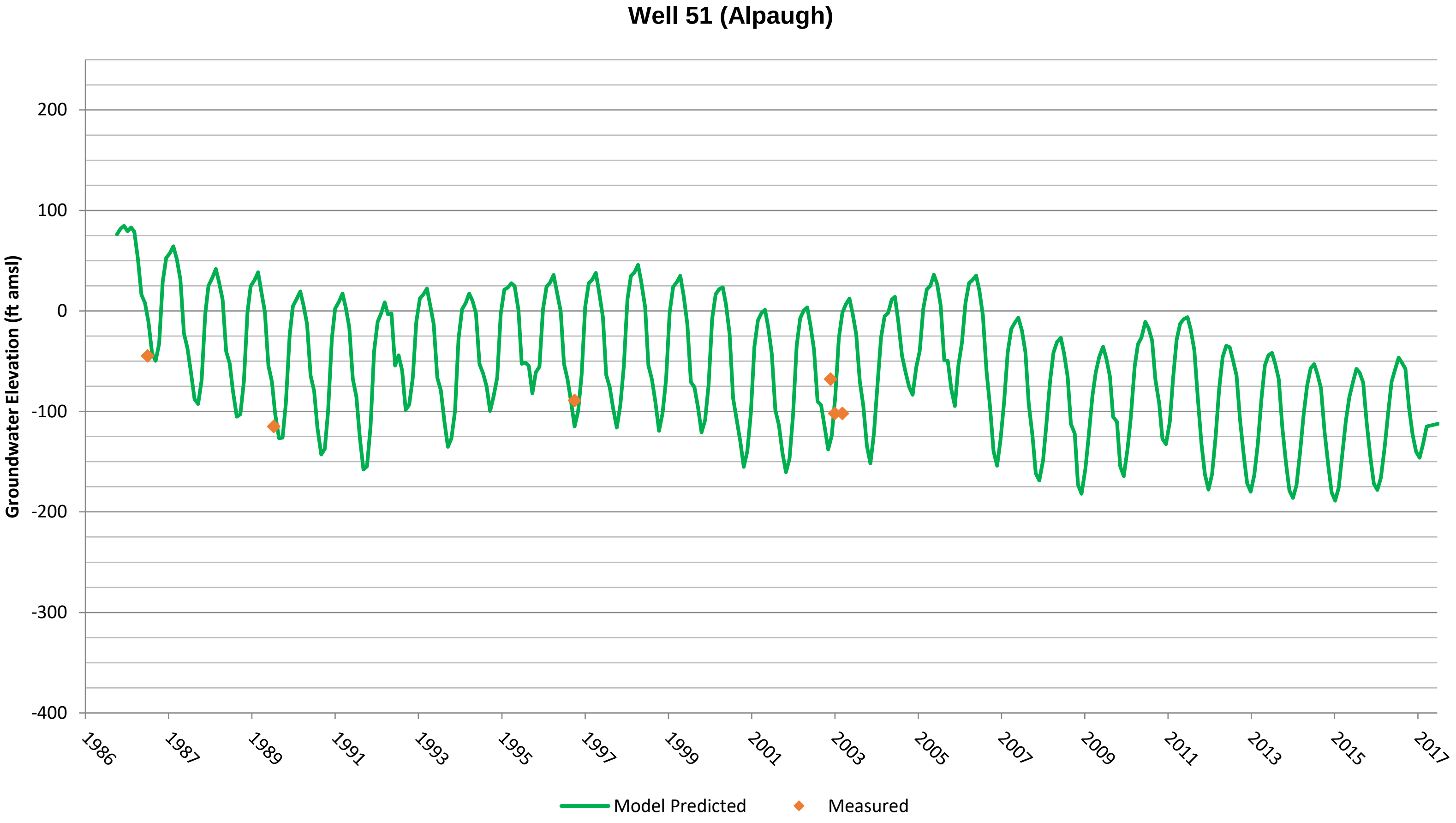
Model Calibration Hydrographs



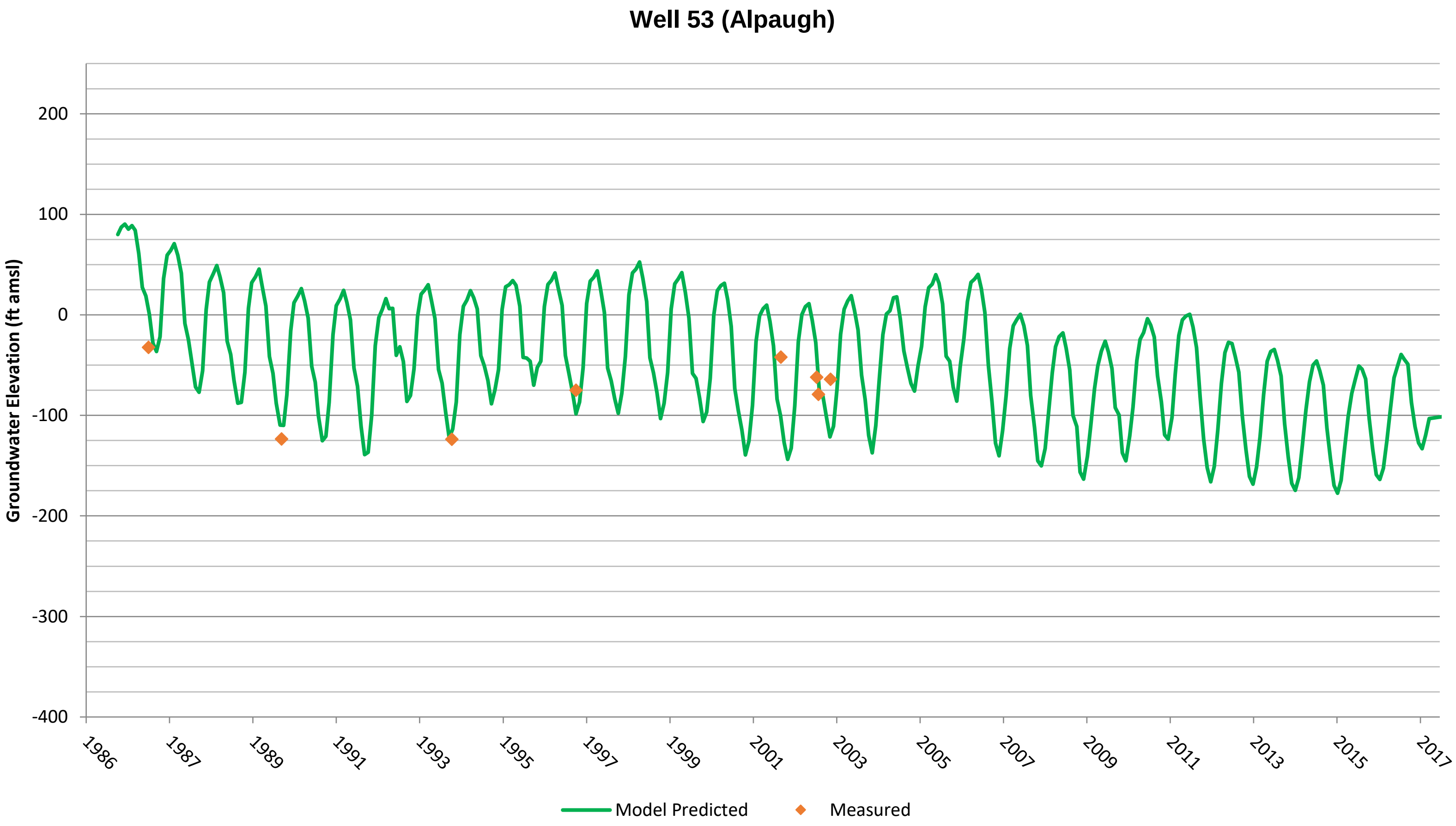
Model Calibration Hydrographs



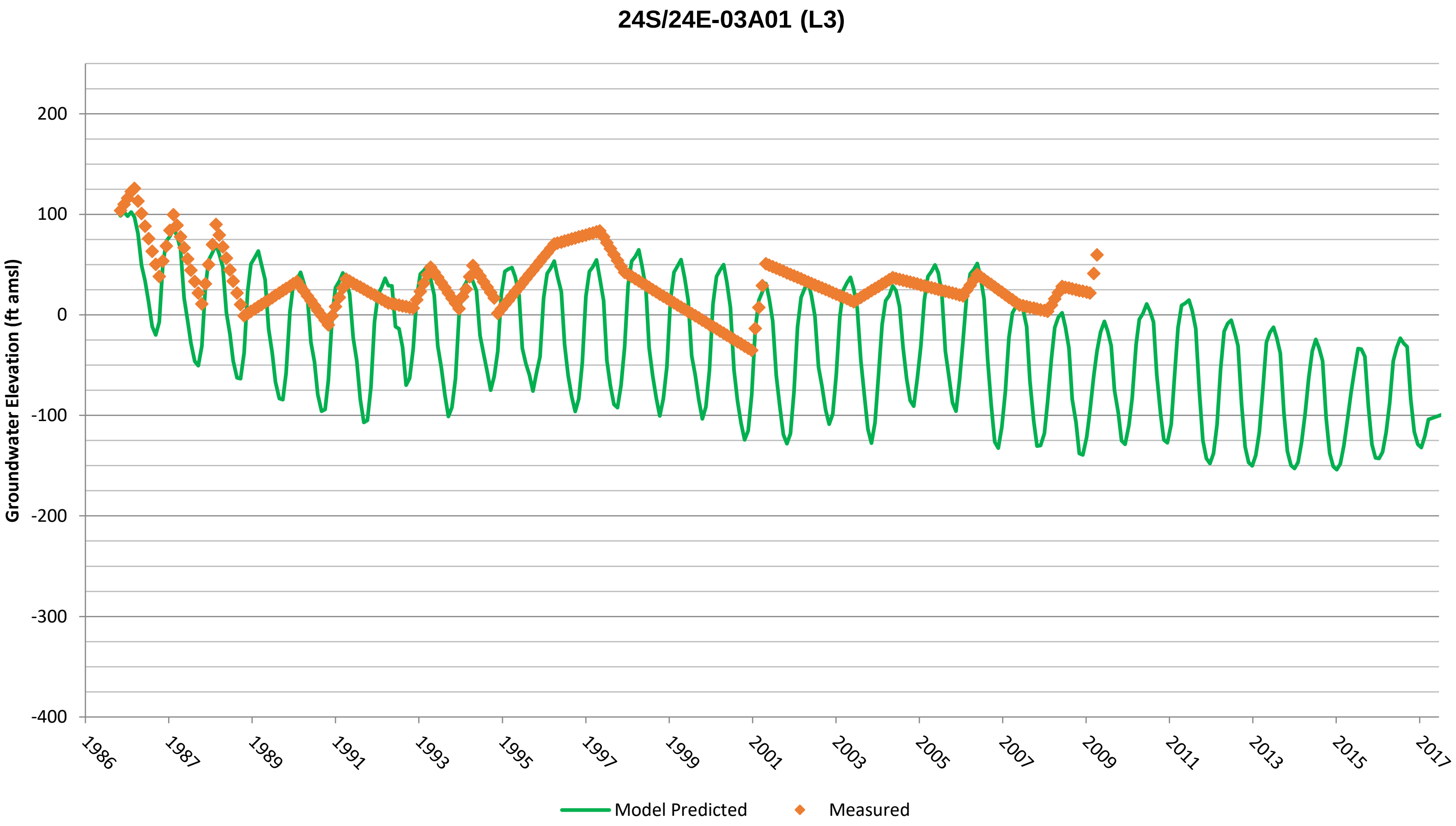
Model Calibration Hydrographs



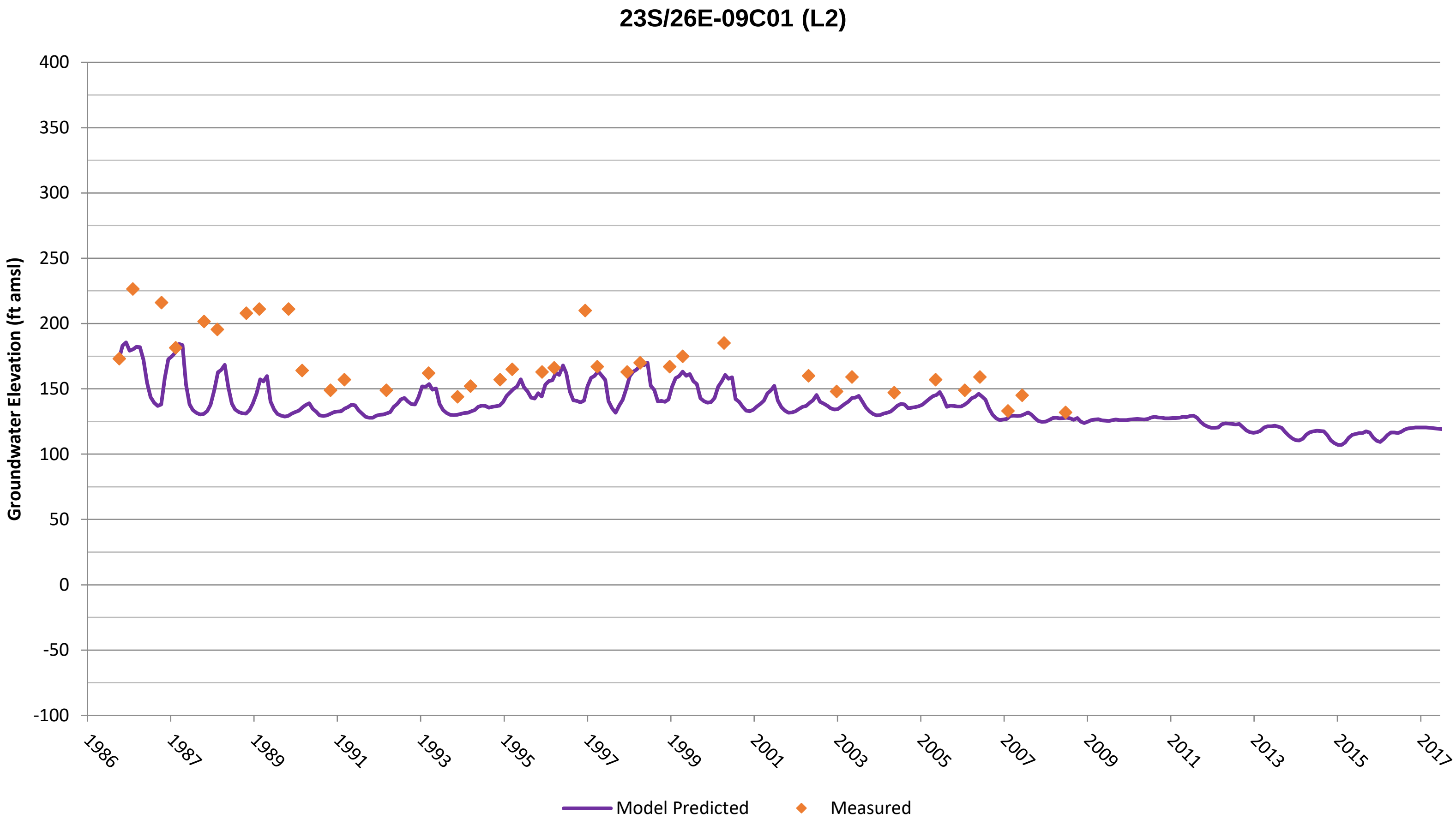
Model Calibration Hydrographs



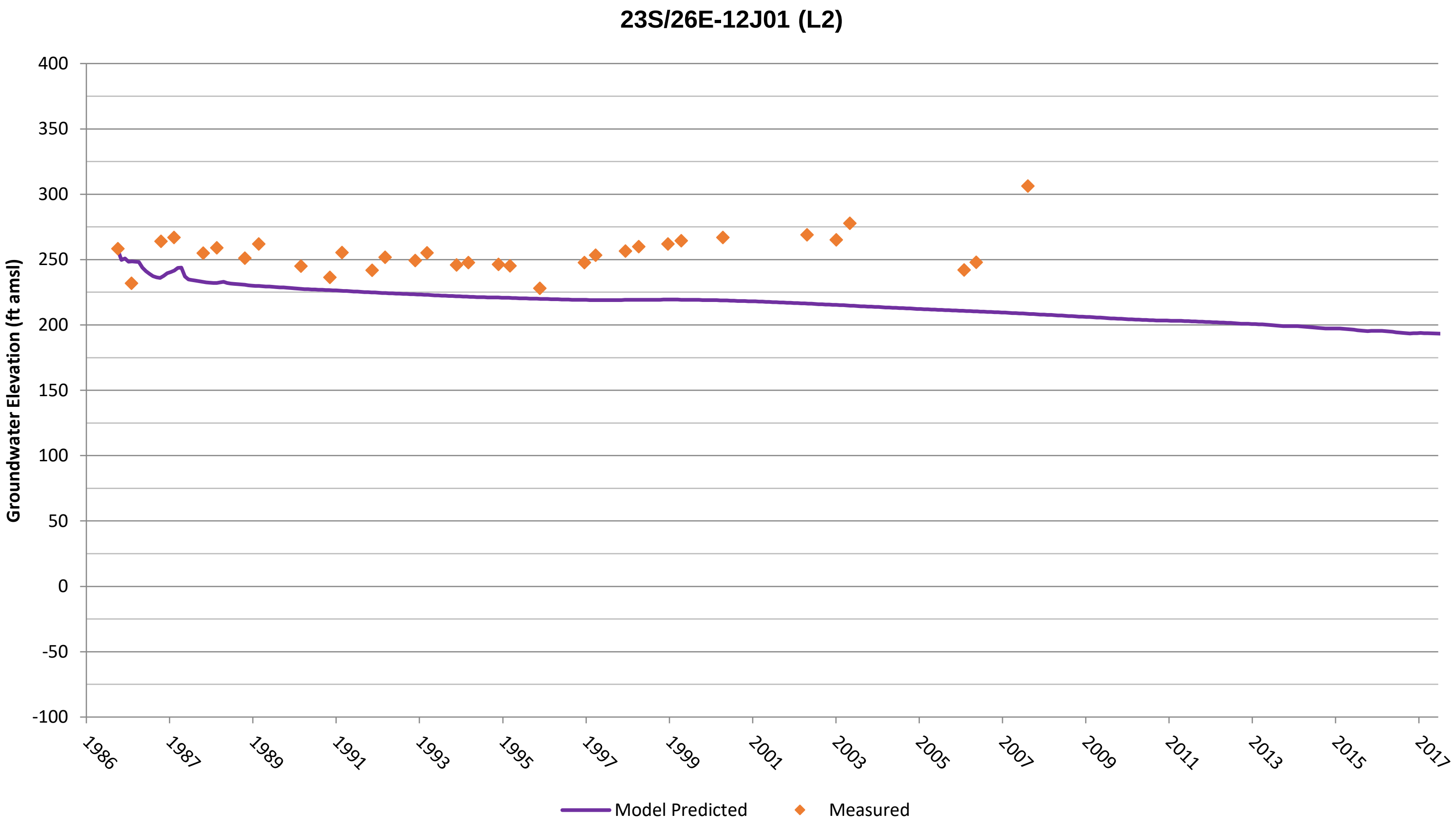
Model Calibration Hydrographs



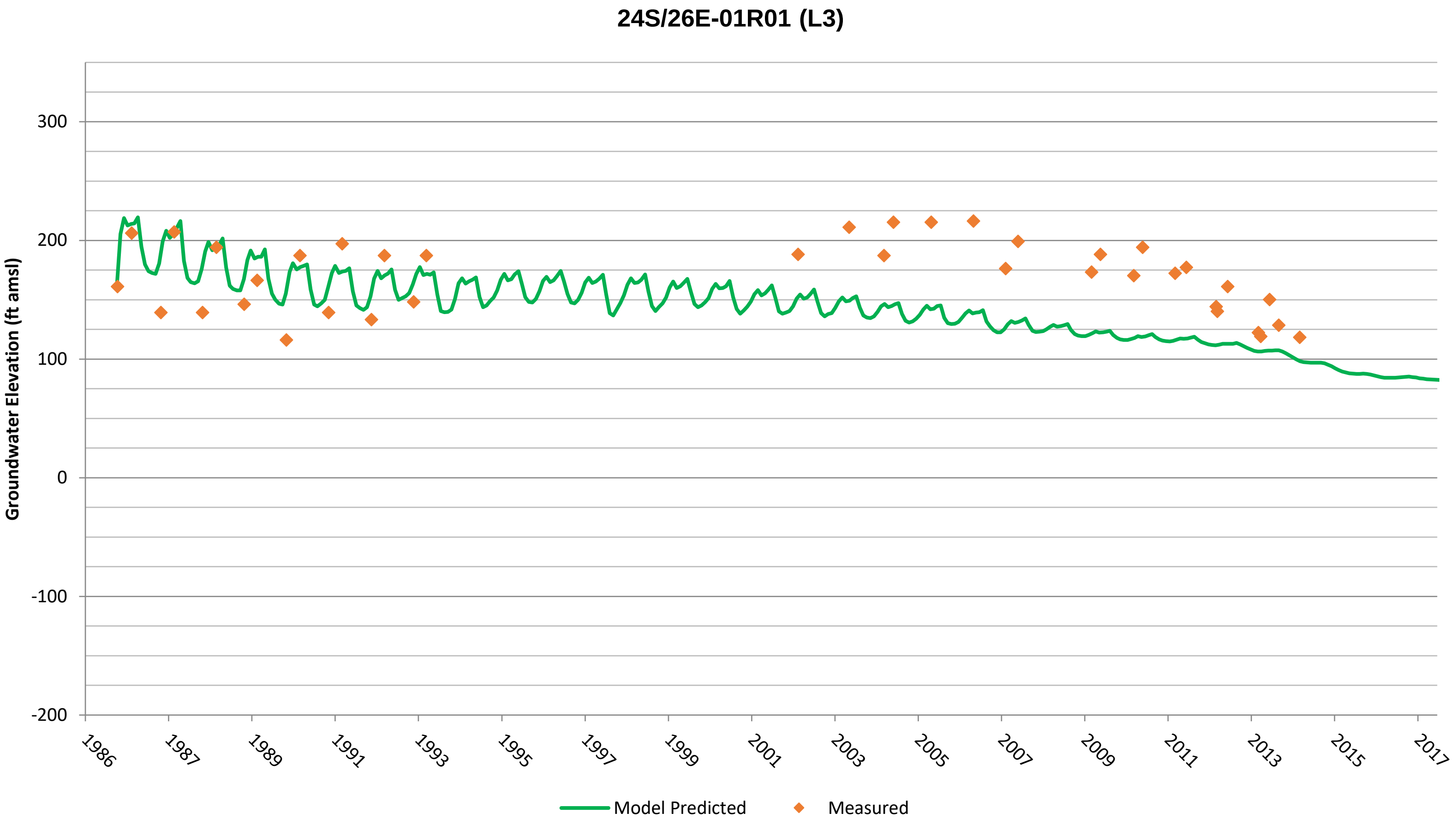
Model Calibration Hydrographs



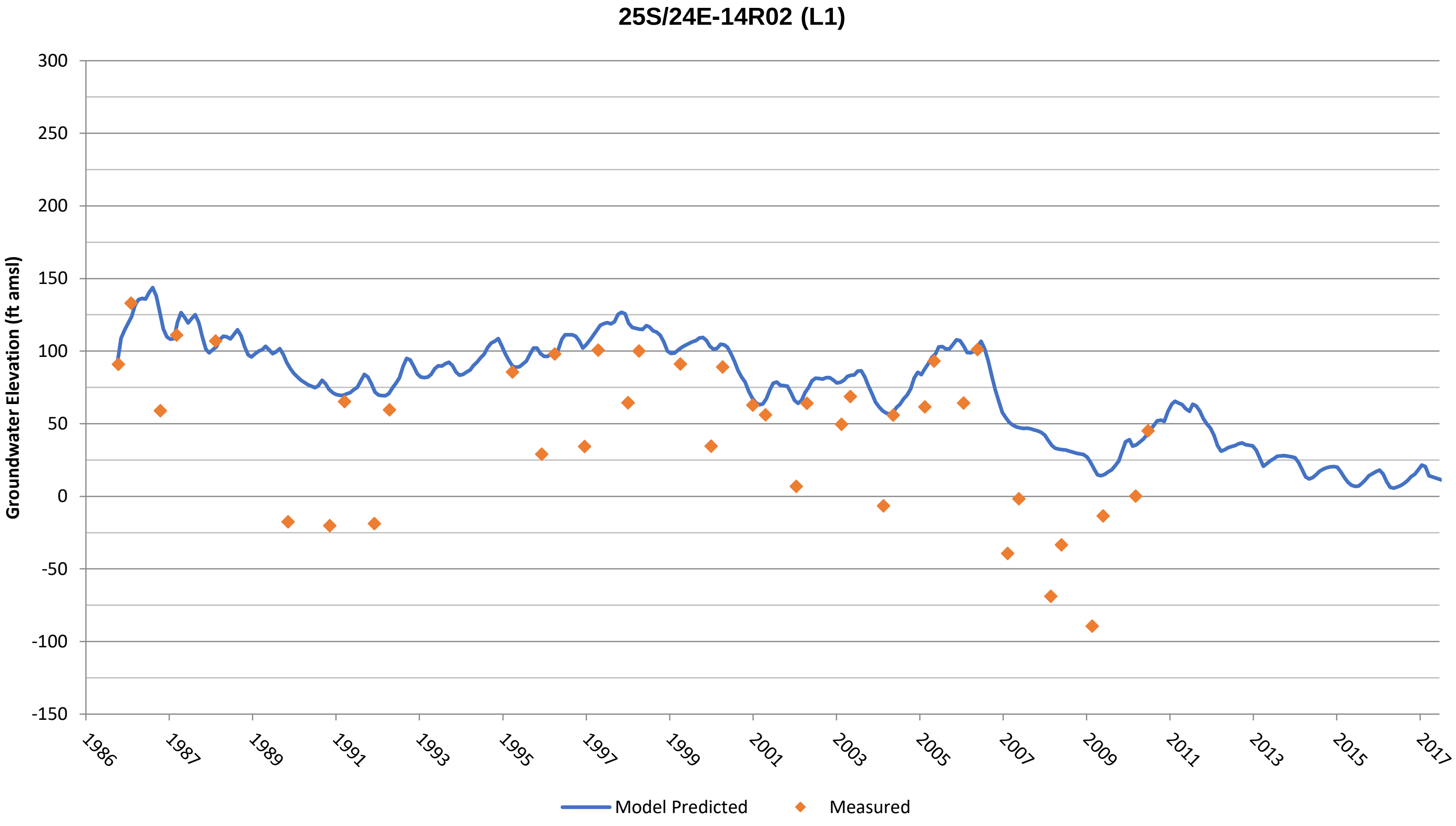
Model Calibration Hydrographs



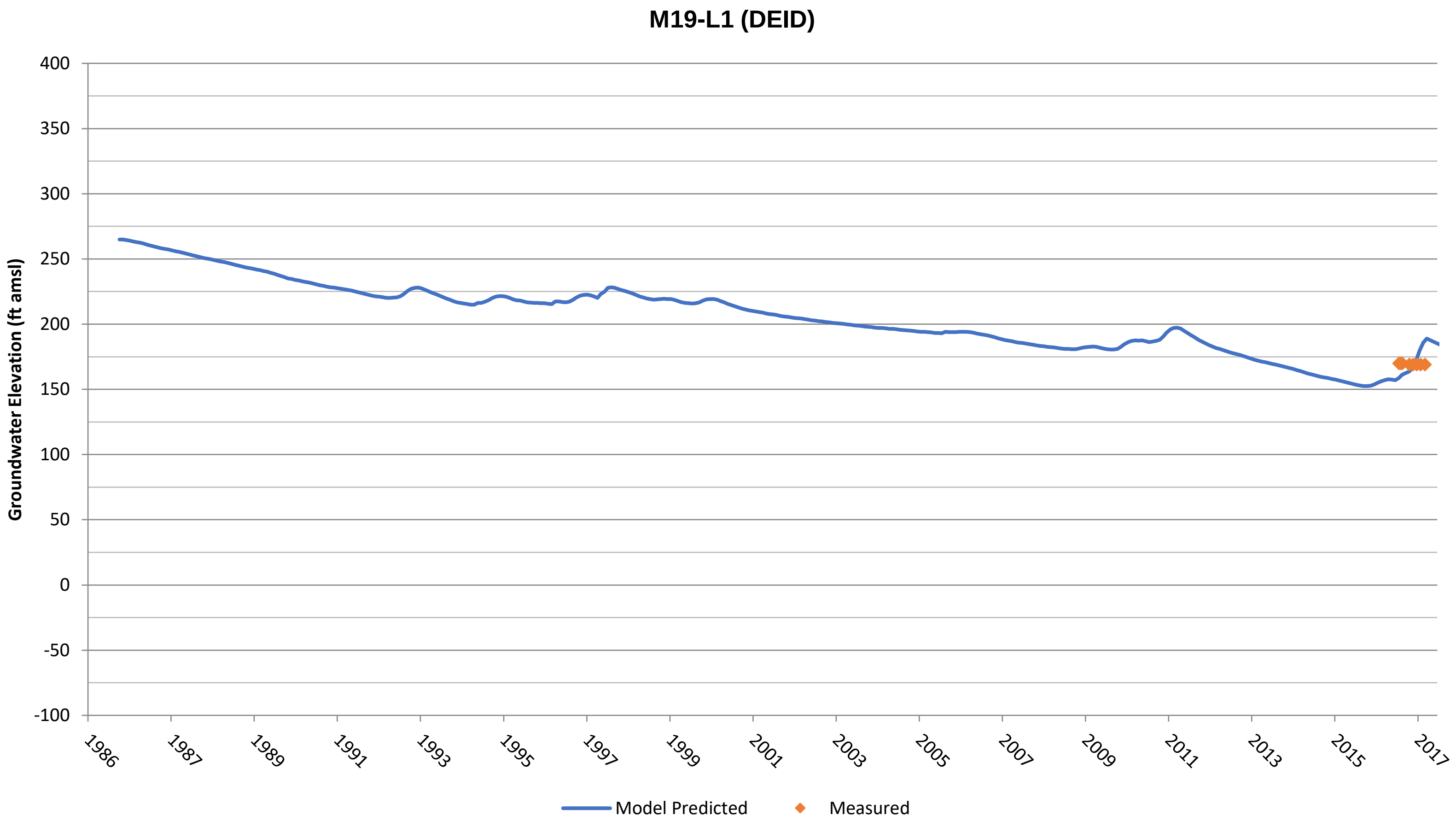
Model Calibration Hydrographs



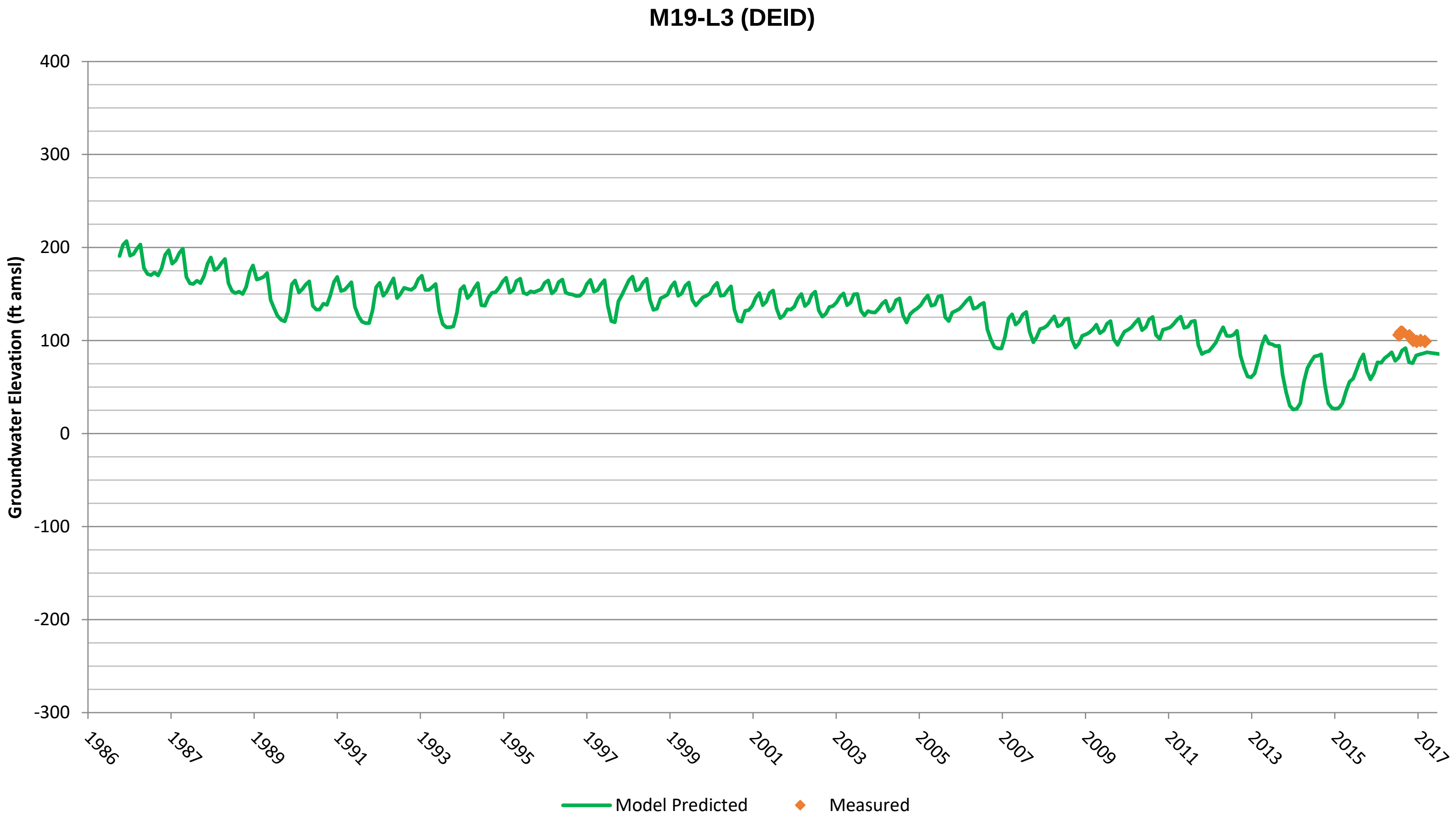
Model Calibration Hydrographs



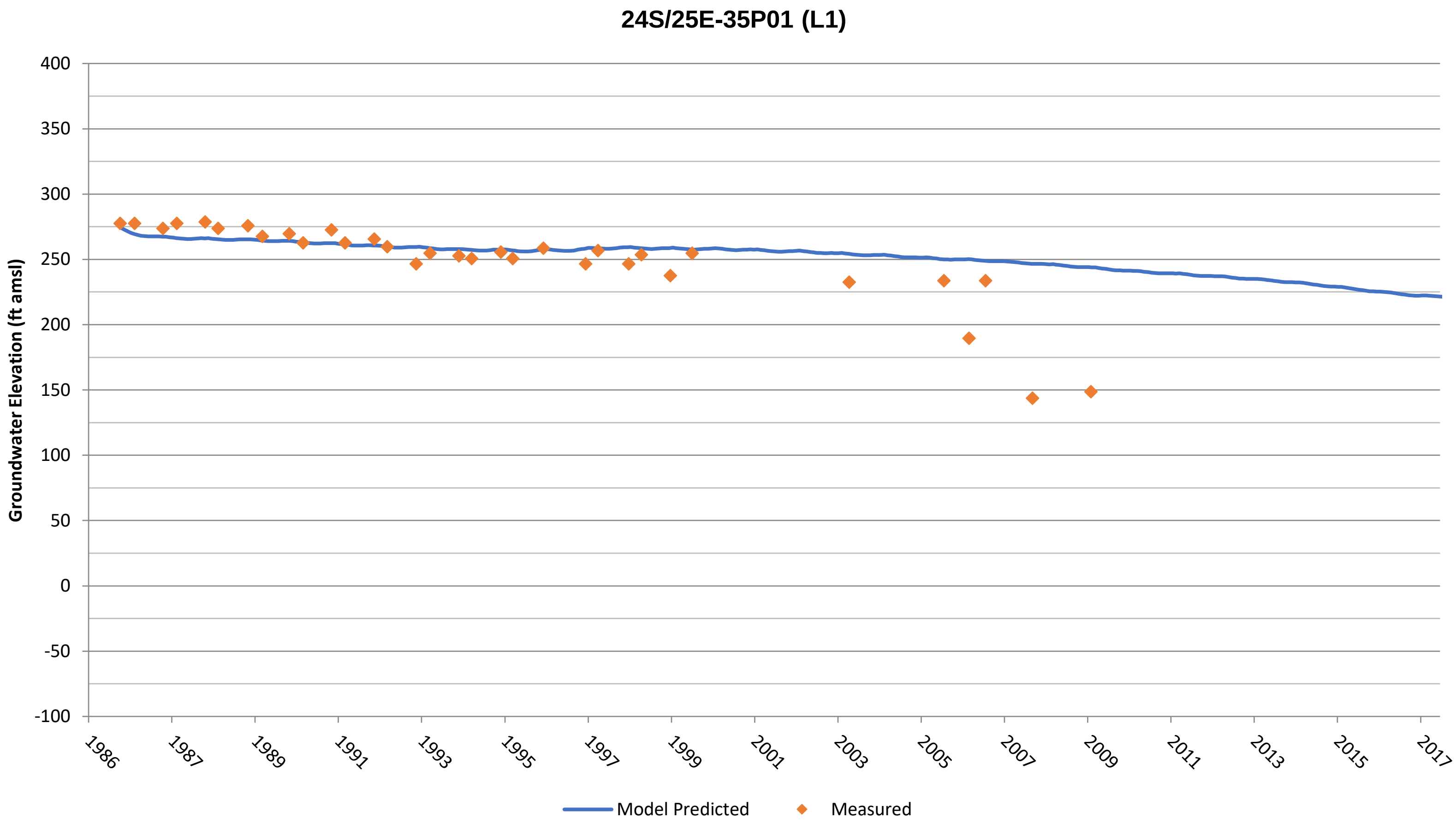
Model Calibration Hydrographs



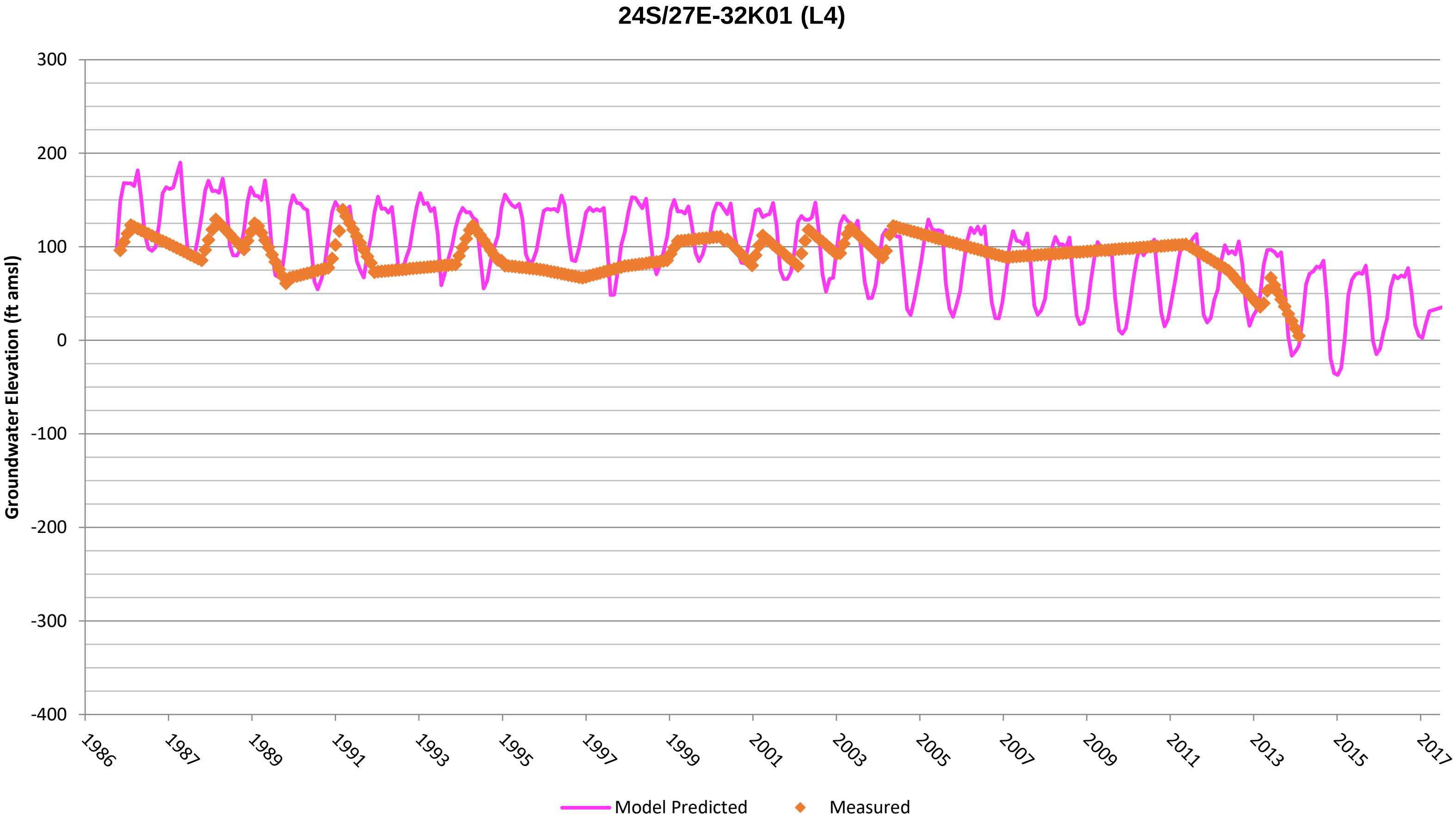
Model Calibration Hydrographs



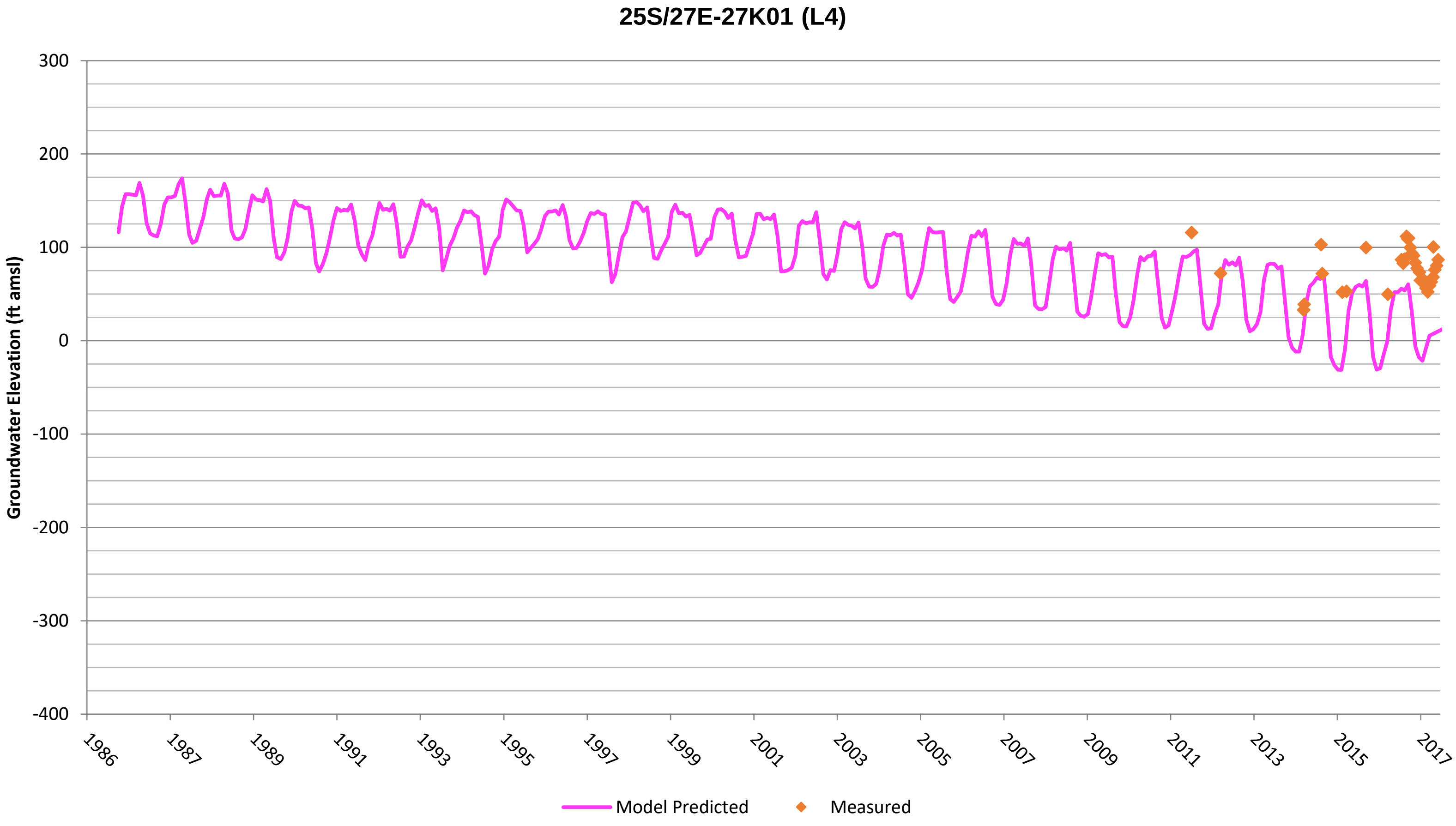
Model Calibration Hydrographs



Model Calibration Hydrographs



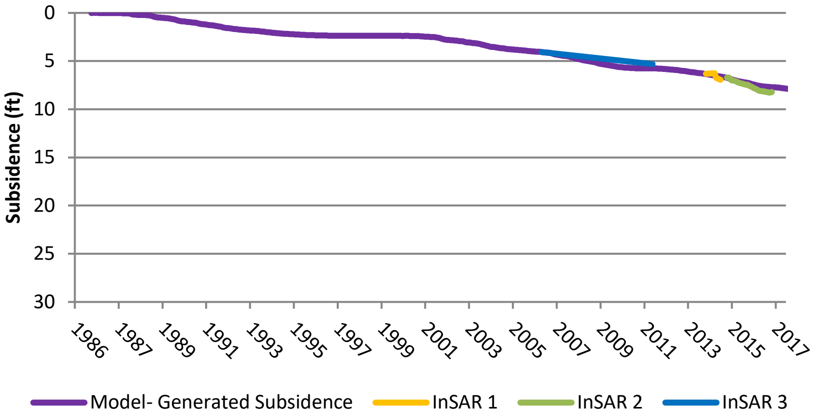
Model Calibration Hydrographs

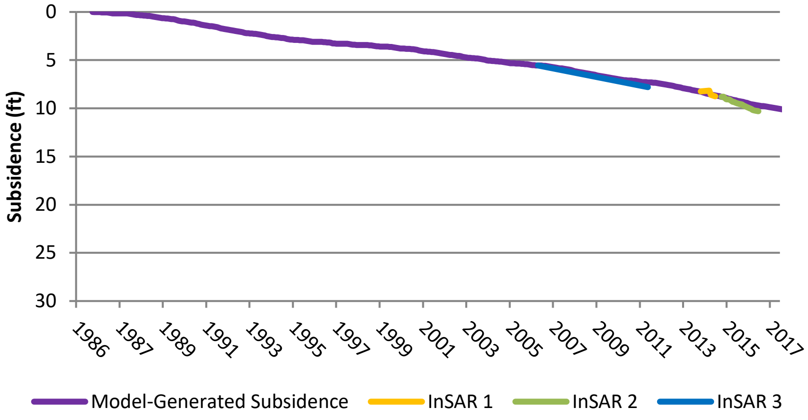


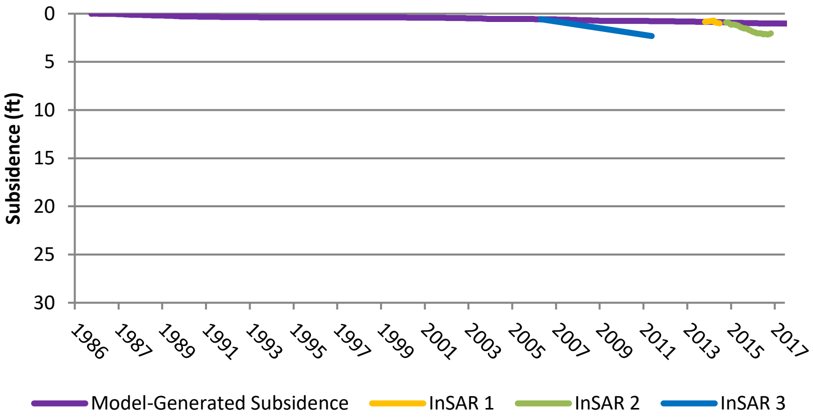
Appendix E

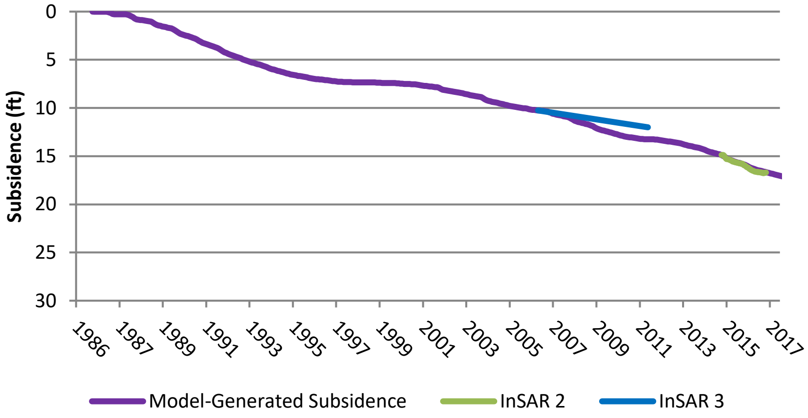
Land Subsidence Calibration Graphs

Land Subsidence Calibration Graphs

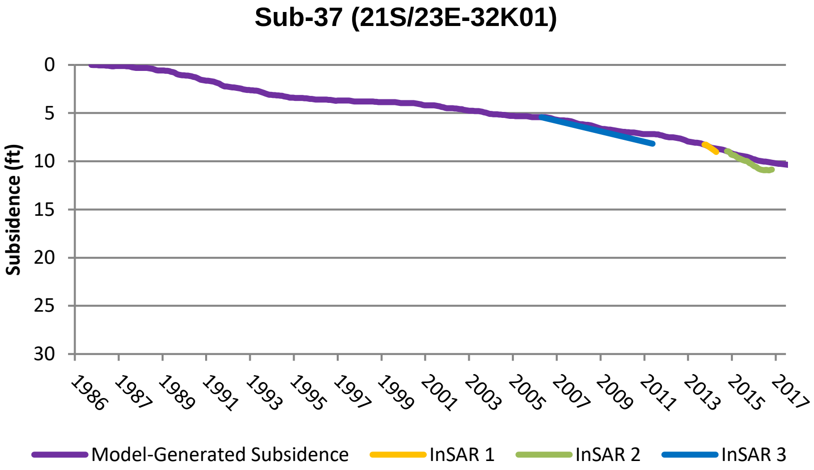

Sub-28

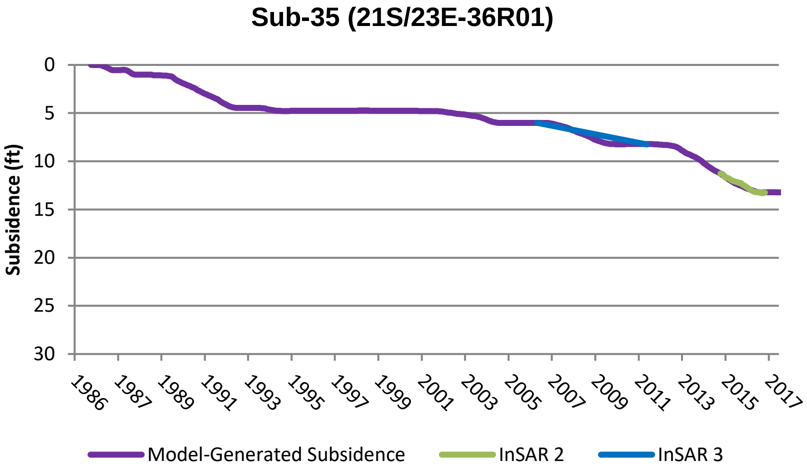

Sub-23

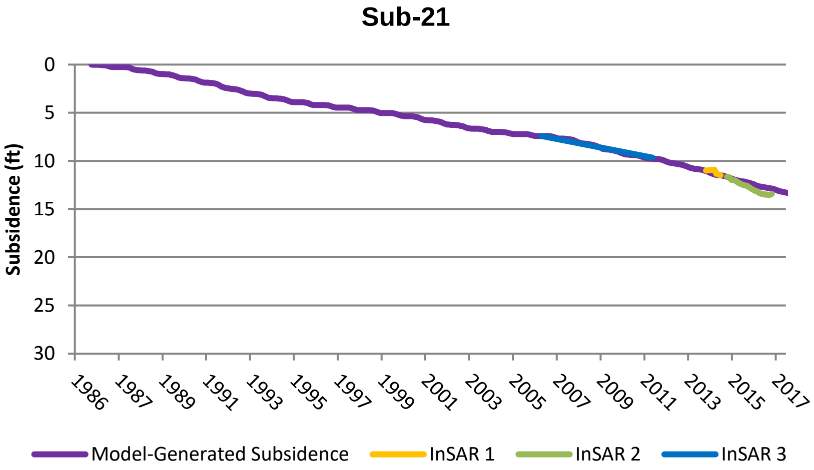

Sub-29

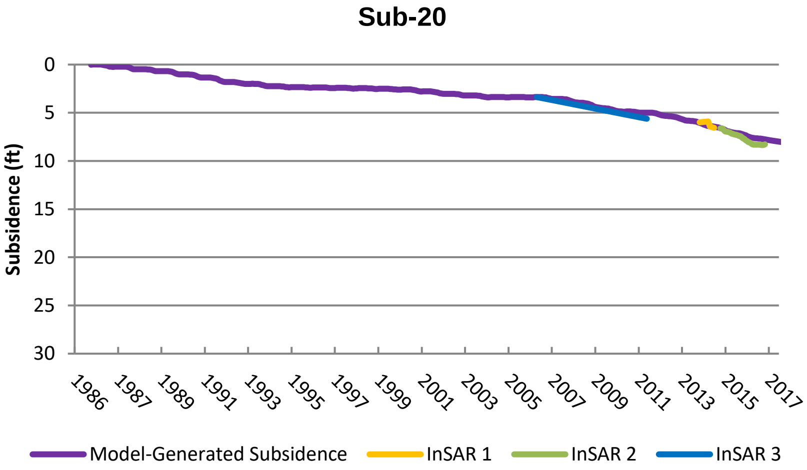

Sub-3

Land Subsidence Calibration Graphs



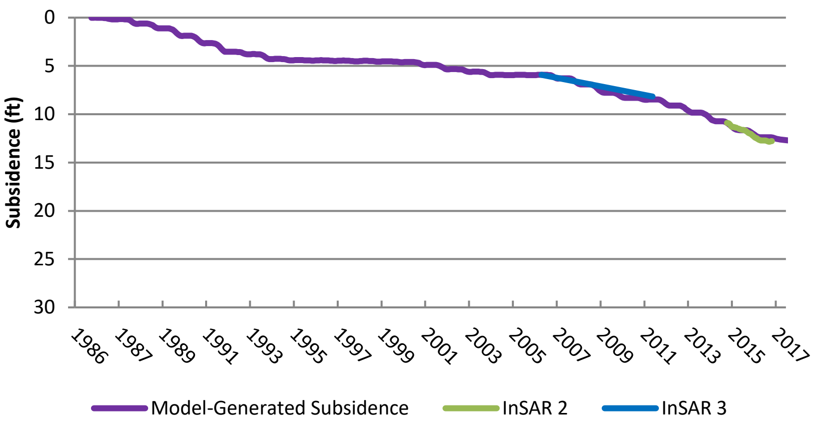




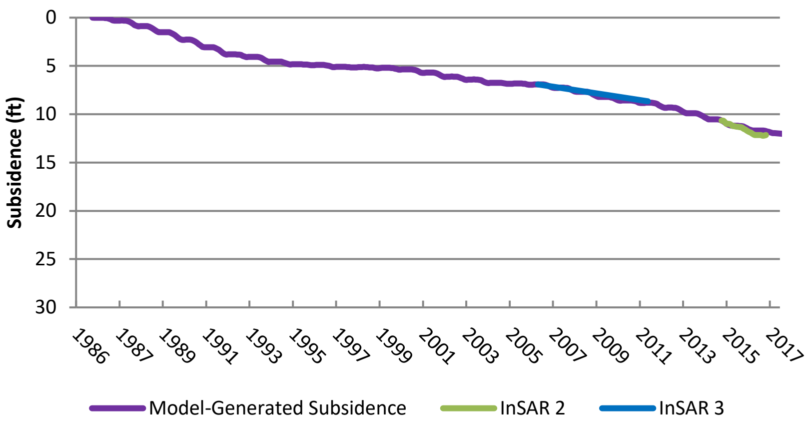


Land Subsidence Calibration Graphs

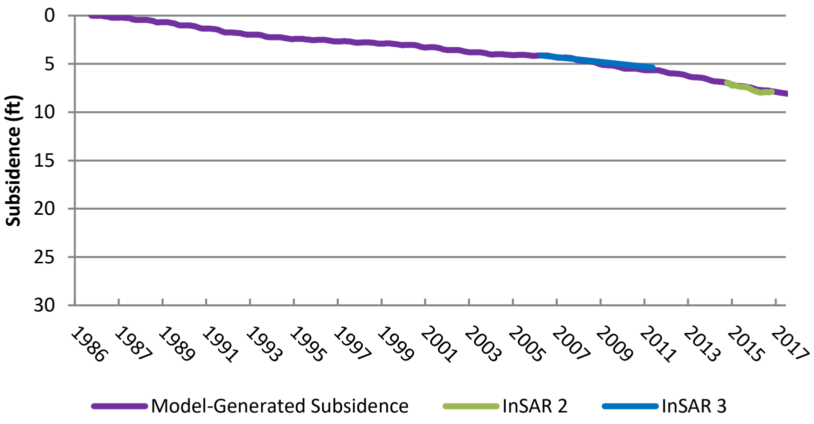
Sub-1



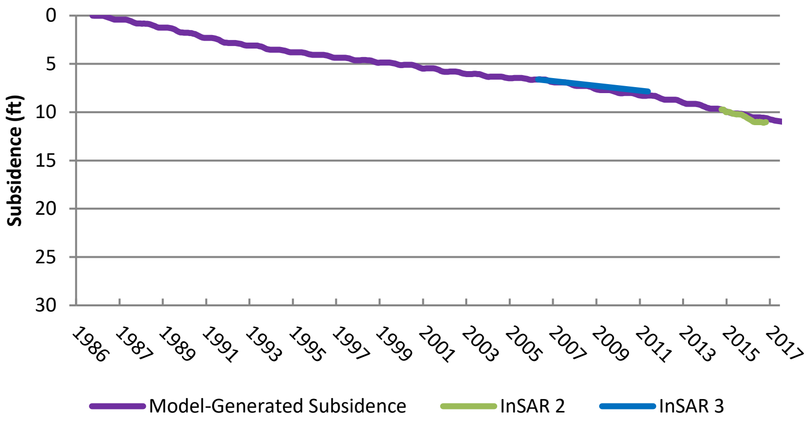
Sub-18



Sub-19



Sub-30 (24S/24E-03A01)



Land Subsidence Calibration Graphs