Update on the Status of Hydrogeological Work in the Tule Subbasin in Support of SGMA Compliance

May 3, 2018

Prepared for:
Eastern Tule Groundwater Sustainability Agency

Thomas Harder & Co.
Groundwater Consulting

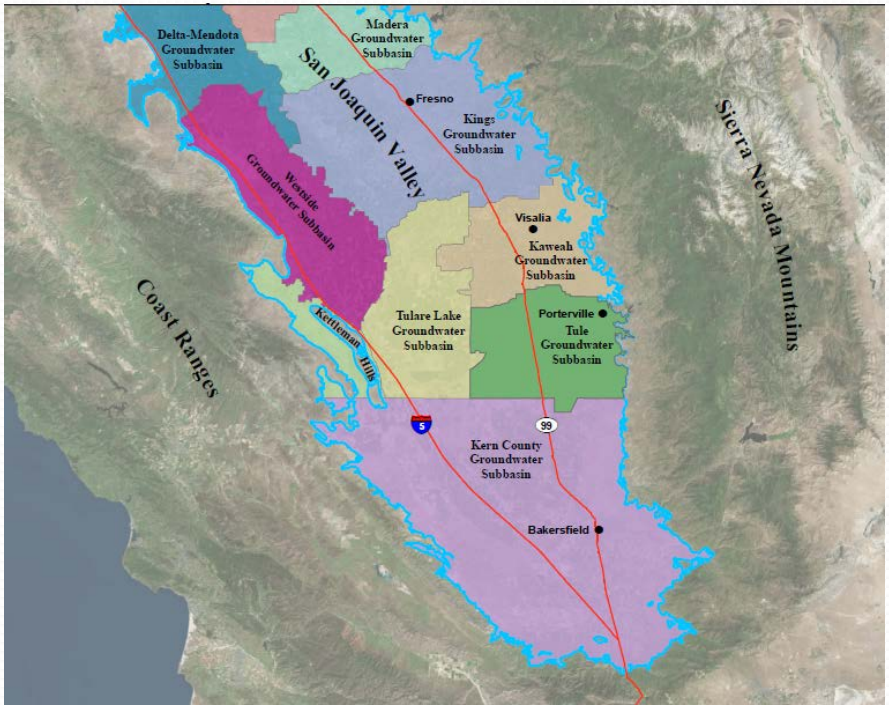
Presentation Overview

- Short History of Our Involvement in the Tule Subbasin
- Work Conducted to Date
  - Hydrogeological Conceptual Model
  - Preliminary Detailed Water Budget
  - Preliminary Estimate of Sustainable Yield
- Work in Progress – Groundwater Flow Model
- Next Steps

Ultimate Objective – Basin Sustainability

Sustainable Yield:

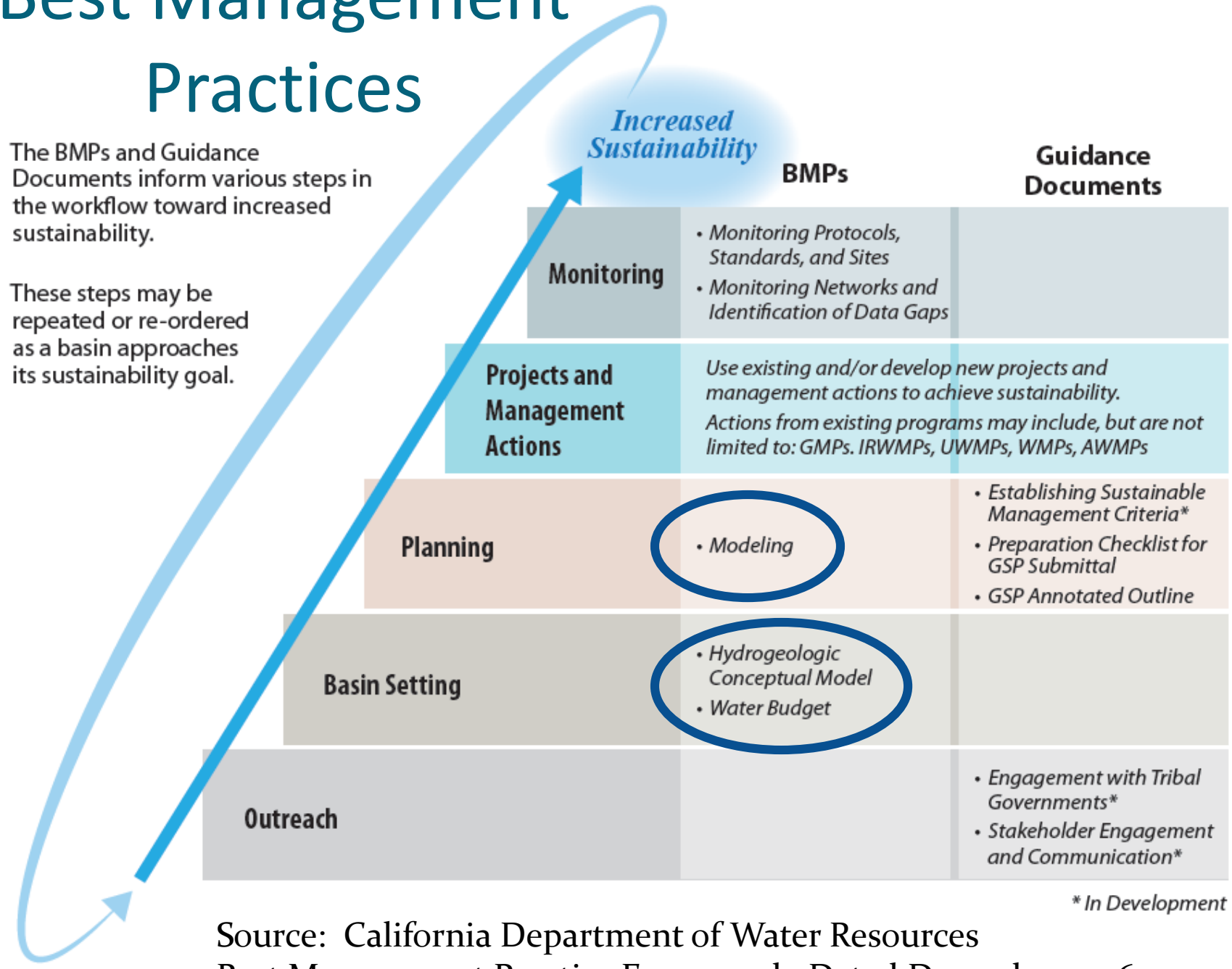
The maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.



Best Management Practices

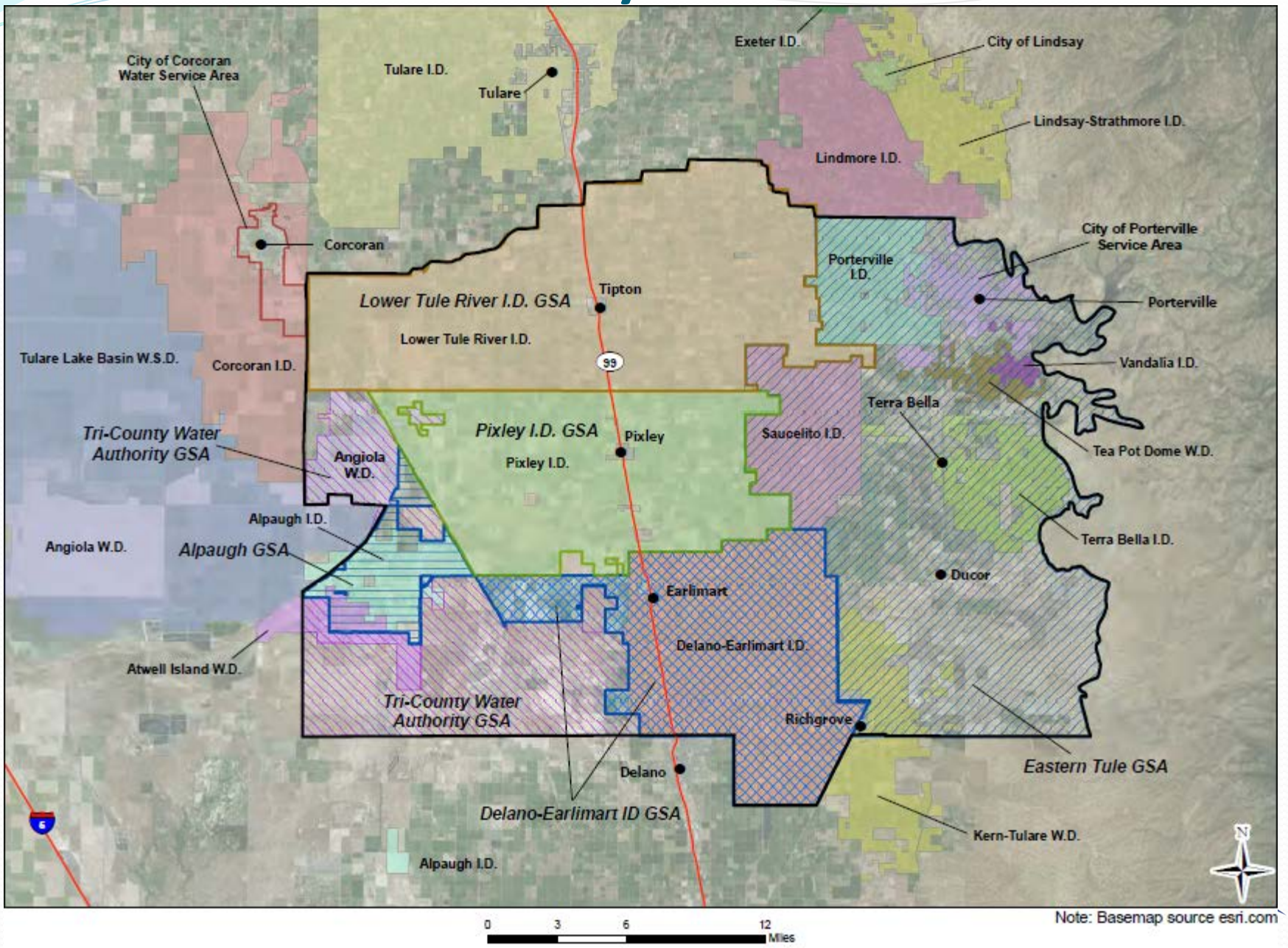
The BMPs and Guidance Documents inform various steps in the workflow toward increased sustainability.

These steps may be repeated or re-ordered as a basin approaches its sustainability goal.

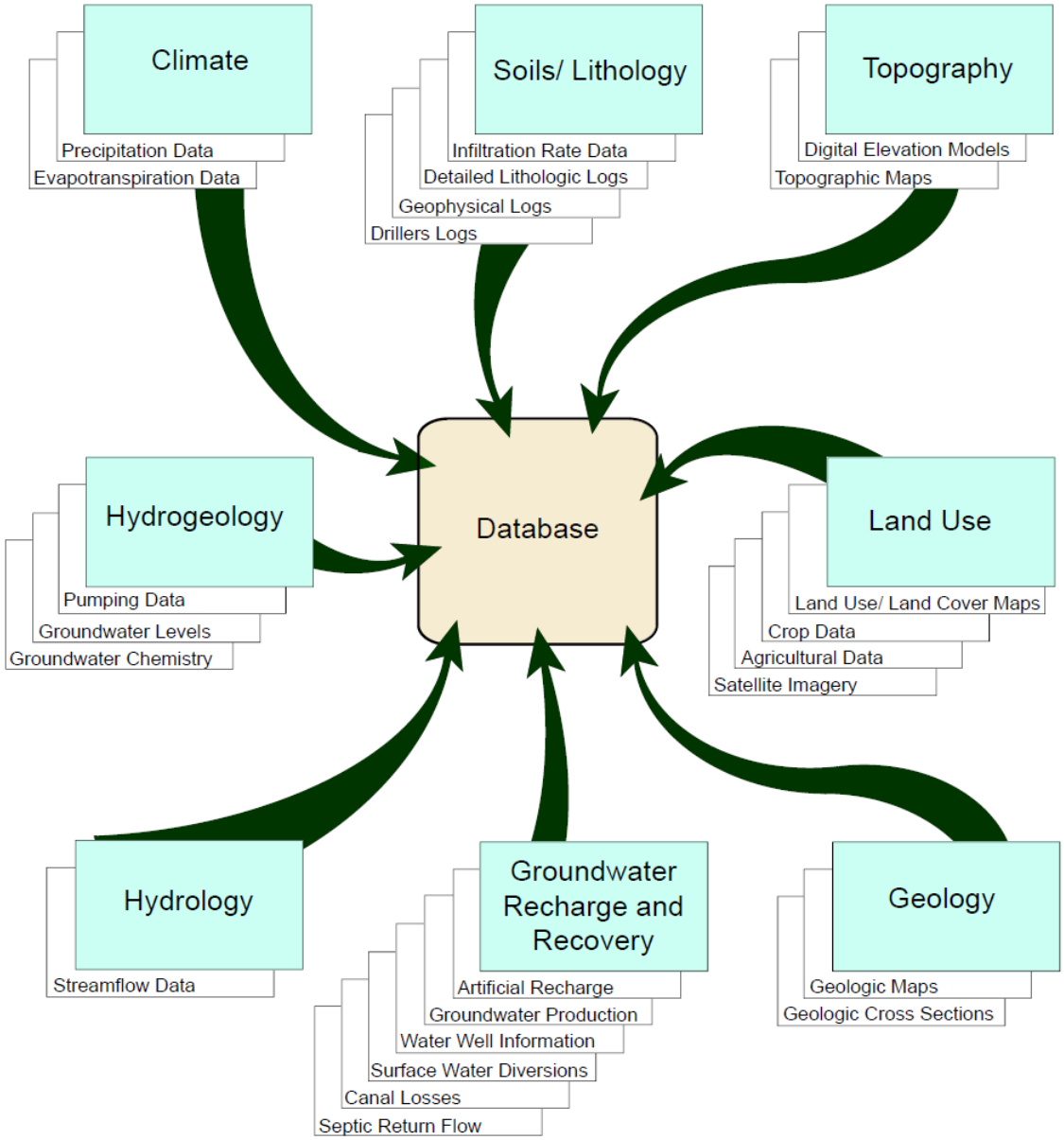


Source: California Department of Water Resources
Best Management Practice Framework, Dated December 2016

Study Area


City of Corcoran Water Service Area
Tulare I.D.
Tulare
Exeter I.D.
City of Lindsay
Lindsay-Strathmore I.D.
Lindmore I.D.
City of Porterville Service Area
Porterville I.D.
Porterville
Corcoran
Lower Tule River I.D. GSA
Tipton
Lower Tule River I.D.
Tulare Lake Basin W.S.D.
Corcoran I.D.
99
Vandalia I.D.
Terra Bella
Tri-County Water Authority GSA
Pixley I.D. GSA
Pixley
Saucelito I.D.
Tea Pot Dome W.D.
Angiola W.D.
Pixley I.D.
Alpaugh I.D.
Angiola W.D.
Alpaugh GSA
Terra Bella I.D.
Ducor
Earlimart
Delano-Earlimart I.D.
Atwell Island W.D.
Tri-County Water Authority GSA
Richgrove
Eastern Tule GSA
Delano
Delano-Earlimart ID GSA
Kern-Tulare W.D.
Alpaugh I.D.
N
0 3 6 12 Miles
Note: Basemap source esri.com

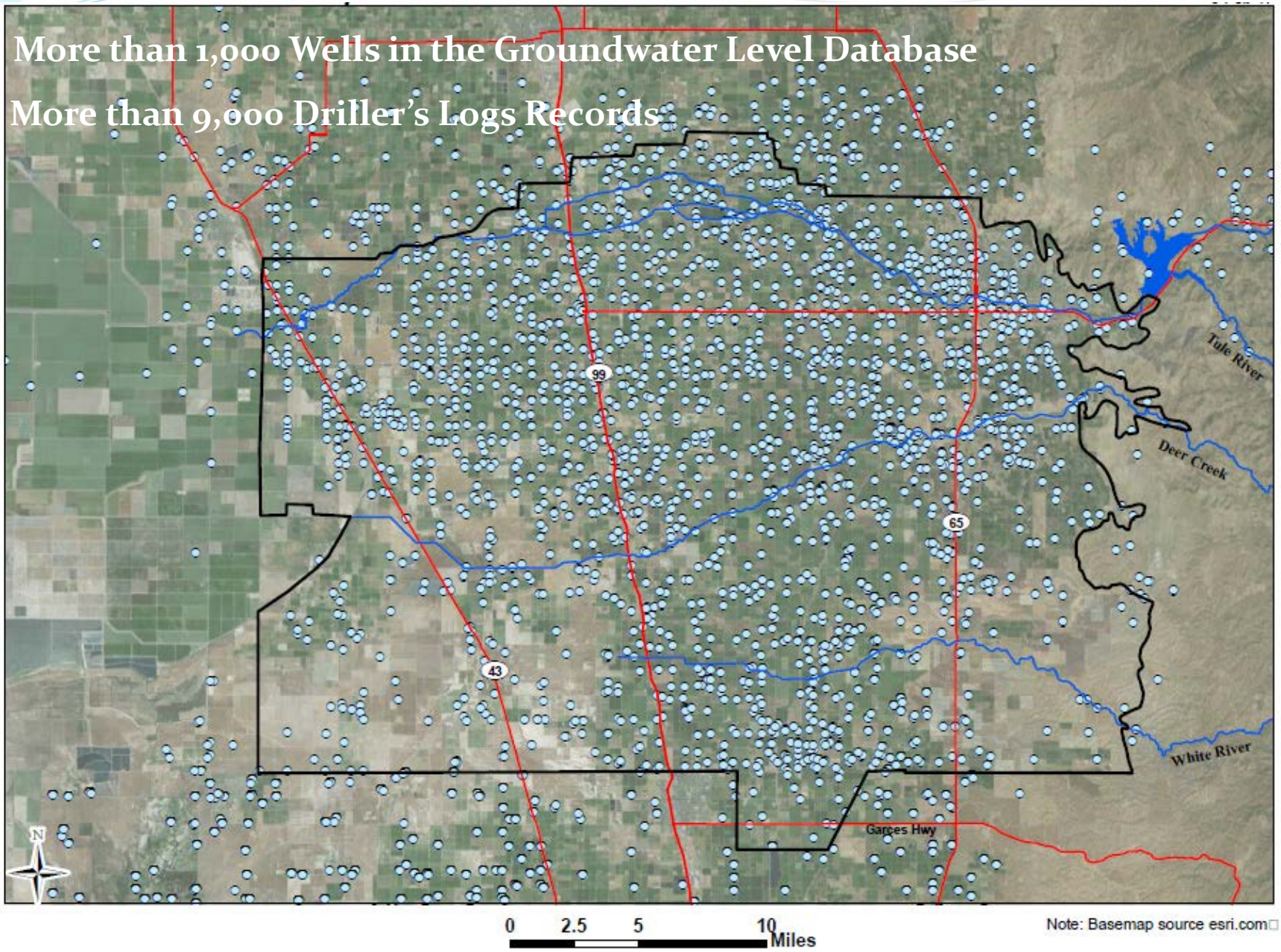
Data for the Analysis are Stored in a Database that Includes:



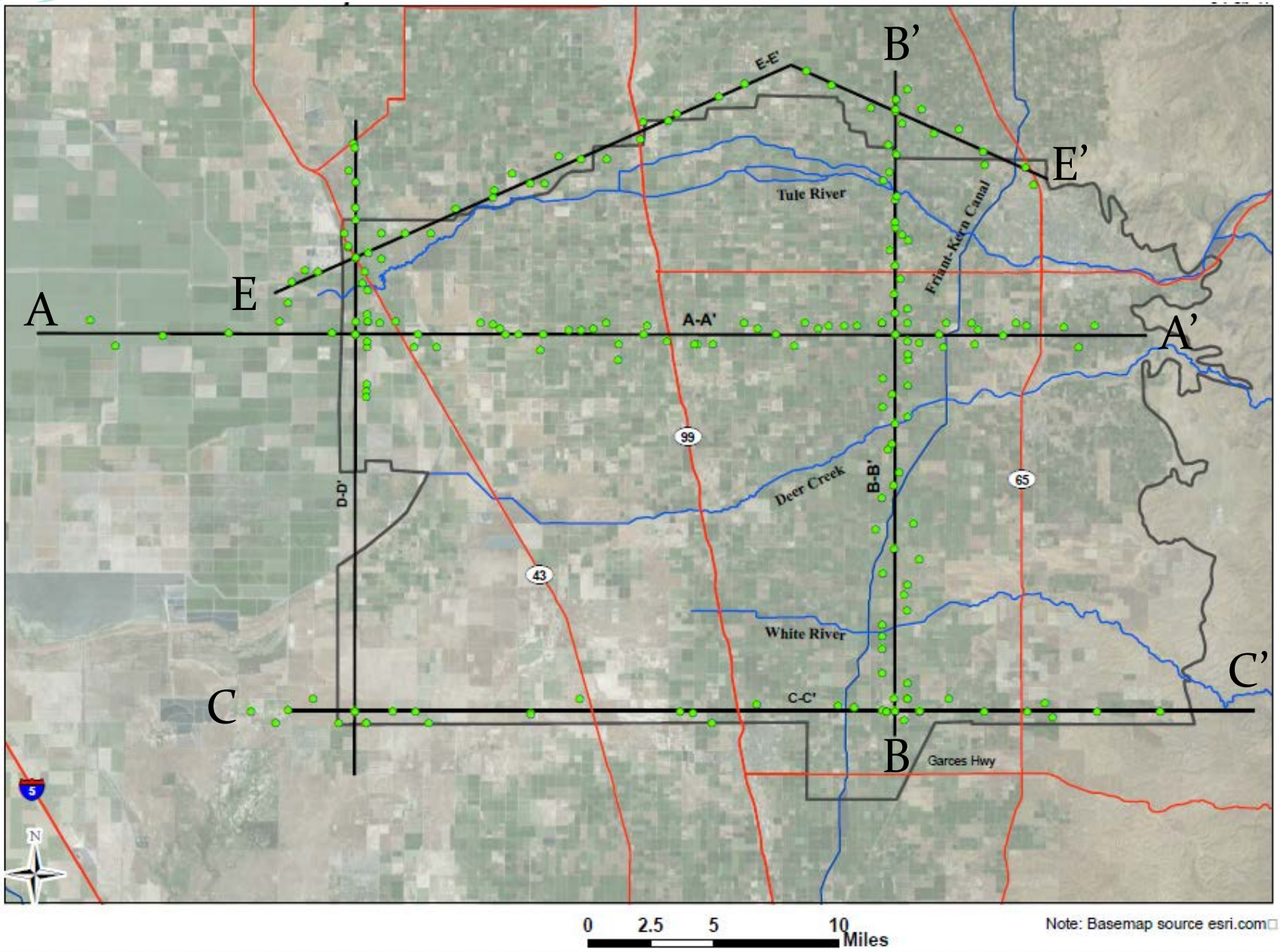
Sources for the Data Have Included:

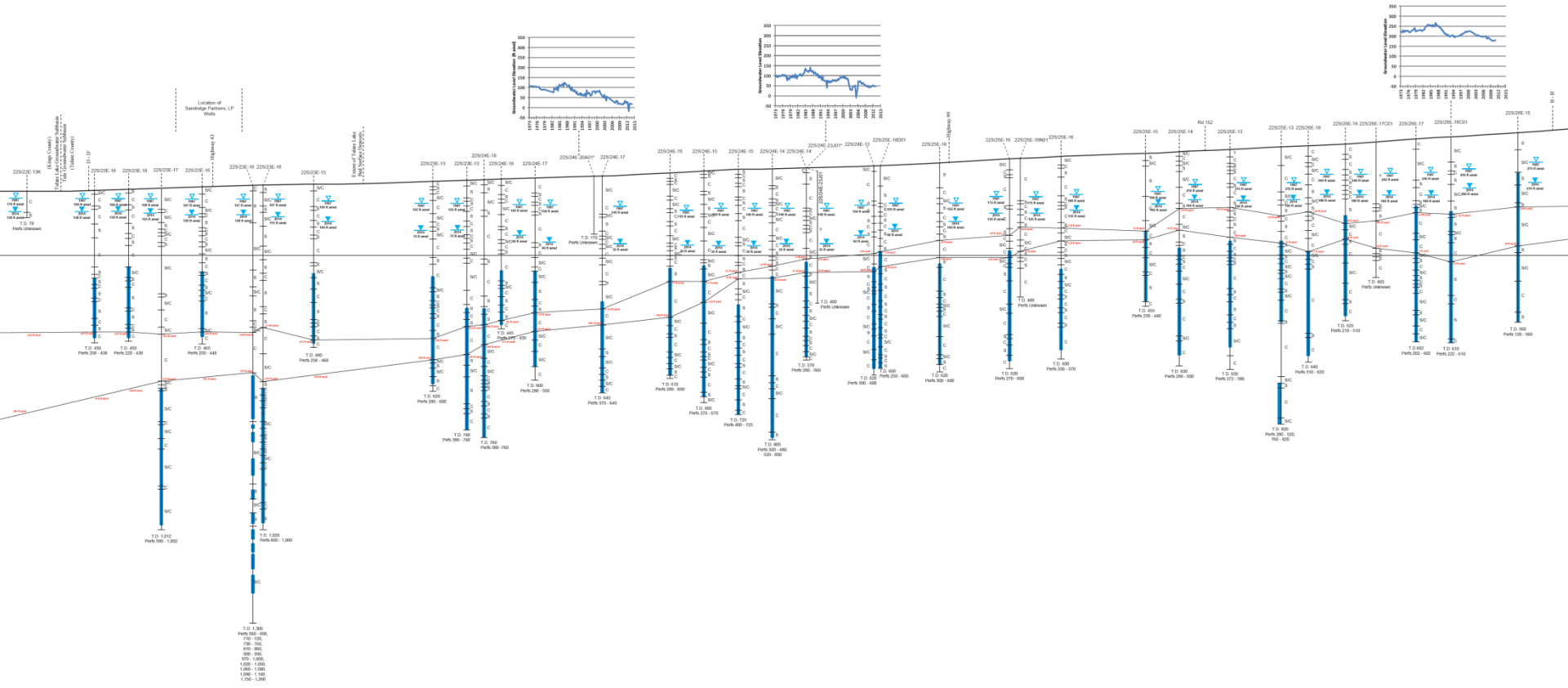
- Deer Creek Tule River Authority
- Tule River Association
- California Statewide Groundwater Elevation Monitoring Database (CASGEM)
- California Department of Water Resources (DWR)
- Cities and Agencies within the Tule Subbasin
- Kern County Water Agency
- Tulare Lake Bed Coordinated Groundwater Management Plan
- United States Geological Survey (USGS)

Wells in the Database



Cross Sections (A-E)

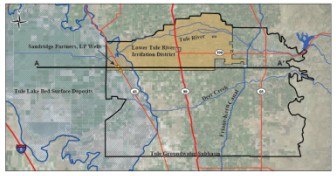




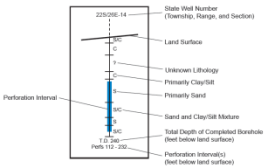
Vertical Scale
0
50
100
200
Feet

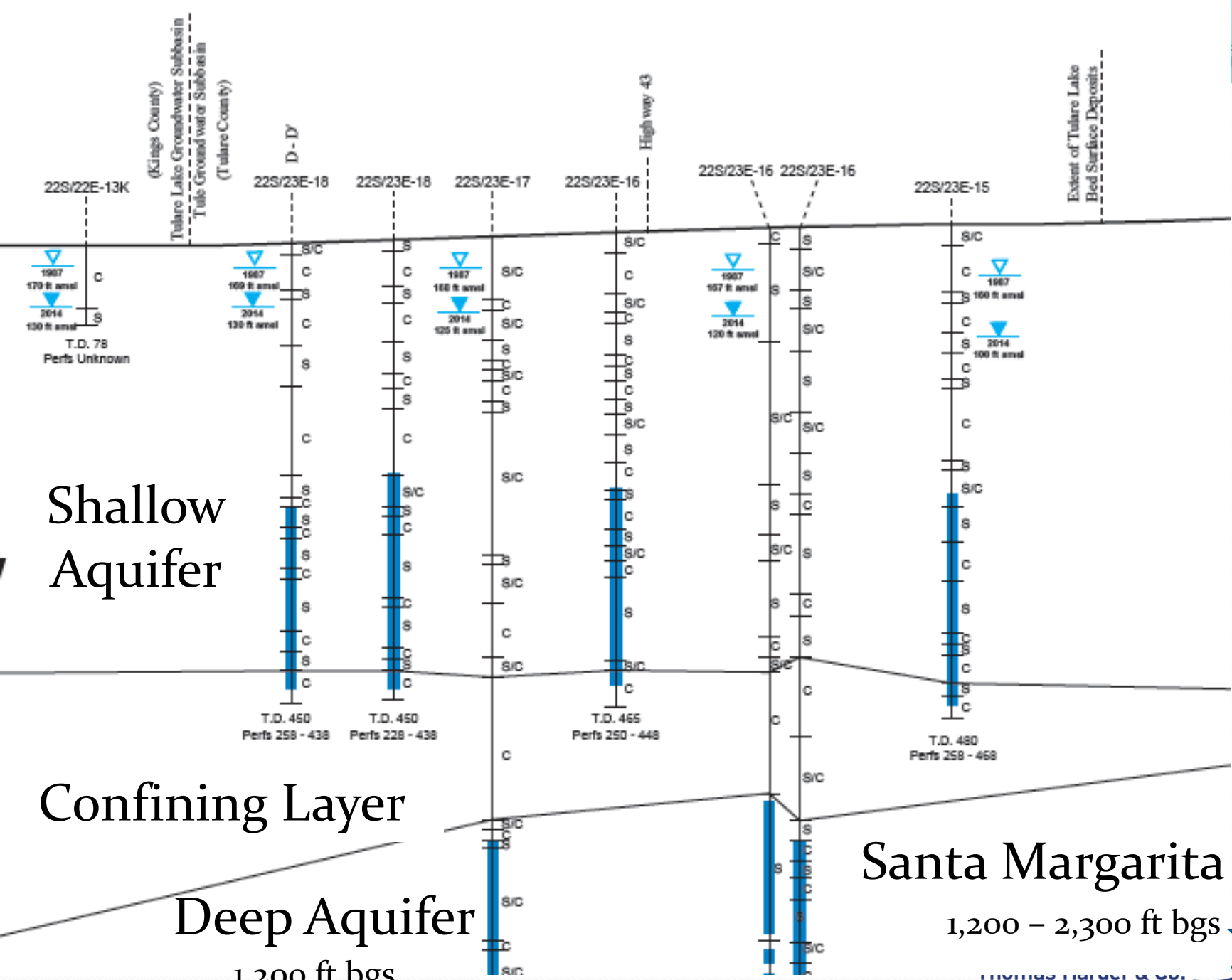
Horizontal Scale
0 1/2 1 2
Miles

Notes:
Lithologic data from Department of Water Resources Well Completion Reports.
Wells within one half mile from cross section line unless otherwise noted by " * ".
Corcoran Clay from USGS Professional Paper 1796.
http://water.usgs.gov/GIS/dsdl/pp1796_CorcoranClay.zip



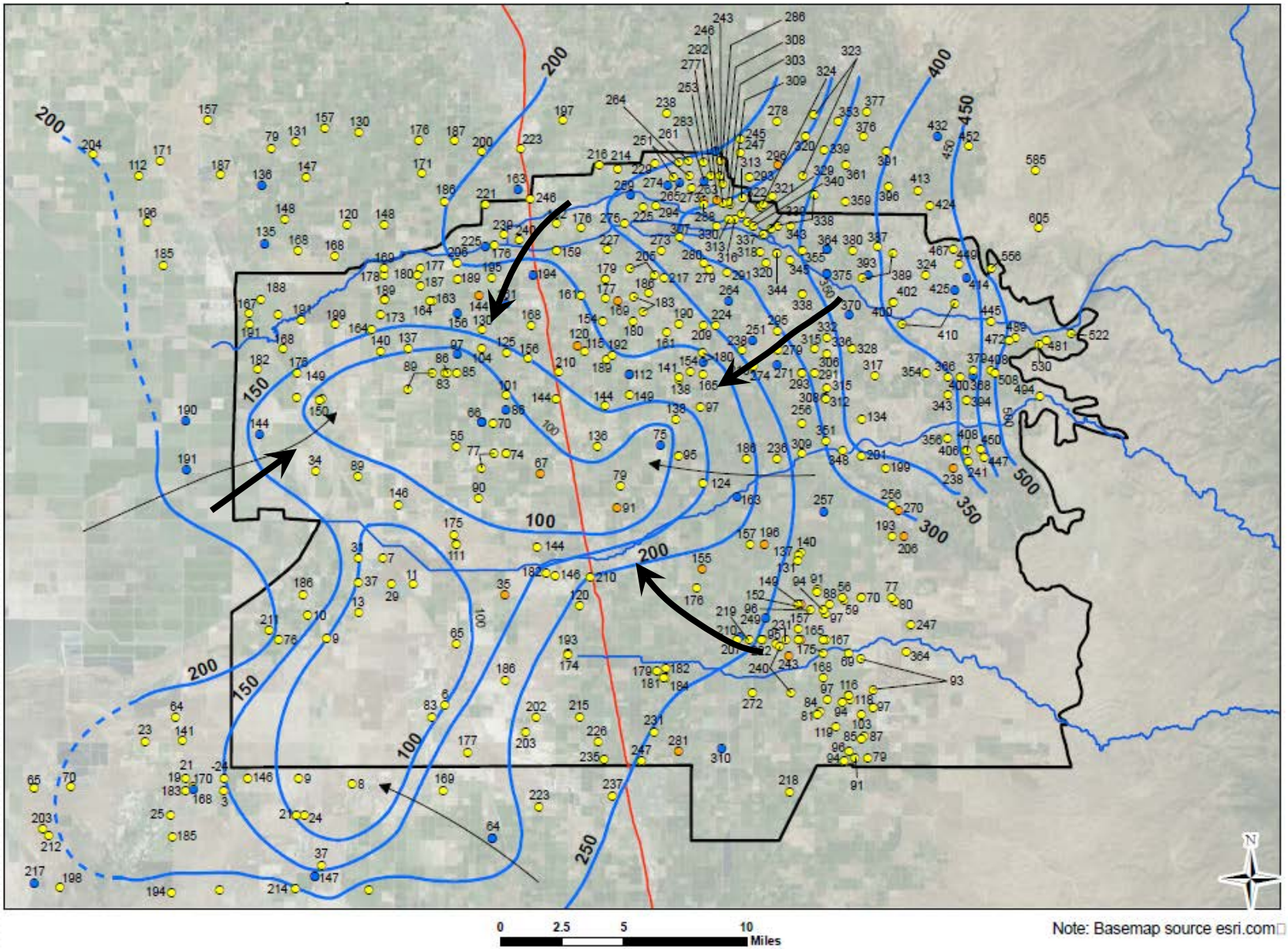
Legend



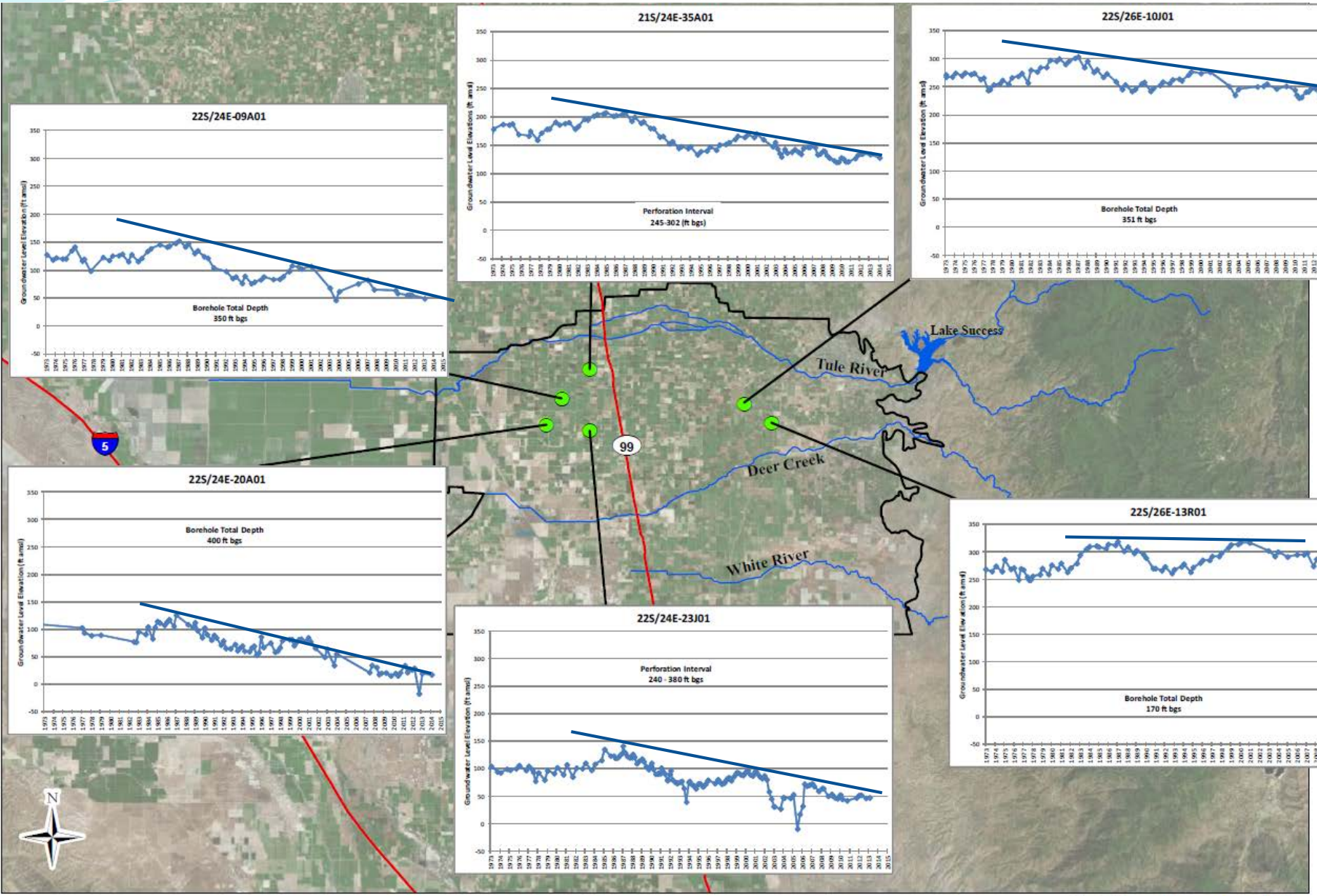


Groundwater Consulting

1998 Groundwater Contours – Shallow Aquifer

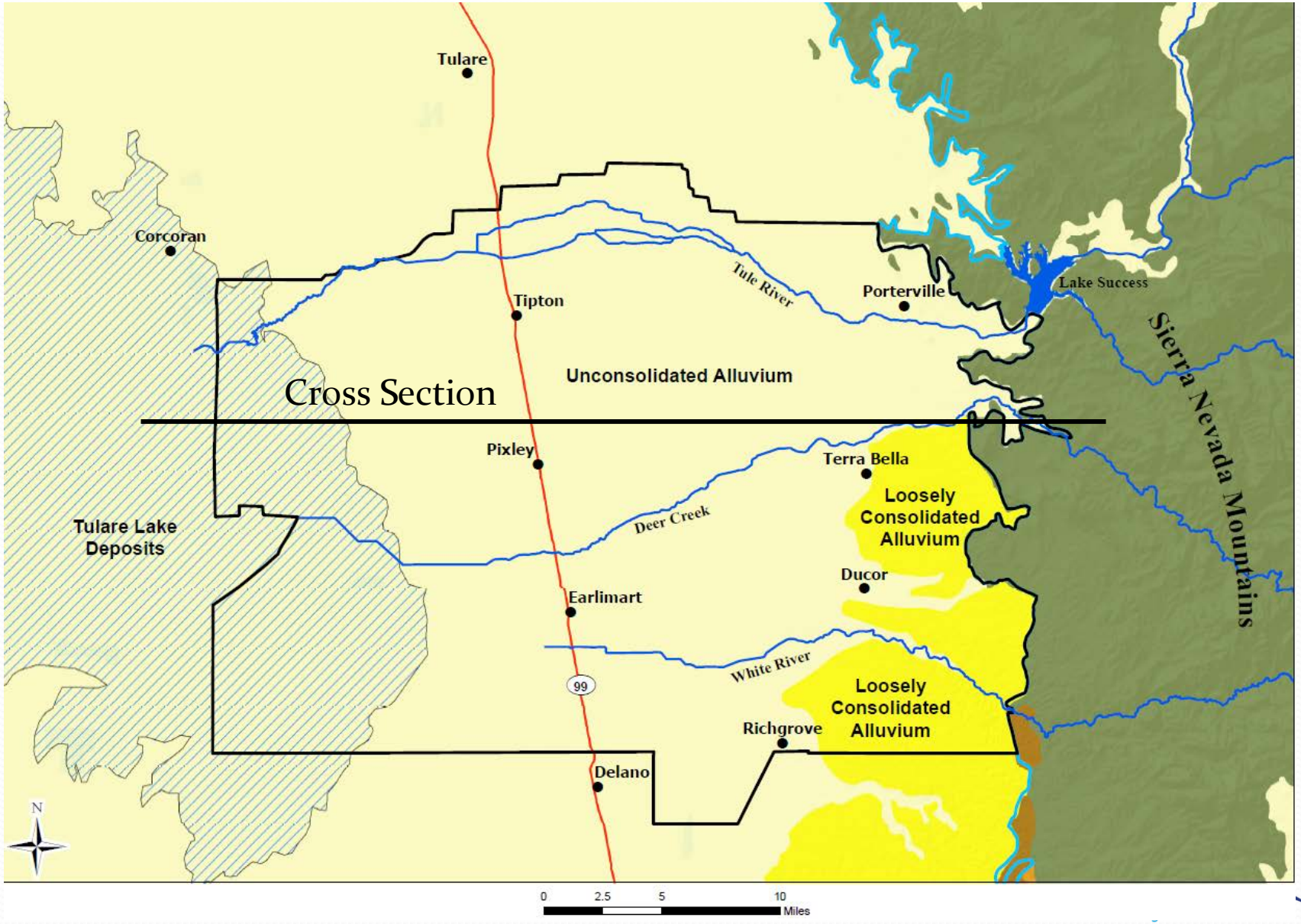


Historical Groundwater Level Trends – Shallow Aquifer



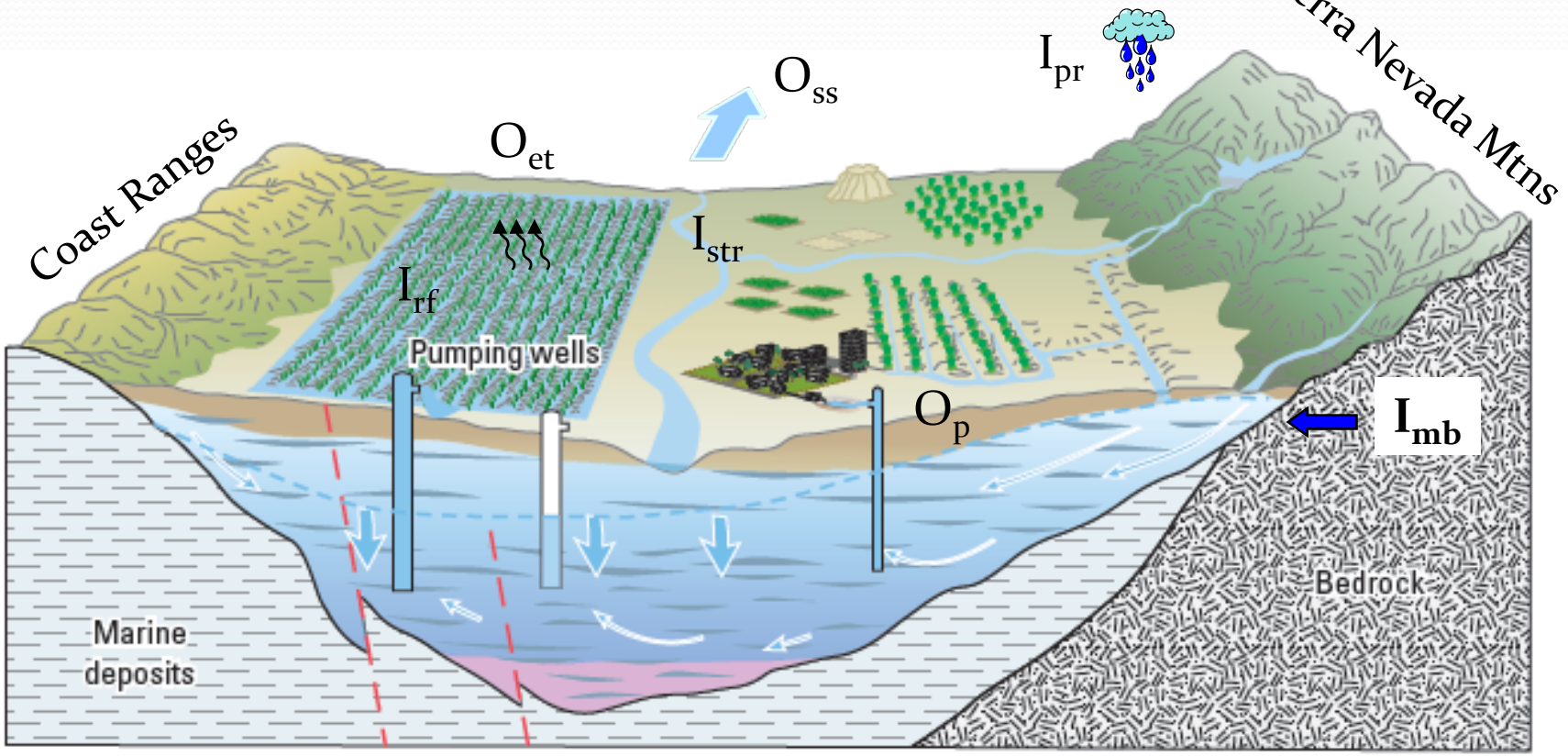
Note: Basemap source esri.com

Surface Geology



Inflow Outflow Change in Storage

$$I_{ss} + I_{mb} + I_{pr} + I_{str} + I_{rf} + I_{ar} - O_{ss} + O_{et} + O_p = \Delta S$$



Modified from USGS PP 1766

Tule Subbasin Surface Water Budget Inflow

	Surface Water Inflow (acre-ft)										
	A	B	C	D	E	F	G	H	I	J	K
Water Year	Precipitation	Stream Inflow					Imported Water				
		Tule River	Deer Creek	White River	Delano-Earlimart ID	LTRID	Pixley ID	Porterville ID	Saucelito ID	Tea Pot Dome WD	Alpaugh ID
1990 - 1991	331,713	51,275	7,247	1,362	105,876	71,430	0	11,322	19,848	5,636	0
1991 - 1992	285,661	34,325	4,080	739	90,001	51,949	0	15,569	21,336	6,607	0
1992 - 1993	462,864	115,640	15,422	3,623	140,611	321,973	0	12,310	41,261	6,968	11,062
1993 - 1994	293,336	61,313	6,908	1,148	83,988	71,784	96,890	12,895	22,064	6,526	3,263
1994 - 1995	611,034	218,480	32,053	10,596	129,338	229,683	7,793	9,455	37,477	6,562	7,480
1995 - 1996	321,702	174,473	23,095	5,957	145,404	236,845	55,365	13,808	48,924	7,993	10,076
1996 - 1997	450,183	353,968	58,781	12,920	154,747	192,934	60,931	13,379	40,908	7,298	0
1997 - 1998	728,835	439,125	88,360	36,764	117,161	101,180	37,048	10,159	28,221	4,913	0
1998 - 1999	373,094	108,466	18,410	7,469	139,754	183,971	41,823	16,107	37,062	9,218	0
1999 - 2000	354,740	102,354	15,230	4,878	136,829	177,192	34,736	15,545	39,734	7,191	0
2000 - 2001	264,970	55,249	7,016	4,695	116,592	83,405	40,076	15,436	25,252	6,456	0
2001 - 2002	252,289	73,206	10,370	6,176	128,383	78,511	9,098	13,628	26,131	6,388	0
2002 - 2003	247,283	125,004	15,678	5,875	118,771	131,470	13,588	14,646	33,692	5,844	94
2003 - 2004	206,904	51,738	6,882	2,350	127,194	71,472	32,195	14,698	26,988	6,913	0
2004 - 2005	395,453	172,558	22,758	6,502	121,589	247,595	9,839	14,748	42,840	5,217	13,117
2005 - 2006	401,460	195,667	23,868	7,585	121,249	194,019	59,211	13,251	45,106	6,436	14,586
2006 - 2007	169,861	38,587	6,901	1,812	71,995	33,174	60,634	9,775	16,280	5,489	0
2007 - 2008	189,217	74,030	8,411	2,362	113,026	71,872	7,200	12,988	24,083	6,894	0
2008 - 2009	203,567	54,737	6,620	1,753	109,154	113,189	12,243	18,000	31,282	6,165	1,929
2009 - 2010	325,707	144,778	16,470	5,075	119,497	200,064	23,620	14,335	42,855	5,845	2,418
Average:	343,494	132,249	19,728	6,482	119,558	143,186	30,115	13,603	32,567	6,528	3,201

Tule Subbasin Surface Water Budget Outflow

Water Year	A	B	C	D	E	F	G	H	I	T	U
	Precipitation		Tule River								ted Water Deliveries
	Areal Recharge	Crops/Native Evapo-transpiration	Success to Oettle Bridge Infiltration	Oettle Bridge to Turnbull Weir Infiltration	Canal Loss	Recharge in Basins	Return Flow	Surface Outflow	Evapo-transpiration	Recharge in Basins	Return Flow
1990 - 1991	6,948	324,766	6,275	0	6,883	5,247	6,846	0	585	0	43,959
1991 - 1992	1,413	284,248	4,287	0	3,077	3,673	3,004	0	420	0	40,346
1992 - 1993	56,601	406,263	18,493	0	27,124	8,191	10,853	0	695	6,272	98,648
1993 - 1994	1,909	291,427	6,037	0	14,255	5,005	6,246	0	580	468	41,546
1994 - 1995	143,977	467,057	36,355	10,974	42,741	7,836	23,319	25,337	915	10,585	81,436
1995 - 1996	4,916	316,786	20,703	3,337	28,554	21,164	19,824	6,717	1,025	38,997	92,204
1996 - 1997	50,231	399,952	34,563	15,305	46,552	25,338	18,589	121,019	805	14,834	82,539
1997 - 1998	219,370	509,465	41,092	15,459	55,070	32,007	29,206	95,424	970	15,959	52,316
1998 - 1999	18,124	354,970	14,268	1,001	19,134	17,564	10,881	0	750	19,385	78,640
1999 - 2000	12,029	342,711	16,930	2,323	13,056	8,882	11,425	4,740	695	13,327	77,088
2000 - 2001	338	264,632	12,226	0	6,983	4,992	6,248	0	420	2,137	52,328
2001 - 2002	24	252,265	14,802	0	12,864	5,798	6,646	0	475	82	55,820
2002 - 2003	2	247,281	19,714	4,851	23,989	12,186	10,286	5,008	695	5,013	63,626
2003 - 2004	0	206,904	9,910	442	7,552	3,876	5,125	603	530	0	54,708
2004 - 2005	25,957	369,496	24,143	2,640	30,618	19,036	12,408	22,123	815	32,483	83,140
2005 - 2006	28,272	373,188	28,092	7,227	42,131	23,345	18,496	11,203	860	26,337	80,214
2006 - 2007	0	169,861	6,073	1,184	5,299	4,310	3,813	0	530	0	33,048
2007 - 2008	0	189,217	11,675	1,536	15,635	6,884	6,736	804	640	1,595	49,951
2008 - 2009	0	203,567	9,484	244	7,144	5,154	6,279	0	475	9,292	56,895
2009 - 2010	5,622	320,084	25,636	5,116	32,478	14,286	13,414	0	860	30,225	71,544
Average:	28,787	314,707	18,038	3,582	22,057	11,739	11,482	14,649	687	11,349	64,500

Tule Subbasin Groundwater Budget Inflows

	Groundwater Inflows (acre-ft)										
	A	B	C	D	E	F	G	H	I	J	K
Water Year	Areal Recharge from Precipitation	Tule River					Deer Creek				
		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
1990 - 1991	6,948	6,275	0	6,883	5,247	6,846	6,945	0	0	0	0
1991 - 1992	1,413	4,287	0	3,077	3,673	3,004	3,750	0	0	0	0
1992 - 1993	56,601	18,493	0	27,124	8,191	10,853	15,062	0	0	0	0
1993 - 1994	1,909	6,037	0	14,255	5,005	6,246	6,612	0	0	0	0
1994 - 1995	143,977	36,355	10,974	42,741	7,836	23,319	21,248	980	3,766	1,786	822
1995 - 1996	4,916	20,703	3,337	28,554	21,164	19,824	13,746	724	2,784	659	1,012
1996 - 1997	50,231	34,563	15,305	46,552	25,338	18,589	45,099	1,790	6,881	1,946	568
1997 - 1998	219,370	41,092	15,459	55,070	32,007	29,206	14,855	12,687	48,757	929	2,565
1998 - 1999	18,124	14,268	1,001	19,134	17,564	10,881	13,280	641	2,465	352	276
1999 - 2000	12,029	16,930	2,323	13,056	8,882	11,425	10,079	628	2,413	508	261
2000 - 2001	338	12,226	0	6,983	4,992	6,248	6,695	0	0	0	0
2001 - 2002	24	14,802	0	12,864	5,798	6,646	10,054	0	0	0	0
2002 - 2003	2	19,714	4,851	23,989	12,186	10,286	13,621	108	416	319	179
2003 - 2004	0	9,910	442	7,552	3,876	5,125	6,596	0	0	0	0
2004 - 2005	25,957	24,143	2,640	30,618	19,036	12,408	14,404	389	1,495	2,950	664
2005 - 2006	28,272	28,092	7,227	42,131	23,345	18,496	14,352	888	3,413	3,152	358
2006 - 2007	0	6,073	1,184	5,299	4,310	3,813	6,593	0	0	0	0
2007 - 2008	0	11,675	1,536	15,635	6,884	6,736	8,114	0	0	0	0
2008 - 2009	0	9,484	244	7,144	5,154	6,279	6,322	0	0	0	0
2009 - 2010	5,622	25,636	5,116	32,478	14,286	13,414	16,110	0	0	0	0
Average:	28,787	18,038	3,582	22,057	11,739	11,482	12,677	942	3,619	630	335

Tule Subbasin Groundwater Budget Inflows/Outflows

	Groundwater Inflows (cont.) (acre-ft)			
	T	U	V	
Water Year	Release of Water from Compression of Aquitards	Sub-surface Inflow	Mountain-Block Recharge	Total In
1990 - 1991	85,300	48,296	19,314	432,421
1991 - 1992	85,300	48,296	16,633	403,767
1992 - 1993	85,300	48,296	26,950	696,611
1993 - 1994	85,300	48,296	17,080	442,411
1994 - 1995	85,300	48,296	35,578	777,329
1995 - 1996	85,300	48,296	18,731	597,747
1996 - 1997	85,300	48,296	26,212	695,304
1997 - 1998	85,300	48,296	42,437	933,384
1998 - 1999	85,300	43,991	21,724	544,857
1999 - 2000	85,300	47,173	20,655	529,957
2000 - 2001	85,300	44,940	15,428	429,202
2001 - 2002	85,300	49,797	14,690	443,366
2002 - 2003	85,300	51,107	14,398	506,329
2003 - 2004	85,300	49,994	12,047	411,230
2004 - 2005	85,300	49,742	23,025	612,018
2005 - 2006	85,300	47,283	23,375	627,163
2006 - 2007	85,300	44,128	9,890	389,533
2007 - 2008	85,300	42,936	11,017	414,392
2008 - 2009	85,300	48,296	11,853	445,213
2009 - 2010	85,300	60,164	18,964	570,378
Average:	85,300	48,296	20,000	545,131

	Groundwater Outflows (acre-ft)					
	W	X	Y	Z		
	Groundwater Pumping					
Water Year	Municipal	Irrigated Agriculture (incld S.M. Frm)	Exports	Sub-surface Outflow	Total Out	Change in Storage (acre-ft)
1990 - 1991	15,786	759,938	44,745	14,722	835,192	-402,771
1991 - 1992	16,178	786,776	41,120	14,722	858,796	-455,029
1992 - 1993	16,702	450,070	12,159	14,722	493,653	202,958
1993 - 1994	17,210	762,302	11,598	14,722	805,833	-363,421
1994 - 1995	17,823	500,576	9,377	14,722	542,498	234,831
1995 - 1996	17,782	446,699	0	14,722	479,202	118,545
1996 - 1997	20,125	502,012	0	14,722	536,859	158,445
1997 - 1998	18,526	592,523	0	14,722	625,771	307,613
1998 - 1999	18,918	563,631	0	11,662	594,210	-49,353
1999 - 2000	19,309	603,655	7,621	8,211	638,796	-108,838
2000 - 2001	19,212	683,648	33,734	13,766	750,360	-321,159
2001 - 2002	21,053	672,437	44,367	17,422	755,280	-311,913
2002 - 2003	20,795	615,411	28,232	13,564	678,002	-171,673
2003 - 2004	21,391	659,764	36,249	19,183	736,586	-325,356
2004 - 2005	21,578	480,880	16,592	8,654	527,704	84,314
2005 - 2006	21,120	477,621	100	16,814	515,654	111,509
2006 - 2007	21,828	757,715	39,594	16,411	835,548	-446,015
2007 - 2008	22,978	641,340	55,350	12,330	731,997	-317,605
2008 - 2009	22,959	669,418	51,456	14,722	758,554	-313,342
2009 - 2010	22,531	477,783	28,758	24,472	553,543	16,835
Average:	19,690	605,210	23,053	14,749	662,702	-117,571
					Cummulative Change in Storage	-2,351,427

Approx. Average Annual Overdraft: -118,000 acre-ft/yr

Approx. Cumulative Change in Storage: -2,350,000 acre-ft

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Tule Subbasin Preliminary Sustainable Yield Estimate

Water Year	Groundwater Inflows (acre-ft)									Groundwater Outflow (acre-ft)	Sustainable Yield
	Areal Recharge from Precipitation	Streambed Infiltration					Irrigated Agriculture (incld S.M. Frm)	Sub-surface Inflow	Mountain-Block Recharge	Sub-surface Outflow	
		Tule River		Deer Creek		White River					
		Success to Oettle Bridge	Oettle Bridge to Turnbull Weir	Before Trenton Weir Infiltration	Trenton Weir to Homeland Canal Infiltration						
1990 - 1991	6,948	6,275	0	6,945	0	1,278	165,265	48,296	19,314	14,722	239,599
1991 - 1992	1,413	4,287	0	3,750	0	672	171,000	48,296	16,633	14,722	231,328
1992 - 1993	56,601	18,493	0	15,062	0	3,536	100,406	48,296	26,950	14,722	254,622
1993 - 1994	1,909	6,037	0	6,612	0	1,050	166,088	48,296	17,080	14,722	232,349
1994 - 1995	143,977	36,355	10,974	21,248	980	10,476	111,250	48,296	35,578	14,722	404,411
1995 - 1996	4,916	20,703	3,337	13,746	724	5,844	99,984	48,296	18,731	14,722	201,559
1996 - 1997	50,231	34,563	15,305	45,099	1,790	12,805	111,928	48,296	26,212	14,722	331,507
1997 - 1998	219,370	41,092	15,459	14,855	12,687	36,610	130,800	48,296	42,437	14,722	546,883
1998 - 1999	18,124	14,268	1,001	13,280	641	7,315	124,832	43,991	21,724	11,662	233,513
1999 - 2000	12,029	16,930	2,323	10,079	628	4,764	133,336	47,173	20,655	8,211	239,706
2000 - 2001	338	12,226	0	6,695	0	4,597	150,176	44,940	15,428	13,766	220,633
2001 - 2002	24	14,802	0	10,054	0	6,080	148,113	49,797	14,690	17,422	226,137
2002 - 2003	2	19,714	4,851	13,621	108	5,763	136,182	51,107	14,398	13,564	232,183
2003 - 2004	0	9,910	442	6,596	0	2,266	145,641	49,994	12,047	19,183	207,714
2004 - 2005	25,957	24,143	2,640	14,404	389	6,390	108,172	49,742	23,025	8,654	246,209
2005 - 2006	28,272	28,092	7,227	14,352	888	7,459	107,509	47,283	23,375	16,814	247,645
2006 - 2007	0	6,073	1,184	6,593	0	1,700	166,487	44,128	9,890	16,411	219,645
2007 - 2008	0	11,675	1,536	8,114	0	2,264	142,259	42,936	11,017	12,330	207,471
2008 - 2009	0	9,484	244	6,322	0	1,641	148,228	48,296	11,853	14,722	211,345
2009 - 2010	5,622	25,636	5,116	16,110	0	4,949	107,950	60,164	18,964	24,472	220,040
Average:	28,787	18,038	3,582	12,677	942	6,373	133,780	48,296	20,000	14,749	257,725

Sustainable Yield = Groundwater Inflows - Groundwater Outflows

Basin Area (acres)	475,895
Basin-Wide Sustainable Yield (acre-ft/yr/acre)	0.54

Annual Average Sustainable Yield: 257,725 acre-ft/yr
0.54 acre-ft/acre

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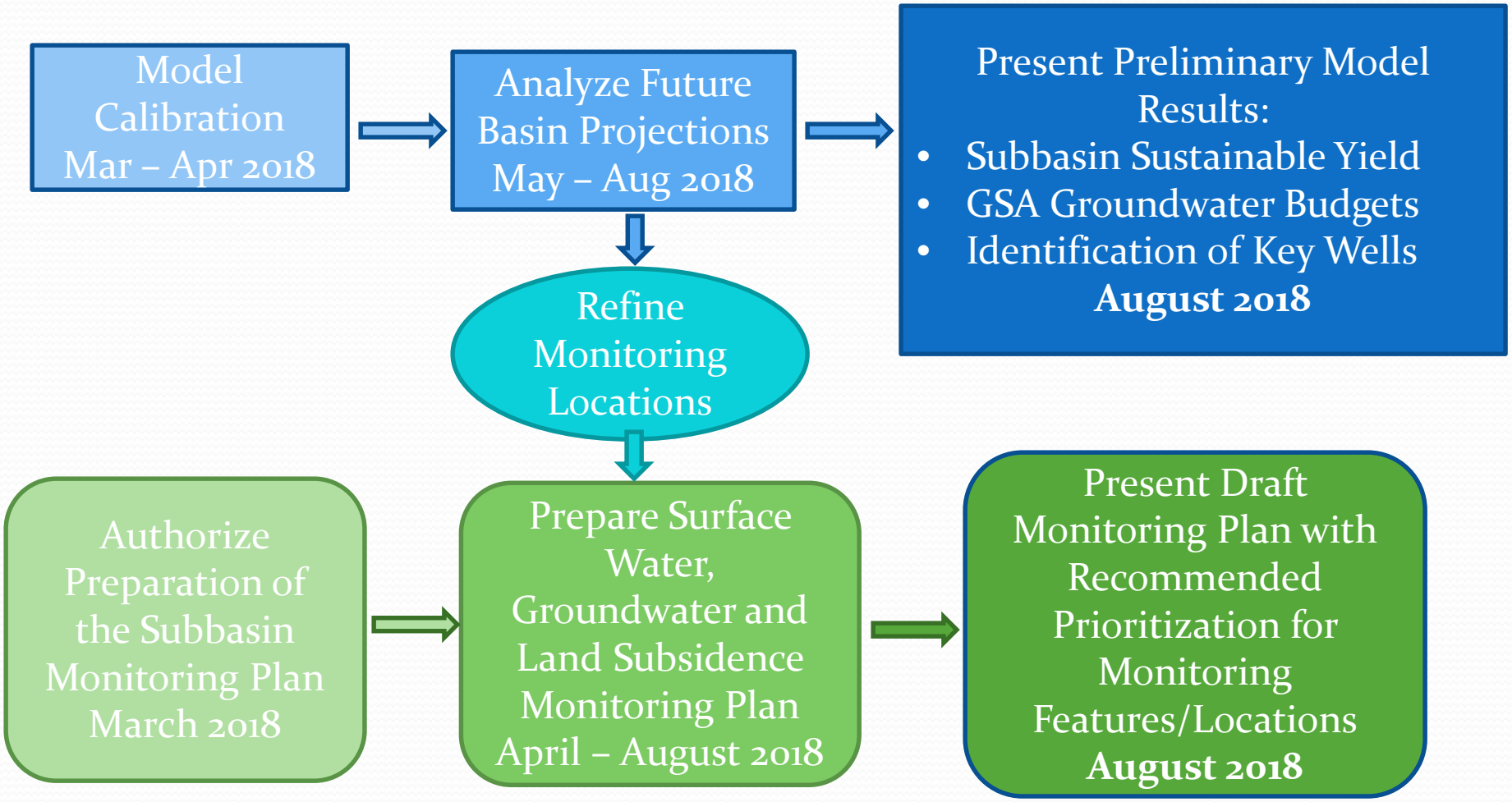
Work in Progress

- A Groundwater Flow Model of the Subbasin is Being Developed (BMP-5)
  - Refine the Preliminary Water Budget
  - Refine the Estimate of Sustainable Yield
  - Develop Water Budgets Specific to Each GSA
  - Identify Key Well Locations
  - Assess the Impact of Neighboring Basins on the Tule Subbasin Sustainable Yield
- Preparing a Basin-Wide Monitoring Plan

What is the Schedule for Making Model Results Available to the GSAs?



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Questions