Wasteload Allocation Model Review and Recommendations

May 13, 2020

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Agenda

- Part 1 – Review of Updated Calibration
  - Objectives of review
  - Scope of review
  - Findings
- Part 2 – WEI Recommendations for Further Review of WLAM
  - Framework for review
  - HSPF model overview and review examples

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Objectives of the Review

- EVMWD and EMWD are updating their Upper Temescal Valley SNMP, including updates of current and projected ambient water quality
- The Regional Board requested that the 2016 WLAM is used for this effort.
- The information from the 2016 WLAM needed to complete these efforts in the Upper Temescal Valley:
  - Surface water discharge and TDS/N concentrations
  - Streambed infiltration volume and TDS/N concentrations

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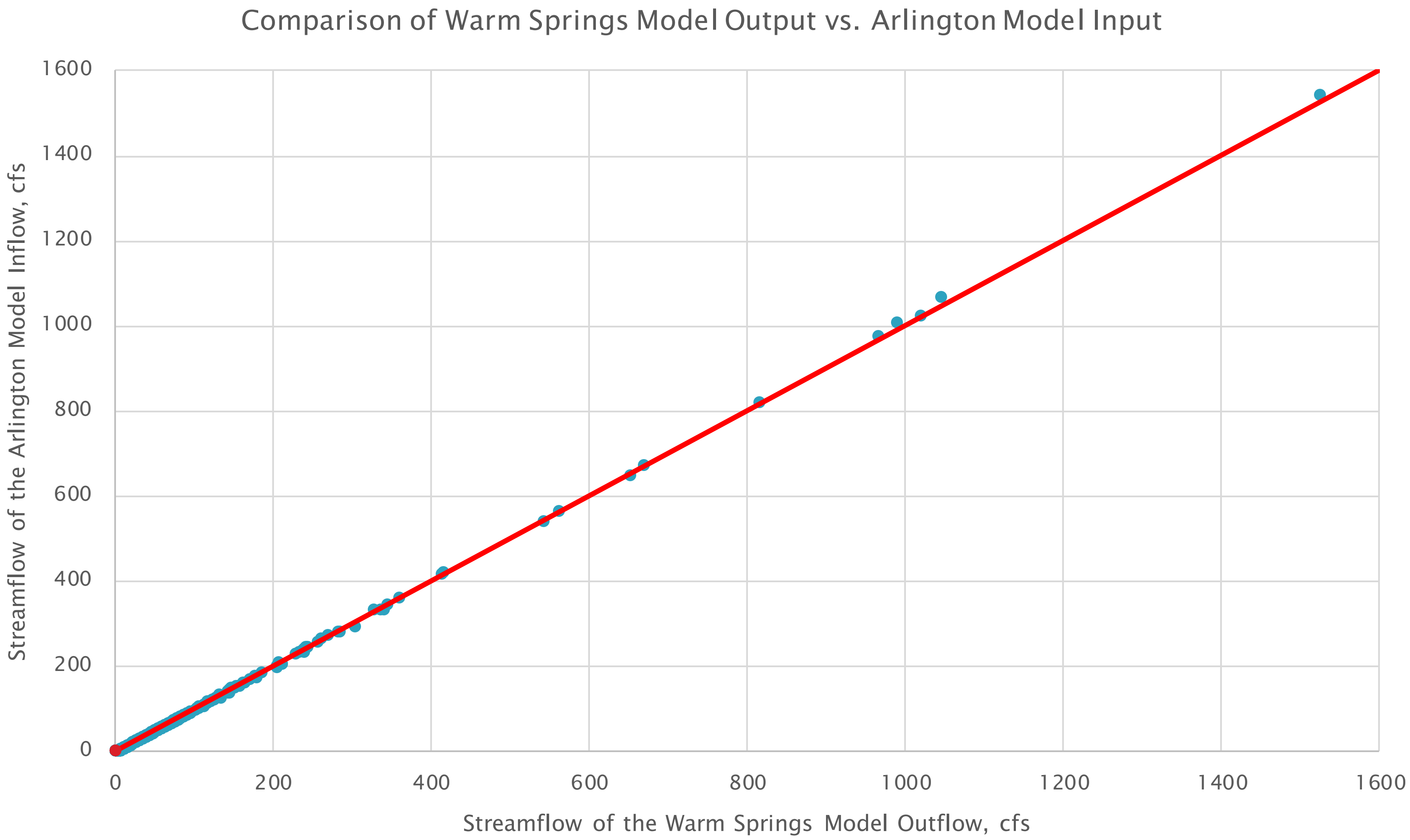
Scope of Review: Upper Temescal Valley Study Area

- Model connection → Are the Warm Springs and Arlington sub-models connected?
- Model parameters → What parameters where changed in the models to re-calibrate?
- Streambed Infiltration TDS estimates → Is the post-processing methodology to assign TDS concentrations to the streambed infiltration reasonable?

Model Connection

✓The two models are connected



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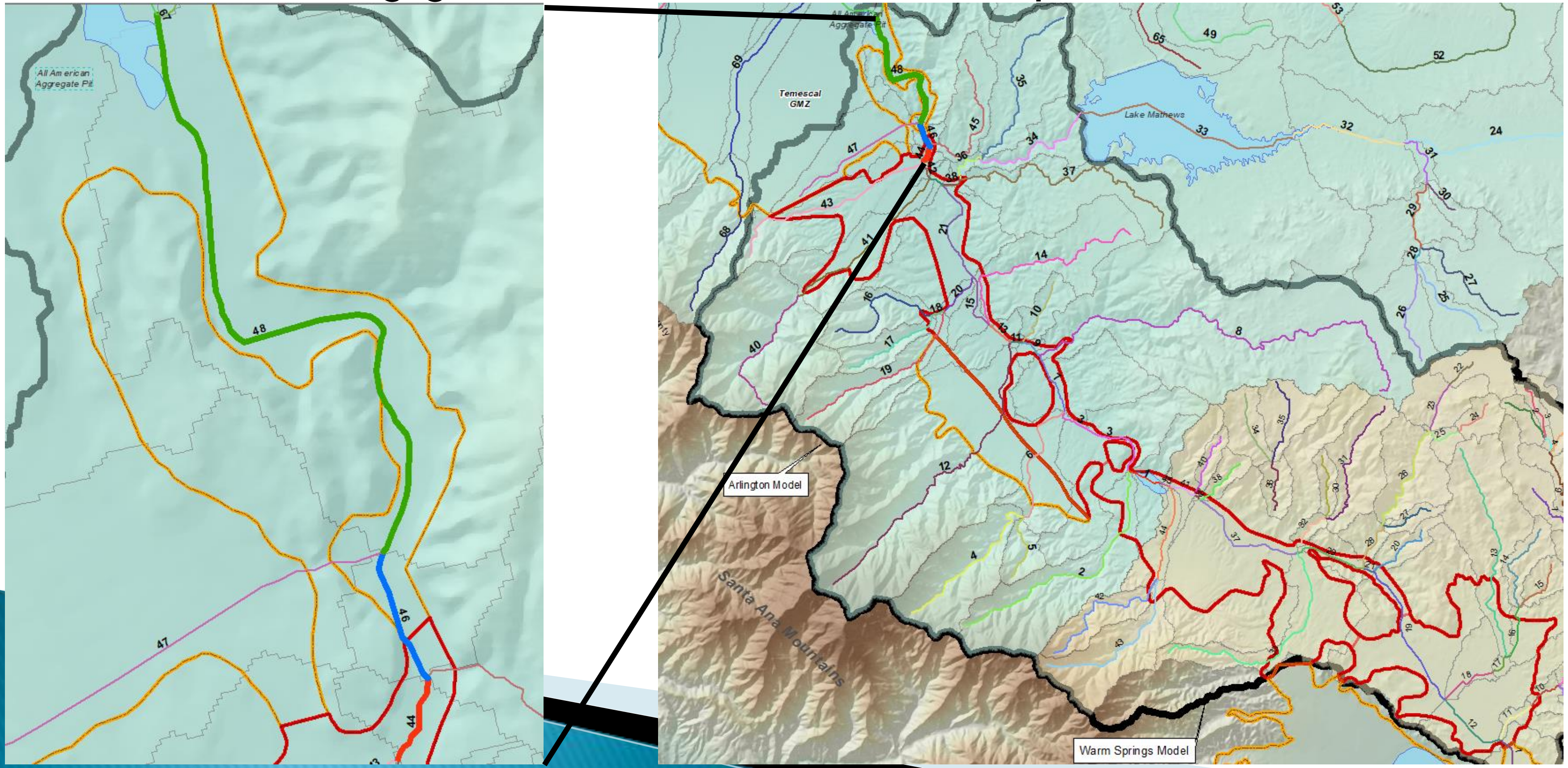
Model Parameters

- There were no changes to the Warm Springs model.
- The infiltration rate of the following reaches in the Arlington model changes:

Reach No. (Arlington Submodel)	Original Average Infiltration Rate (ft/day)	Revised Average Infiltration Rate (ft/day)
Reach 1	24.2	0.2
Reach 44	0.05	1.6
Reach 46	0.05	1.6
Reach 48	32.2	1.7
Typical values in other Reaches of the Arlington and Warm Springs Models	0.2 – 0.5	

MODEL PARAMETERS

Reach 44 (location of rising groundwater), 46, and 48 → The infiltration rate was increased in Reaches 44 and 46, which are within a bedrock narrows where it is not likely that (1) the infiltration rates are higher than other areas of the Temescal Wash or (2) there is the capacity in the underlying alluvium to accept the recharge. The volume of infiltration is nearly always greater than the rising groundwater volume that is input into Reach 44.

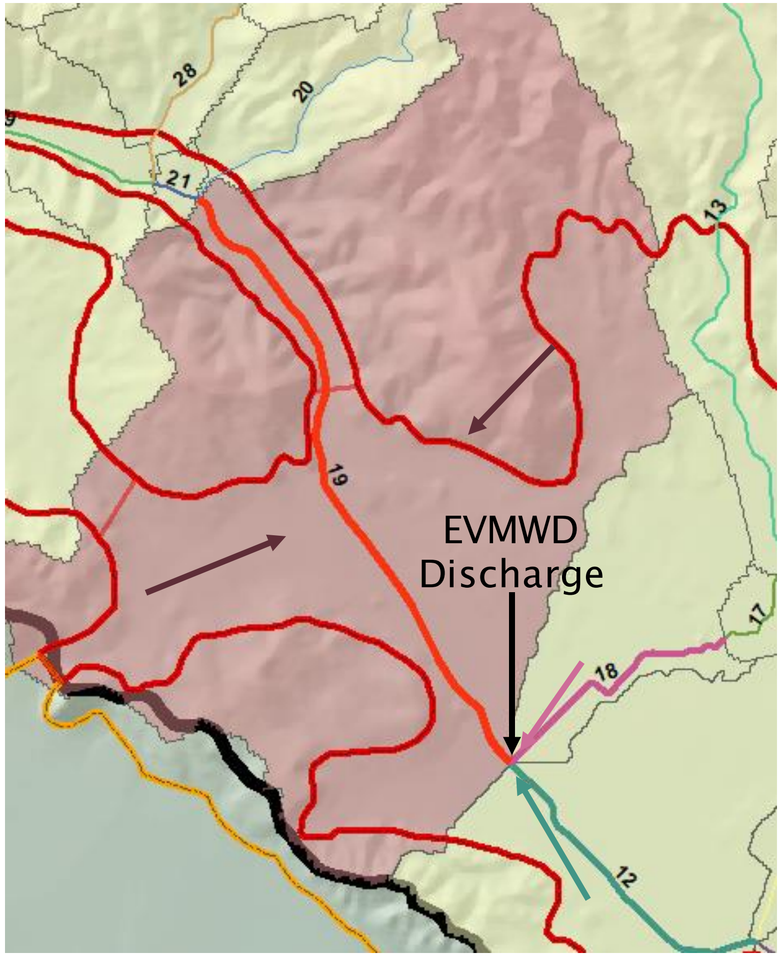


Water Year	Rising Groundwater Entering Reach 44 (afy)	Streambed Infiltration in Reaches 44, 46, 48 (afy)
2005	5,020	7,741
2006	4,805	4,151
2007	3,943	3,144
2008	2,802	3,062
2009	2,432	2,546
2010	2,144	3,090
2011	2,840	3,789
2012	1,188	1,268
2013	801	1,013
2014	464	671
2015	464	904
2016	463	719
Average (1995-2016)	*2,012*	*2,449*

Streambed Infiltration TDS estimates

- We do not agree with the proposed methodology used to assign TDS concentration to the streambed infiltration when reaches "dry up" and the model assumes a zero TDS concentration.

- Recommended methodology →
  Use the volume-weighted TDS concentration of the inputs to the surface flow of each reach that's drying up for that specific day. For example, for Reach 19 use:
  - Inflow from Reaches 12 and 18
  - Runoff from Watershed 19
  - EVMWD discharge



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Use of the WLAM-HSPF for the Upper Temescal Valley SNMP

- The model will be used in the Upper Temescal Valley SNMP Update under the following assumptions:
  - The model results for streamflow and streambed infiltration to the Upper Temescal Valley GMZ (which excludes Reaches 44, 46, and 48) will be used if the Task Force and Regional Board proceed with the WLAM planning runs based on this version of the model calibration.
  - For days where the WLAM model estimates zero TDS concentration for streambed infiltration, the TDS will be estimated based on the volume-weighted TDS concentration of the inputs to the surface flow of each reach that's drying up for that specific day.

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How Modeling is Used to Assess Compliance with Basin Plan Objectives

- The WLAM-HSPF is a numerical surface water model used to estimate the volume and associated TDS and TIN concentration of surface water discharge and streambed infiltration in the Santa Ana River and its tributaries

- The model estimates are used to assess compliance with the following TDS and nitrate Basin Plan objectives:
  - Surface Water: Reaches 2 and 3 of the Santa Ana River
  - Groundwater Management Zones: Beaumont, San Timoteo, Bunker Hill-B, Colton, Riverside-A, Chino South, Upper Temescal Valley, Orange County

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Models as Water Resource Planning Tools

- Models are a representation of the physical world and are used to help understand how water resources management plans could impact physical processes such a streamflow, groundwater recharge, water quality
- No model will ever perfectly capture the full extent and complexity of physical processes in a hydrogeologic system
- No two modelers will produce the same model; they will have different approaches to building and calibrating that can lead to non-unique, but satisfactory results.
- We use models despite these limitations because they can help us to better understand the hydrogeologic system and are valuable decision-support tools when the limitations of use are understood and acknowledged.

Model Review

- Model calibration statistics – how well does the model output align with measured observations in the real world?
- Typically there are many areas within a model domain where there are limited or no real world data to make such comparisons
- How else can we review model outputs to assess its ability to represent the physical world, given the limitations?
  - We can use our understanding of the physical system to assess if model results are reasonable in areas where critical evaluations are being made

Review Framework for WLAM-HSPF

- Focus review on model estimates of surface water flow and streambed infiltration for reaches that overlie the GMZs where compliance evaluations are being performed. What does this approach look like in implementation?

- For the UTV objectives, the following was asked to drive the review process:
  - How does the streamflow and streambed infiltration change across GMZs, particularly at hydrogeologic points of interest, such as the Lee Lake Reservoir? **This resulted in identifying the disconnect between the two sub-models.**
  - Is the total streambed infiltration volume and associated TDS/N concentration along Temescal Wash reasonable based on our understanding of the local hydrogeologic conditions? **This resulted in identifying that the WLAM model was assigning the streambed infiltration a TDS concentration of 0 mgl on certain days when the volume was a non-zero value.**

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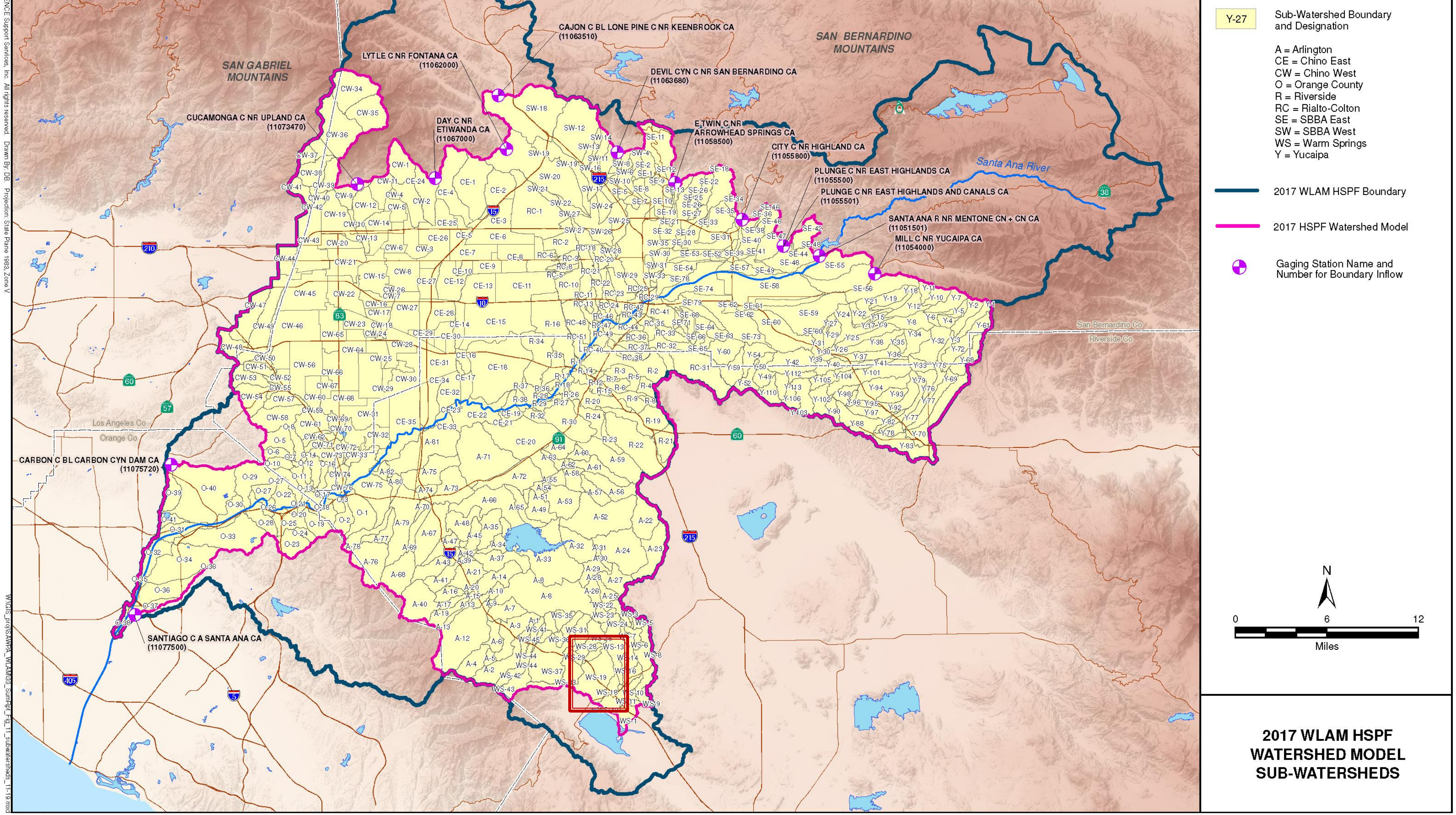
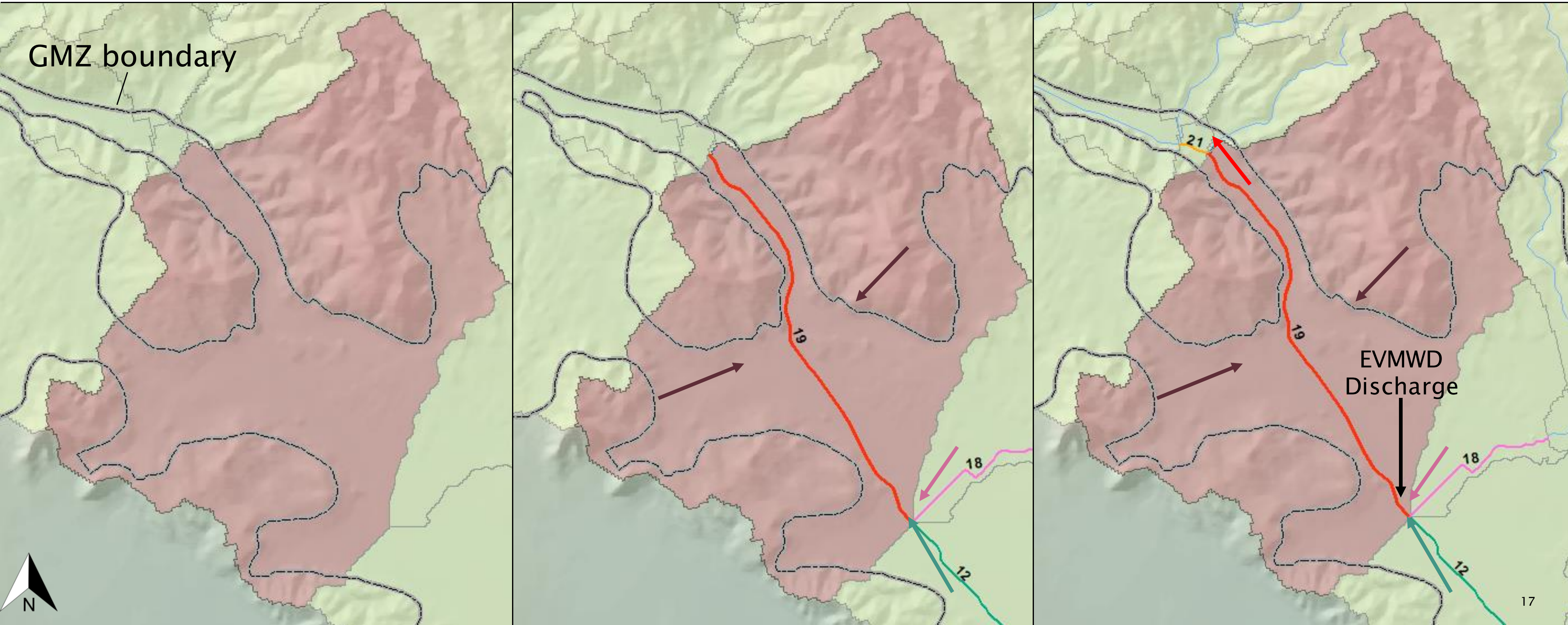


2017 WLAM HSPF WATERSHED MODEL SUB-WATERSHEDS

12-Nov-19

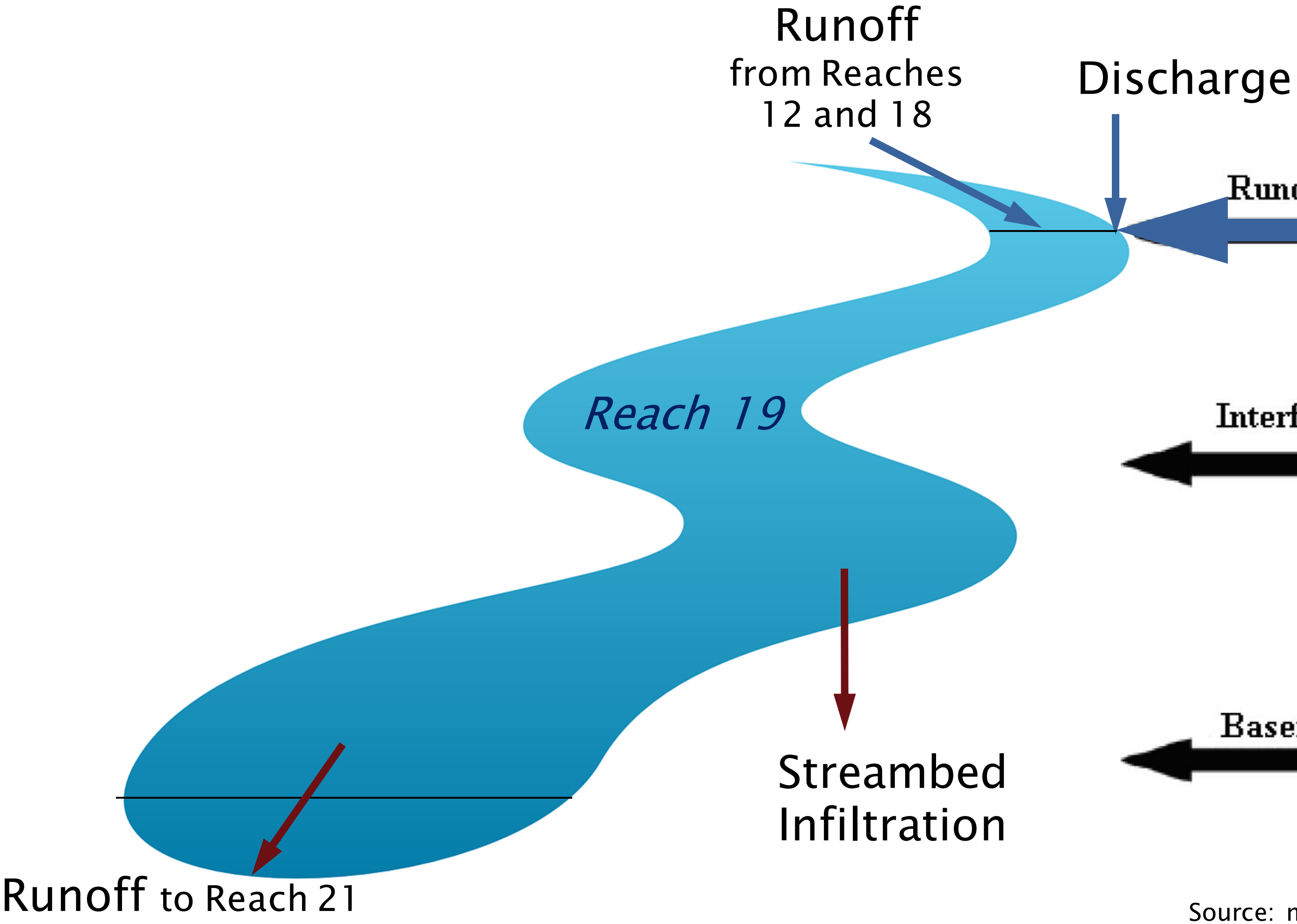
How does HSPF work?

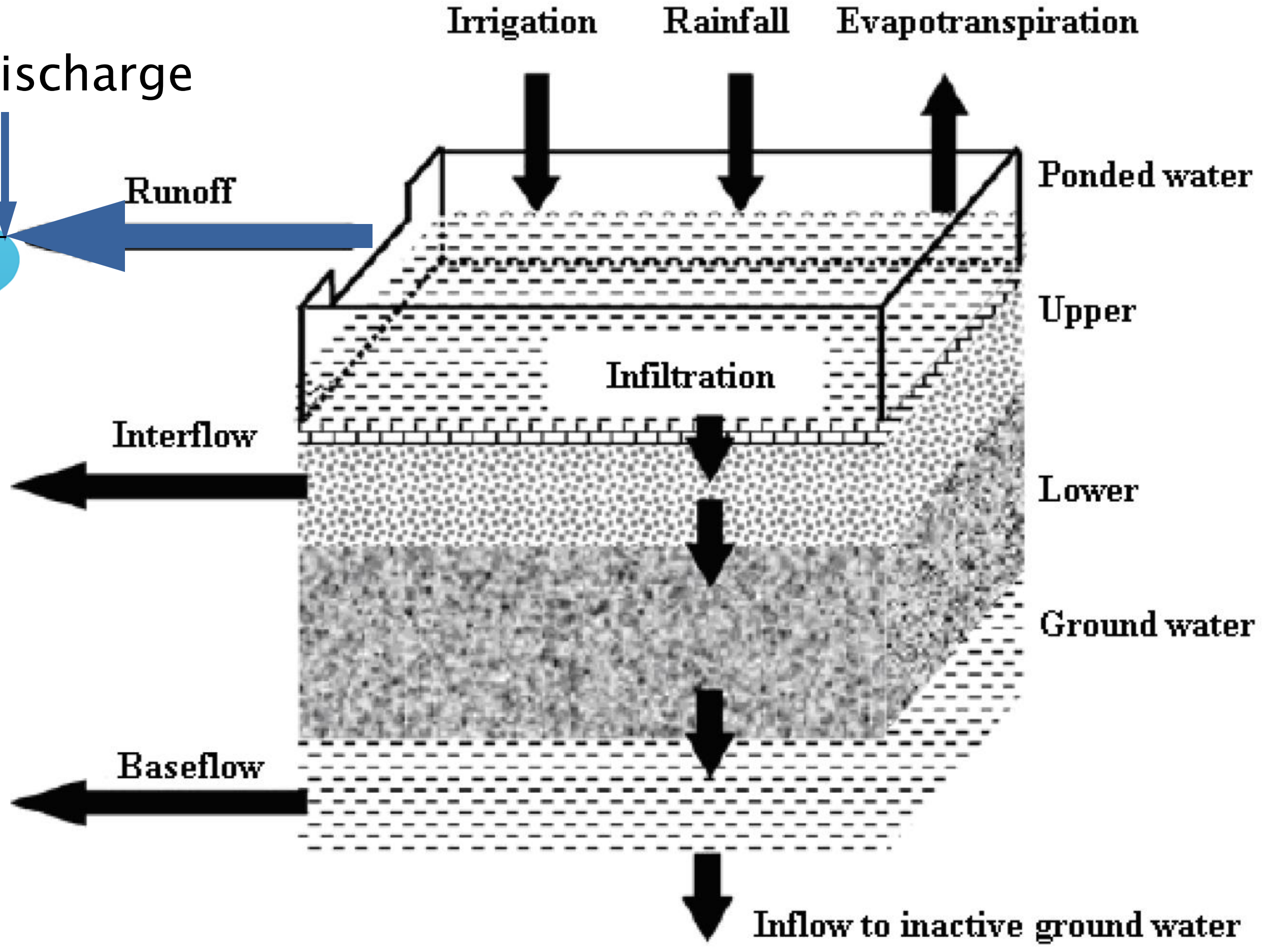
- Watersheds and reaches



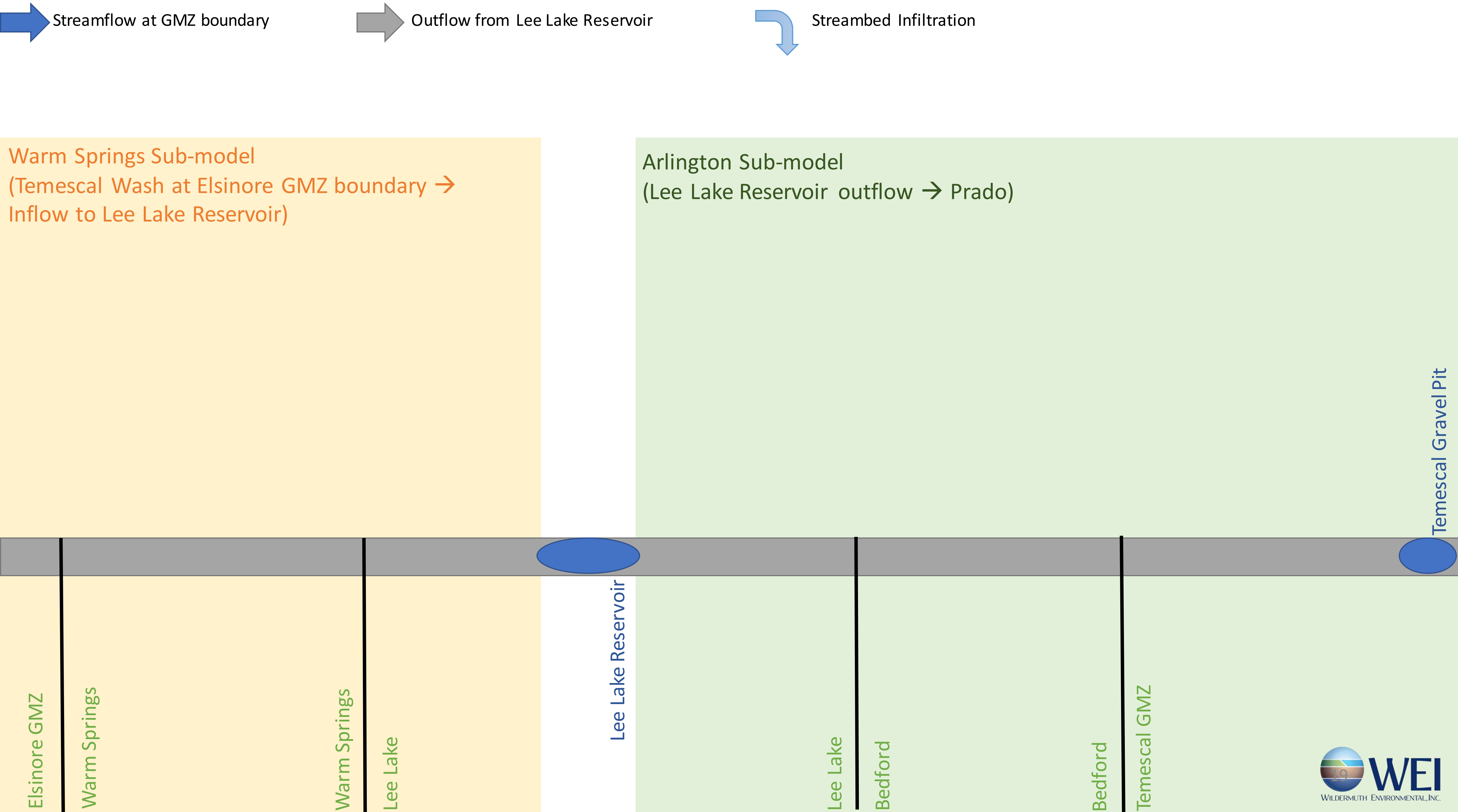
HOW DOES HSPF WORK?

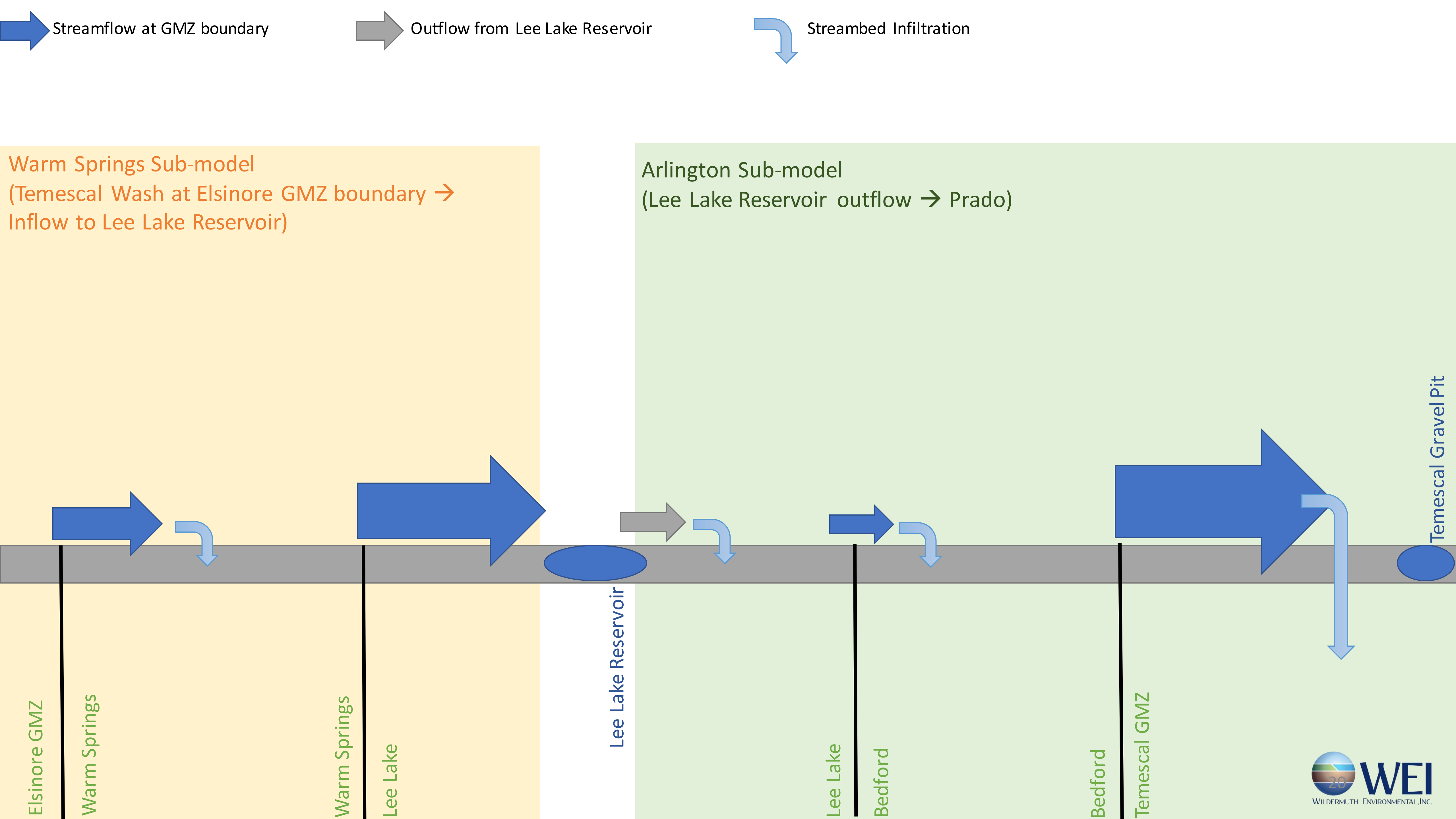
- Reach water budget
- Watershed water budget





Source: mdpi.com


Streamflow at GMZ boundary
Outflow from Lee Lake Reservoir
Streambed Infiltration
Warm Springs Sub-model
(Temescal Wash at Elsinore GMZ boundary →
Inflow to Lee Lake Reservoir)
Arlington Sub-model
(Lee Lake Reservoir outflow → Prado)
Temescal Gravel Pit
Elsinore GMZ
Warm Springs
Warm Springs
Lee Lake
Lee Lake Reservoir
Lee Lake
Bedford
Bedford
Temescal GMZ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Lee Lake Reservoir
Lee Lake
Bedford
Bedford
Temescal GMZ
Temescal Gravel Pit
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Implementation of Review

- Prepare time history plots of daily streamflow Q, TDS, and N at key locations in each GMZ, including:
  - the inflow and outflow points to confirm continuity,
  - reaches/HSAs where wastewater discharges occur, and
  - other points of hydrologic interest (e.g. surface impoundments, bedrock narrows)

Note that the axis is cut-off to better illustrate flows

Plotting streamflow at the end of the Warm Springs sub-model and the beginning of the Arlington sub-model shows us that the models are now connected.

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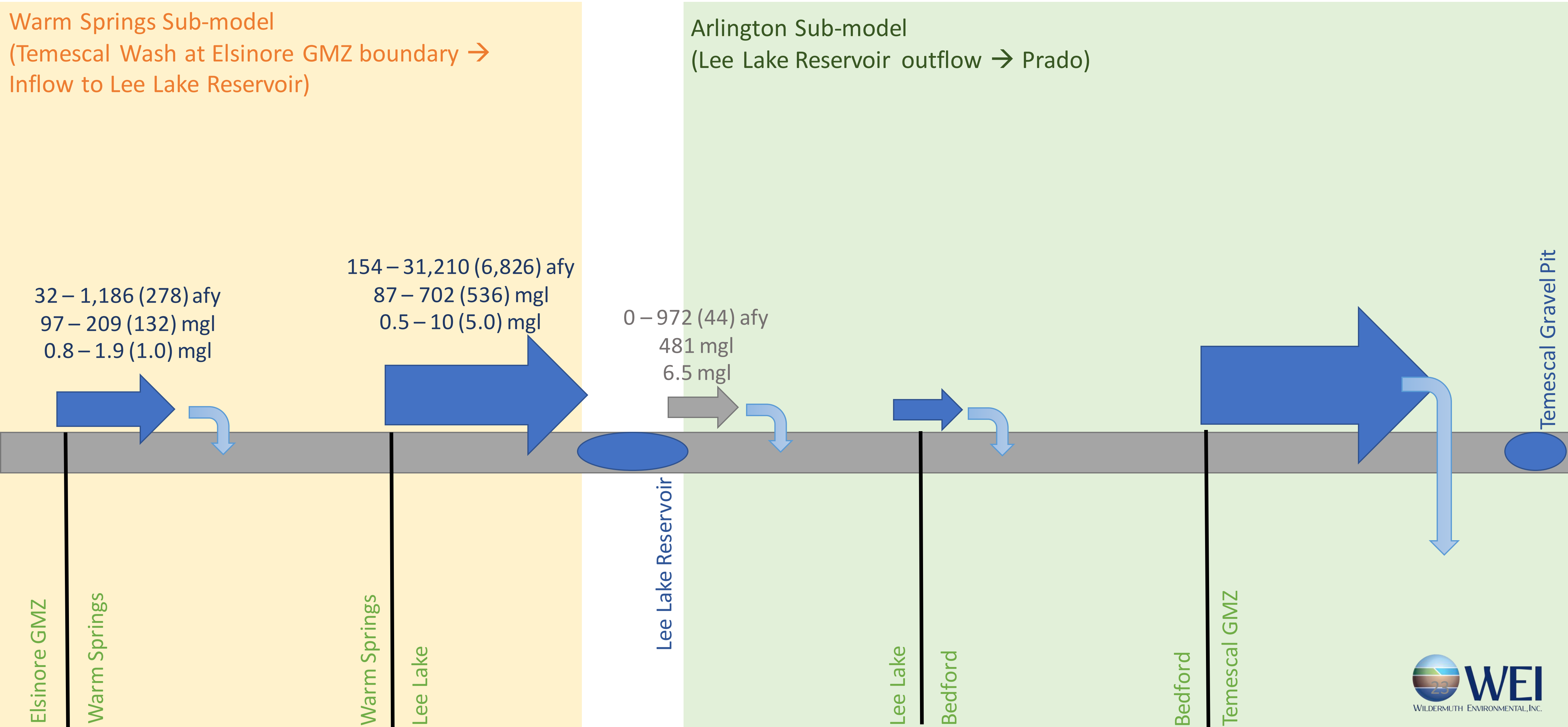
Streamflow at GMZ boundary
Annual flow in afy: Min – Max (Avg)
Annual TDS in mgl: Min – Max (Avg)
Annual NO3-N in mgl: Min – Max (Avg)

Outflow from Lee Lake Reservoir
Annual flow in afy: Min – Max (Avg)
WY 2013 TDS in mgl*
WY 2013 NO3-N in mgl*
*The model assumes outflow from Lee Lake only occurs in WY 2013

Streambed Infiltration
Annual flow in afy: Min – Max (Avg)
Annual TDS in mgl: Min – Max (Avg)
Annual NO3-N in mgl: Min – Max (Avg)



Implementation of Review

- Reach-by-reach assessment of streambed infiltration (Q, TDS, N) within each management zone. This could include:
  - summary tables of the reach parameters and annual infiltration Q, TDS, N
  - time-history plots to assess the daily model output for reaches of interest within a GMZ

WY	Streambed Infiltration in Temescal Wash estimated by WEI		Streambed Infiltration in Temescal Wash in TM-6 (Appendix A; A-21)		Streambed Infiltration in Temescal Wash in Final Report	
	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)
2005	9,326	412	9,357	412	9,357	428
2006	6,753	546	6,776	546	6,776	604
2007	5,704	519	5,716	519	5,716	645
2008	4,219	388	4,241	390	4,241	567
2009	4,300	349	4,328	351	4,328	474
2010	4,875	330	4,898	331	4,898	408
2011	7,107	377	7,141	378	7,141	417
2012	3,475	225	3,490	226	3,490	353
2013	3,843	267	3,866	269	3,866	429
2014	2,207	56	2,231	62	2,231	214
2015	2,666	69	2,692	74	2,692	189
2016	2,389	45	2,413	51	2,413	203
Min	2,207	45	2,231	51	2,231	189
Avg	4,739	299	4,762	301	4,762	411
Max	9,326	546	9,357	546	9,357	645

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Streambed Infiltration Along Temescal Wash

Reach Number	1		12		19		21		29		37		39		41		45	
Tributary Area (ac)	1,082		1,481		3,548		37		373		4,498		12		527		49	
Cumulative Trib Area (ac)	1,082		7,867		15,443		15,823		19,472		28,758		29,029		29,765		32,409	
Description	Temescal Wash		Temescal Wash EMWD Discharge		Temescal Wash EVMWD Discharge		Temescal Wash		Temescal Wash		Temescal Wash		Temescal Wash		Temescal Wash		Temescal Wash	
WY	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)
1995	39	221	537	145	1,479	658	166	658	468	649	1,212	537	48	548	728	468	236	452
1996	50	227	151	40	1,476	669	167	670	468	675	1,230	591	51	593	657	273	65	393
1997	50	228	159	43	1,474	701	167	702	468	705	1,227	625	51	625	745	456	105	382
1998	50	219	613	234	1,501	583	168	584	473	576	1,235	502	52	499	869	476	286	460
1999	50	230	153	48	1,475	714	167	715	469	718	1,228	648	51	649	864	632	188	457
2000	49	222	113	41	1,479	674	167	675	470	680	1,231	627	51	628	841	573	145	412
2001	50	227	182	42	1,477	654	167	655	470	657	1,229	594	51	594	887	595	255	502
2002	49	229	85	40	1,472	697	167	698	462	676	1,120	622	44	650	715	549	123	439
2003	50	225	346	74	1,474	622	167	623	463	597	1,064	448	39	501	595	432	147	361
2004	51	230	209	326	1,493	691	168	692	471	697	1,234	630	52	631	728	434	148	580
2005	51	214	885	506	1,566	603	172	604	482	595	1,249	542	55	541	888	527	304	526
2006	50	232	595	624	1,536	681	171	681	477	682	1,241	655	54	657	894	658	319	660
2007	47	213	522	622	1,453	580	136	670	377	673	1,031	627	43	666	699	670	248	674
2008	50	226	407	555	1,076	420	71	647	192	636	726	411	21	644	332	635	115	645
2009	51	227	354	400	1,029	284	48	570	136	535	662	270	14	558	232	545	81	549
2010	51	227	369	301	1,066	347	55	554	144	515	723	239	15	500	208	495	85	429
2011	50	227	509	306	1,276	534	135	556	381	553	1,077	477	42	515	716	516	254	515
2012	50	230	194	273	977	162	33	418	89	399	471	172	8	414	141	388	46	410
2013	49	227	153	343	899	133	21	513	61	475	378	190	6	505	101	481	33	505
2014	49	218	91	51	755	50	8	198	24	118	304	34	3	179	42	133	12	135
2015	50	229	126	62	817	78	16	205	44	133	370	41	4	155	71	126	23	129
2016	51	233	89	28	778	34	6	174	20	87	322	20	2	160	32	98	9	108
Min	39	213	85	28	755	34	6	174	20	87	304	20	2	155	32	98	9	108
Avg	49	225	311	232	1,274	480	116	566	323	547	935	432	34	519	545	462	147	442
Max	51	233	885	624	1,566	714	172	715	482	718	1,249	655	55	666	894	670	319	674

Reach Number	1		3		7		9		11		13		15		21		39		42		44		46		48	
Tributary Area (ac)	629		2,385		1,560		106		29		789		300		1,965		91		64		81		121		1,902	
Cumulative Trib Area (ac)	629		5,454		7,014		14,533		14,967		22,282		24,524		27,980		32,972		37,605		39,582		40,637		43,811	
Description	Temescal Wash Lee Lake Reservoir		Temescal Wash		Temescal Wash		Temescal Wash		Temescal Wash		Temescal Wash		Temescal Wash		Temescal Wash LLWD Discharge		Temescal Wash Cor No. 3		Temescal Wash		Temescal Wash Rising Groundwater		Temescal Wash		Temescal Wash (includes AAAP)	
WY	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)
1995	1,619	384	220	248	345	235	233	188	78	216	327	191	600	166	522	142	109	179	110	178	314	502	502	512	3,748	350
1996	263	276	60	206	103	196	92	49	15	136	149	68	132	85	301	29	22	117	26	115	126	593	220	622	1,165	435
1997	355	277	71	201	123	183	94	73	21	144	205	114	218	76	327	39	30	123	35	114	166	563	297	575	1,467	424
1998	2,190	396	258	307	431	298	253	219	85	281	357	218	664	216	620	180	126	246	140	248	331	401	535	410	4,018	281
1999	386	435	56	261	90	246	82	72	14	180	119	83	125	108	400	31	21	159	24	149	86	636	153	652	666	548
2000	262	316	45	206	76	200	62	61	12	139	83	58	114	93	459	24	20	135	24	126	107	609	191	625	875	492
2001	492	378	71	236	122	210	104	64	19	149	197	126	217	83	525	35	30	147	35	136	114	520	196	550	1,222	341
2002	171	396	33	249	55	244	47	79	9	185	66	77	88	111	465	25	13	183	16	159	58	661	103	688	435	593
2003	597	301	111	207	169	197	161	103	30	107	182	93	170	64	685	105	58	94	35	95	181	525	310	555	1,959	332
2004	732	560	97	463	160	463	108	261	28	476	125	269	202	388	714	99	42	443	49	444	202	665	356	677	1,674	579
2005	3,752	520	464	482	799	482	370	468	169	475	458	434	1,013	437	908	428	240	442	264	443	510	456	850	467	6,381	350
2006	3,038	668	307	644	516	647	275	509	100	648	290	573	622	624	875	382	144	611	164	634	328	686	515	690	3,307	635
2007	2,405	668	270	654	474	658	225	588	96	658	270	608	610	631	842	346	189	626	188	583	273	707	429	713	2,442	709
2008	1,367	652	179	611	317	614	160	516	63	626	202	506	414	575	587	318	161	606	146	509	245	660	404	669	2,413	579
2009	971	579	140	524	244	532	138	390	46	550	171	389	318	498	835	493	222	509	157	419	212	652	353	662	1,981	556
2010	740	556	125	451	209	461	138	271	36	489	220	273	293	363	903	503	232	508	168	418	229	580	389	599	2,471	427
2011	2,398	510	252	422	404	419	261	279	76	399	318	285	547	316	784	276	181	458	175	428	274	518	445	529	3,070	401
2012	413	405	64	343	111	349	80	181	20	349	97	179	143	262	840	286	172	359	80	271	116	653	202	670	951	558
2013	384	540	69	437	121	442	74	297	24	437	101	268	173	362	693	173	139	463	98	403	92	648	159	660	761	598
2014	101	122	27	191	47	198	41	57	8	137	58	49	72	77	626	13	11	152	13	129	53	557	94	573	524	387
2015	216	114	46	158	83	160	61	64	15	116	83	57	116	79	714	17	21	147	24	135	66	459	113	486	725	304
2016	75	105	34	186	58	193	55	52	9	127	74	46	87	72	717	16	14	160	16	137	54	541	92	581	573	359
Min	75	105	27	158	47	160	41	49	8	107	58	46	72	64	301	13	11	94	13	95	53	401	92	410	435	281
Avg	1,042	416	136	349	230	347	142	220	44	319	189	226	315	258	652	180	100	312	90	285	188	582	314	598	1,947	465
Max	3,752	668	464	654	799	658	370	588	169	658	458	608	1,013	631	908	503	240	626	264	634	510	707	850	713	6,381	709

*Note that TDS is based on the model output and does not include the post-processing required.

STREAMBED INFILTRATION ALONG TEMESCAL WASH

Reach Number	1		12		19	
Tributary Area (ac)	1,082		1,481		3,548	
Cumulative Trib Area (ac)	1,082		7,867		15,443	
Description	Temescal Wash		Temescal Wash EMWD Discharge		Temescal Wash EVMWD Discharge	
WY	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)	Flow (afy)	TDS (mgl)
1995	39	221	537	145	1,479	658
1996	50	227	151	40	1,476	669
1997	50	228	159	43	1,474	701
1998	50	219	613	234	1,501	583
1999	50	230	153	48	1,475	714
2000	49	222	113	41	1,479	674
2001	50	227	182	42	1,477	654
2002	49	229	85	40	1,472	697
2003	50	225	346	74	1,474	622
2004	51	230	209	326	1,493	691
2005	51	214	885	506	1,566	603
2006	50	232	595	624	1,536	681
2007	47	213	522	622	1,453	580
2008	50	226	407	555	1,076	420
2009	51	227	354	400	1,029	284
2010	51	227	369	301	1,066	347
2011	50	227	509	306	1,276	534
2012	50	230	194	273	977	162
2013	49	227	153	343	899	133
2014	49	218	91	51	755	50
2015	50	229	126	62	817	78
2016	51	233	89	28	778	34
Min	39	213	85	28	755	34
Avg	49	225	311	232	1,274	480
Max	51	233	885	624	1,566	714

*Note that TDS is based on the model output and does not include the post-processing required.

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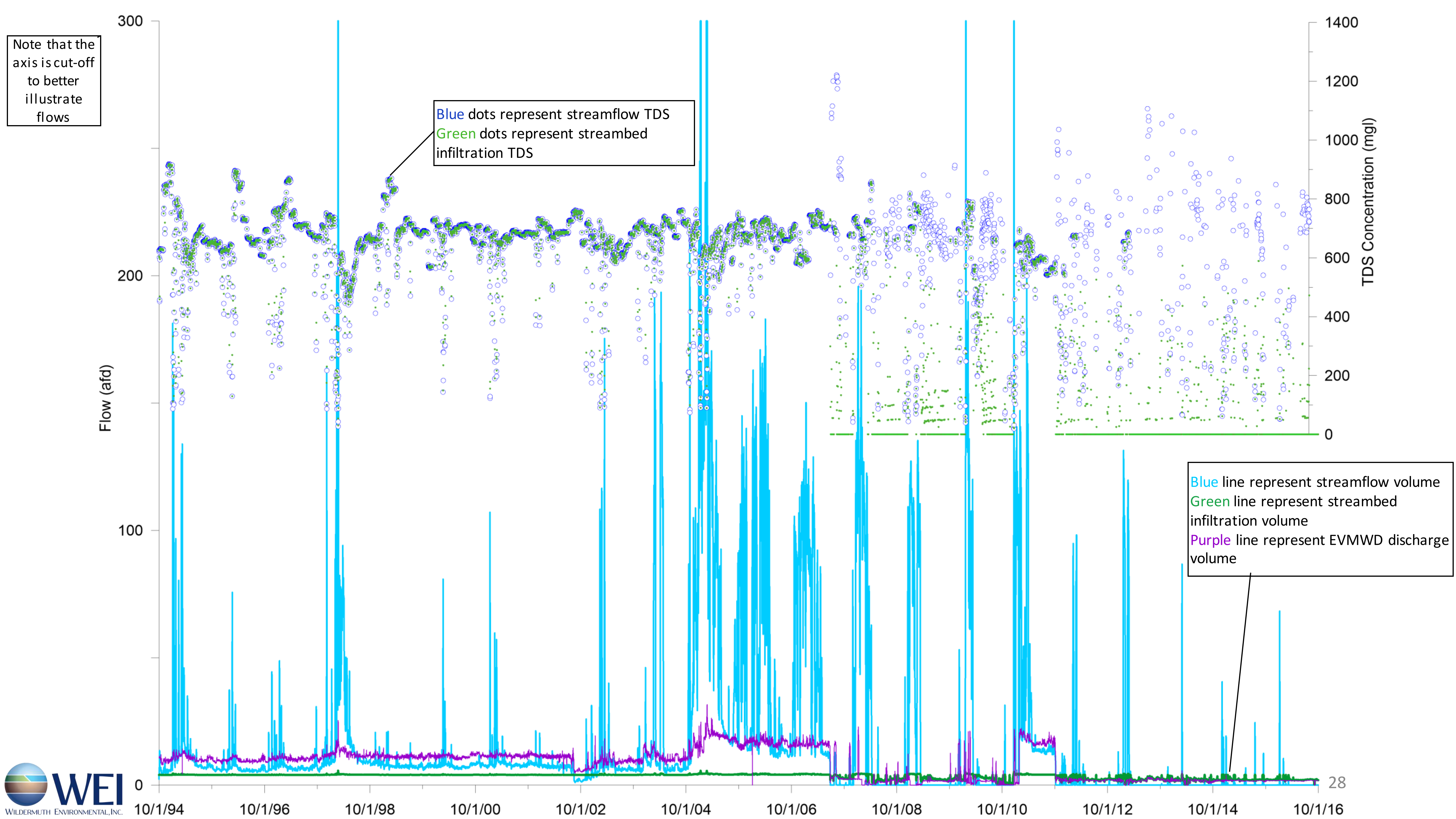
Note that the axis is cut-off to better illustrate flows
Blue dots represent streamflow TDS
Green dots represent streambed infiltration TDS
Blue line represent streamflow volume
Green line represent streambed infiltration volume
Purple line represent EVMWD discharge volume
Flow (afd)
TDS Concentration (mgl)
300
200
100
0
1400
1200
1000
800
600
400
200
0
10/1/94
10/1/96
10/1/98
10/1/00
10/1/02
10/1/04
10/1/06
10/1/08
10/1/10
10/1/12
10/1/14
10/1/16
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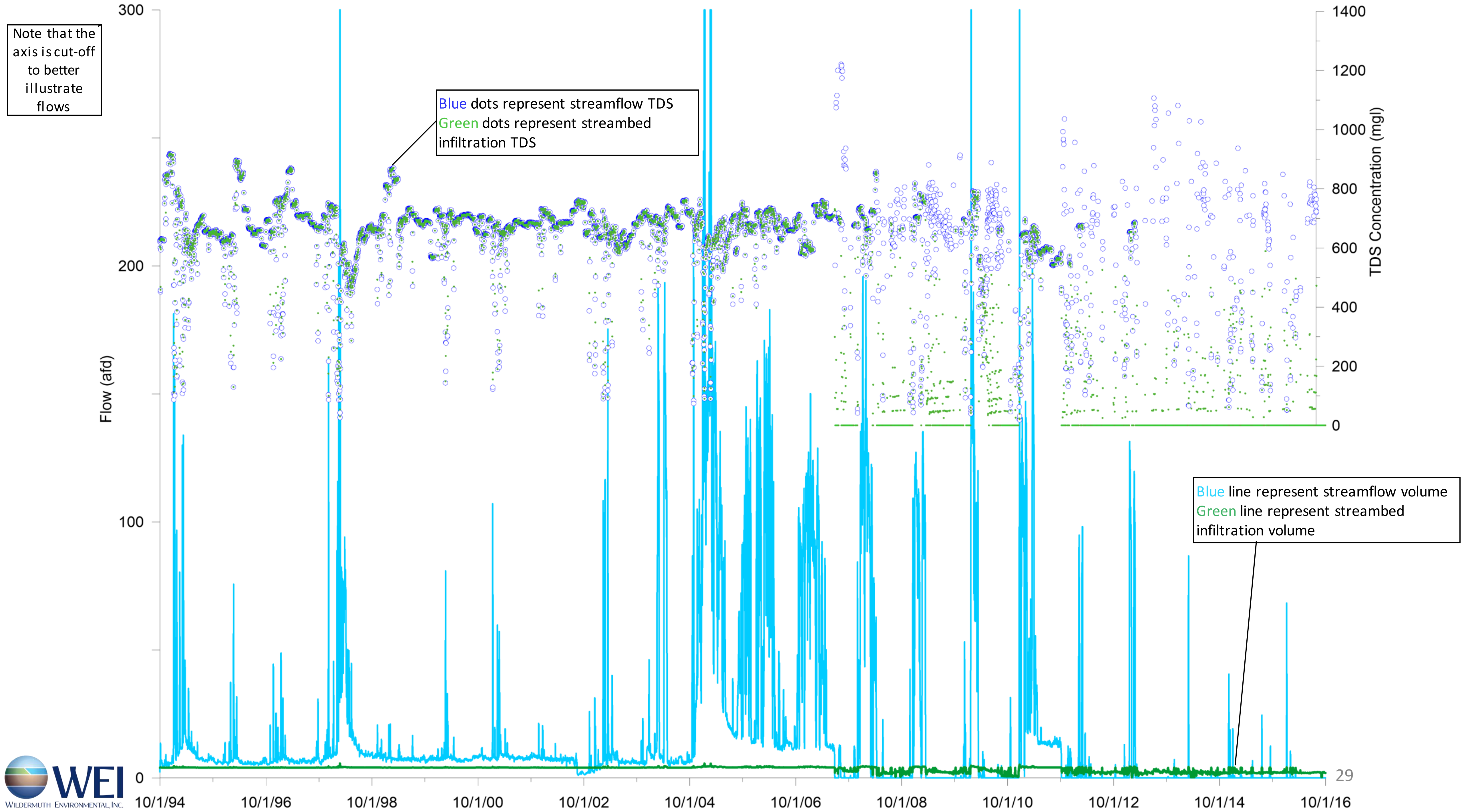
Note that the axis is cut-off to better illustrate flows
Blue dots represent streamflow TDS
Green dots represent streambed infiltration TDS
Blue line represent streamflow volume
Green line represent streambed infiltration volume
Flow (afd)
TDS Concentration (mgl)
300
200
100
0
1400
1200
1000
800
600
400
200
0
10/1/94
10/1/96
10/1/98
10/1/00
10/1/02
10/1/04
10/1/06
10/1/08
10/1/10
10/1/12
10/1/14
10/1/16
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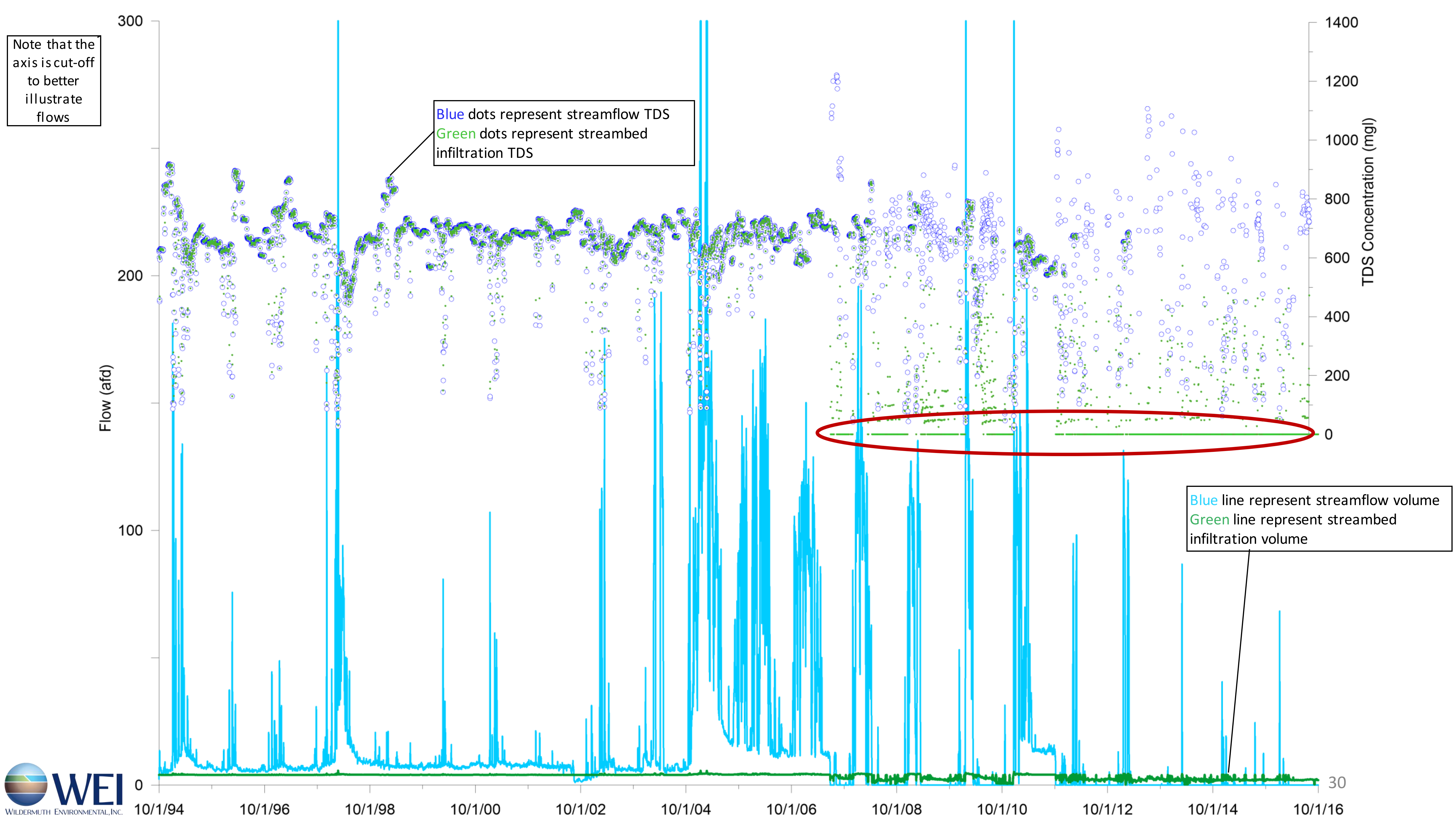

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Blue dots represent streamflow TDS
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Flow (afd)
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0
10/1/94
10/1/96
10/1/98
10/1/00
10/1/02
10/1/04
10/1/06
10/1/08
10/1/10
10/1/12
10/1/14
10/1/16
30
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Summary

- Schematics, charts, and tables similar to those prepared for the UTV SNMP could readily be assembled for other GMZs from the model input and output files
- The exhibits can be reviewed by the Task Force members and other overlying agencies and experts in the local hydrogeology of the GMZs to assess if (1) obvious errors exist and (2) the results reasonably represent the GMZ.
- A finding that the representation of a GMZ is not fully reasonable does not mean the WLAM could not move forward to completion, but it would enable the Task Force to: highlight limitations in the use of the model and identify areas where additional monitoring and/or studies are needed to improve future versions of the model.

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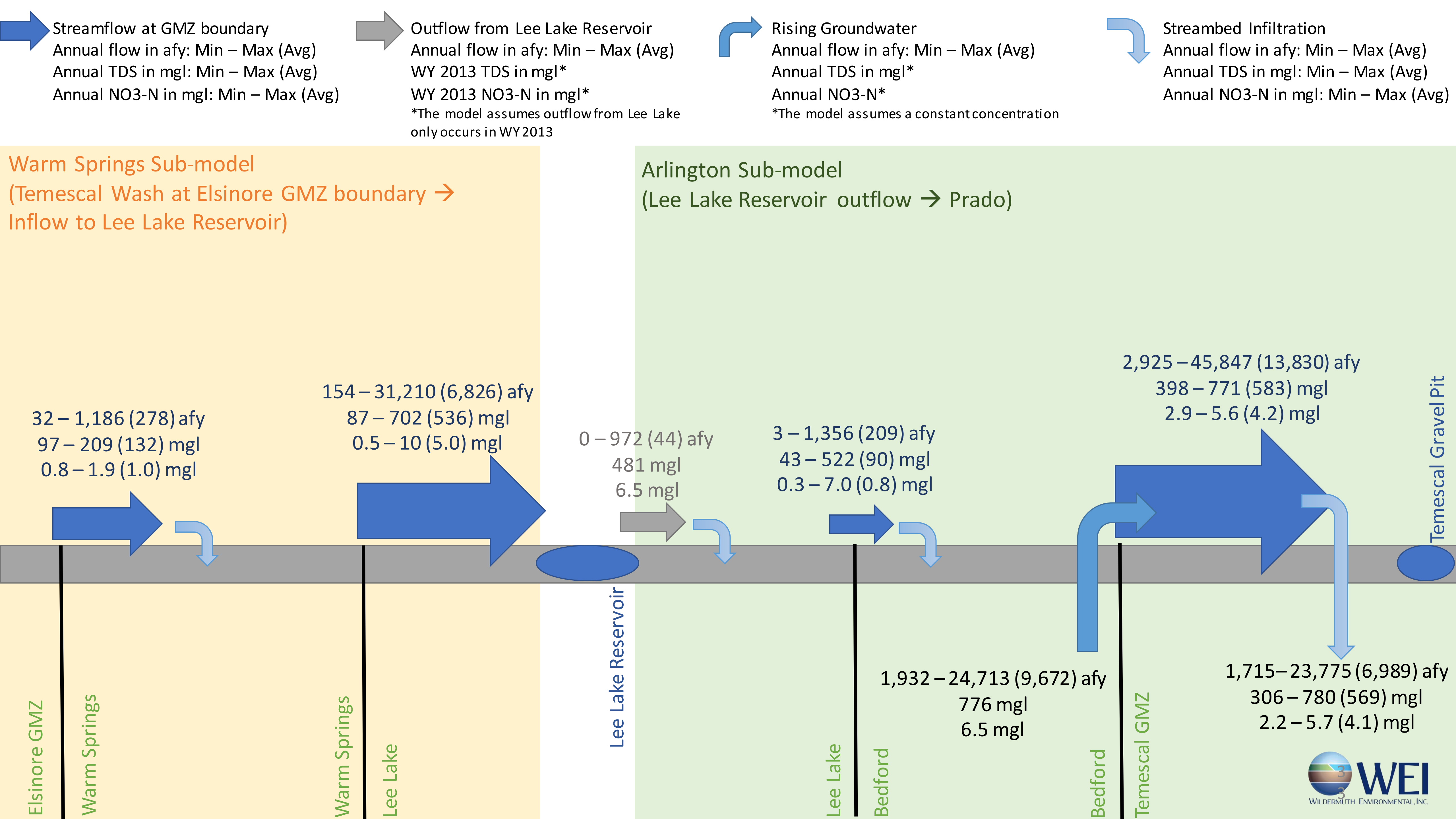
END



Streamflow at GMZ boundary
Annual flow in afy: Min – Max (Avg)
Annual TDS in mgl: Min – Max (Avg)
Annual NO3-N in mgl: Min – Max (Avg)
Outflow from Lee Lake Reservoir
Annual flow in afy: Min – Max (Avg)
WY 2013 TDS in mgl*
WY 2013 NO3-N in mgl*
*The model assumes outflow from Lee Lake only occurs in WY 2013
Rising Groundwater
Annual flow in afy: Min – Max (Avg)
Annual TDS in mgl*
Annual NO3-N*
*The model assumes a constant concentration
Streambed Infiltration
Annual flow in afy: Min – Max (Avg)
Annual TDS in mgl: Min – Max (Avg)
Annual NO3-N in mgl: Min – Max (Avg)
Warm Springs Sub-model
(Temescal Wash at Elsinore GMZ boundary → Inflow to Lee Lake Reservoir)
Arlington Sub-model
(Lee Lake Reservoir outflow → Prado)
32 – 1,186 (278) afy
97 – 209 (132) mgl
0.8 – 1.9 (1.0) mgl
154 – 31,210 (6,826) afy
87 – 702 (536) mgl
0.5 – 10 (5.0) mgl
0 – 972 (44) afy
481 mgl
6.5 mgl
3 – 1,356 (209) afy
43 – 522 (90) mgl
0.3 – 7.0 (0.8) mgl
2,925 – 45,847 (13,830) afy
398 – 771 (583) mgl
2.9 – 5.6 (4.2) mgl
1,932 – 24,713 (9,672) afy
776 mgl
6.5 mgl
1,715– 23,775 (6,989) afy
306 – 780 (569) mgl
2.2 – 5.7 (4.1) mgl
Elsinore GMZ
Warm Springs
Warm Springs
Lee Lake
Lee Lake Reservoir
Lee Lake
Bedford
Bedford
Temescal GMZ
Temescal Gravel Pit
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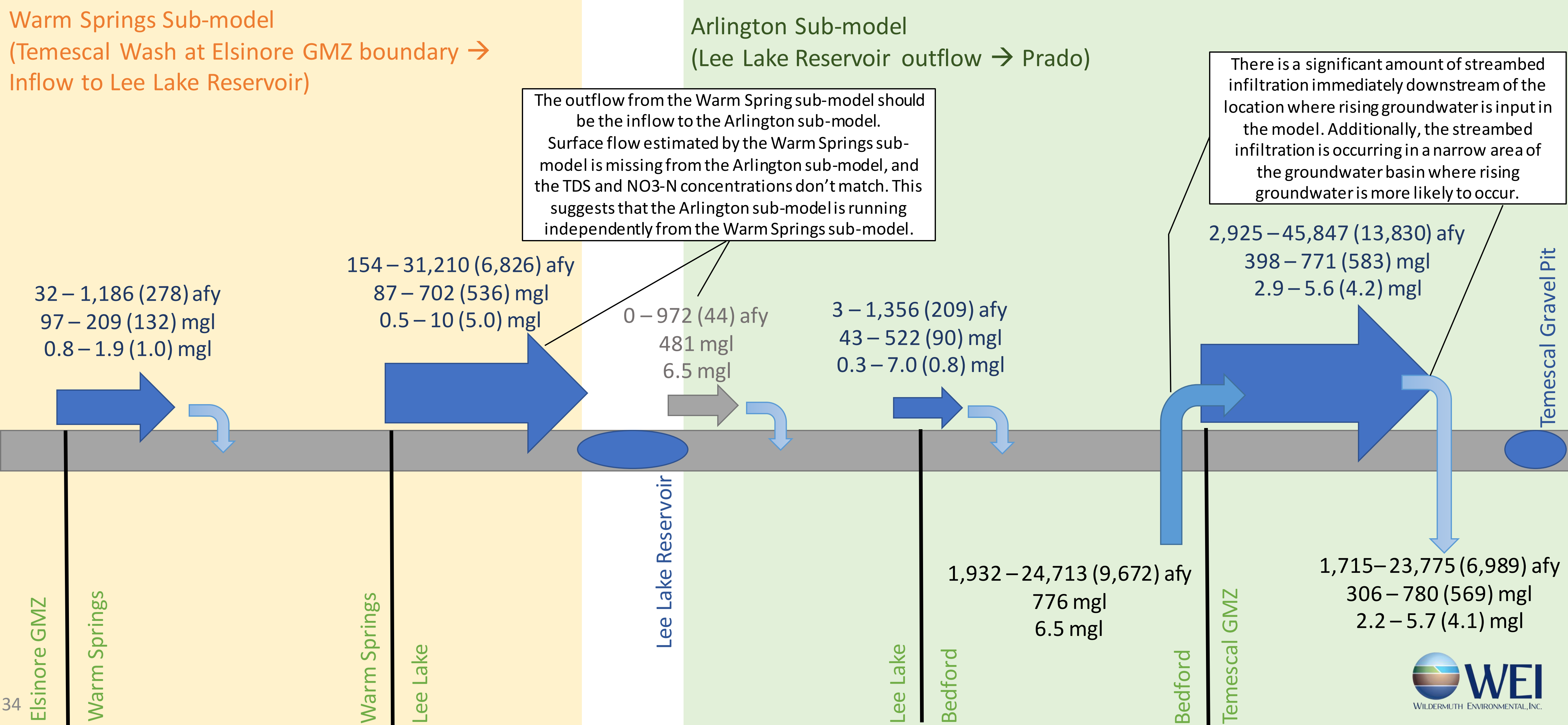
Streamflow at GMZ boundary
Annual flow in afy: Min – Max (Avg)
Annual TDS in mgl: Min – Max (Avg)
Annual NO3-N in mgl: Min – Max (Avg)

Outflow from Lee Lake Reservoir
Annual flow in afy: Min – Max (Avg)
WY 2013 TDS in mgl*
WY 2013 NO3-N in mgl*
*The model assumes outflow from Lee Lake only occurs in WY 2013

Rising Groundwater
Annual flow in afy: Min – Max (Avg)
Annual TDS in mgl*
Annual NO3-N*
*The model assumes a constant concentration

Streambed Infiltration
Annual flow in afy: Min – Max (Avg)
Annual TDS in mgl: Min – Max (Avg)
Annual NO3-N in mgl: Min – Max (Avg)



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