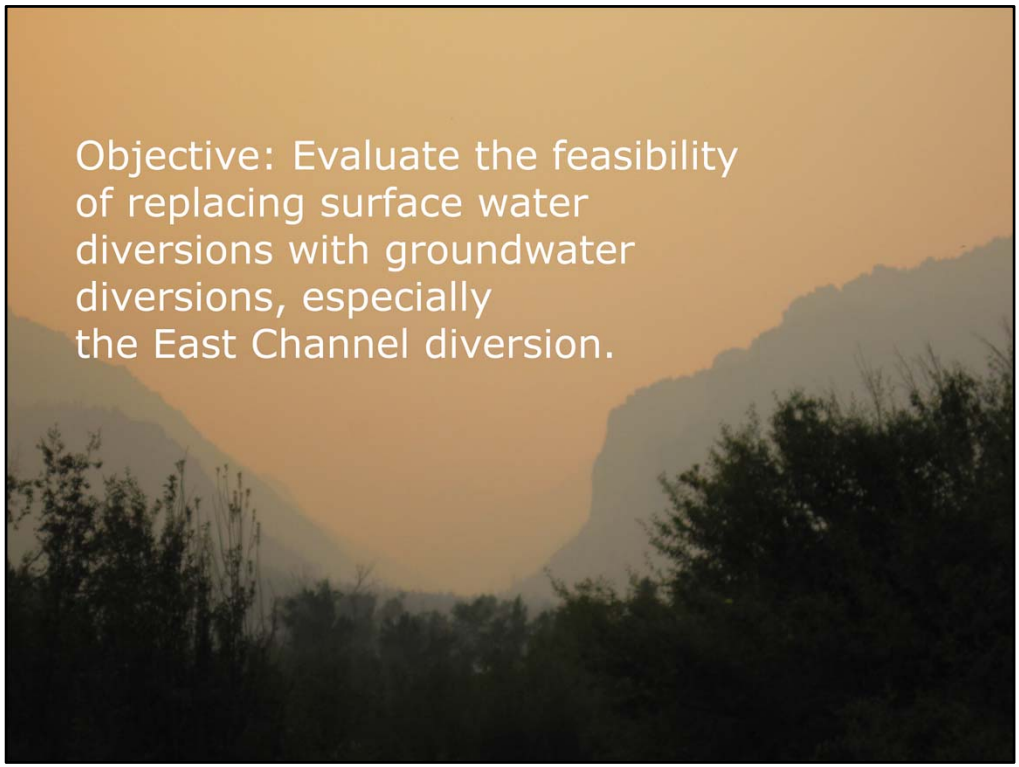
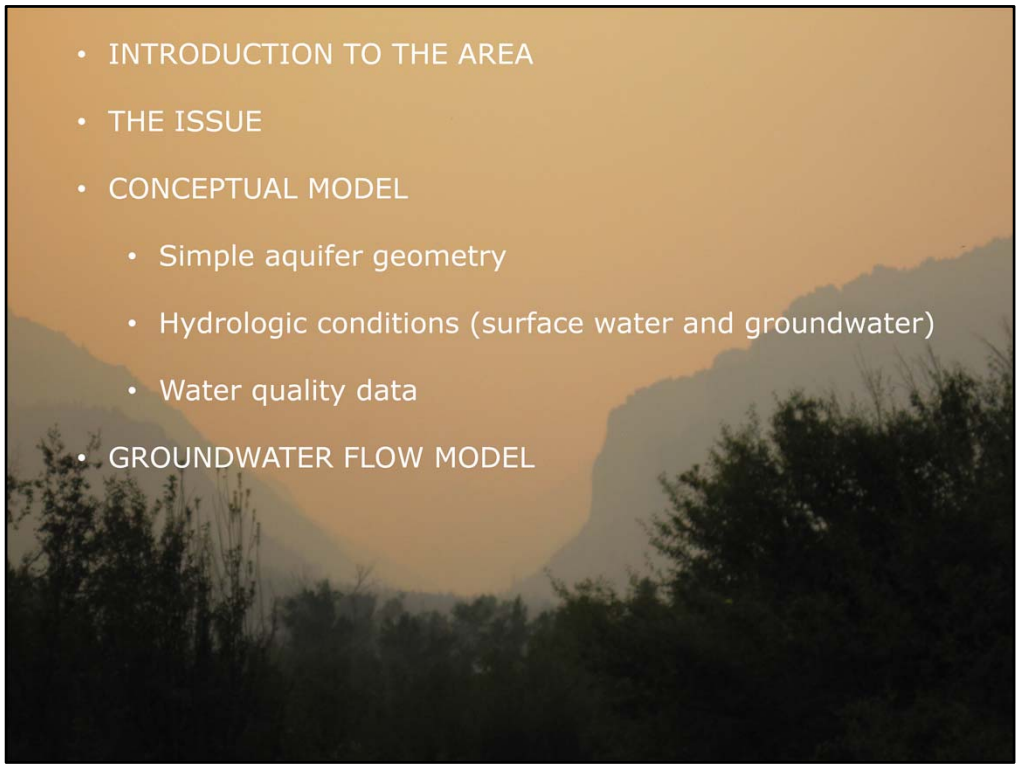
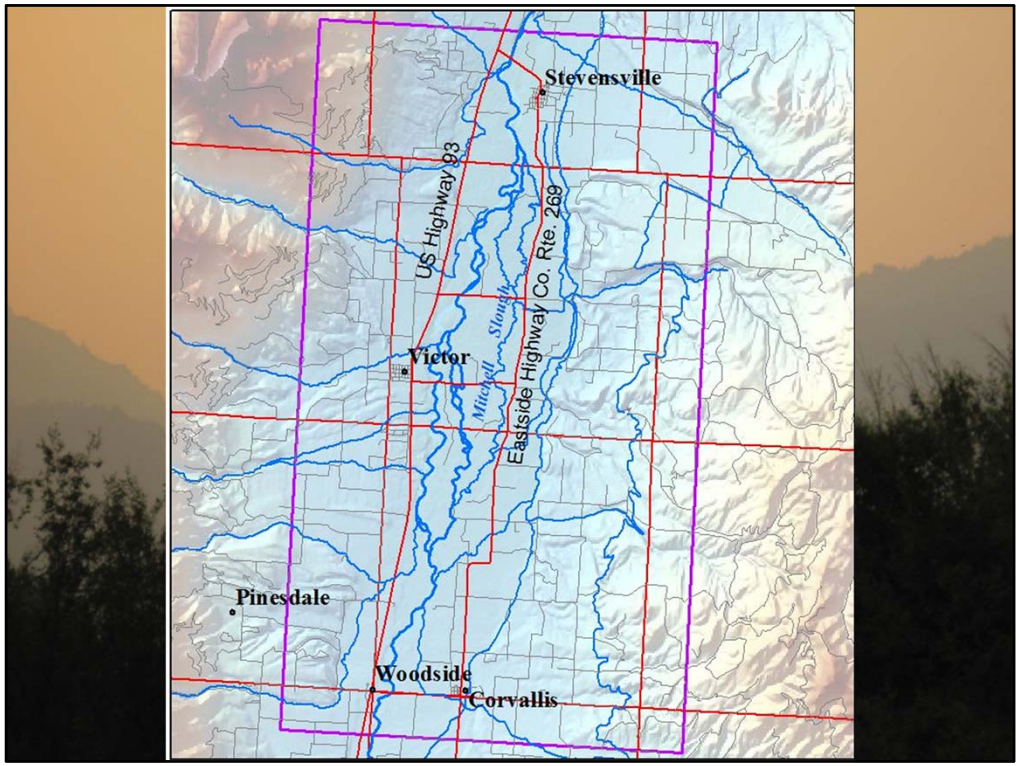
Todd Myse (left) and Kirk Waren (right) measure the flow of the Bitterroot River, west channel at Victor Crossing.



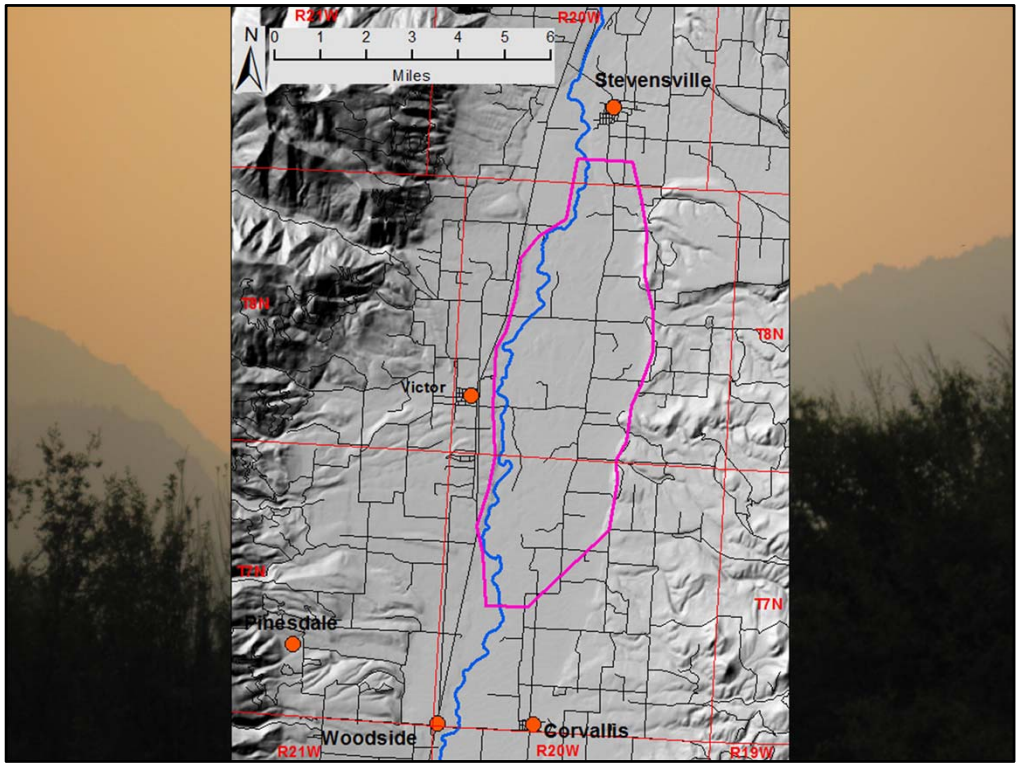
Objective of the Stevensville Ground Water Investigation Program (GWIP) Project



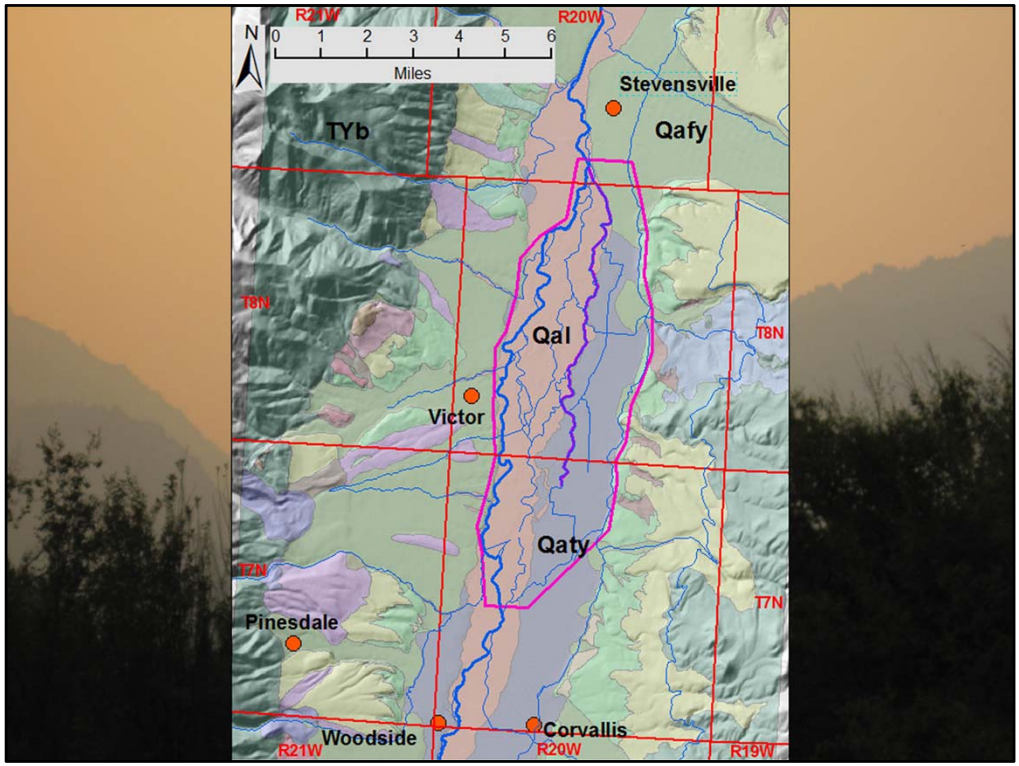
Today's agenda



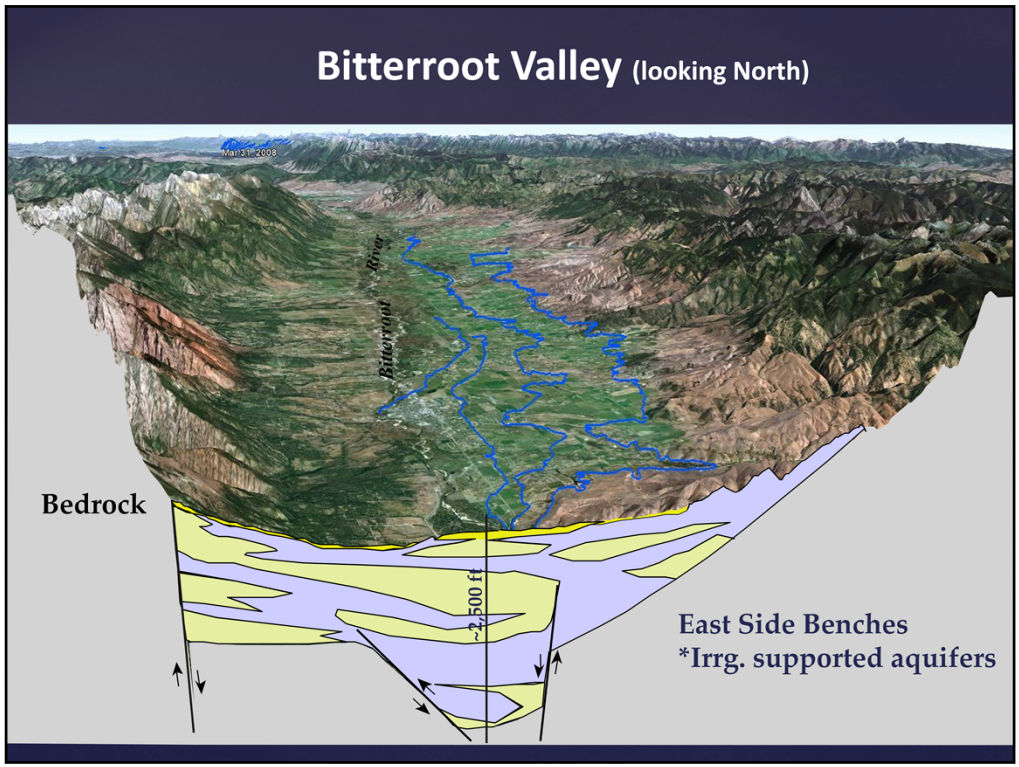
The purple rectangle shows the approximate location of the Stevensville GWIP project study area boundary.



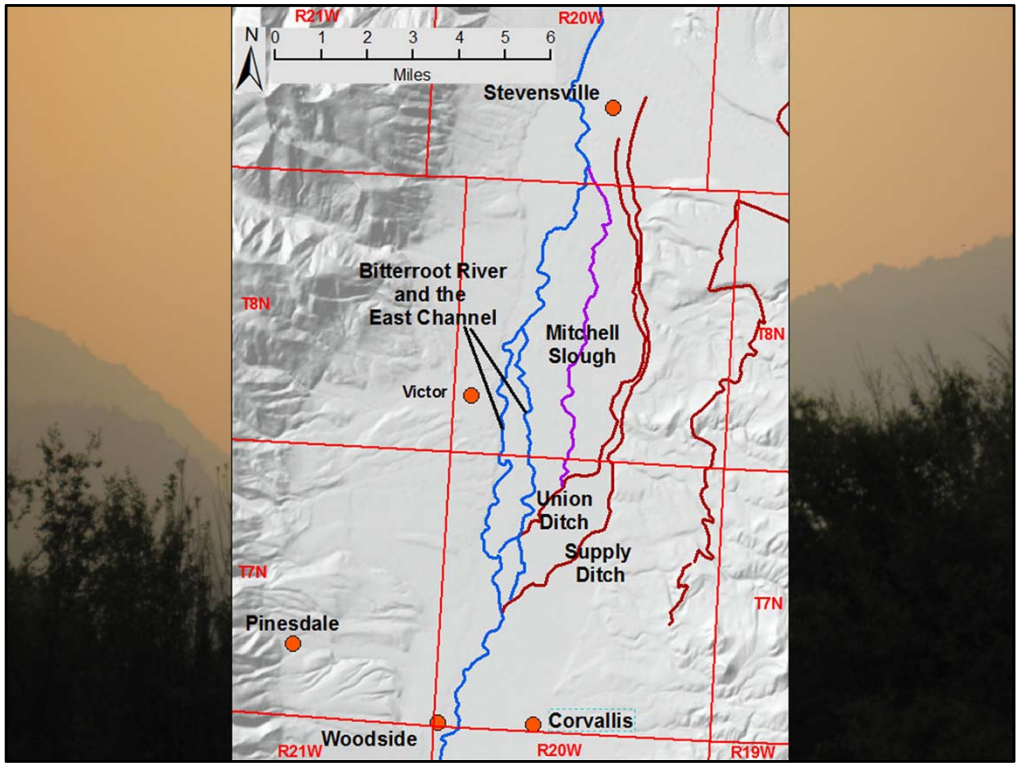
The focus area is on the valley floor, mostly east of the Bitterroot River



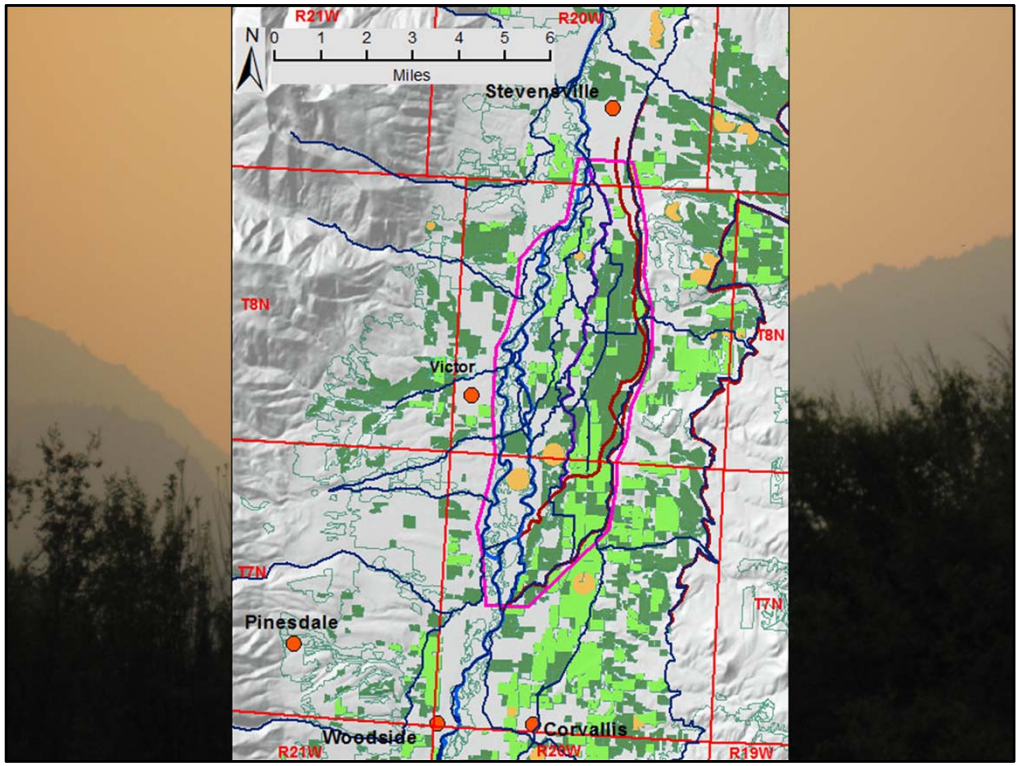
There are two main geologic units in the focus area, the Quaternary alluvium (Qal) of the Bitterroot River floodplain, and the terrace deposits (Qaty) [low terrace].



This composite view was created by Hydrogeologist Dean Snyder. It is meant to show a cut-away view of the geology of the Bitterroot Valley basin fill. The bright yellow represents relatively young stream-deposited materials of the modern and glacially-depostied alluvium beneath the floodplain and low terraces.

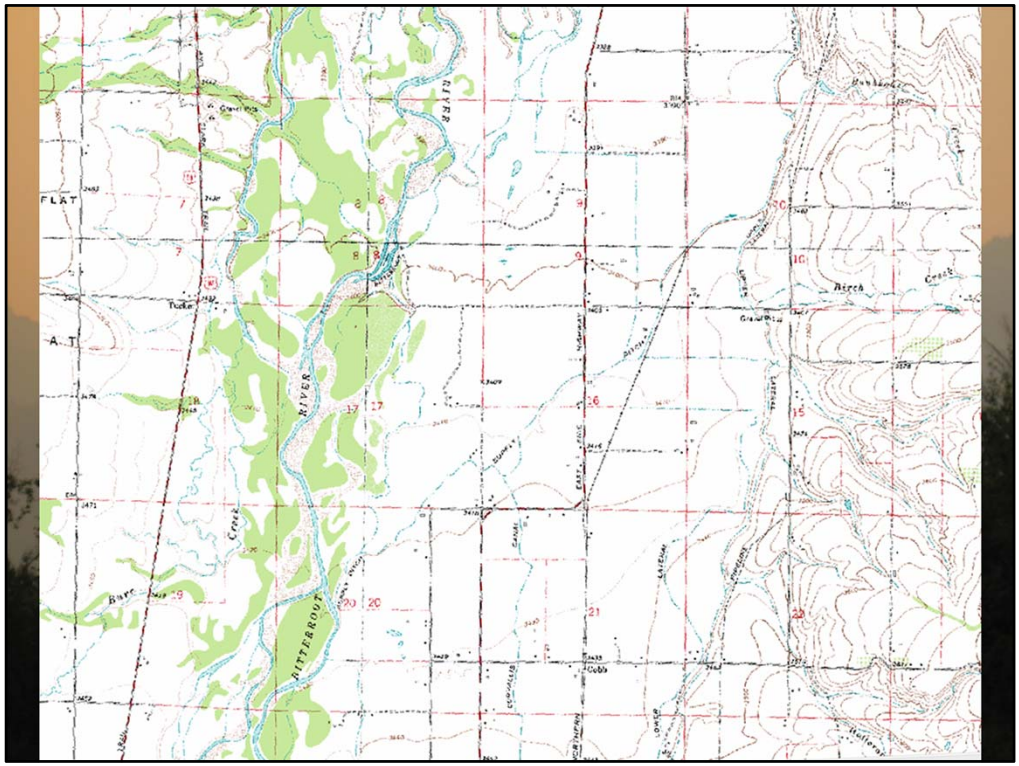


Principle water features in the study area

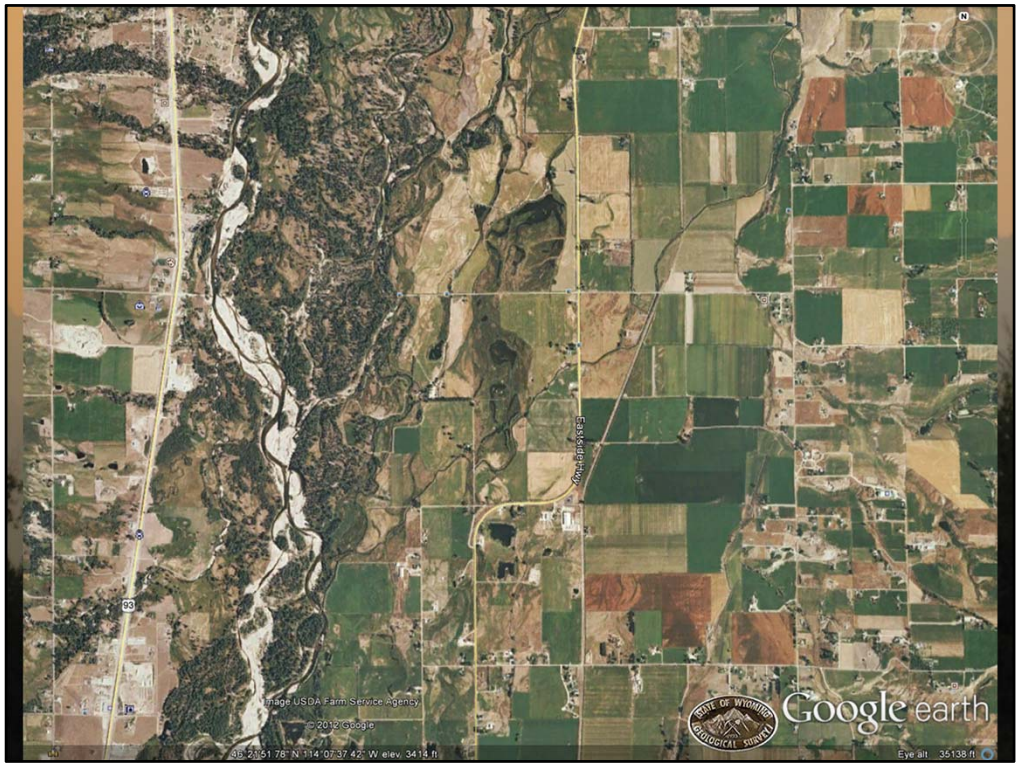


Irrigated lands as depicted in the MT Dept. of Revenues land use (FLU) coverages green: flood irrigation, light green: sprinkler/wheel line irrigation, orange: pivot irrigation.

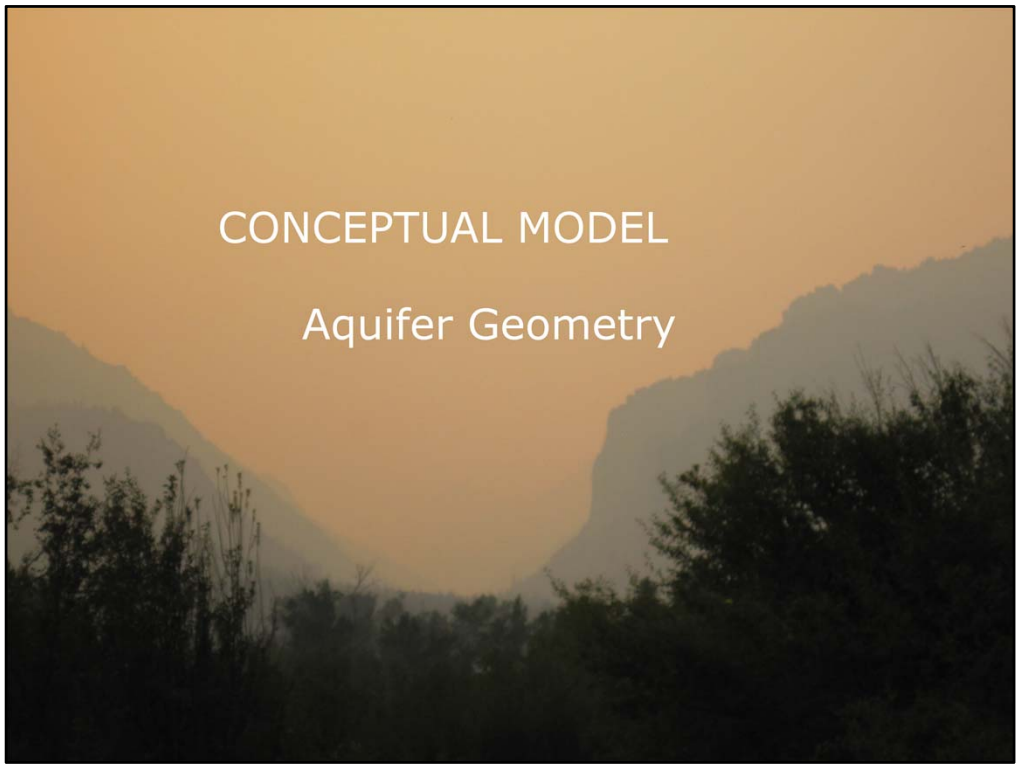

THE ISSUE

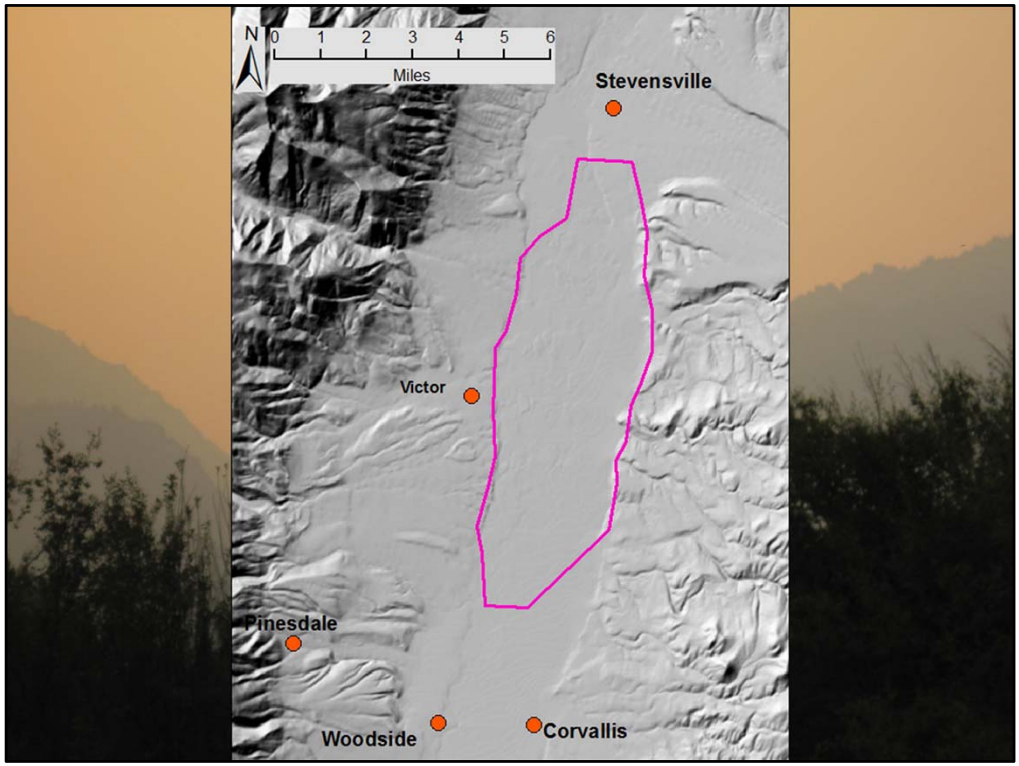


The main stem of the Bitterroot River follows the east channel on this 1967 topographic map

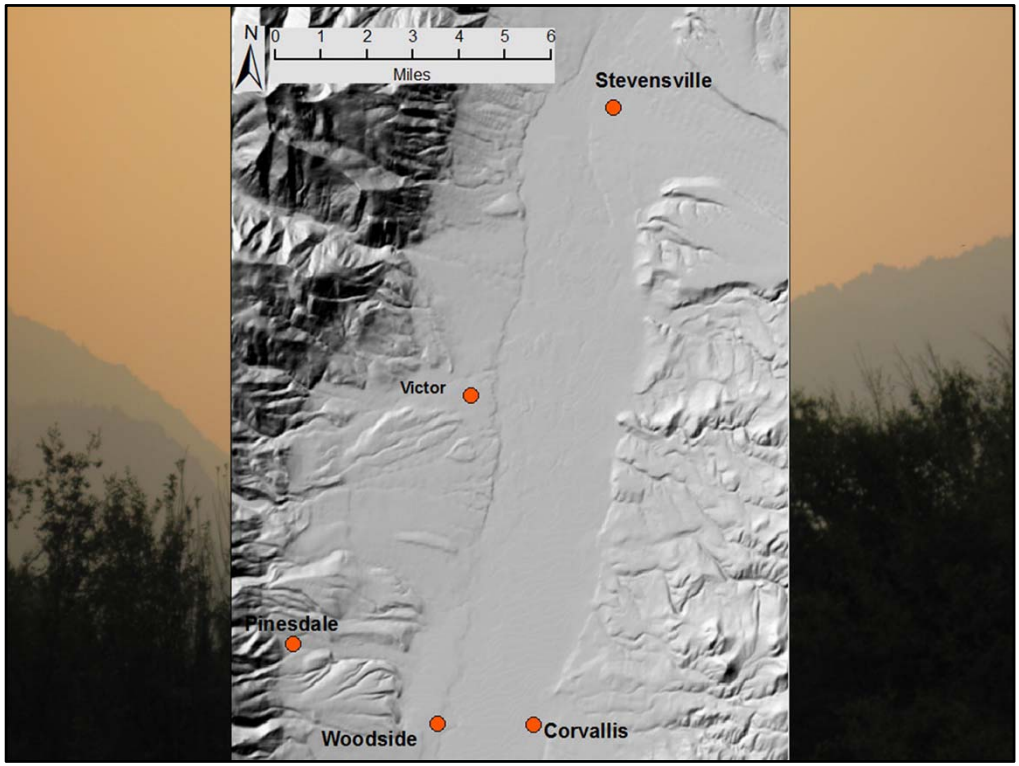


The Bitterroot River mainstem now occupies the west channel, and it takes increasing efforts to get water delivered to the Tucker Headgate on the east channel (2011 image).


CONCEPTUAL MODEL
Aquifer Geometry

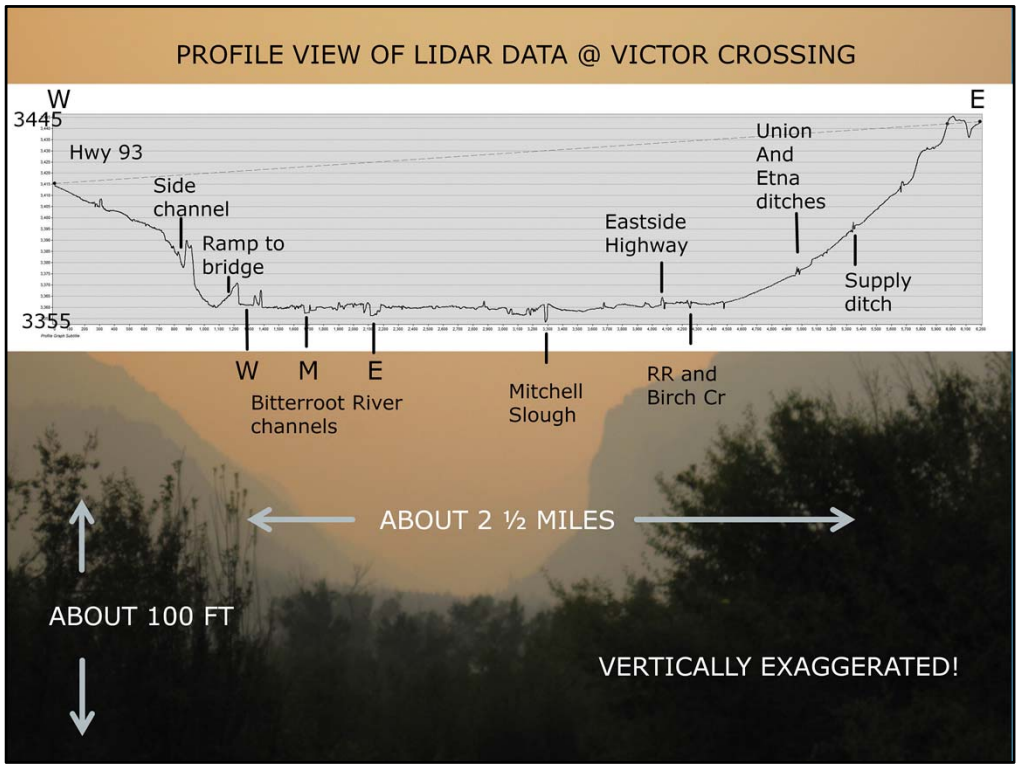


Focus area on shaded relief map

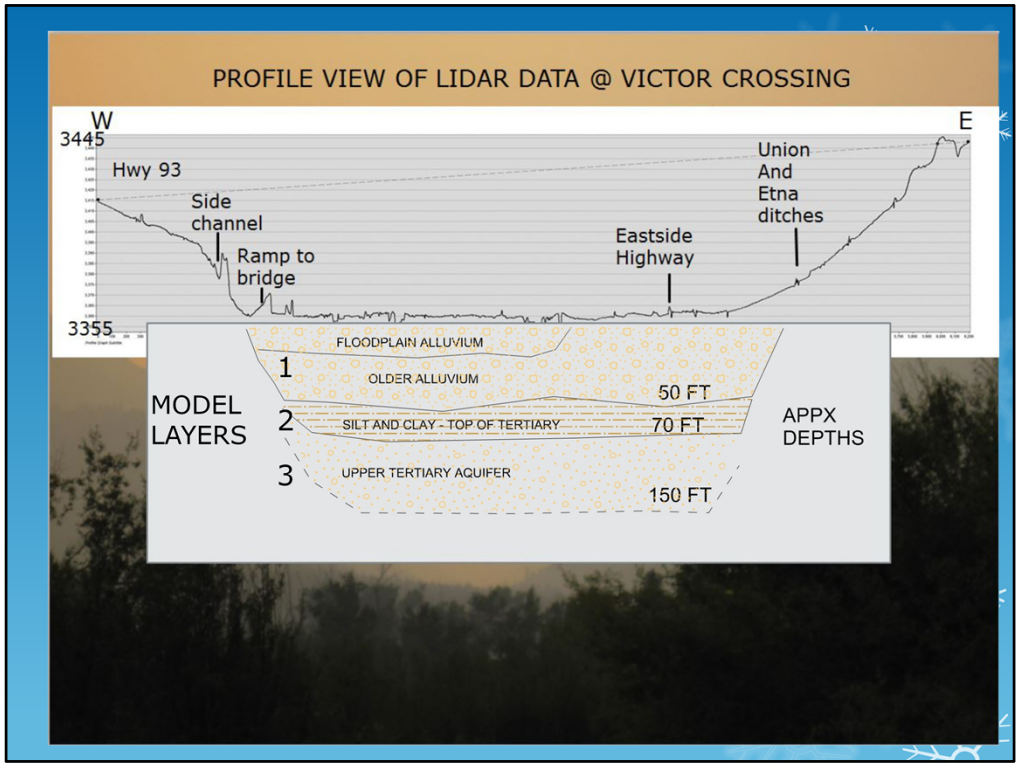


Shaded relief without focus area for clarity. The focus area is rather flat.

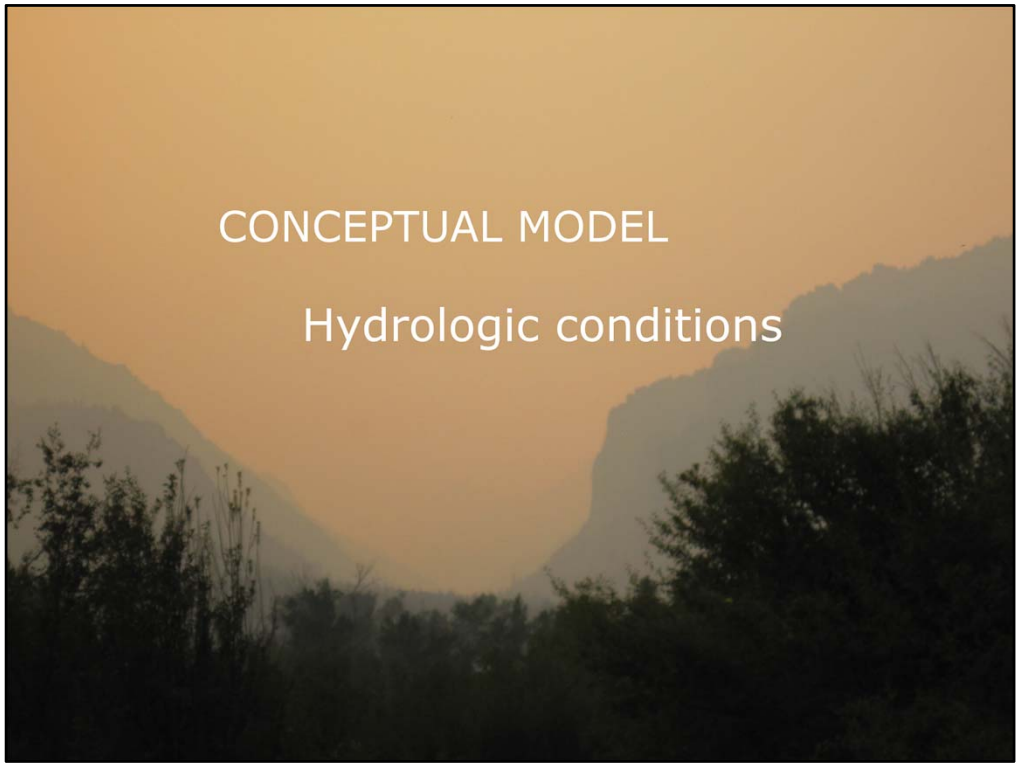
Lidar image from data provided by Ravalli County. Here the floodplain is more readily distinguished from the eastside terrace, which is flatter and has less visible channel features.

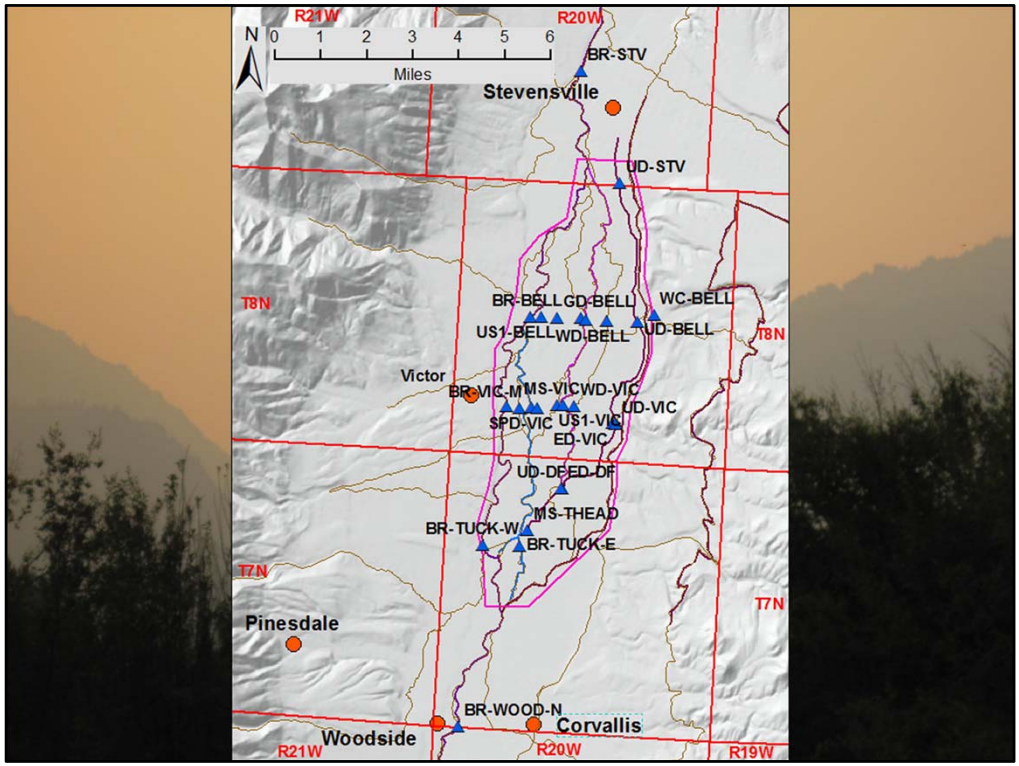


A profile view of the Bitterroot Valley at Victor Crossing. The profile is about 4 miles across, and spans 90 feet vertically, so is greatly vertically exaggerated. Note that Mitchell Slough is lower than the Bitterroot River. This image was derived during high water, the first week of June, 2008, so the elevations of the Bitterroot River channels are actually the high water at that time of year. Stages only decline a few feet in this particular area, based on data collected in 2012.

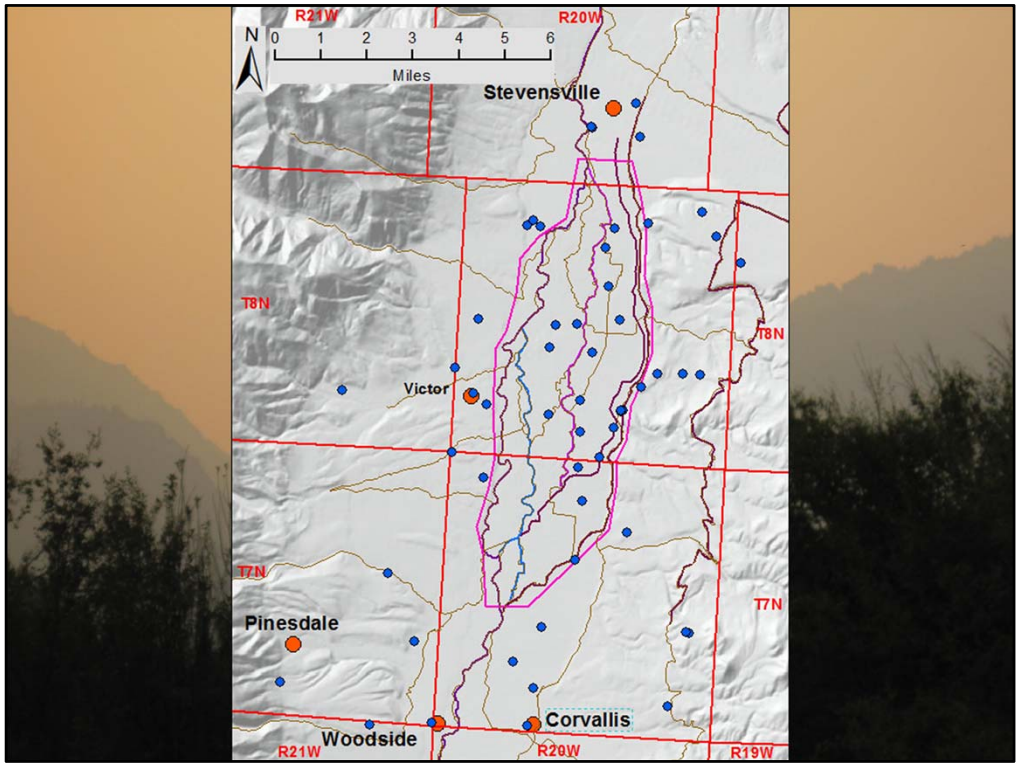


A schematic view of the uppermost 150 ft of the basin fill materials beneath the valley floor.

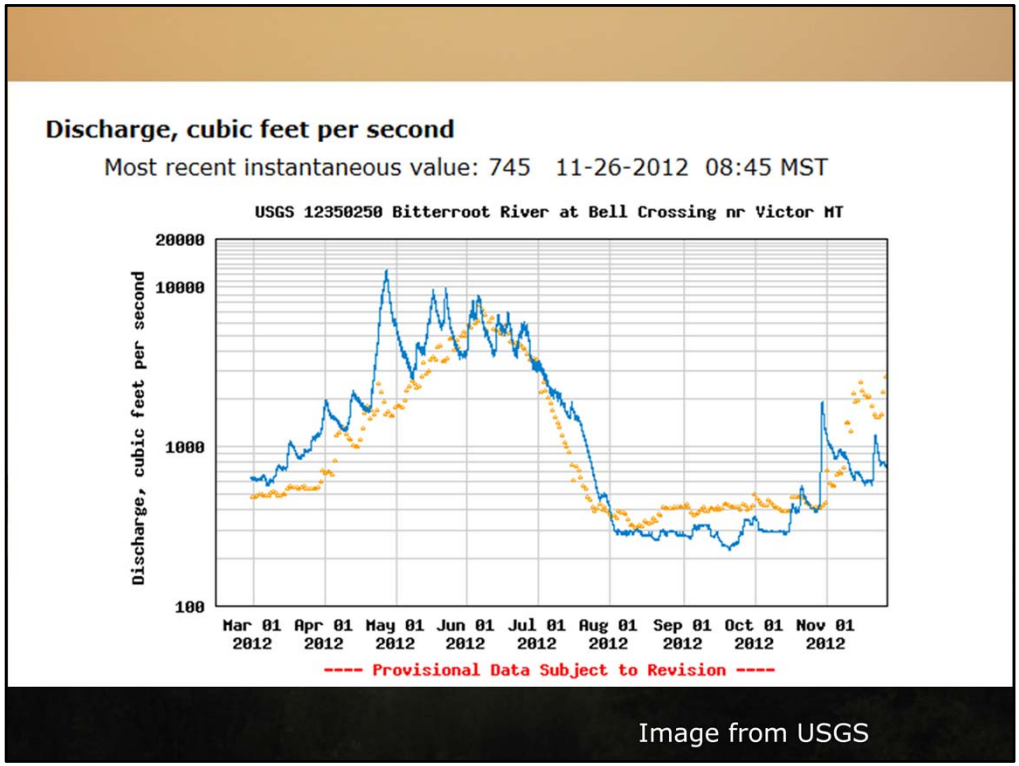

CONCEPTUAL MODEL
Hydrologic conditions



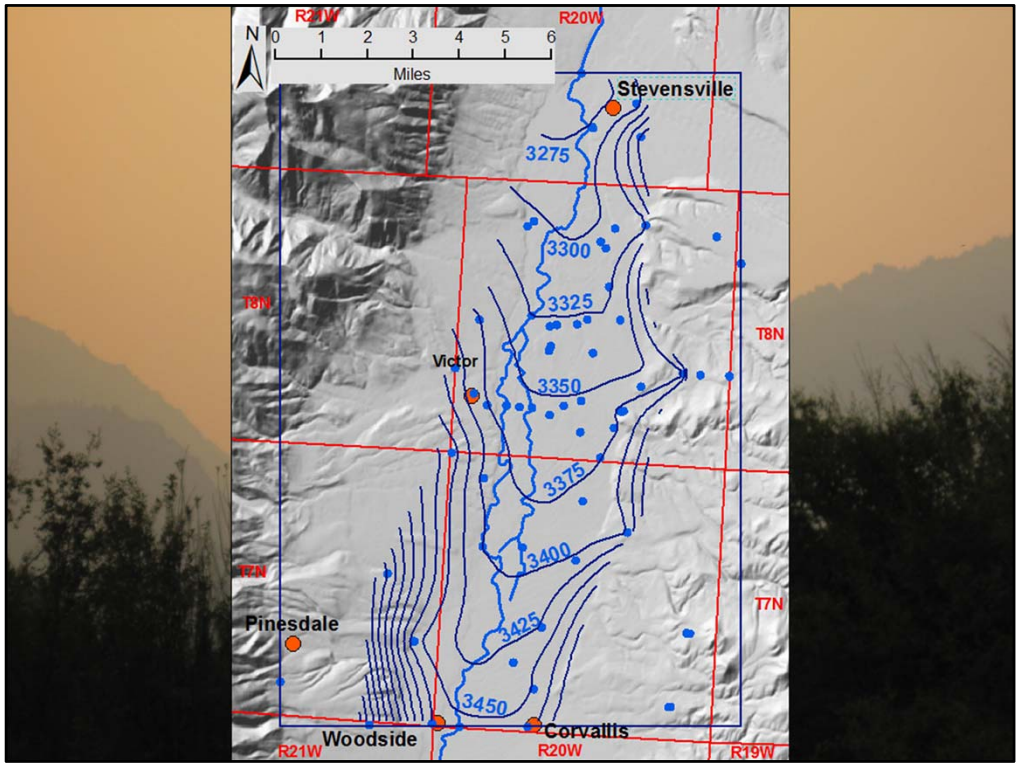
Surface water monitoring sites. Specific conductance, temperature, stage, water samples, and sometimes flow were collected at these sites, generally once a month in the winter and twice a month in the summer.



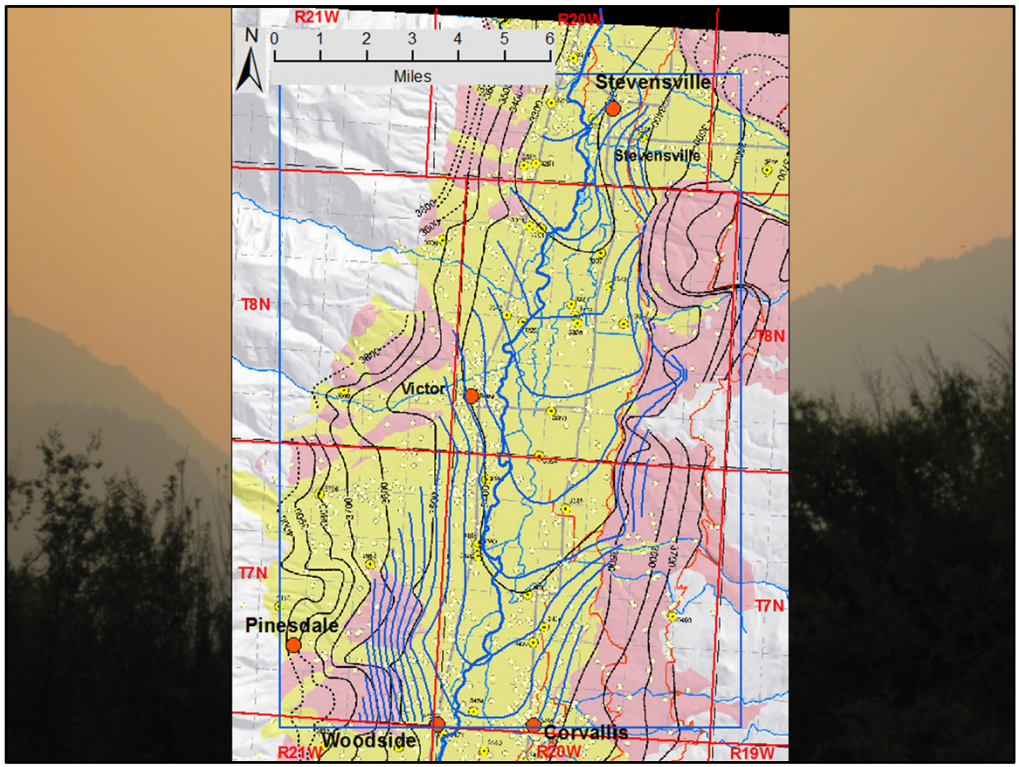
Groundwater levels were measured in over 50 wells – some of the sites shown had more than one well or piezometer.



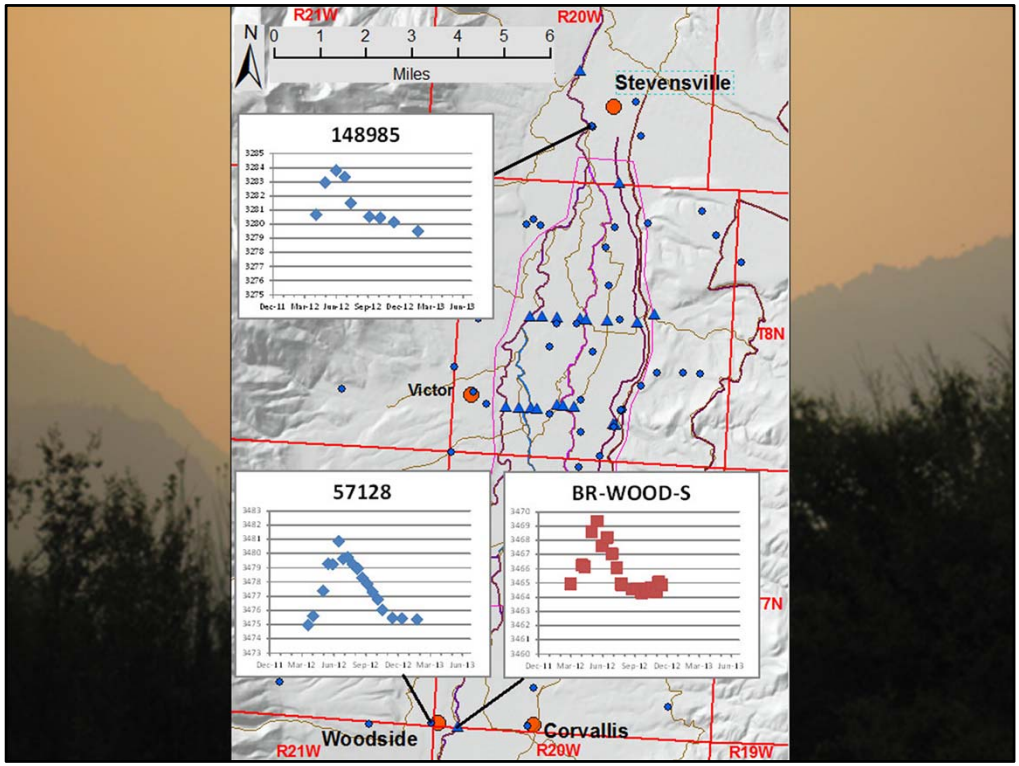
Bitterroot River discharge as depicted on the USGS website



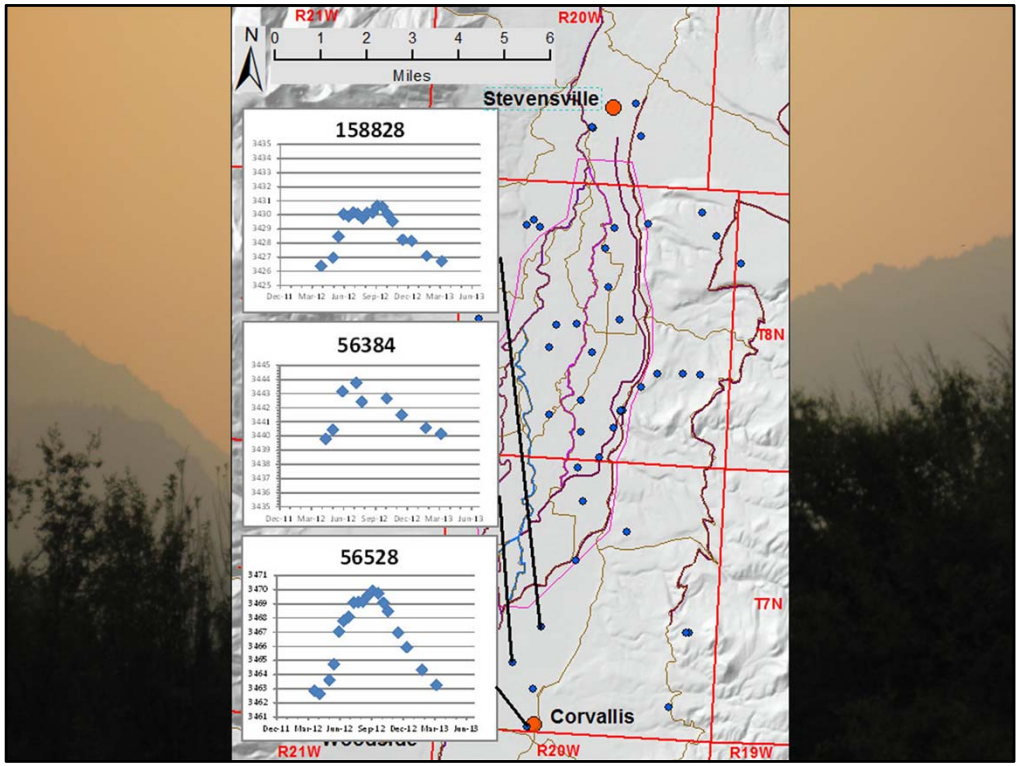
Groundwater potentiometric surface based on wells and selected surface water sites



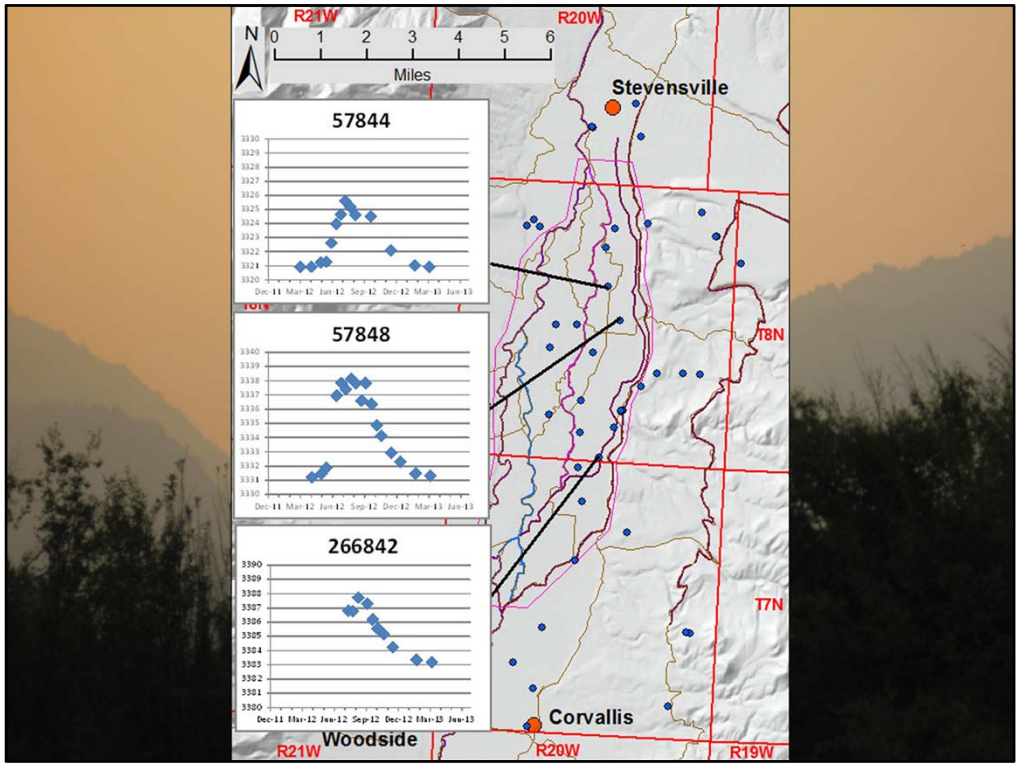
Comparing our contours to the MBMG's Groundwater Assessment Programs Ground Water Characterization Program's maps for Area #4, Part B, Map 8 (LaFave, 2006) – data from 1999 and 2000



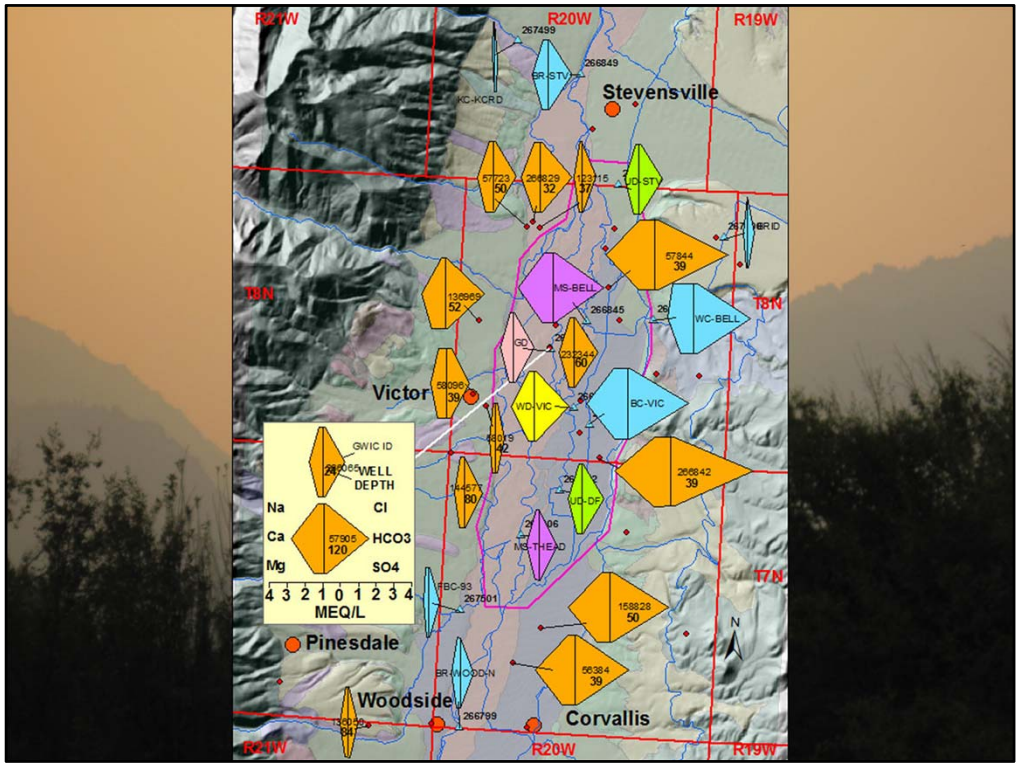
Hydrographs for wells near the Bitterroot River, compared to the stage measured in the Bitterroot River (site BR-WOOD-S). Water levels in wells near the river tend to rise and fall in patterns similar to the stage of the river.



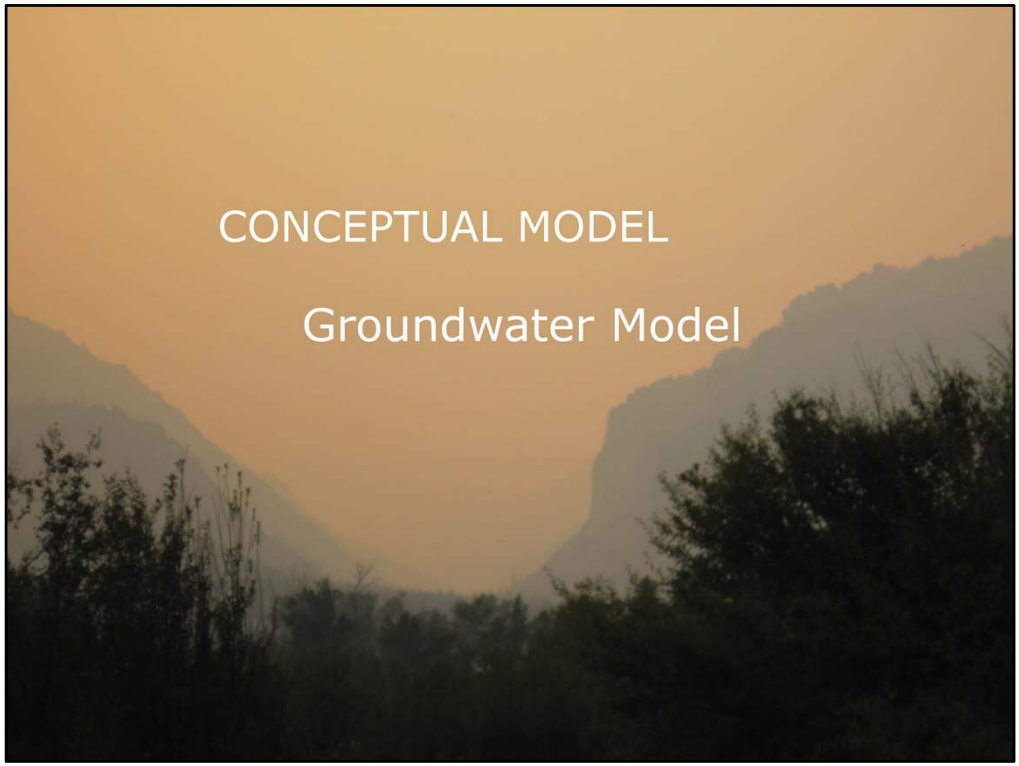
Hydrographs of wells located on the terrace respond to summer irrigation activities



Hydrographs of wells located on the terrace respond to summer irrigation activities



Stiff diagrams showing water quality of various surface water and groundater sites. The orange diagrams are from groundwater sites. The blue are from the Bitterroot River (BR-sites), Kootenai Creek (KC), Fred Burr Creek (FBC), Birch Creek (BC), Willoughby Creek (WC) and the Bitterroot River Irrigation District (BRID) canal. The purple are from Mitchell Slough, the pink from Gerlinger Ditch, the yellow from Webfoot Ditch, and the green from Union Ditch.

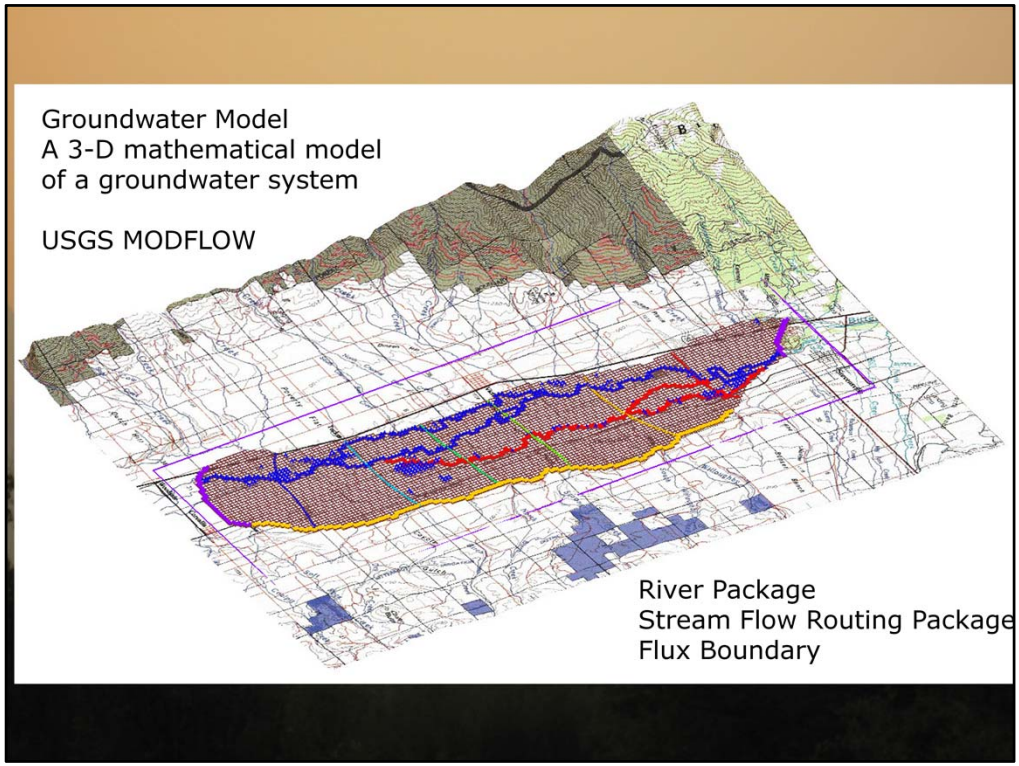

CONCEPTUAL MODEL
Groundwater Model

Quantify:

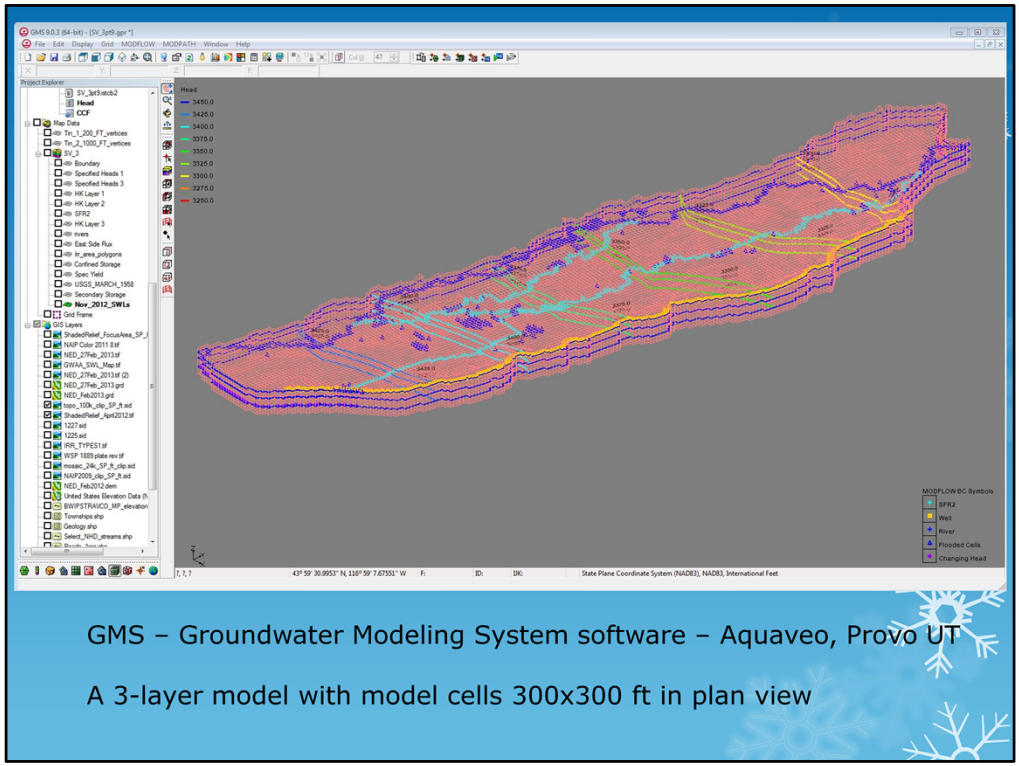
- All sources and sinks, to the extent possible
- Stream flows and stages over time - hydrographs
- Streamflow and canal losses and gains – where feasible
- Groundwater level fluctuations – monitoring wells
- Hydrologic properties: - from aquifer tests and observations
  - Hydraulic conductivity – (varies)
  - Storativity – (varies)
- Recharge from irrigation ditches and irrigated fields

- Incorporate data into a groundwater flow model

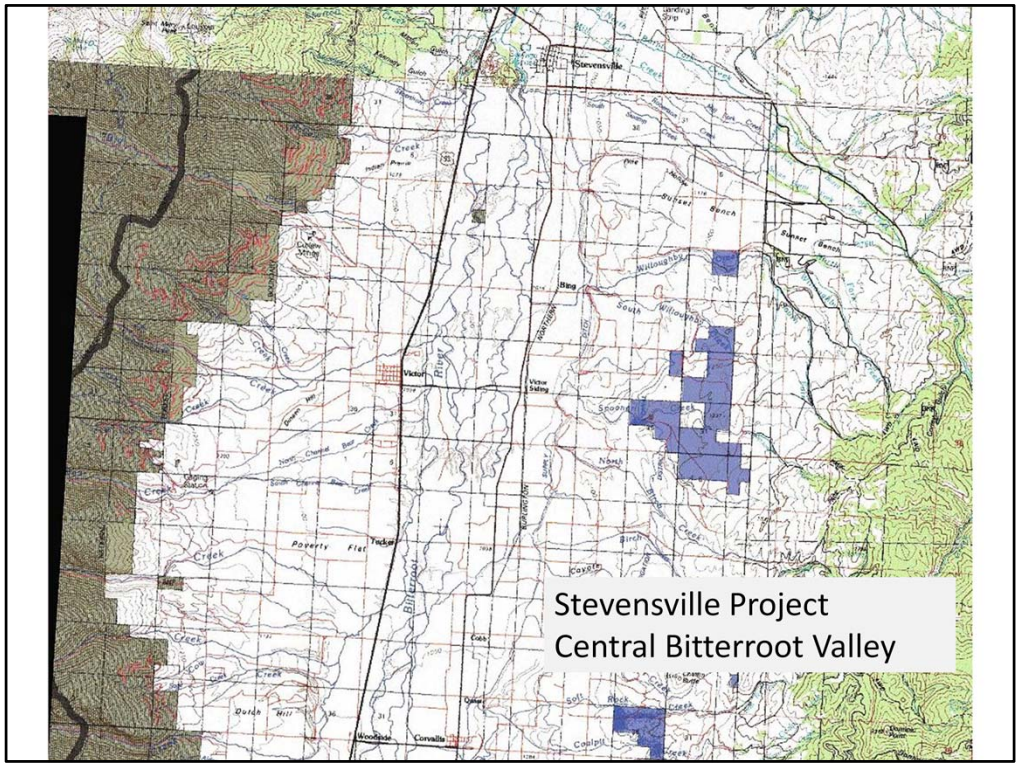
Things we must try to quantify…

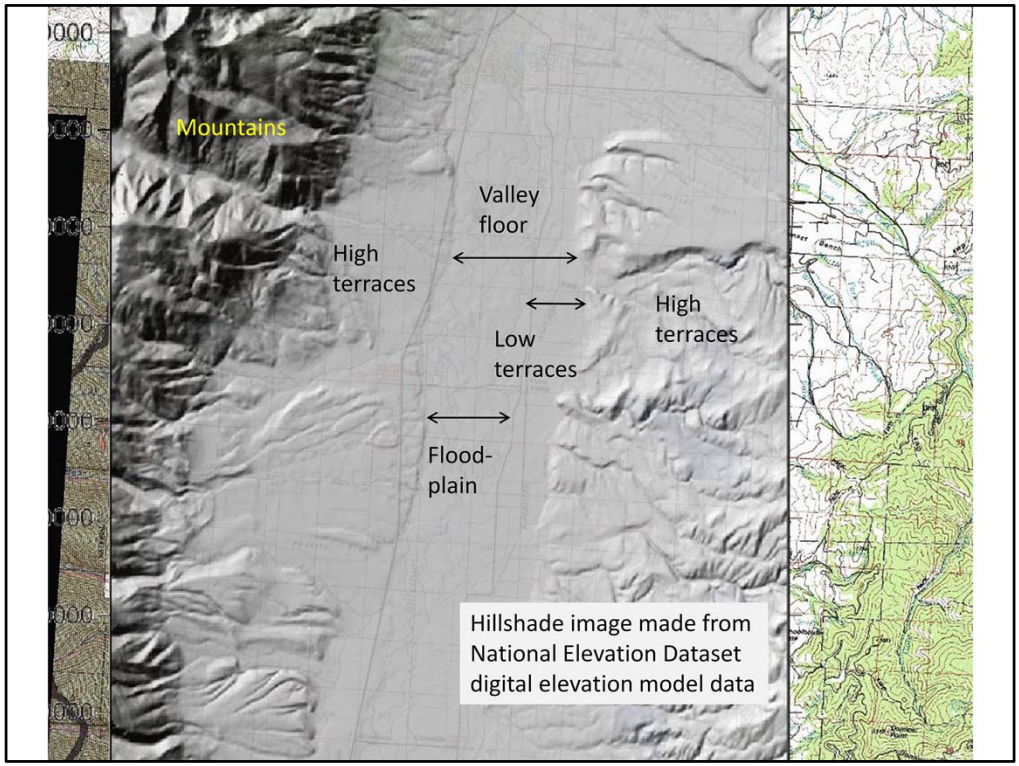


Groundwater Model grid and features

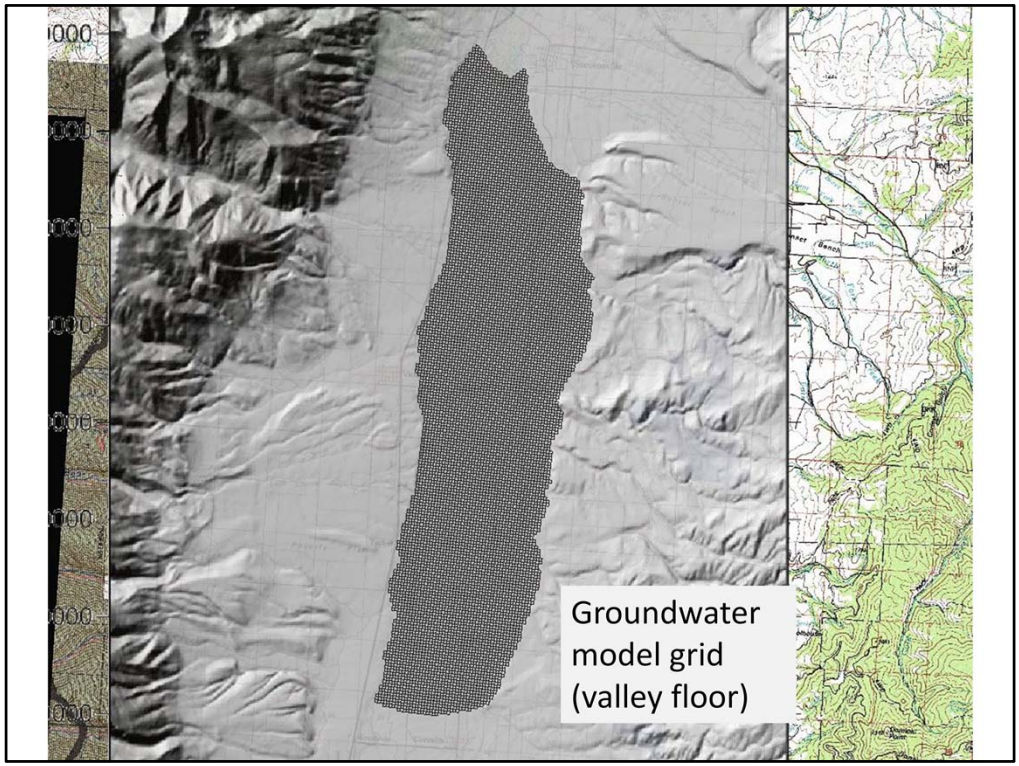


A glimpse of the groundwater modeling software

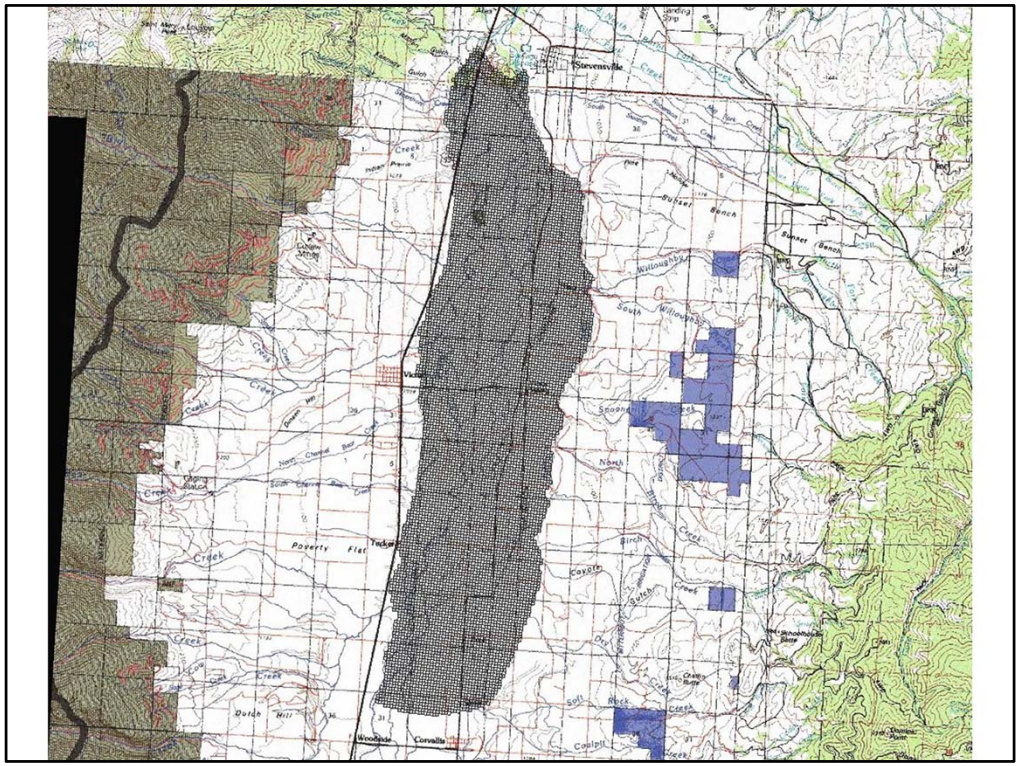

Stevensville Project
Central Bitterroot Valley



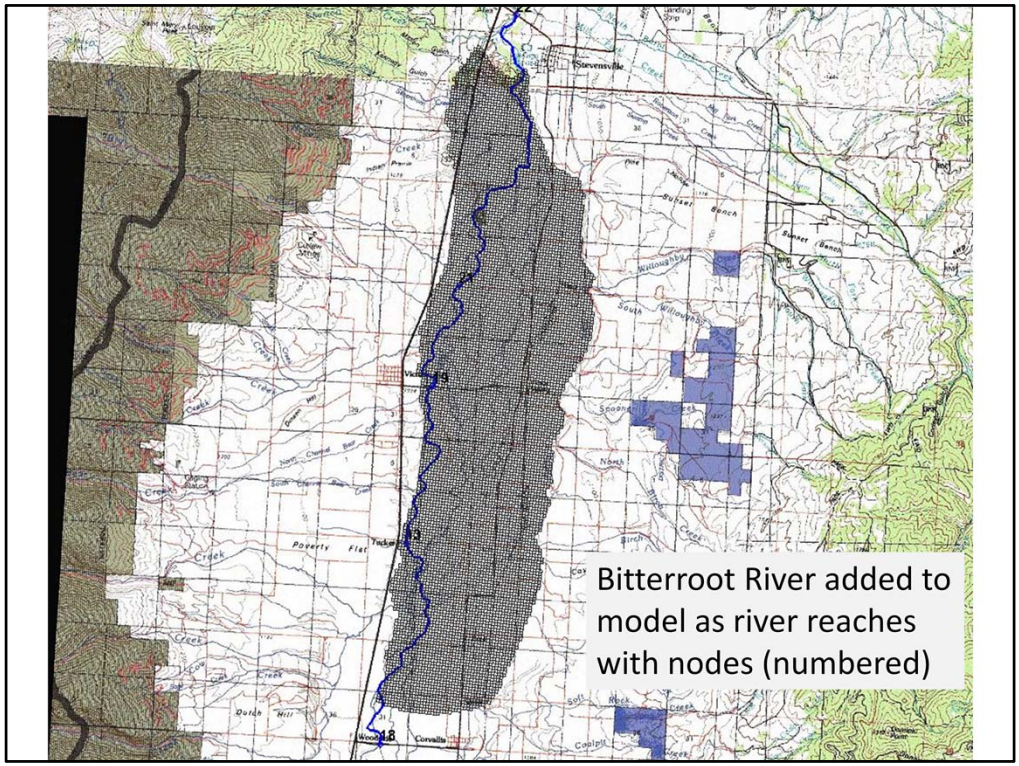
Terrace features



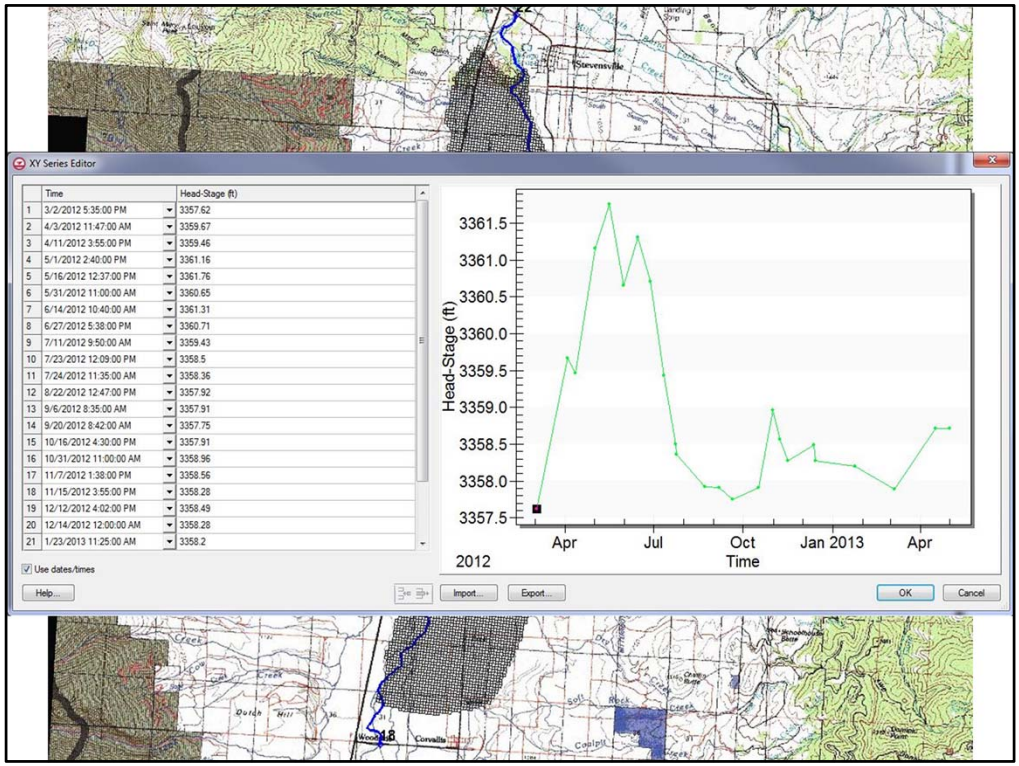
Model constructed for the valley floor area, which includes the floodplain and low terraces.



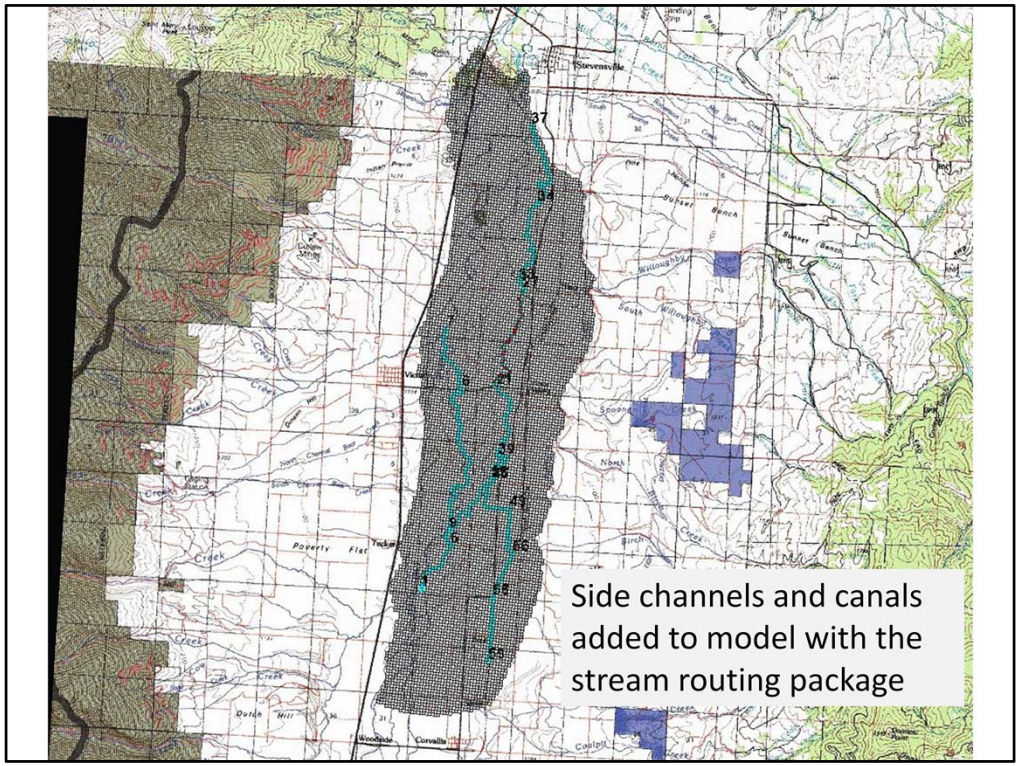
Map view of the model grid



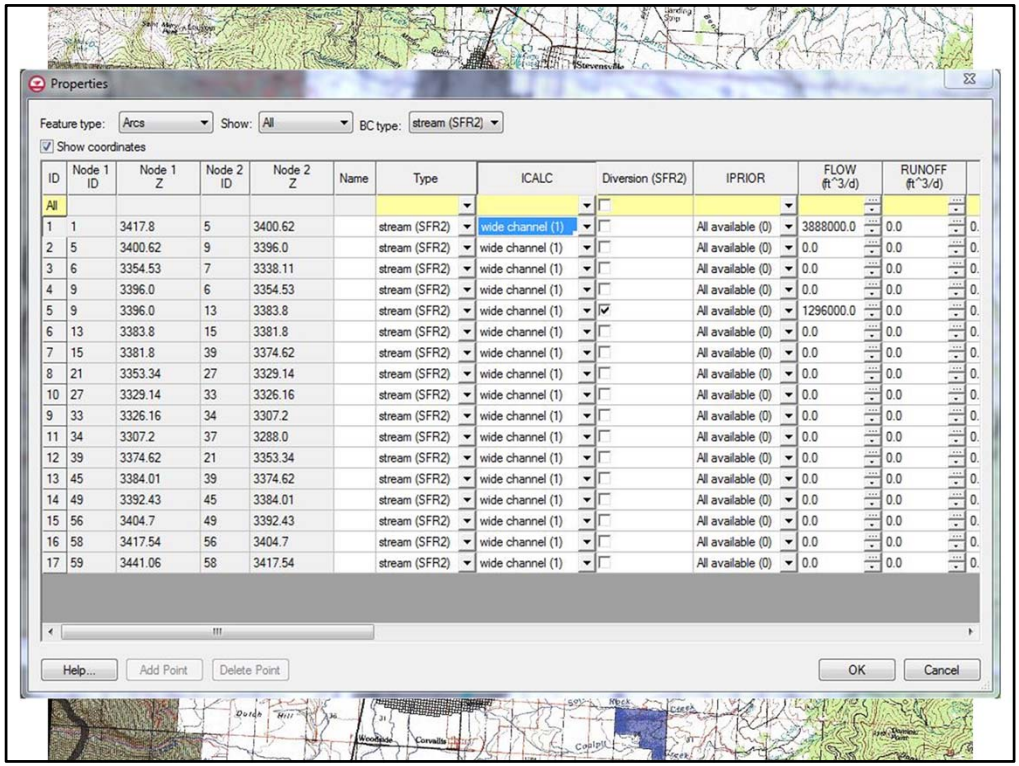
Adding features to a groundwater model -



How stages are entered in the groundwater modeling program

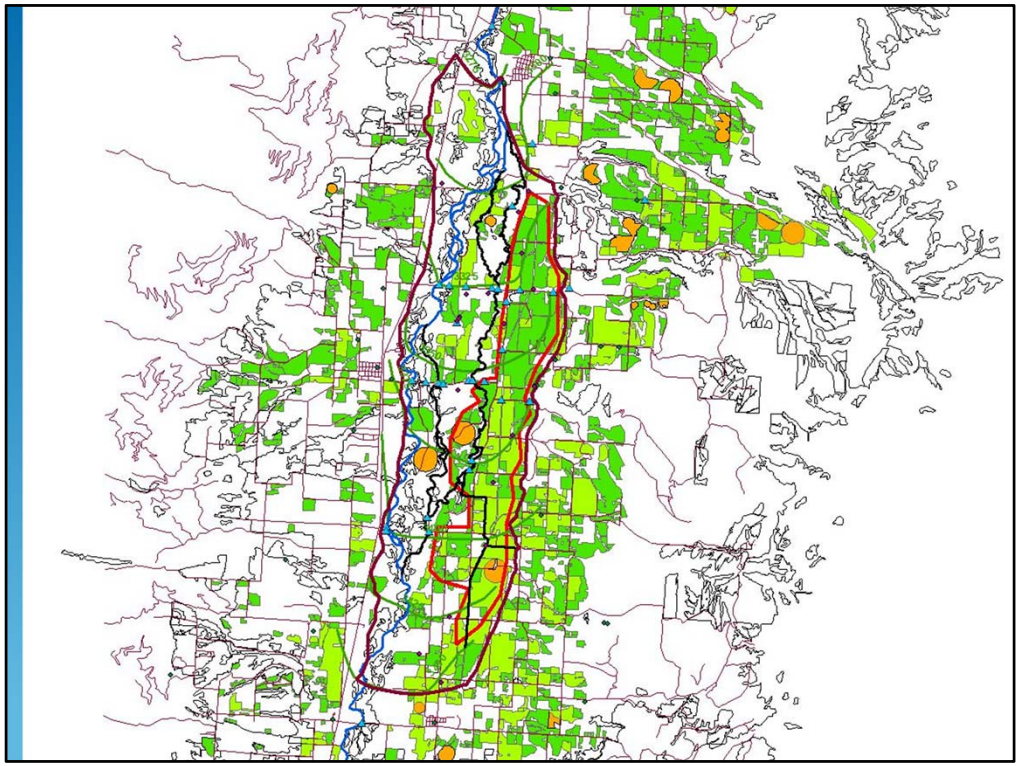


Canals and other streams added to the model using the Stream Flow Routing package

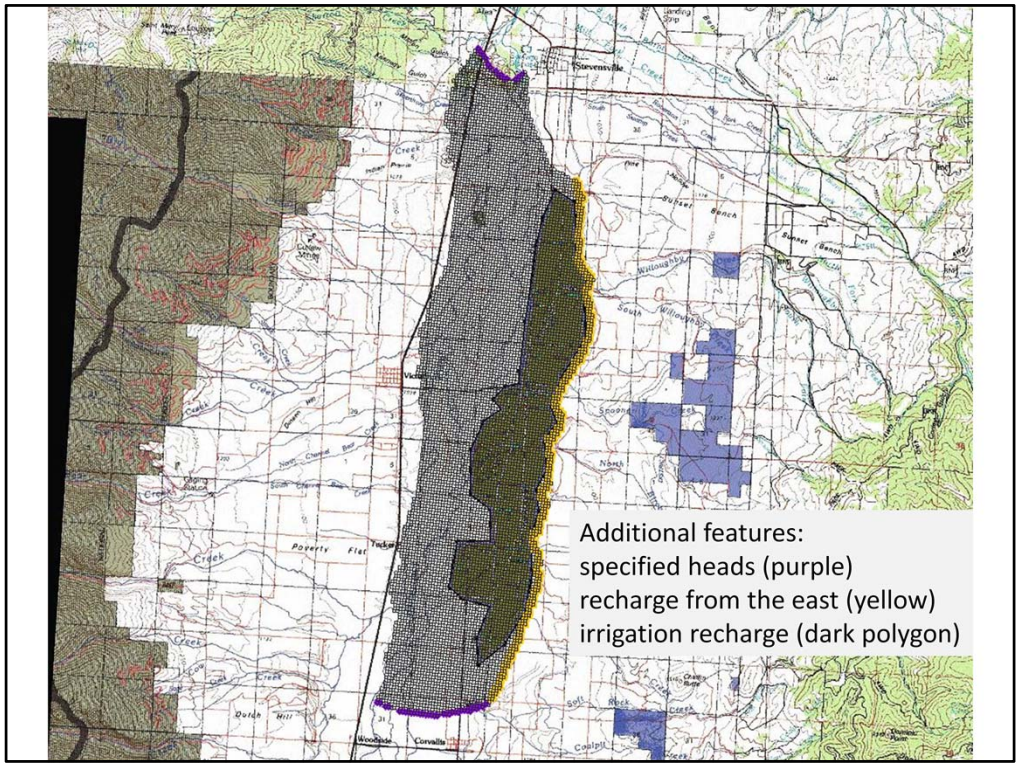


ID	Node 1 ID	Node 1 Z	Node 2 ID	Node 2 Z	Name	Type	ICALC	Diversion (SFR2)	IPRIOR	FLOW (ft^3/d)	RUNOFF (ft^3/d)
All											
1	1	3417.8	5	3400.62		stream (SFR2)	wide channel (1)		All available (0)	3888000.0	0.0
2	5	3400.62	9	3396.0		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
3	6	3354.53	7	3338.11		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
4	9	3396.0	6	3354.53		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
5	9	3396.0	13	3383.8		stream (SFR2)	wide channel (1)	☑	All available (0)	1296000.0	0.0
6	13	3383.8	15	3381.8		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
7	15	3381.8	39	3374.62		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
8	21	3353.34	27	3329.14		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
10	27	3329.14	33	3326.16		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
9	33	3326.16	34	3307.2		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
11	34	3307.2	37	3288.0		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
12	39	3374.62	21	3353.34		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
13	45	3384.01	39	3374.62		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
14	49	3392.43	45	3384.01		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
15	56	3404.7	49	3392.43		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
16	58	3417.54	56	3404.7		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0
17	59	3441.06	58	3417.54		stream (SFR2)	wide channel (1)		All available (0)	0.0	0.0

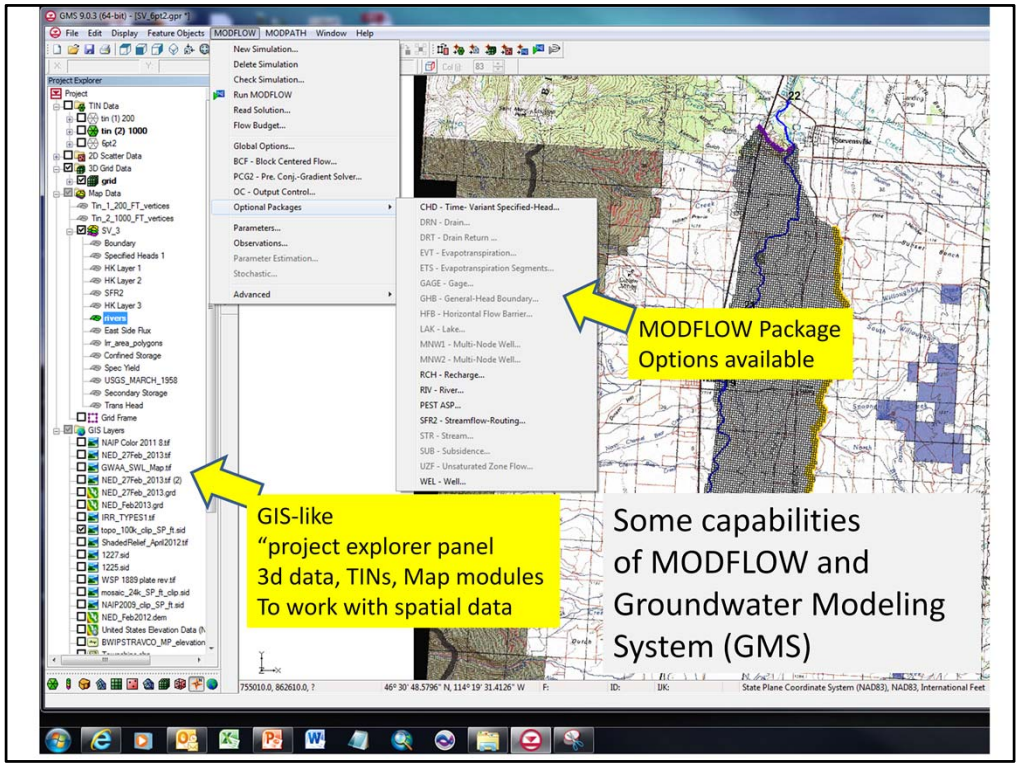
Stream Flow Routing package arcs with details partially shown



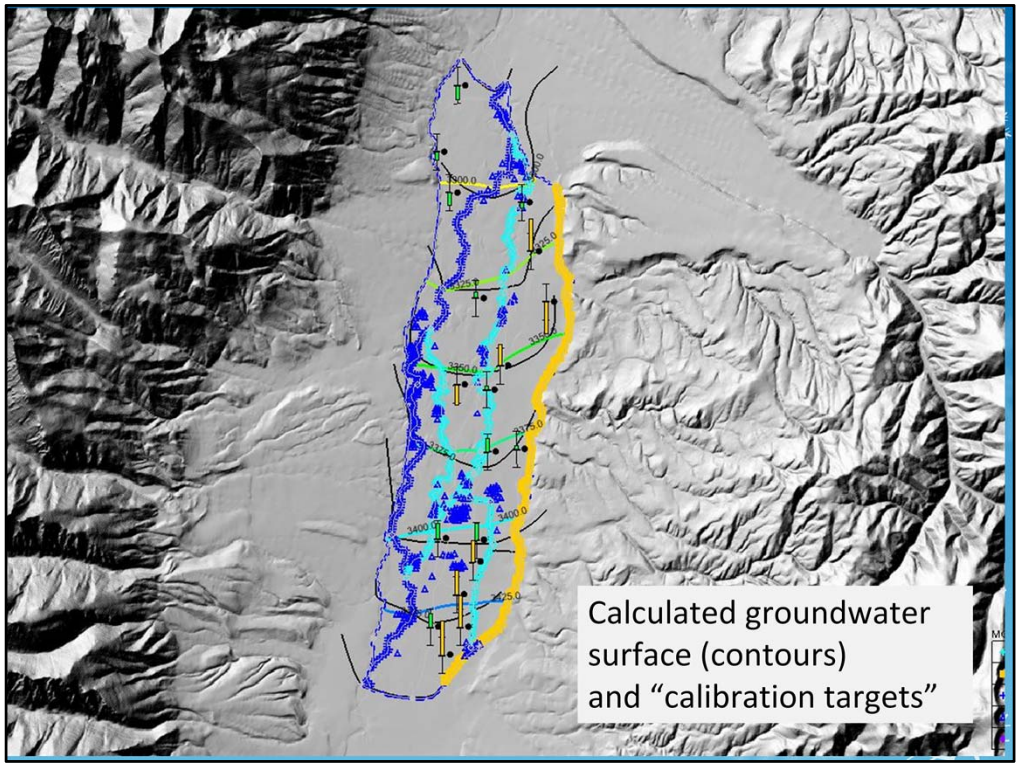
Irrigation recharge polygon (red) used to add summer recharge due to ditch leakage and excess irrigation waters applied to fields.



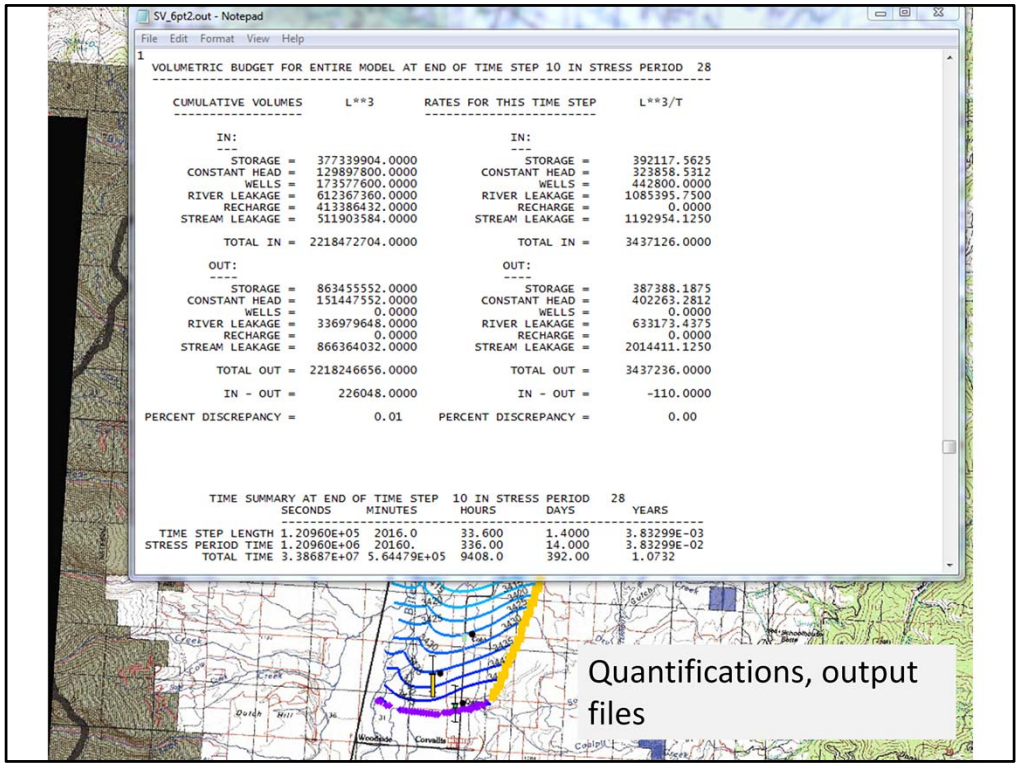
Additional features in the model.



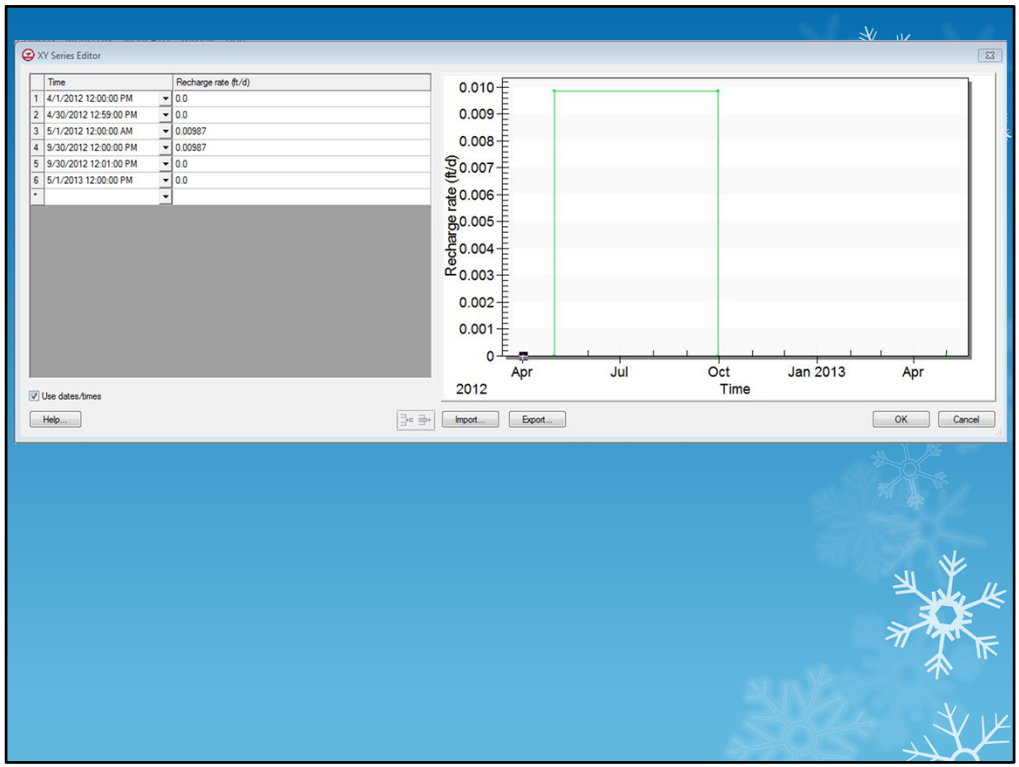
Another glimpse of the GMS software being used.



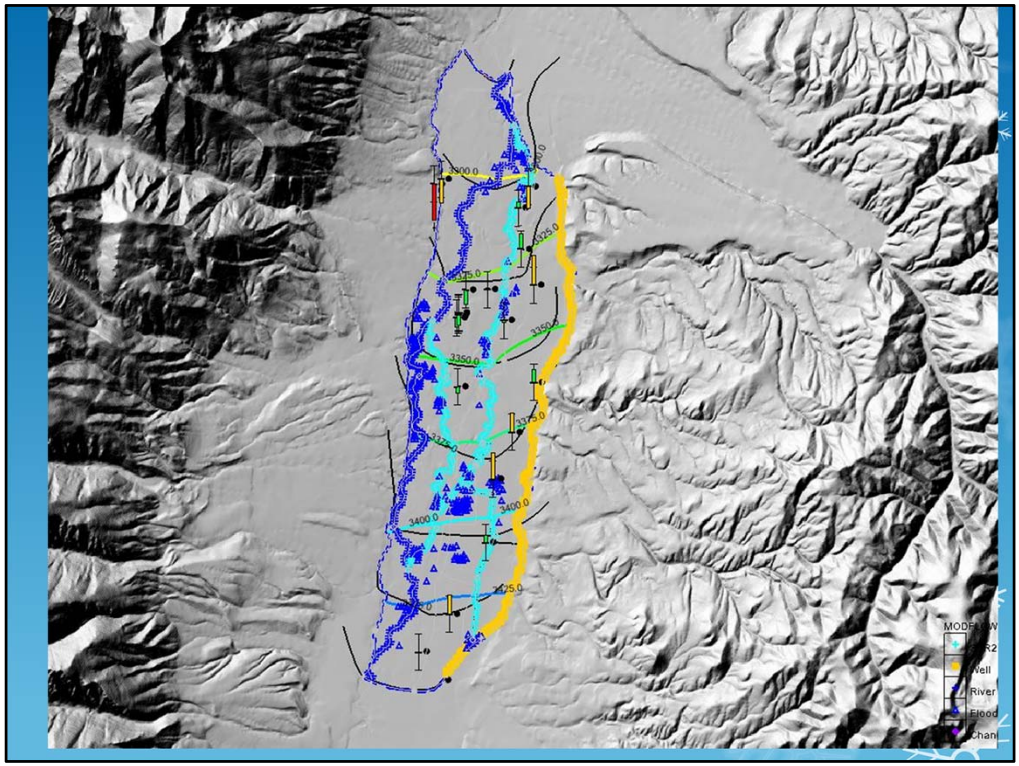
Calculated groundwater levels compared to observed values



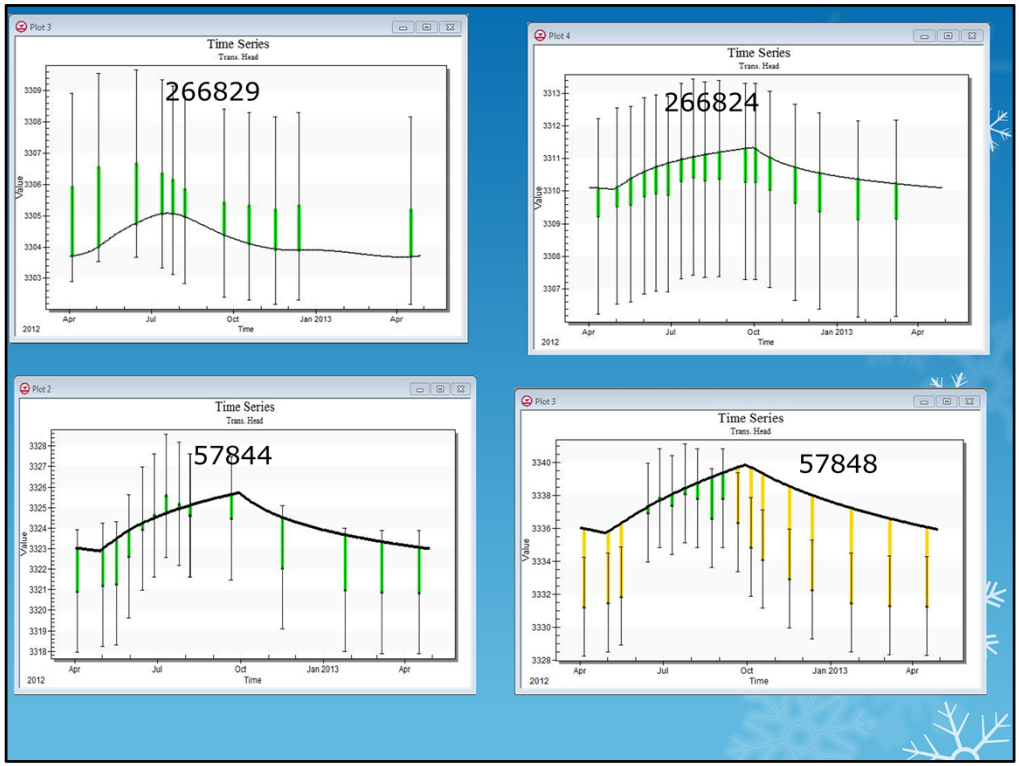
The groundwater model itself runs in Fortran programming language, and input and output files quantify the water budget.



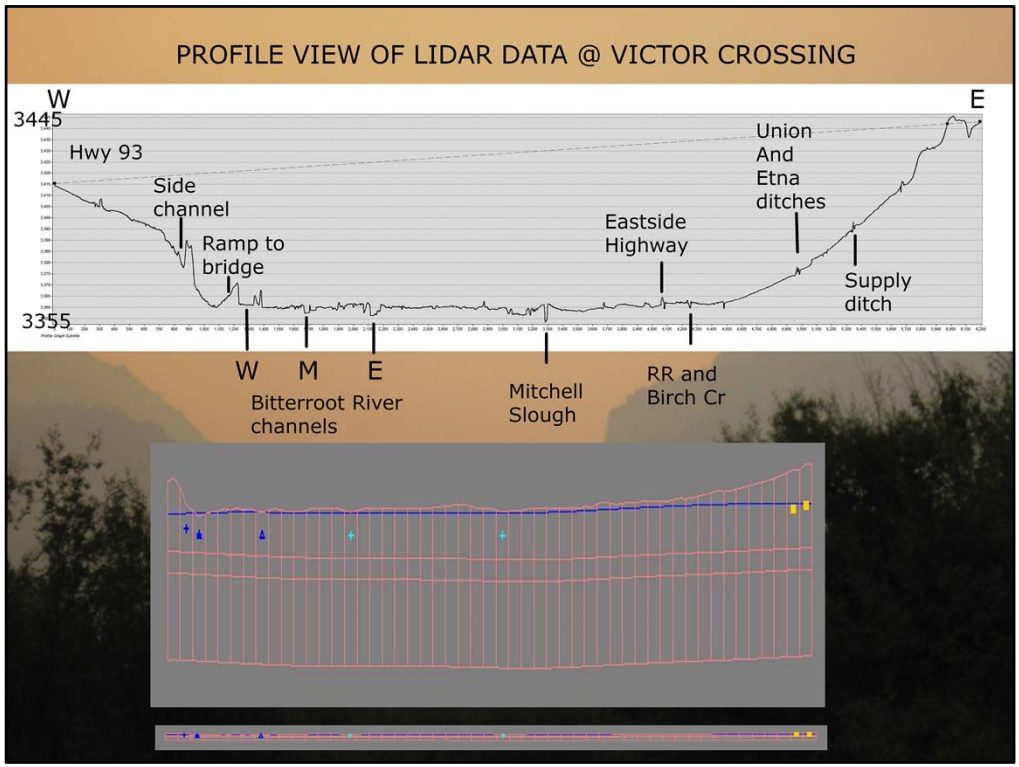
How recharge is added to the Irrigation Recharge polygon – on during irrigation months and off during the fall and winter.



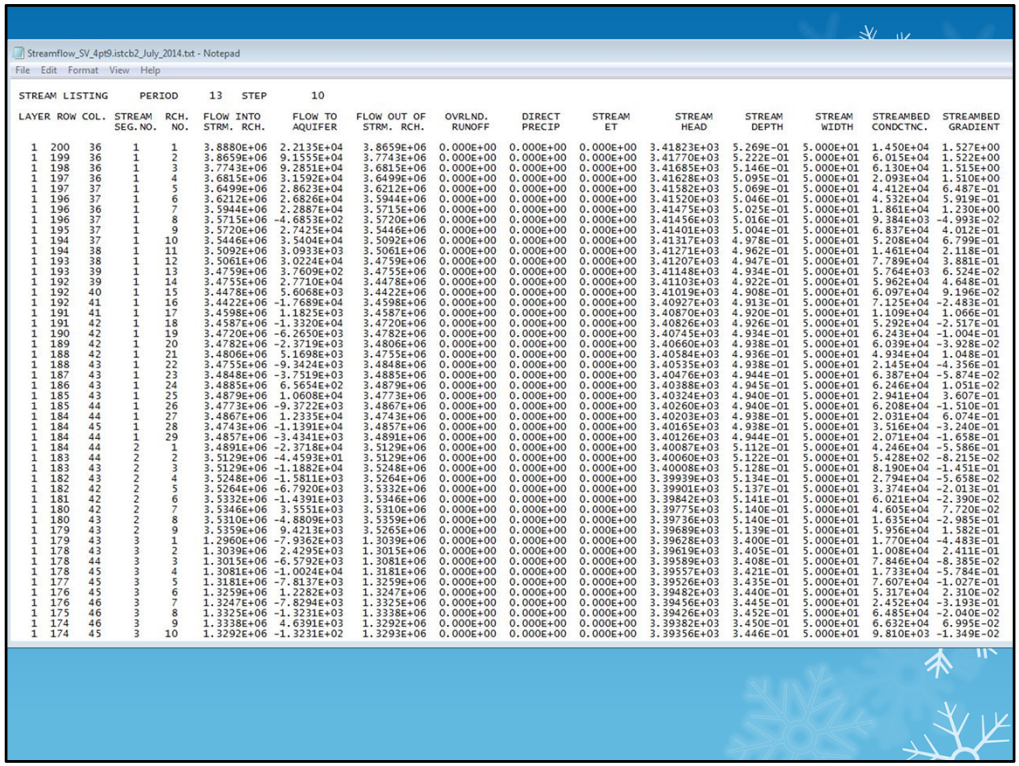
Another calibration view.



Model responses (dark black line) compared to periodic water level measurements in wells.



A profile view of the Bitterroot Valley at Victor Crossing. The profile is about 4 miles across, and spans 90 feet vertically, so is greatly vertically exaggerated. Note that Mitchell Slough is lower than the Bitterroot River. This image was derived during high water, the first week of June, 2008, so the elevations of the Bitterroot River channels are actually the high water at that time of year. Stages only decline a few feet in this particular area, based on data collected in 2012.



Streamflow_SV_4pt9.istcb2_July_2014.txt - Notepad

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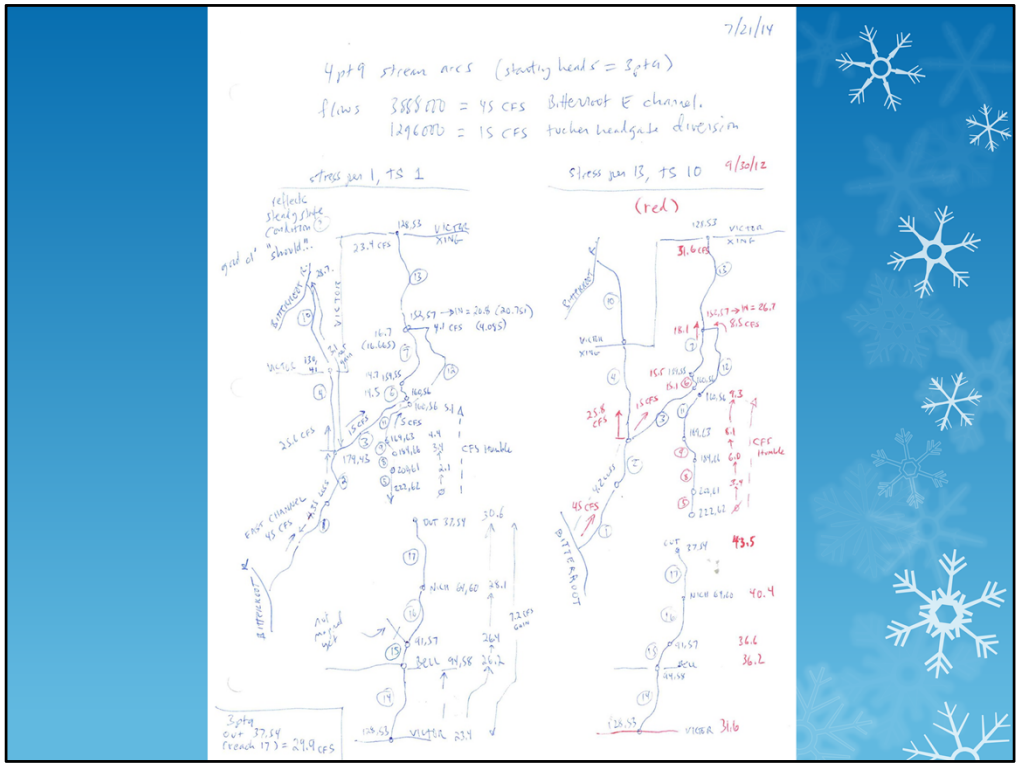
STREAM LISTING PERIOD 13 STEP 10

LAYER	ROW	COL.	STREAM SEG.NO.	RCH. NO.	FLOW INTO STRM. RCH.	FLOW TO AQUIFER	FLOW OUT OF STRM. RCH.	OVRLND. RUNOFF	DIRECT PRECIP	STREAM ET	STREAM HEAD	STREAM DEPTH	STREAM WIDTH	STREAMBED CONDCTNC.	STREAMBED GRADIENT
1	200	36	1	1	3.8880E+06	2.2135E+04	3.8659E+06	0.000E+00	0.000E+00	0.000E+00	3.41823E+03	5.269E-01	5.000E+01	1.450E+04	1.527E+00
1	199	36	1	2	3.8659E+06	9.1555E+04	3.7743E+06	0.000E+00	0.000E+00	0.000E+00	3.41770E+03	5.222E-01	5.000E+01	6.015E+04	1.522E+00
1	198	36	1	3	3.7743E+06	9.2851E+04	3.6815E+06	0.000E+00	0.000E+00	0.000E+00	3.41685E+03	5.146E-01	5.000E+01	6.130E+04	1.515E+00
1	197	36	1	4	3.6815E+06	3.1592E+04	3.6499E+06	0.000E+00	0.000E+00	0.000E+00	3.41628E+03	5.095E-01	5.000E+01	2.093E+04	1.510E+00
1	197	37	1	5	3.6499E+06	2.8623E+04	3.6212E+06	0.000E+00	0.000E+00	0.000E+00	3.41582E+03	5.069E-01	5.000E+01	4.412E+04	6.487E-01
1	196	37	1	6	3.6212E+06	2.6826E+04	3.5944E+06	0.000E+00	0.000E+00	0.000E+00	3.41520E+03	5.046E-01	5.000E+01	4.532E+04	5.919E-01
1	196	36	1	7	3.5944E+06	2.2887E+04	3.5715E+06	0.000E+00	0.000E+00	0.000E+00	3.41475E+03	5.025E-01	5.000E+01	1.861E+04	1.230E+00
1	196	37	1	8	3.5715E+06	-4.6853E+02	3.5720E+06	0.000E+00	0.000E+00	0.000E+00	3.41456E+03	5.016E-01	5.000E+01	9.384E+03	-4.993E-02
1	195	37	1	9	3.5720E+06	2.7425E+04	3.5446E+06	0.000E+00	0.000E+00	0.000E+00	3.41401E+03	5.004E-01	5.000E+01	6.837E+04	4.012E-01
1	194	37	1	10	3.5446E+06	3.5404E+04	3.5092E+06	0.000E+00	0.000E+00	0.000E+00	3.41317E+03	4.978E-01	5.000E+01	5.208E+04	6.799E-01
1	194	38	1	11	3.5092E+06	3.0933E+03	3.5061E+06	0.000E+00	0.000E+00	0.000E+00	3.41271E+03	4.962E-01	5.000E+01	1.461E+04	2.118E-01
1	193	38	1	12	3.5061E+06	3.0224E+04	3.4759E+06	0.000E+00	0.000E+00	0.000E+00	3.41207E+03	4.947E-01	5.000E+01	7.789E+04	3.881E-01
1	193	39	1	13	3.4759E+06	3.7609E+02	3.4755E+06	0.000E+00	0.000E+00	0.000E+00	3.41148E+03	4.934E-01	5.000E+01	5.764E+03	6.524E-02
1	192	39	1	14	3.4755E+06	2.7710E+04	3.4478E+06	0.000E+00	0.000E+00	0.000E+00	3.41103E+03	4.922E-01	5.000E+01	5.962E+04	4.648E-01
1	192	40	1	15	3.4478E+06	5.6068E+03	3.4422E+06	0.000E+00	0.000E+00	0.000E+00	3.41019E+03	4.908E-01	5.000E+01	6.097E+04	9.196E-02
1	192	41	1	16	3.4422E+06	-1.7689E+04	3.4598E+06	0.000E+00	0.000E+00	0.000E+00	3.40927E+03	4.913E-01	5.000E+01	7.125E+04	-2.483E-01
1	191	41	1	17	3.4598E+06	1.1825E+03	3.4587E+06	0.000E+00	0.000E+00	0.000E+00	3.40870E+03	4.920E-01	5.000E+01	1.109E+04	1.066E-01
1	191	42	1	18	3.4587E+06	-1.3320E+04	3.4720E+06	0.000E+00	0.000E+00	0.000E+00	3.40826E+03	4.926E-01	5.000E+01	5.292E+04	-2.517E-01
1	190	42	1	19	3.4720E+06	-6.2650E+03	3.4782E+06	0.000E+00	0.000E+00	0.000E+00	3.40745E+03	4.934E-01	5.000E+01	6.243E+04	-1.004E-01
1	189	42	1	20	3.4782E+06	-2.3719E+03	3.4806E+06	0.000E+00	0.000E+00	0.000E+00	3.40660E+03	4.938E-01	5.000E+01	6.039E+04	-3.928E-02
1	188	42	1	21	3.4806E+06	5.1698E+03	3.4755E+06	0.000E+00	0.000E+00	0.000E+00	3.40584E+03	4.936E-01	5.000E+01	4.934E+04	1.048E-01
1	188	43	1	22	3.4755E+06	-9.3424E+03	3.4848E+06	0.000E+00	0.000E+00	0.000E+00	3.40535E+03	4.938E-01	5.000E+01	2.145E+04	-4.356E-01
1	187	43	1	23	3.4848E+06	-3.7519E+03	3.4885E+06	0.000E+00	0.000E+00	0.000E+00	3.40476E+03	4.944E-01	5.000E+01	6.387E+04	-5.874E-02
1	186	43	1	24	3.4885E+06	6.5654E+02	3.4879E+06	0.000E+00	0.000E+00	0.000E+00	3.40388E+03	4.945E-01	5.000E+01	6.246E+04	1.051E-02
1	185	43	1	25	3.4879E+06	1.0608E+04	3.4773E+06	0.000E+00	0.000E+00	0.000E+00	3.40324E+03	4.940E-01	5.000E+01	2.941E+04	3.607E-01
1	185	44	1	26	3.4773E+06	-9.3722E+03	3.4867E+06	0.000E+00	0.000E+00	0.000E+00	3.40260E+03	4.940E-01	5.000E+01	6.208E+04	-1.510E-01
1	184	44	1	27	3.4867E+06	1.2335E+04	3.4743E+06	0.000E+00	0.000E+00	0.000E+00	3.40203E+03	4.938E-01	5.000E+01	2.031E+04	6.074E-01
1	184	45	1	28	3.4743E+06	-1.1391E+04	3.4857E+06	0.000E+00	0.000E+00	0.000E+00	3.40165E+03	4.938E-01	5.000E+01	3.516E+04	-3.240E-01
1	184	44	1	29	3.4857E+06	-3.4341E+03	3.4891E+06	0.000E+00	0.000E+00	0.000E+00	3.40126E+03	4.944E-01	5.000E+01	2.071E+04	-1.658E-01
1	184	44	2	1	3.4891E+06	-2.3718E+04	3.5129E+06	0.000E+00	0.000E+00	0.000E+00	3.40087E+03	5.112E-01	5.000E+01	4.246E+04	-5.586E-01
1	183	44	2	2	3.5129E+06	-4.4593E+01	3.5129E+06	0.000E+00	0.000E+00	0.000E+00	3.40060E+03	5.122E-01	5.000E+01	5.428E+02	-8.215E-02
1	183	43	2	3	3.5129E+06	-1.1882E+04	3.5248E+06	0.000E+00	0.000E+00	0.000E+00	3.40008E+03	5.128E-01	5.000E+01	8.190E+04	-1.451E-01
1	182	43	2	4	3.5248E+06	-1.5811E+03	3.5264E+06	0.000E+00	0.000E+00	0.000E+00	3.39939E+03	5.134E-01	5.000E+01	2.794E+04	-5.658E-02
1	182	42	2	5	3.5264E+06	-6.7920E+03	3.5332E+06	0.000E+00	0.000E+00	0.000E+00	3.39901E+03	5.137E-01	5.000E+01	3.374E+04	-2.013E-01
1	181	42	2	6	3.5332E+06	-1.4391E+03	3.5346E+06	0.000E+00	0.000E+00	0.000E+00	3.39842E+03	5.141E-01	5.000E+01	6.021E+04	-2.390E-02
1	180	42	2	7	3.5346E+06	3.5551E+03	3.5310E+06	0.000E+00	0.000E+00	0.000E+00	3.39775E+03	5.140E-01	5.000E+01	4.605E+04	7.720E-02
1	180	43	2	8	3.5310E+06	-4.8809E+03	3.5359E+06	0.000E+00	0.000E+00	0.000E+00	3.39736E+03	5.140E-01	5.000E+01	1.635E+04	-2.985E-01
1	179	43	2	9	3.5359E+06	9.4213E+03	3.5265E+06	0.000E+00	0.000E+00	0.000E+00	3.39689E+03	5.139E-01	5.000E+01	5.956E+04	1.582E-01
1	179	43	3	1	1.2960E+06	-7.9362E+03	1.3039E+06	0.000E+00	0.000E+00	0.000E+00	3.39628E+03	3.400E-01	5.000E+01	1.770E+04	-4.483E-01
1	178	43	3	2	1.3039E+06	2.4295E+03	1.3015E+06	0.000E+00	0.000E+00	0.000E+00	3.39619E+03	3.405E-01	5.000E+01	1.008E+04	2.411E-01
1	178	44	3	3	1.3015E+06	-6.5792E+03	1.3081E+06	0.000E+00	0.000E+00	0.000E+00	3.39589E+03	3.408E-01	5.000E+01	7.846E+04	-8.385E-02
1	178	45	3	4	1.3081E+06	-1.0024E+04	1.3181E+06	0.000E+00	0.000E+00	0.000E+00	3.39557E+03	3.421E-01	5.000E+01	1.733E+04	-5.784E-01
1	177	45	3	5	1.3181E+06	-7.8137E+03	1.3259E+06	0.000E+00	0.000E+00	0.000E+00	3.39526E+03	3.435E-01	5.000E+01	7.607E+04	-1.027E-01
1	176	45	3	6	1.3259E+06	1.2282E+03	1.3247E+06	0.000E+00	0.000E+00	0.000E+00	3.39482E+03	3.440E-01	5.000E+01	5.317E+04	2.310E-02
1	176	46	3	7	1.3247E+06	-7.8294E+03	1.3325E+06	0.000E+00	0.000E+00	0.000E+00	3.39456E+03	3.445E-01	5.000E+01	2.452E+04	-3.193E-01
1	175	46	3	8	1.3325E+06	-1.3231E+03	1.3338E+06	0.000E+00	0.000E+00	0.000E+00	3.39426E+03	3.452E-01	5.000E+01	6.485E+04	-2.040E-02
1	174	46	3	9	1.3338E+06	4.6391E+03	1.3292E+06	0.000E+00	0.000E+00	0.000E+00	3.39382E+03	3.450E-01	5.000E+01	6.632E+04	6.995E-02
1	174	45	3	10	1.3292E+06	-1.3231E+02	1.3293E+06	0.000E+00	0.000E+00	0.000E+00	3.39356E+03	3.446E-01	5.000E+01	9.810E+03	-1.349E-02

Model output is voluminous and requires effort to interpret.

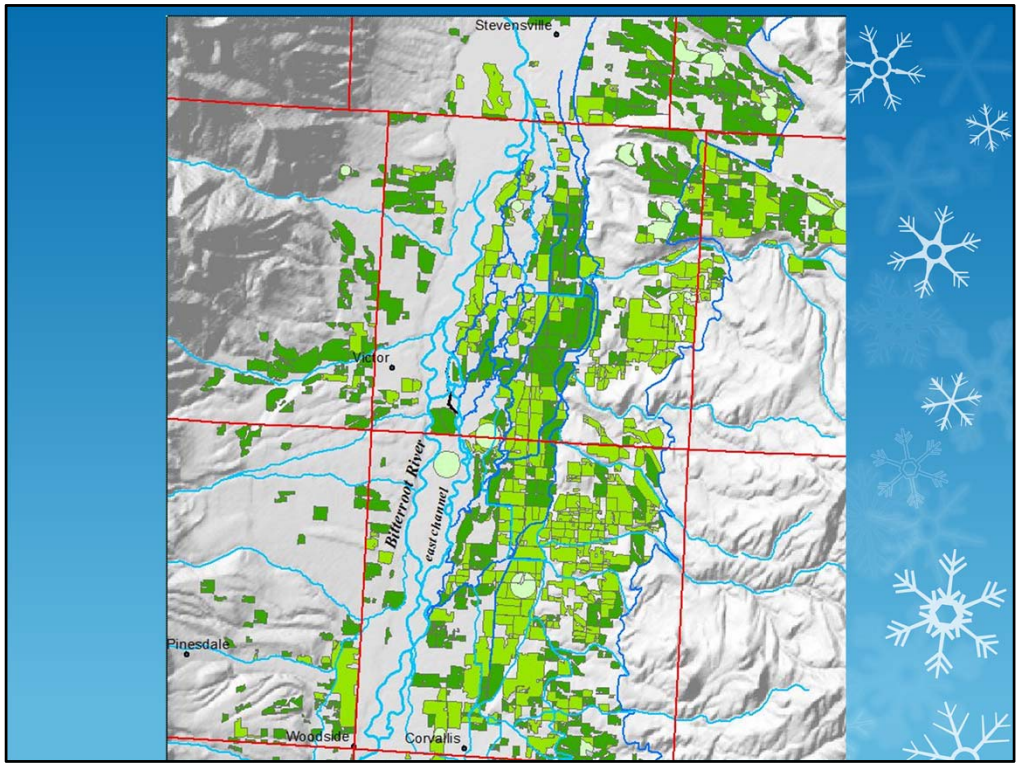


Sketches have to be made to track and interpret stream flow routing results.

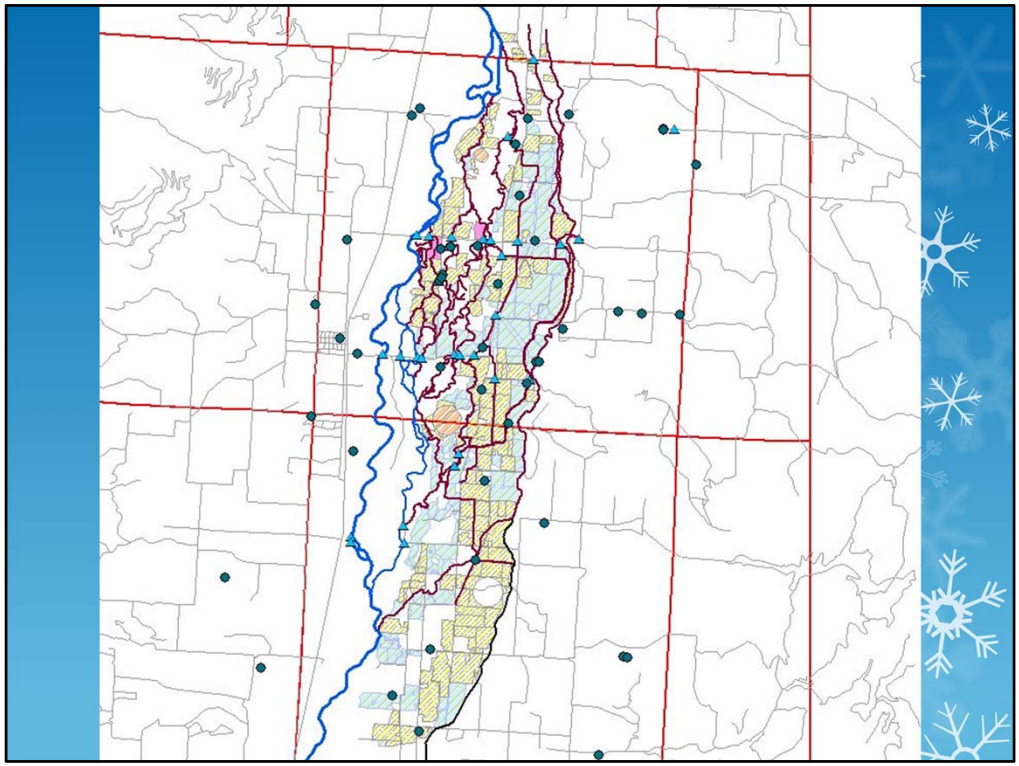
Groundwater Flow Model

- Model results are compared to groundwater maps and observations
- Various features are added to the model using MODFLOW packages
- Bitterroot River utilizes river stages – rather than flow
- Flow from the groundwater system to or from the river is modeled within the model area
- Canals are modeled using the MODFLOW stream flow routing package or as seasonal groundwater recharge along canals that are likely contributing water to the underlying aquifer
- Riparian vegetation water use will be added to the model
- Model calibration and refinement is underway
- Scenarios will be tested with the model

Summary



Extra slides



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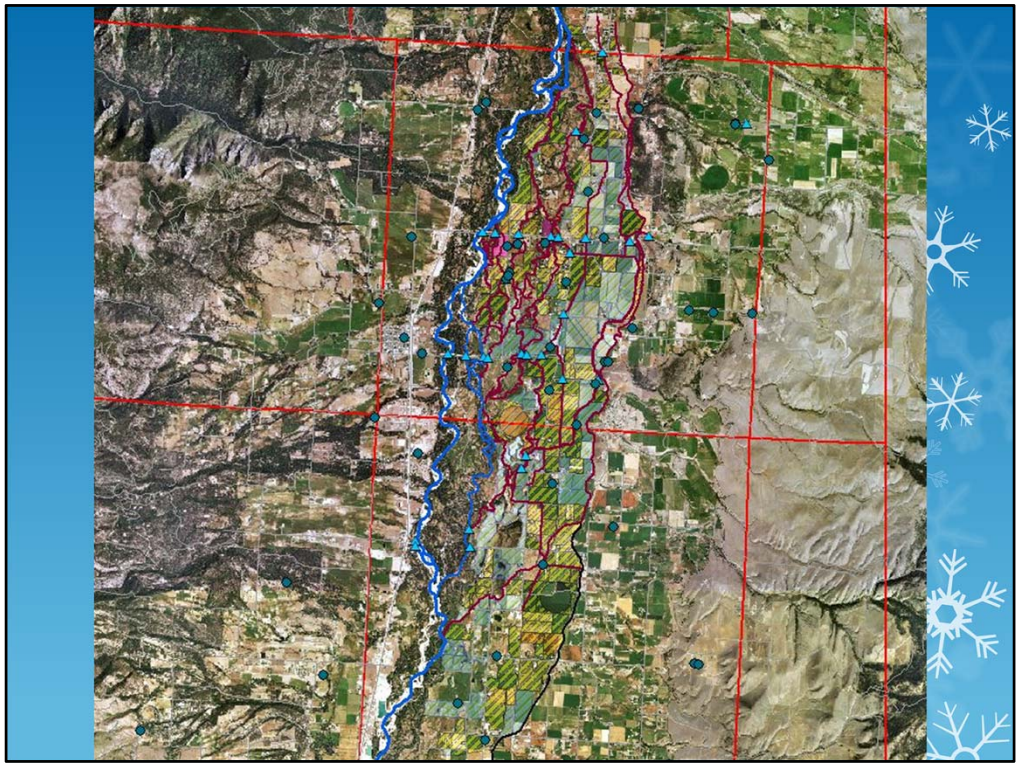

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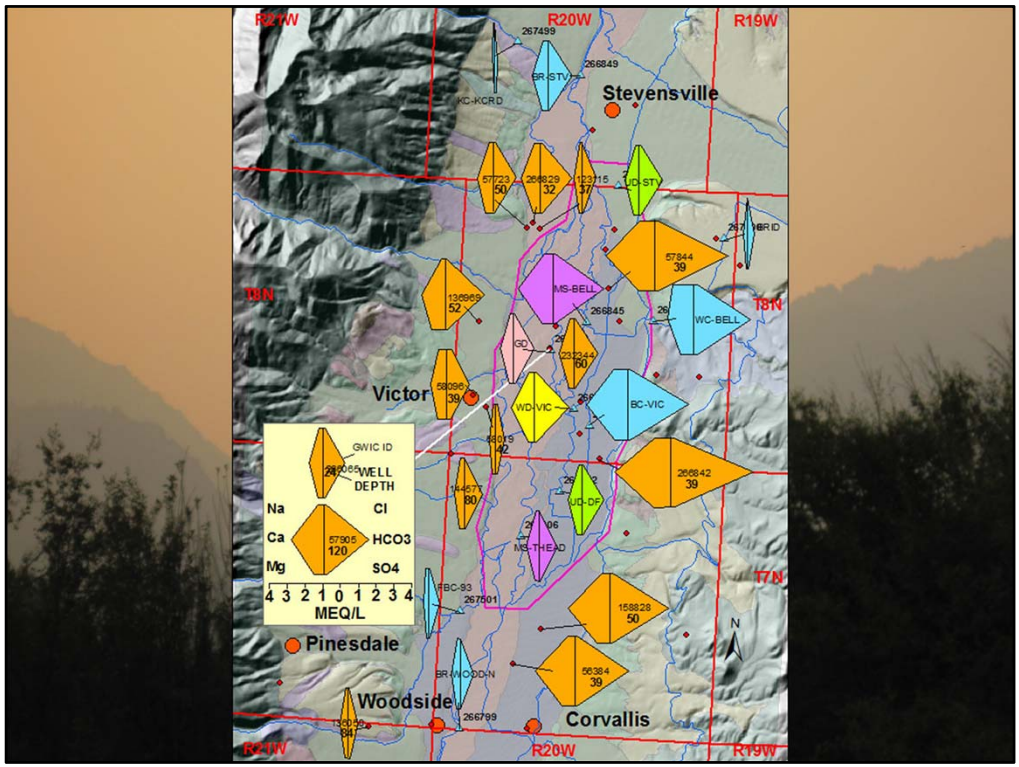

Stiff diagrams showing water quality of various surface water and groundater sites. The orange diagrams are from groundwater sites. The blue are from the Bitterroot River (BR-sites), Kootenai Creek (KC), Fred Burr Creek (FBC), Birch Creek (BC), Willoughby Creek (WC) and the Bitterroot River Irrigation District (BRID) canal. The purple are from Mitchell Slough, the pink from Gerlinger Ditch, the yellow from Webfoot Ditch, and the green from Union Ditch.