Round 2 of Model Results of Potential Projects

Presented by Georgina King & Cameron Tana, Montgomery & Associates
Santa Margarita Groundwater Agency
February 25, 2021

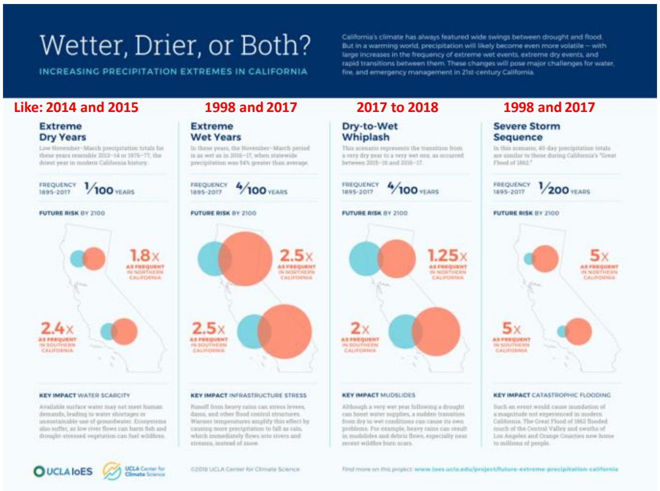
Objectives

- Understand the new climate projection used in modeling
- Understand the Baseline scenario that represents "No Project" condition with the new climate projection
- Review the changes to the Basin from 2 different model scenarios
- Compare Baseline and Scenarios against each other
- Discuss next steps

New Climate Projection

Presented by Cameron Tana, M&A

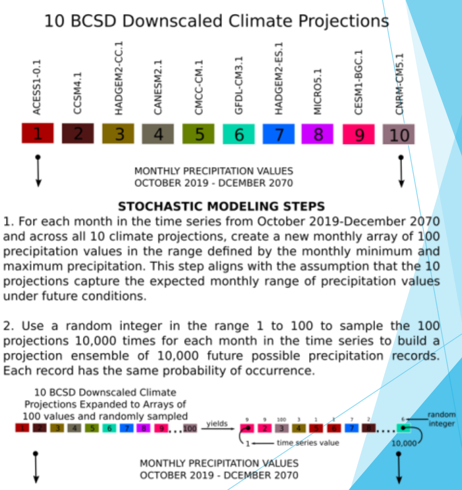
Climate Change Expected to Result in Greater Variability



Source: https://www.ioes.ucla.edu/article/study-forecasts-a-severe-climate-future-for-california/

Representation of Climate Change with Statistical Ensemble by Balance Hydrologics

- Statistically sample 4 climate change models
- Precipitation variability
  - Dry years: 10th percentile
  - Wet years: 75th percentile
- Temperature variability with warming trend enforced
  - Cooler years: 50th percentile
  - Warmer years: 99th percentile



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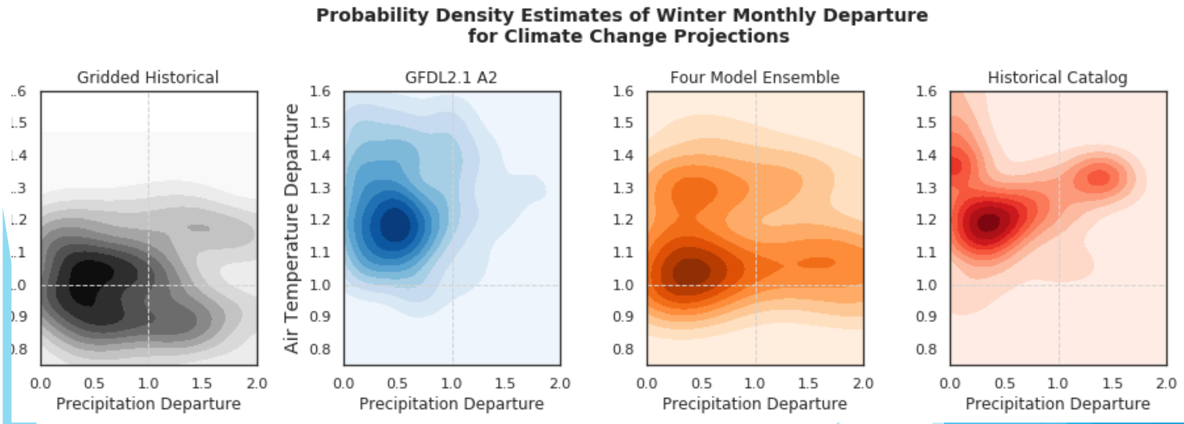
Four Model Ensemble 50-99 has greater variability for both temperature and precipitation in winter (Dec-Mar)



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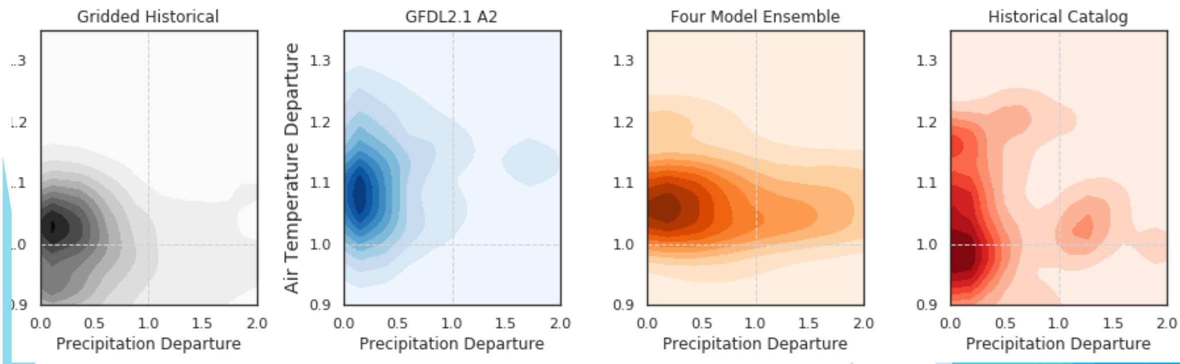
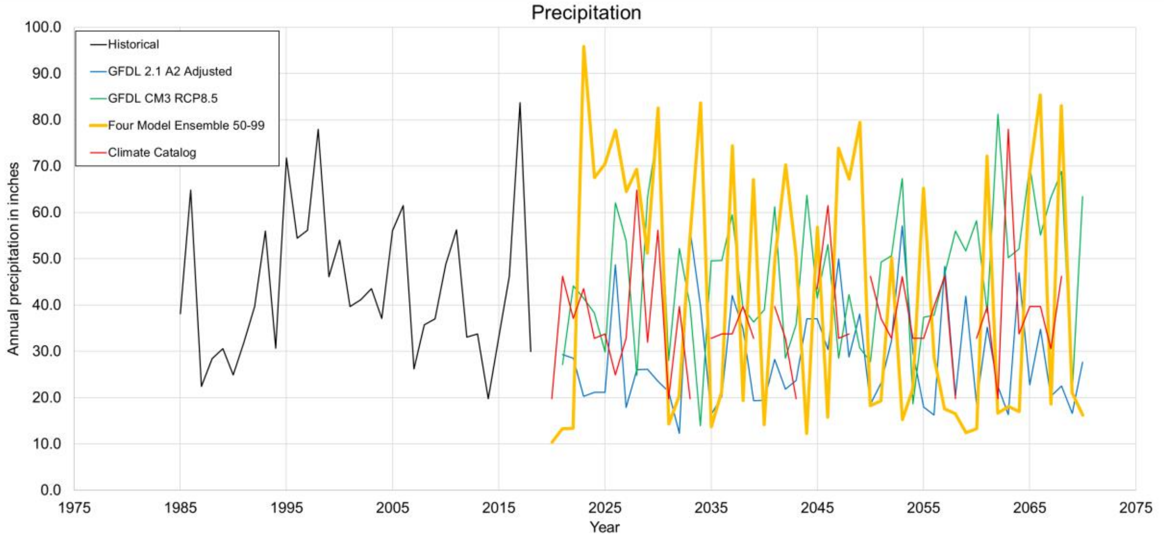
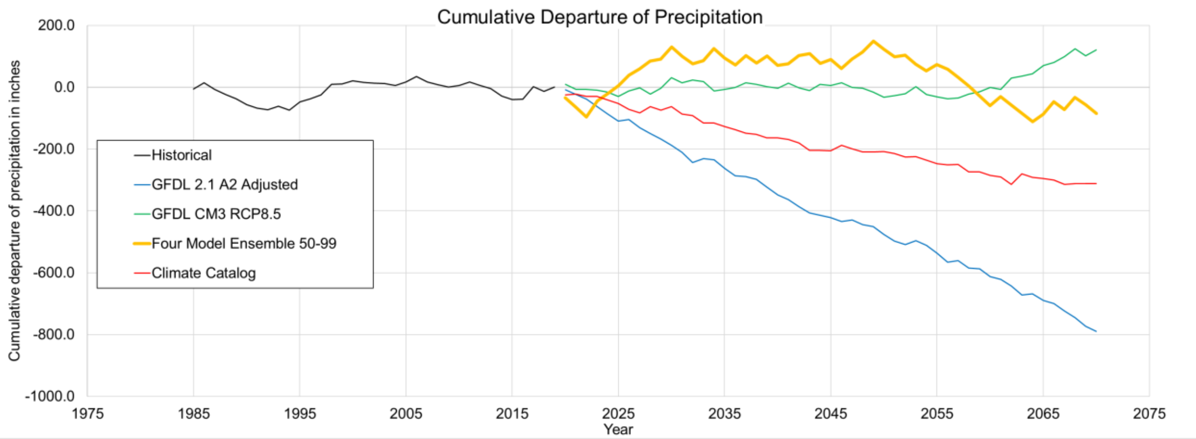
Four Model Ensemble 50-99 has greater potential for precipitation in summer (Jul-Nov)



Four Model Ensemble 50-99 has greater precipitation variability



Four Model Ensemble 50-99 is slightly drier overall than historical average



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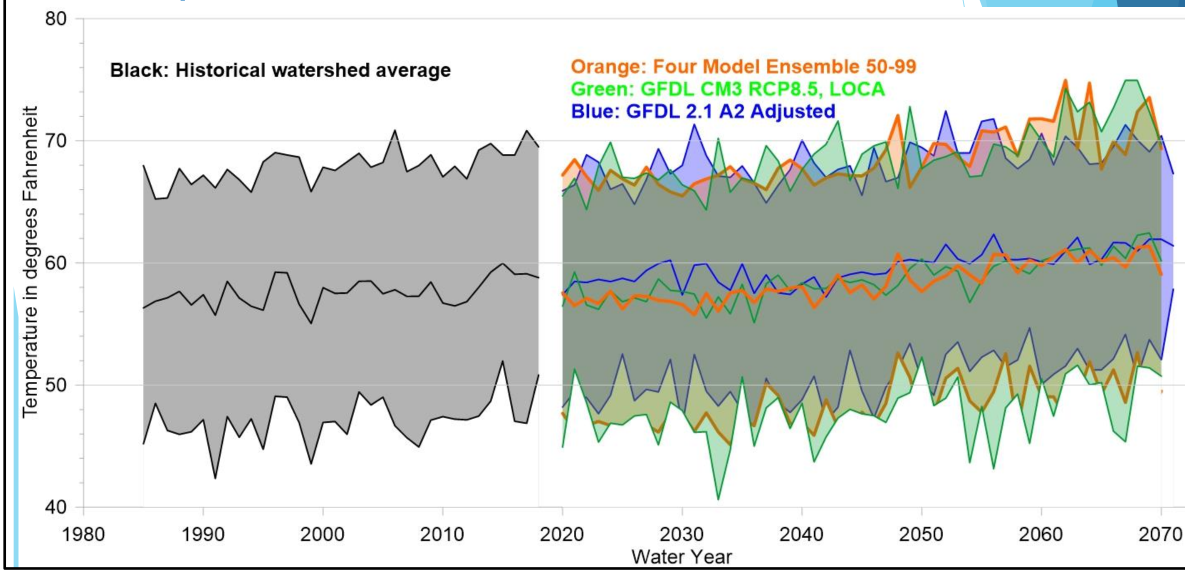
Four Model Ensemble 50-99 shows rising temperatures over time



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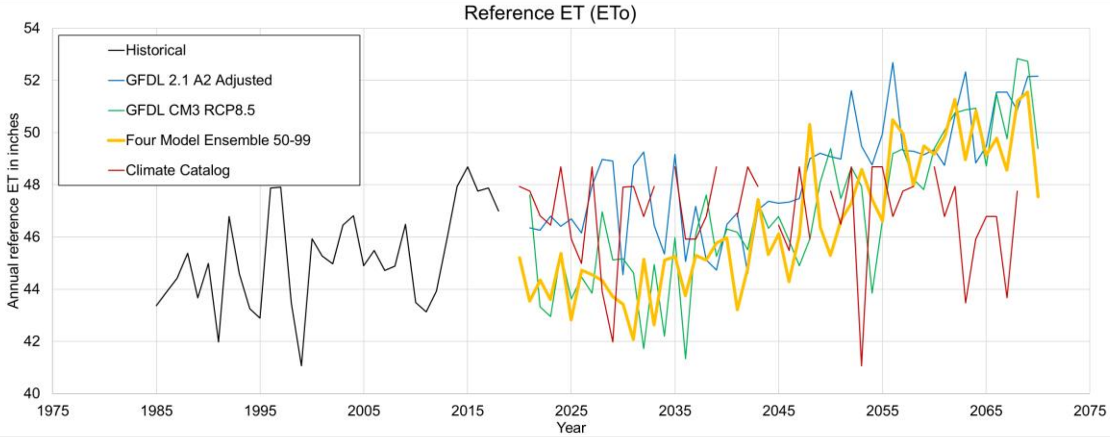
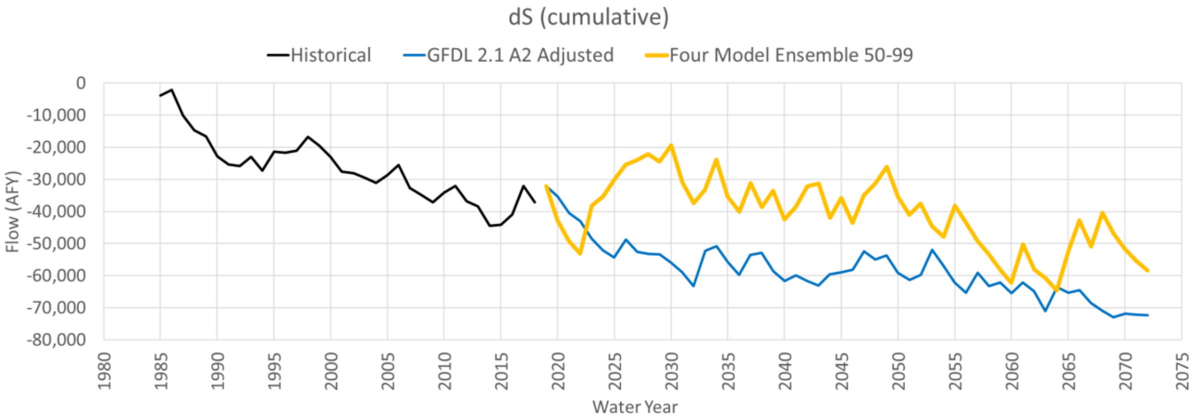
Four Model Ensemble 50-99 shows increasing potential for evapotranspiration over time



Less long-term baseline reduction of stored groundwater with Four Model Ensemble 50-99



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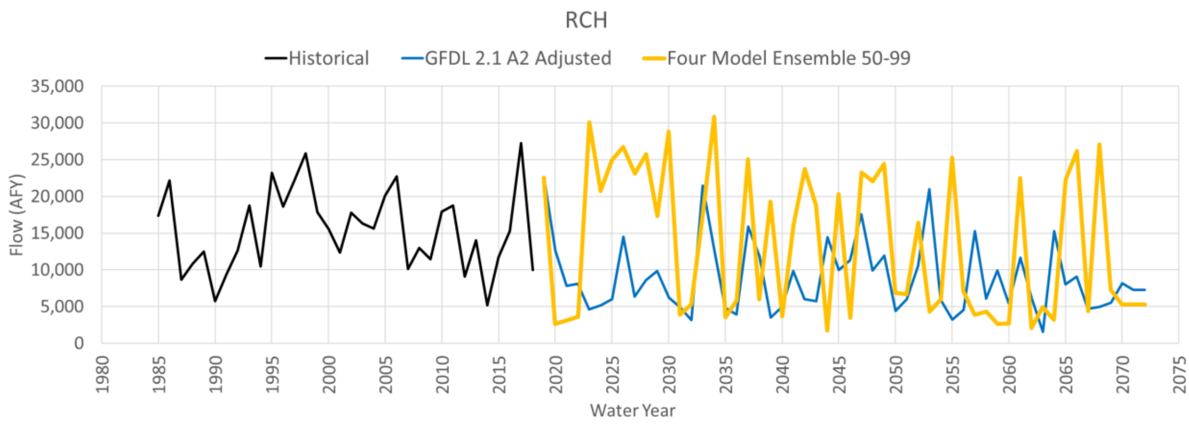
Greater variability of annual recharge with Four Model Ensemble 50-99



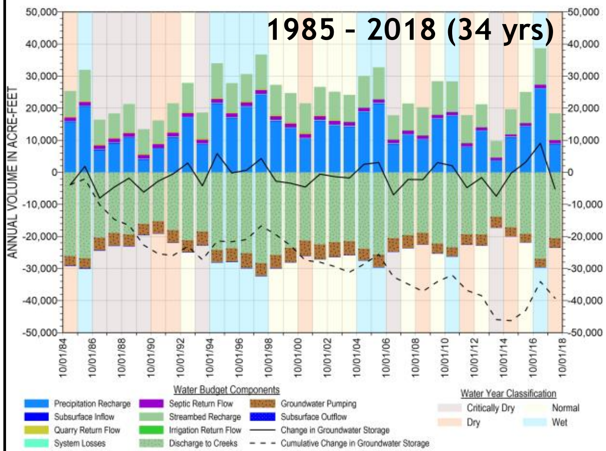
Baseline Scenario with Four Model Ensemble 50-99 Climate Projection

Presented by Georgina King, M&A

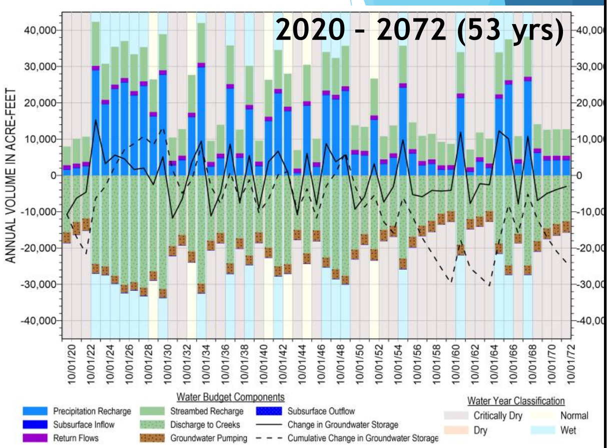
Baseline Scenario Assumptions

- SVWD demand increase of 0.26% per year
- SLVWD demand increase of 0.18 % per year
- Mount Hermon future demand remains the same as demand based on different water year types over the past 10 years
- Private well owners demand is constant at 0.3 acre-feet per year; no increase in population
- Small water system demand is based on historical demand
- Uses Four Model Ensemble 50-99th percentile climate projection

Basin Baseline Water Budget



Average loss of groundwater in storage over 34 years is 1,150 acre-feet per year



Average loss of groundwater in storage over 53 years is 450 acre-feet per year

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Take note of the water year types in the future baseline scenario – there are only 6 average years (11% of simulation), 19 wet years (36%), no dry years, and 28 critically dry years (53%). Change in storage seem to do okay for the first half of the simulation, only declining a small amount overall. However, there is a greater decline in the later half of the simulation because of a prolonged dry stretch starting in 2048.

Baseline Annual Average Basin Water Budget Compared to Historical & Current (in acre-feet per year)

		1985-2018	2010-2018	2020 - 2072
	Components	**Historical**	**Current**	**Baseline**
Inflows	Precipitation Recharge	13,690	13,080	12,130
	Subsurface Inflow	140	130	130
	Return Flows (System Losses, Septic Systems, Quarry, Irrigation)	1,600	1,210	1,140
	Streambed Recharge	8,690	8,630	8,420
Outflows	Groundwater Pumping	3,730	2,980	2,770
	Subsurface Outflow	120	110	110
	Groundwater Discharge To Creeks	21,410	20,200	19,410
Storage	Cumulative Change in Storage	-39,250	-2,110	-23,950
	Change in Storage per year	-1,150	-230	-450

93% of Current

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Red boxes indicate the main water budget components to look at to understand the changes during each period.

Baseline Annual Average Mount Hermon/ South Scotts Valley Water Budget Compared to Historical & Current (in acre-feet per year)

		1985-2018	2010-2018	2020 - 2072
	Components	**Historical**	**Current**	**Baseline**
Inflows	Precipitation Recharge	1,940	1,830	1,730
	Subsurface Inflow	30	20	20
	Return Flows (System Losses, Septic Systems, Quarry, Irrigation)	500	290	250
	Streambed Recharge	360	340	340
	Flow from Other Subareas	1,680	1,500	1,410
Outflows	Groundwater Pumping	2,060	1,480	1,170
	Subsurface Outflow	10	0	0
	Groundwater Discharge To Creeks	1,780	1,600	1,520
	Flow to Other Subareas	1,430	1,210	1,290
Storage	Cumulative Change in Storage	-22,020	-1,990	-7,040
	Change in Storage per year	-650	-220	-130

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Red boxes indicate the main water budget components to look at to understand the changes during each period.

Summary of Scenarios

Scenario	Volume of Water Involved & Where It Is Used
~~Aquifer Storage and Recovery (ASR)~~	~~Average of 820 AFY is injected (stored) in the Lompico aquifer in South Scotts Valley area~~ ~~90% is pumped out (recovered)~~
Injection Only	710 AFY is injected into the Lompico aquifer in Central Scotts Valley and is not pumped out
In-Lieu Recharge of 520 AFY Plus Injection of 710 AFY (Combination Scenario)	An average of 207 AFY of excess surface water plus 313 AFY Loch Lomond water is used in-lieu of winter pumping by SLVWD and SVWD = total of 520 AFY. Excess available is ~200 AFY less than previously modeled because 40 cfs winter bypass flows at Big Trees gauge is now taken into account 710 AFY is injected into the Lompico aquifer in Central Scotts Valley and is not pumped out

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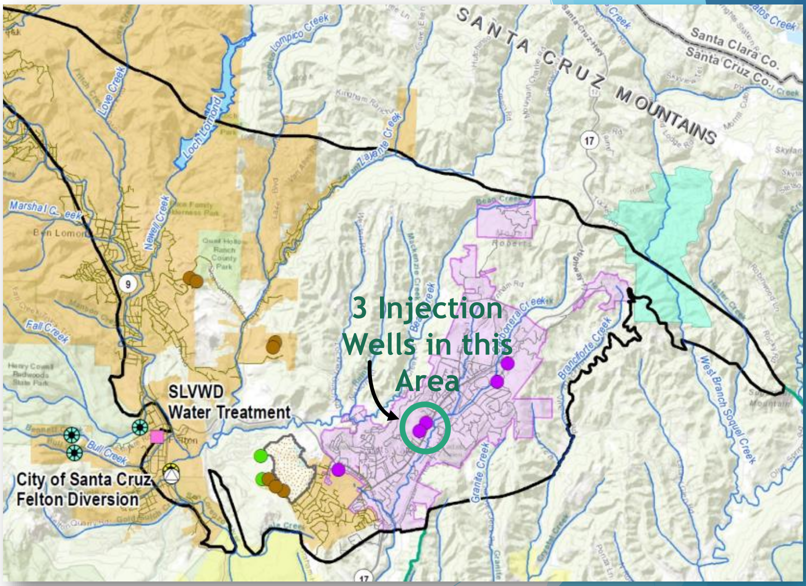
Scenarios that are presented in the next slides

Injection Only Assumptions

- Injection of 710 acre-feet/year occurs in 3 injection wells around SVWD's El Pueblo Yard
- Monthly injection is uniformly distributed over all months



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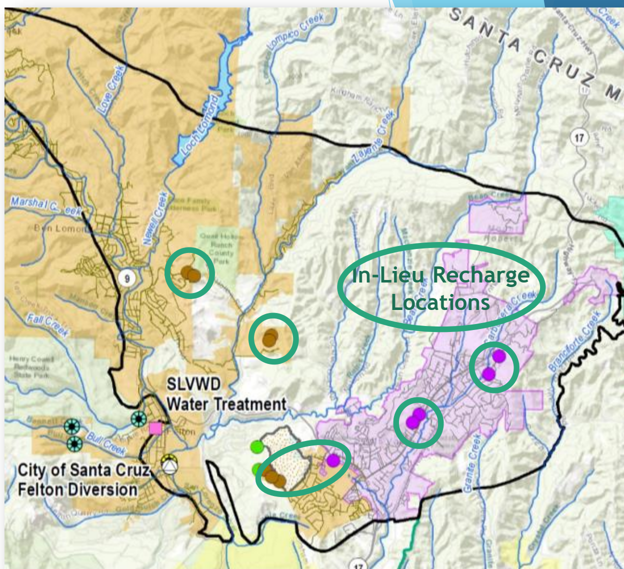
Injection Only Annual Average Mount Hermon/ South Scotts Valley Water Budget Compared to Current & Baseline (acre-feet/yr)

		2010-2018	2020 - 2072	
	Components	**Current**	**Baseline**	**Injection**
Inflows	Precipitation Recharge	1,830	1,730	1,730
	Subsurface Inflow	20	20	20
	Return Flows (System Losses, Septic Systems, Quarry, Irrigation)	290	250	250
	Streambed Recharge	340	340	330
	Injection	0	0	620
	Flow from Other Subareas	1,500	1,410	1,390
Outflows	Groundwater Pumping	1,480	1,170	1,280
	Subsurface Outflow	0	0	0
	Groundwater Discharge To Creeks	1,600	1,520	1,570
	Flow to Other Subareas	1,210	1,290	1,630
Storage	Cumulative Change in Storage	-1,990	-7,040	-2,870
	Change in Storage per year	-220	-130	-50

This table is for reference. There will be charts presented later in the presentation that illustrates the main points in a more digestible way.

In-Lieu Recharge Scenario Assumptions

- Surface water is used in-lieu of SLVWD and SVWD Lompico aquifer pumping starting in 2025
- Average of 520 AFY of surface water is used in-lieu of pumping
- In-lieu water comprises:
  - Loch Lomond 313 AFY (Dec – Mar)
  - Excess surface water from SLVWD North System (Nov – Apr) up to 99 AFY
  - Excess surface water from Felton System streams (Nov – Apr) up to 109 AFY
- How much excess surface water can be taken from Fall Creek is constrained by 40 cfs winter by-pass flows



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Of the in-lieu water, stream diversions, on average, 99 AFY is from the North system and 109 AFY is from the Felton system.

Calculations of physically available water for additional diversion were based on tabulating computed watershed runoff (developed as part of model input pre-processing), and rescaling to the drainage area upstream from each surface water point of diversion.

- Runoff is only calculated during months when there is precipitation, but historical data show that diversions occur all year long, so that streamflow is generally perennial. Therefore, available water for a given month was calculated based on cumulative runoff less cumulative diversion, so that previous months precipitation would be accounting for in determining available streamflow

- In addition to water physically being available in the stream, some other considerations were applied to Fall Creek in the Felton system, consistent with constraints listed in Exponent’s Water Availability Assessment
  - Maximum diversion rate of 1.7 cfs
  - Maximum annual diversion of 1,059 AF
  - Winter bypass flows of either 0.75 or 1.5 cfs, depending on if it is a wet or dry year
  - No diversions if simulated SLR Big Trees streamflow falls below 40 cfs at any time

during Nov-May to comply with City of Santa Cruz Habitat Conservation Plan by-pass flows

Comparison of Basin-Wide Water Budgets

		1985-2018	2010-2018	2020 - 2072		
	Components	**Historical**	**Current**	**Baseline**	**Injection**	**Injection + In-Lieu**
Inflows	Precipitation Recharge	13,590	13,080	12,130	12,130	12,130
	Subsurface Inflow	140	130	130	130	130
	Return Flows (System Losses, Septic Systems, Quarry, Irrigation)	1,600	1,210	1,140	1,140	1,140
	Streambed Recharge	8,690	8,630	8,420	8,390	8,340
	Injection	0	0	0	620	620
Outflows	Groundwater Pumping	3,730	2,980	2,770	2,890	2,430
	Subsurface Outflow	120	110	110	110	120
	Groundwater Discharge To Creeks	21,410	20,200	19,410	19,730	20,040
Storage	Cumulative Change in Storage	-39,250	-2,110	-23,950	-16,250	-11,470
	Change in Storage per year	-1,150	-230	-450	-310	-220
Cumulative Change in Storage from 1985		-39,250	Na	-63,200	-55,500	-50,720

This table is for reference. There will be charts presented later in the presentation that illustrates the main points in a more digestible way.

In-Lieu Recharge Annual Average Mount Hermon/ South Scotts Valley Water Budget Compared to Current & Baseline (acre-feet/yr)

		2010-2018	2020 - 2072	
	Components	**Current**	**Baseline**	**In-Lieu + Injection**
Inflows	Precipitation Recharge	1,830	1,730	1,730
	Subsurface Inflow	20	20	30
	Return Flows (System Losses, Septic Systems, Quarry, Irrigation)	290	250	250
	Streambed Recharge	340	340	330
	Injection	0	0	620
	Flow from Other Subareas	1,500	1,410	1,450
Outflows	Groundwater Pumping	1,480	1,170	1,030
	Subsurface Outflow	0	0	10
	Groundwater Discharge To Creeks	1,600	1,520	1,620
	Flow to Other Subareas	1,210	1,290	1,770
Storage	Cumulative Change in Storage	-1,990	-130	50
	Change in Storage per year	-220	-7,040	2,440

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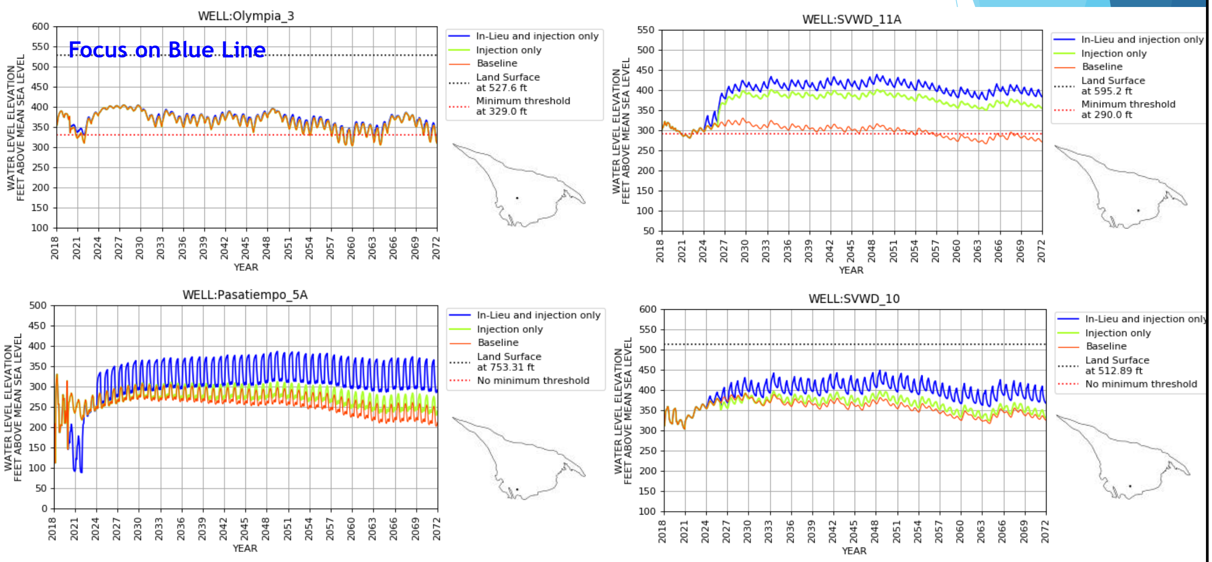
This table is for reference. There will be charts presented later in the presentation that illustrates the main points in a more digestible way.

Hydrographs of Selected Wells showing effects of In-Lieu Recharge + Injection on SM and Lompico Aquifer Levels



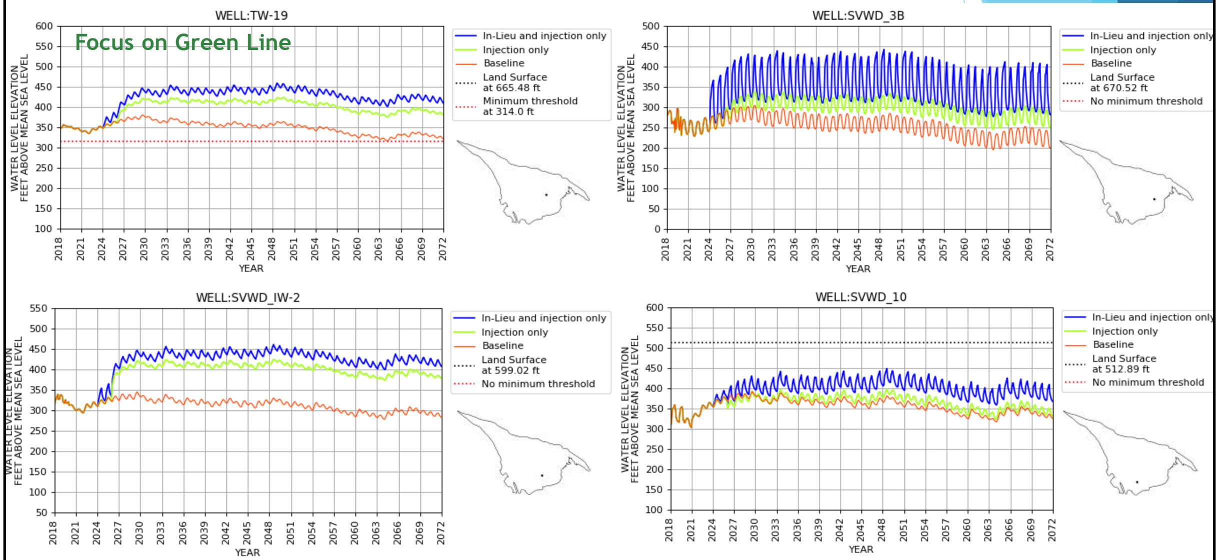
Levels at Olympia 3 well (Santa Margarita aquifer) do not increase much – only a foot or two. Climate has a greater influence on level trends over the simulation.

SVWD 11A (Lompico aquifer) is adjacent to an injection site and has approx.100 ft increase in groundwater levels over baseline levels

Pasatiempo 5A (Lompico aquifer) recovery increases over time from 2024 to 2072 by 90 ft from baseline

SVWD 10 (Lompico aquifer) recovers less than Pasatiempo 5A over the same timeframe but has groundwater levels greater than 2018 levels in 2072

Hydrographs of Selected Wells showing effects of Injection Only on Lompico Groundwater Levels

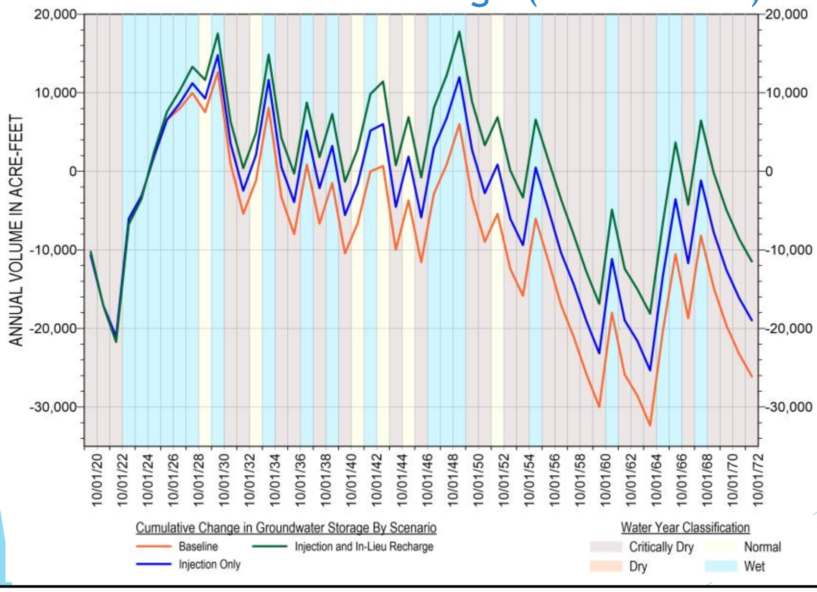


TW-19 located north of injection sees up to a 30 ft increase in levels
At one of the injection wells (IW-2) there is a 80 ft increase in levels
SVWD 3B a production well screened in both the Lompico and Butano aquifer, and located north of the injection has an increase of about 20 ft
SVWD 10 located south of injection has an increase of about 25 ft

Comparison of Cumulative Change of Groundwater in Storage

Basin-Wide and Subareas

Comparison of Basin-Wide Cumulative Change in Groundwater in Storage (2020 – 2072)



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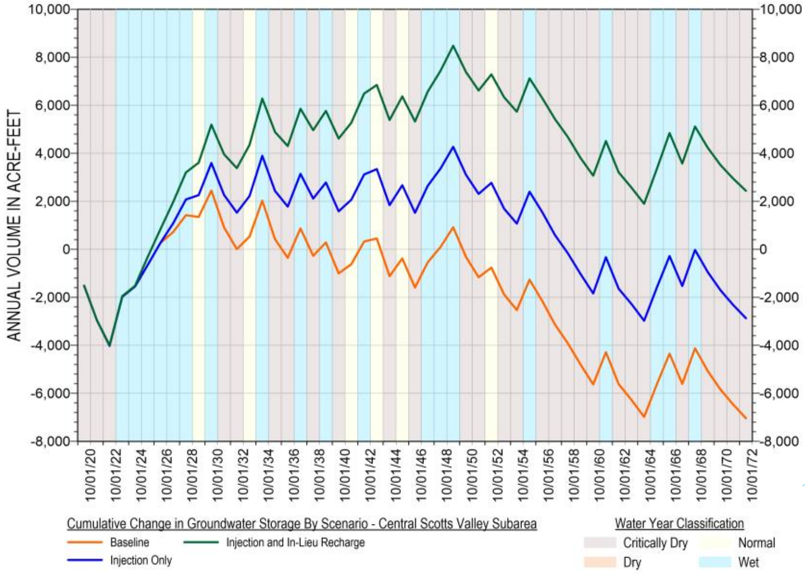
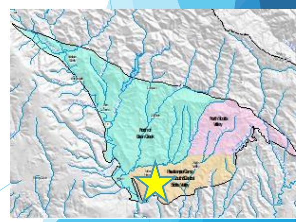
The combination of in-lieu and injection improves cumulative change in storage over baseline conditions by 12,490 AF over the 53-year simulation period. Injection alone only gains 7,700 AF of storage over baseline conditions.
Average change in storage for the first half of the simulation is slightly gaining groundwater in storage for both scenarios. The prolonged dry period starting 2052 has the greatest rate of decline and causes about 24,000 AF of groundwater to be lost from storage in the baseline and 2 scenarios.

Comparison of Mount Hermon / South Scotts Valley Subarea Cumulative Change in Groundwater in Storage (2020 – 2072)





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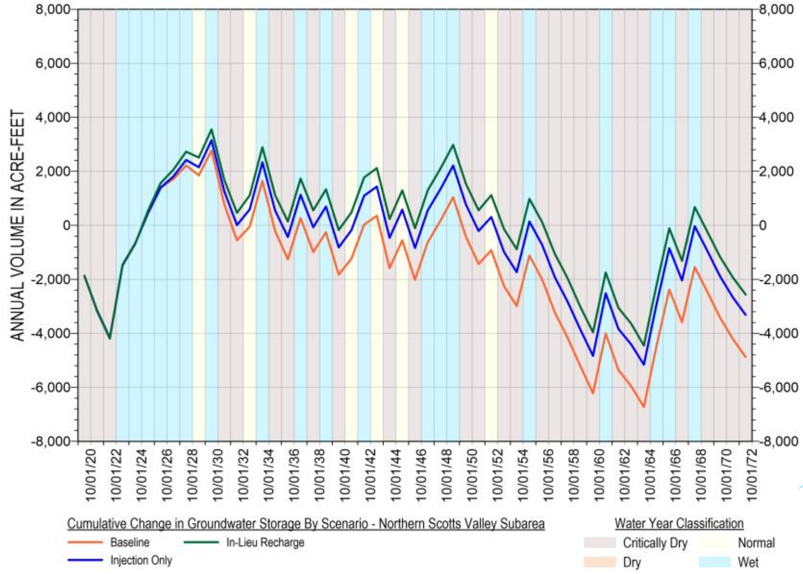
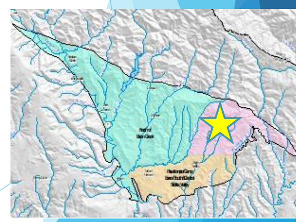
This chart focuses in on the cumulative change in groundwater in storage in the South Scotts Valley subarea. Since both projects modeled occur in this subarea, the greatest increases in levels are simulated here. Increases in storage are:
9,500 AF increase overall for in-lieu and injection together
4,000 AF increase overall for injection only

The combination of projects ensures there is not loss of storage occurring through the entire simulation. With just injection alone (and likely just in-lieu alone) losses in cumulative storage occur in the second half of the simulation.

Northern Scotts Valley Subarea Cumulative Change in Groundwater in Storage (2020 – 2072)





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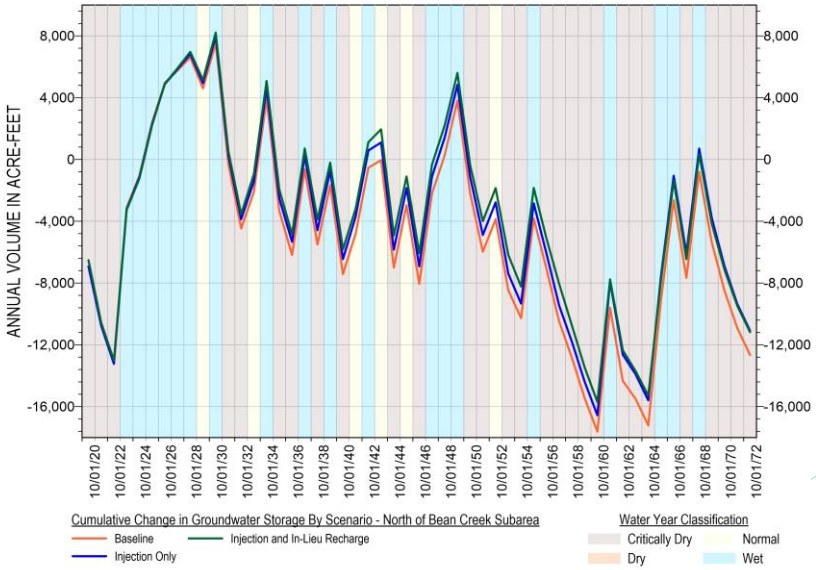
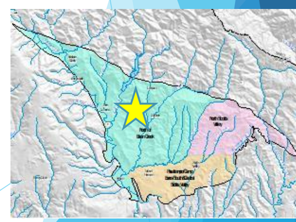
Although the projects are in the southern Scotts Valley subarea, there are increases in change of storage in the northern Scotts Valley subarea. There is an overall loss of storage over the simulation period. Injection along ends up with 1,600 AF more groundwater in storage, and the combination of projects ends up with 2,400 AF more groundwater in storage than baseline conditions.

Comparison of North of Bean Creek Subarea Cumulative Change in Groundwater in Storage (2020 – 2072)





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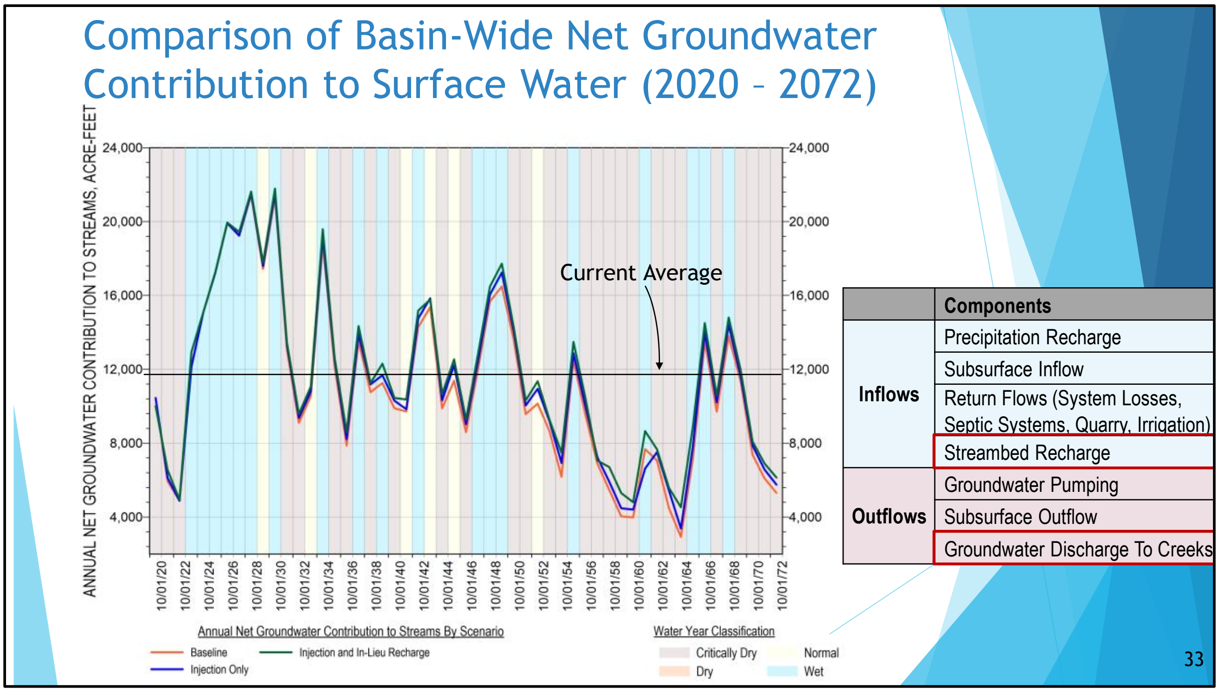
The projects have only a small effect on groundwater in storage north of Bean Creek. There does not seem to be a greater difference from baseline in wet years over dry years. The greatest difference over the simulation is 1,800 AF in 2042 (after a wet year) and also 1,800 AF in 2053 (in a dry year). The overall declines in cumulative change in storage are driven by dryer conditions simulated by the climate projection. This subarea covers the greatest area in the Basin and therefore has the greatest losses in storage 12,000 AF over the simulation.

Comparison of Net Groundwater Contribution to Surface Water

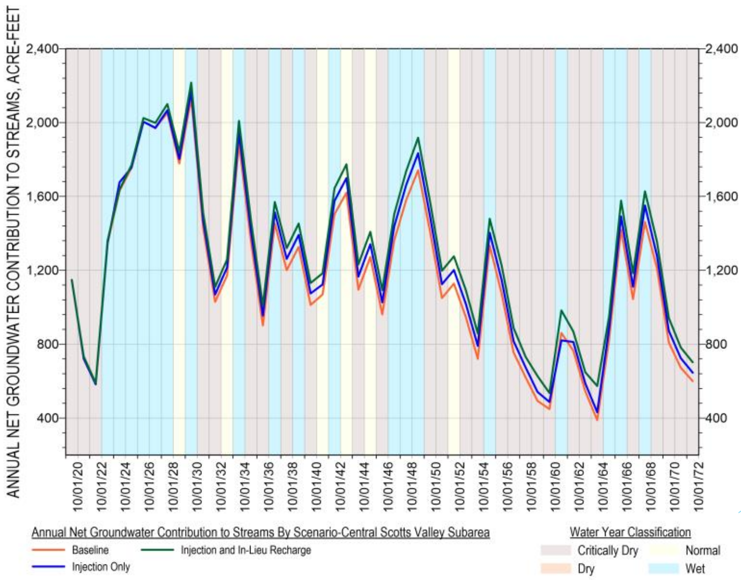
Basin-Wide and Subareas

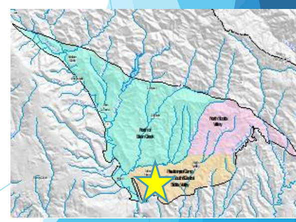


This chart shows the NET groundwater contribution to surface water. The net volume is calculated by subtracting the water budget component streambed recharge (an inflow to groundwater in the water budget) from groundwater discharge to creeks (an outflow from groundwater in the water budget).

Because of the highly permeable nature of the Santa Margarita Sandstone the net changes in groundwater contributions to surface water fluctuates with rainfall. The difference between the projects and baseline using the Four Model Ensemble climate projection is much smaller than simulations using the dryer adjusted GFDL projection. This is because there are more wet years that fill up the Santa Margarita aquifer which is the primary source of groundwater contributions to surface water. It is still noticeable that overall there is a decline in contributions to baseflow over the entire simulation.

Comparison of Mount Hermon / South Scotts Valley Subarea Net Groundwater Contribution to Surface Water (2020 – 2072)





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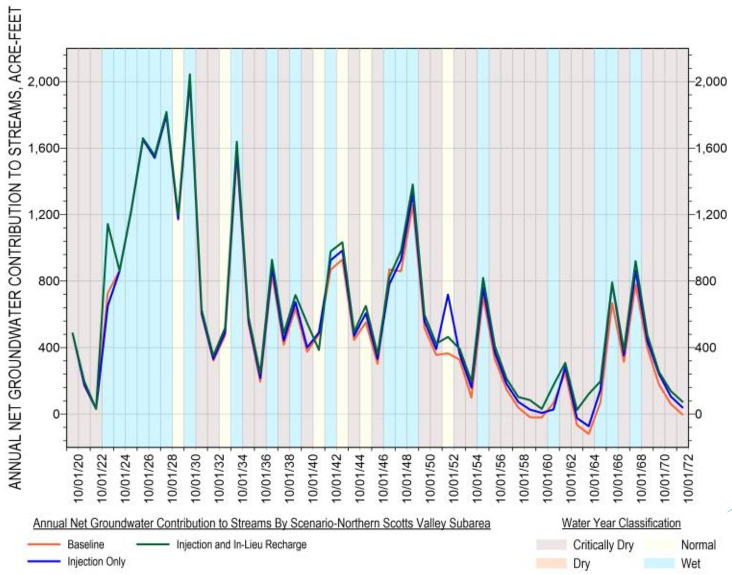
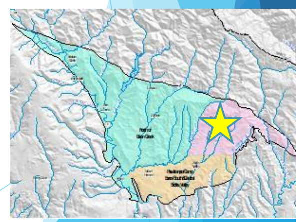
The Southern Scotts Valley subarea has a similar pattern to the basin-wide comparison of Net Groundwater Contribution to Surface Wate, although there is a more noticeable difference between baseline and projects because the projects occur in this subarea (and the scale is larger).

Comparison of Northern Scotts Valley Subarea Net Groundwater Contribution to Surface Water (2020 – 2072)





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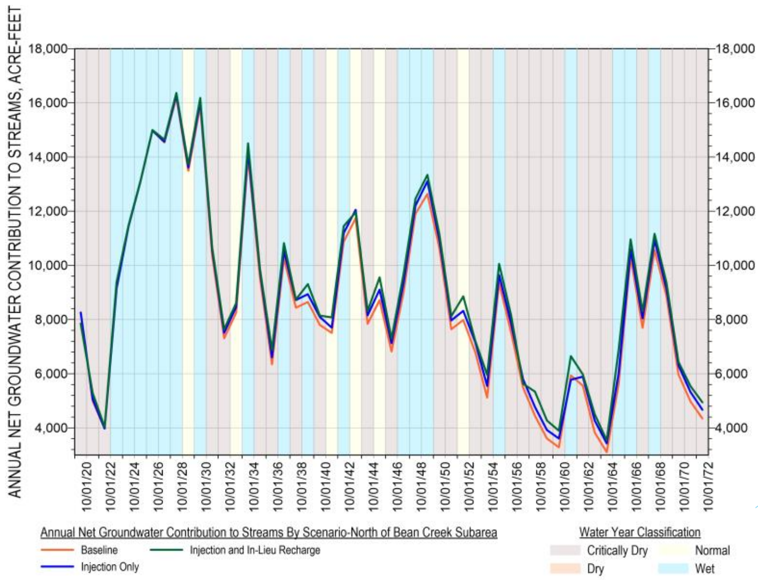
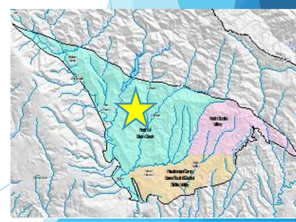
The Northern Scotts Valley subarea has again a similar pattern to the basin-wide and Southern Scotts Valley subarea. However, the major difference in this subarea is that there is one year when the Baseline and scenarios fall below zero, which means there are no net contribution of groundwater to surface water. Note the adjusted GFDL projection resulted in more years when this happened.

Comparison of North of Bean Creek Subarea
Net Groundwater Contribution to Surface Water (2020 – 2072)





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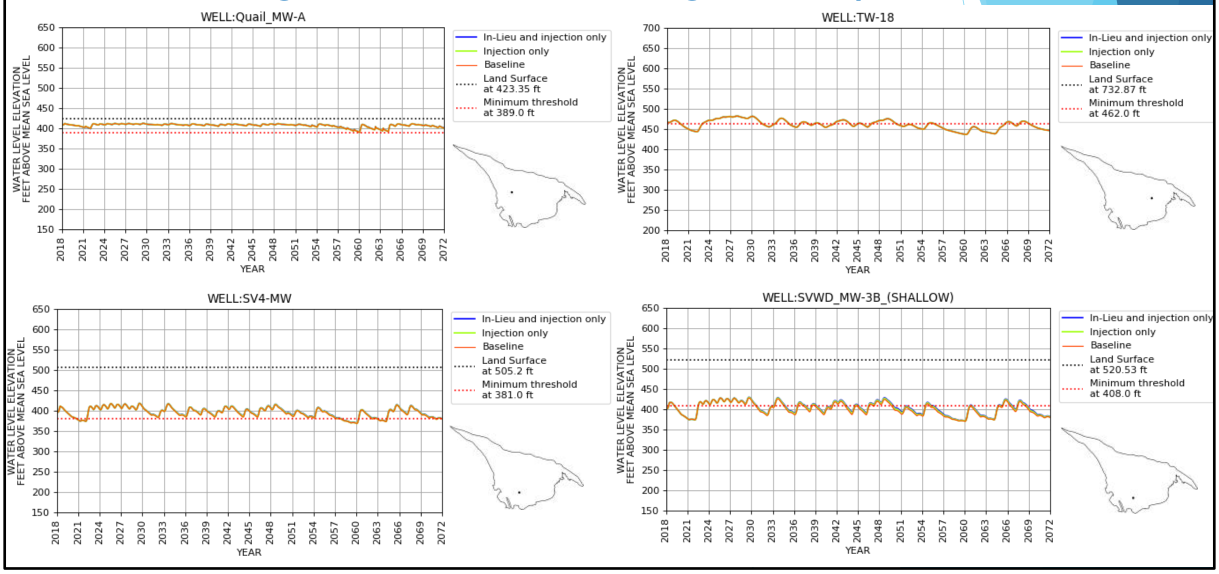
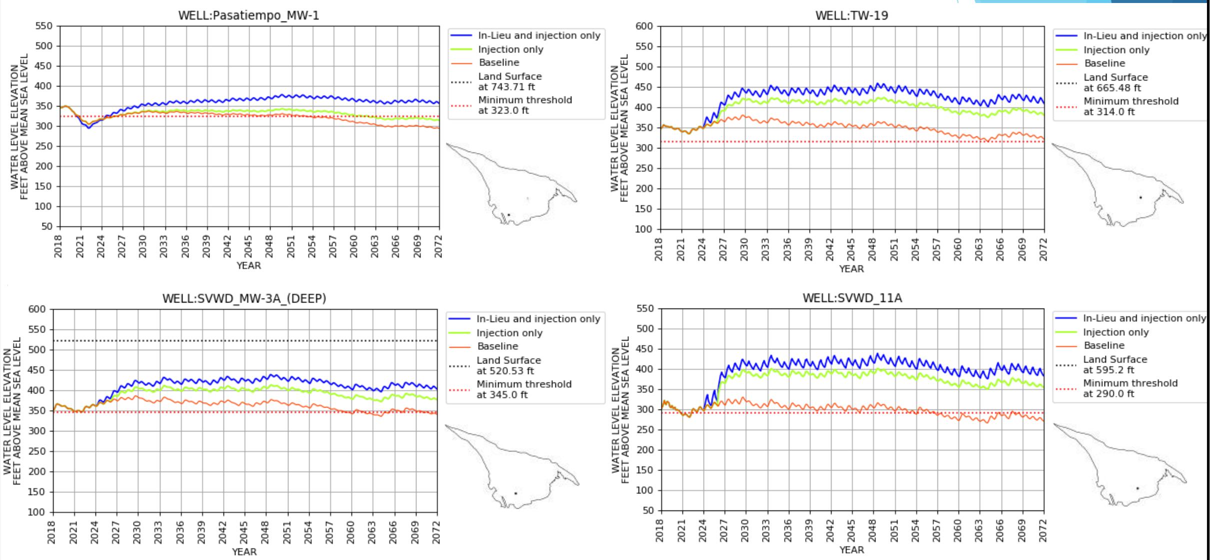
Like the cumulative change in storage, north of Bean Creek subarea does not have a big difference between baseline and the 2 projects.

Selected Hydrographs of Representative Monitoring Wells in Santa Margarita Aquifer



These hydrographs show simulated groundwater levels for Baseline and scenarios compared to minimum thresholds and land surface at select Representative Monitoring Wells in the Santa Margarita aquifer. The well north of Bean Creek (Quail MW-A) is generally above its minimum threshold. Wells in the South Scotts Valley (SV4-MW and SVWD_MW-3B) and Northern Scotts Valley have groundwater levels below minimum thresholds – some more than others.

Selected Hydrographs of Representative Monitoring Wells in Lompico Aquifer



These hydrographs show simulated groundwater levels for Baseline and scenarios compared to minimum thresholds and land surface at select Representative Monitoring Wells in the Lompico aquifer. The Baseline conditions result in most having groundwater levels below their minimum thresholds. The injection only scenario has some groundwater levels falling below minimum thresholds, while the combination of injection and in-lieu results in all levels being above minimum thresholds.

Summary of Impacts on South Scotts Valley Subarea

Scenario	Volume of Water Involved	What happens to that water
Injection Only	• 710 AFY is injected into the Lompico aquifer in Central Scotts Valley • 100% remains in the basin	• Raises groundwater levels up to 80 feet in injection area with smaller increases to the north of injection area • South of injection area groundwater level increases are smaller and up to 25 feet • Small increase in net groundwater contribution to Bean Creek baseflow
In-Lieu Recharge Plus Injection	• An average of **520 AFY** of excess surface water is used in-lieu of winter pumping by SLVWD and SVWD • In-lieu recharge is not pumped out • In combination with **710** AFY injected into Lompico aquifer in Central Scotts Valley	• Raises groundwater levels up to 100 feet in injection area with smaller increases to the north of injection area • South of injection area groundwater level increases are smaller and up to 50 feet • Small increase in net groundwater contribution to Bean Creek baseflow

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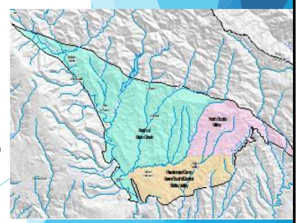
The impacts of In-lieu and Injection are predominantly limited to the area south of Bean Creek. The in-lieu recharge scenario changes pumping patterns at SLVWD's Quail and Olympia wellfields and so there are very small increases is groundwater levels around those wellfields.

Things to Consider for Additional Scenarios

- The In-Lieu plus Injection scenario increases groundwater levels where they are mostly above minimum thresholds. The projects are focused in the south Scotts Valley area.
- The amount of available excess surface water for In-Lieu use is relatively fixed and constrained by bypass flow requirements.
- The amount of injection that can take place can be increased if more injection locations are used.
- There are declines in groundwater in storage in the area north of Bean Creek where overpumping has not been an issue. The declines occur primarily because the area of the subarea is large and the drier climate reduces recharge. Groundwater extractions in the subarea average around 950 AFY (34% of total basin extractions).



Injection only does not improve groundwater levels enough to be higher than minimum thresholds most of the time

Discussion of Potential Model Scenarios

- The project budget only allows for 1 more scenario to be modeled
- The scenarios being run are not actual projects but are being used to determine what volumes and methods of recharge benefit the basin the most
- The GSP due January 2022 does not have to have PMAs finalized for implementation but it does need to know what types of projects are being considered for implementation over the next 20 years and how they will help the basin reach its sustainability goals and metrics

Board discussion of additional scenarios

Thank you for your participation!

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Water Budget Bar Charts

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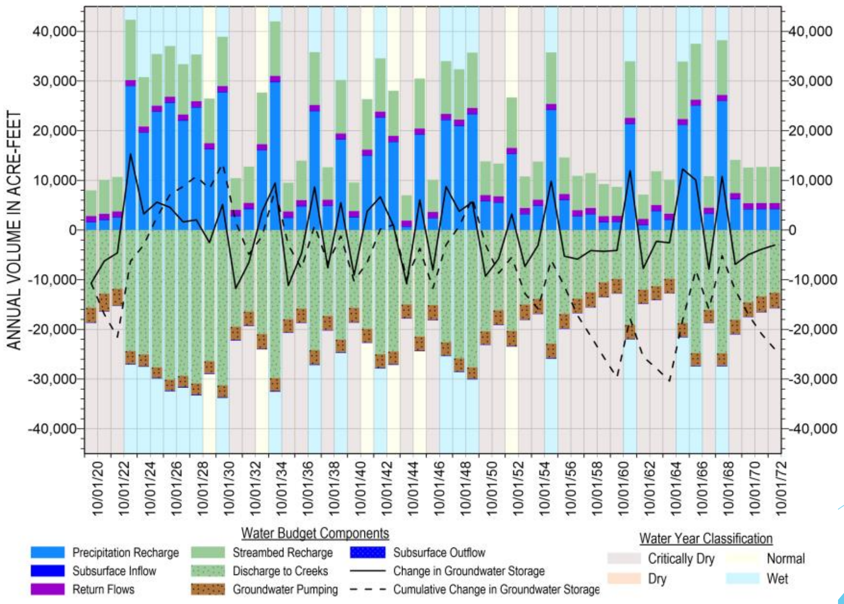
Basin Baseline Water Budget



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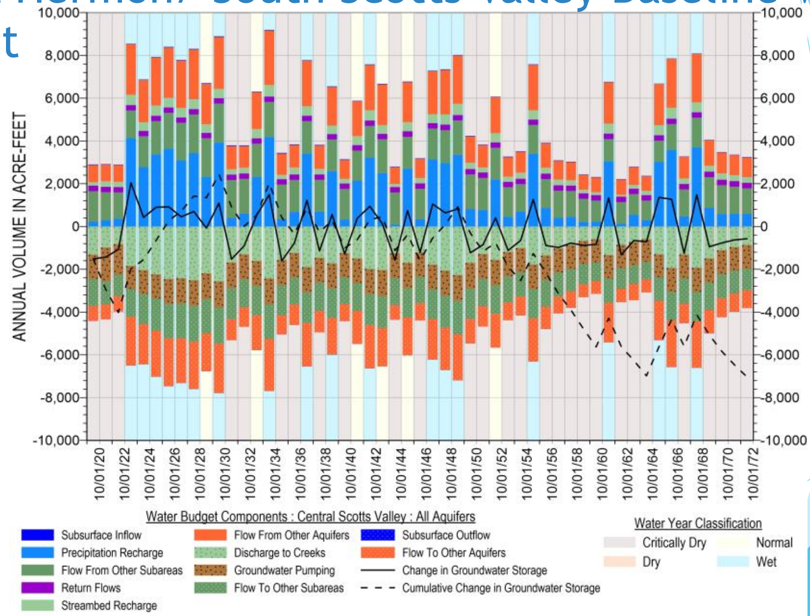
Take note of the water year types in this future baseline scenario – there are more dry or critically dry years than average or wet years

Mount Hermon/ South Scotts Valley Baseline Water Budget



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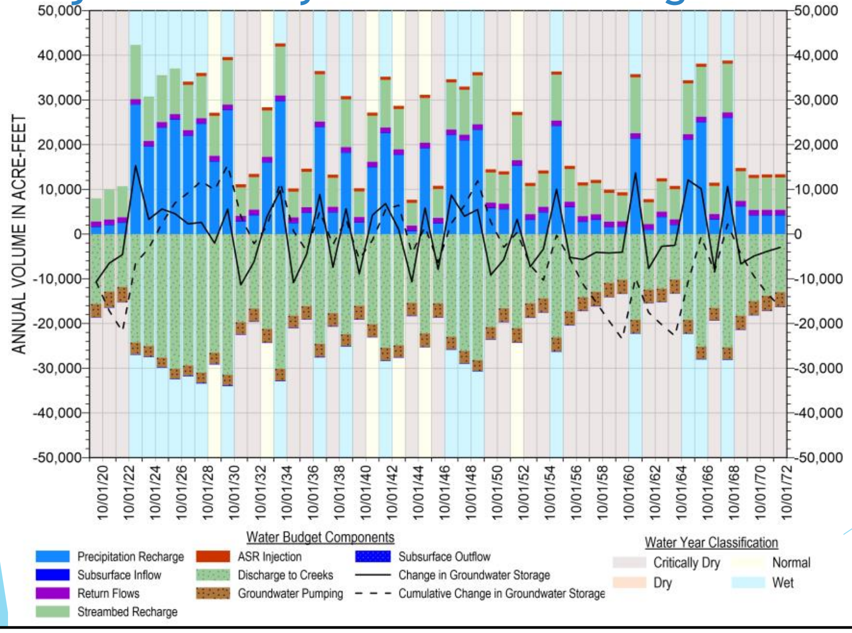
Injection Only Basin Water Budget



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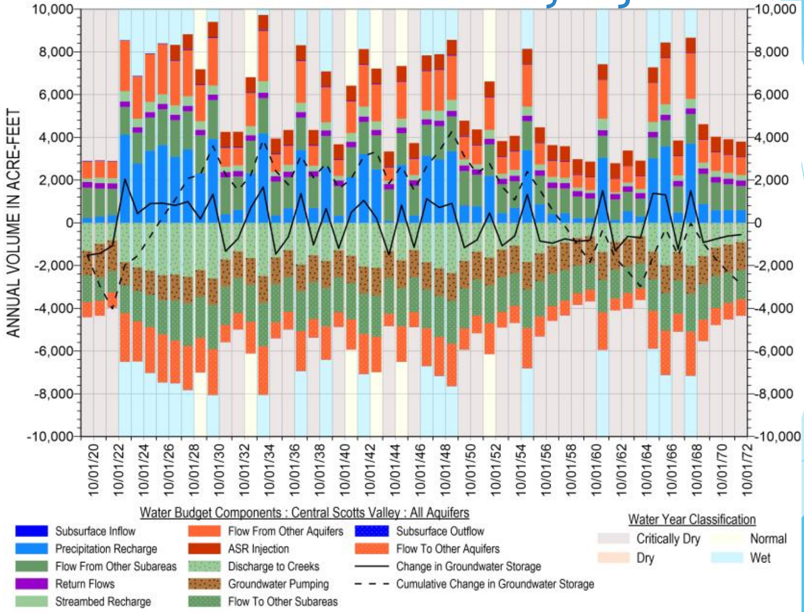
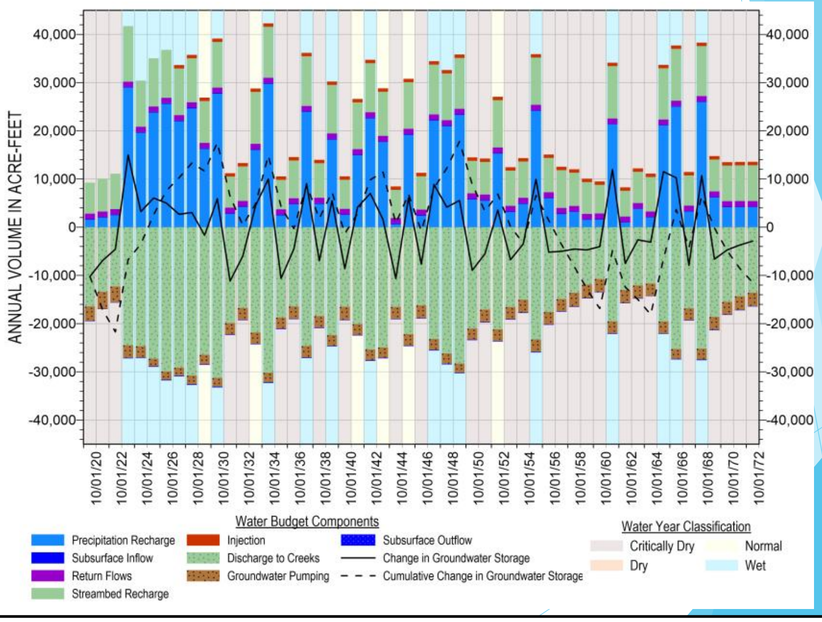
Mount Hermon/ South Scotts Valley Injection Only Water Budget



Injection and In-Lieu Recharge Scenario Basin Water Budget



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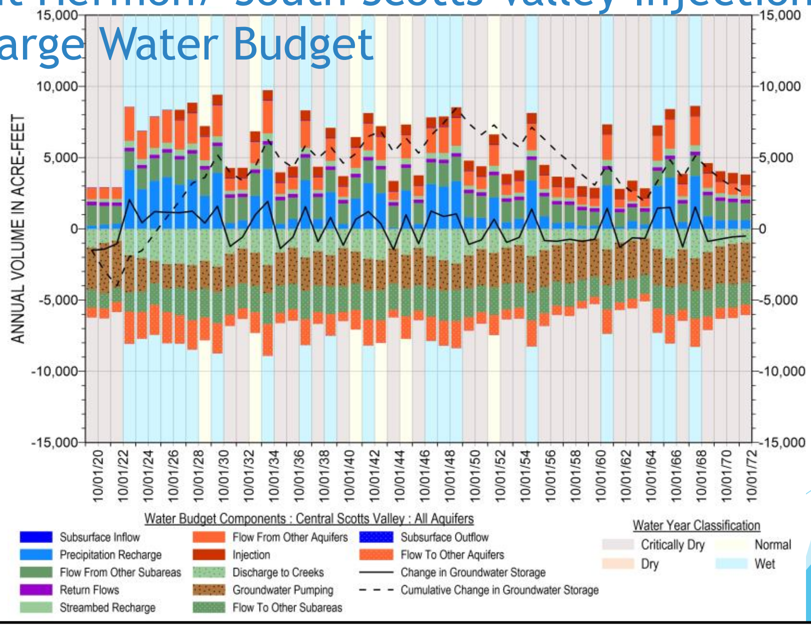
Mount Hermon/ South Scotts Valley Injection and In-Lieu Recharge Water Budget



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In-Lieu Recharge + Injection Annual Average Basin Water Budget Compared to Historical & Current (in acre-feet per year)

		2010-2018	2020 - 2072	
	Components	**Current**	**Baseline**	**In-Lieu + Injection**
Inflows	Precipitation Recharge	13,080	12,130	12,130
	Subsurface Inflow	130	130	130
	Return Flows (System Losses, Septic Systems, Quarry, Irrigation)	1,210	1,140	1,140
	Streambed Recharge	8,630	8,420	8,340
	Injection	0	0	620
Outflows	Groundwater Pumping	2,980	2,770	2,430
	Subsurface Outflow	110	110	120
	Groundwater Discharge To Creeks	20,200	19,410	20,040
Storage	Cumulative Change in Storage	-2,110	-23,950	-11,470
	Change in Storage per year	-230	-450	-220

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This table is for reference. There will be charts presented later in the presentation that illustrates the main points in a more digestible way.

Comparison of Basin-Wide Water Budget

		1985-2018	2010-2018	2020 - 2072		
	Components	**Historical**	**Current**	**Baseline**	**Injection**	**Injection + In-Lieu**
Inflows	Precipitation Recharge	13,590	13,080	12,130	12,130	12,130
	Subsurface Inflow	140	130	130	130	130
	Return Flows (System Losses, Septic Systems, Quarry, Irrigation)	1,600	1,210	1,140	1,140	1,140
	Streambed Recharge	8,690	8,630	8,420	8,390	8,340
	Injection	0	0	0	620	620
Outflows	Groundwater Pumping	3,730	2,980	2,770	2,890	2,430
	Subsurface Outflow	120	110	110	110	120
	Groundwater Discharge To Creeks	21,410	20,200	19,410	19,730	20,040
Storage	Cumulative Change in Storage	-39,250	-2,110	-23,950	-16,250	-11,470
	Change in Storage per year	-1,150	-230	-450	-310	-220
Cumulative Change in Storage from 1985		-39,250	Na	-63,200	-55,500	-50,720

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This table is for reference. There will be charts presented later in the presentation that illustrates the main points in a more digestible way.

Comparison of Mount Hermon / South Scotts Valley Subarea Water Budget

		1985-2018	2010-2018	2020 - 2072		
	Components	**Historical**	**Current**	**Baseline**	**Injection**	**In-Lieu + Injection**
Inflows	Precipitation Recharge	1,940	1,830	1,730	1,730	1,730
	Subsurface Inflow	30	20	20	20	30
	Return Flows (System Losses, Septic Systems, Quarry, Irrigation)	500	290	250	250	250
	Streambed Recharge	360	340	340	330	330
	Injection	0	0	0	620	620
	Flow from Other Subareas	1,680	1,500	1,410	1,390	1,450
Outflows	Groundwater Pumping	2,060	1,480	1,170	1,280	1,030
	Subsurface Outflow	10	0	0	0	10
	Groundwater Discharge To Creeks	1,780	1,600	1,520	1,570	1,620
	Flow to Other Subareas	1,430	1,210	1,290	1,630	1,770
Storage	Cumulative Change in Storage	-22,020	-1,990	-7,040	-2,870	+2,440
	Change in Storage per year	-650	-220	-130	-50	50
Cumulative Change in Storage from 1985		-22,020	NA	-29,060	-24,890	-19,580

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This table is for reference. There will be charts presented later in the presentation that illustrates the main points in a more digestible way.