

Meeting Minutes

**Engineering/Minerals
Tonto National Forest
Phoenix, AZ**

To: Project Record

From: Donna Morey, SWCA

Re: Resolution Groundwater Working Group Meeting 9/12/2018

Attendees:

USFS: Mary Rasmussen, Edward Gazzetti, Greg Olsen

SWCA: Chris Garrett, Donna Morey, Charles Coyle, Nick Enos, Gabi Walser

RCM: Cameo Flood, Jim Butler, Greg Ghidotti, Todd Keay, Tim Bayley, Doug Oliver, Gustavo Mesa-Cuadro

EPA: Pat Kelly

AGFD: Jim Ruff

San Carlos: Jim Wells

Handouts:

Agenda and Draft Tables

2 PowerPoint presentations viewed during meeting

Discussion:

It has been 2 months since our last meeting, we have received model results and sensitivities.

Today's goal is to discuss results received, determine next steps and talk thru approach of climate change (approach & rationale), heads up on mitigation and monitoring, outstanding action items.

WSP – presentation by Doug Oliver and Gustavo Meza-Cuadro (3 slides)

Slide 1 – Sensitivity Superposition Run

- Worst case sensitivity run occurred when graben faults were removed. 8/31 memo shows 84 sensitivity runs.
- What is “donut” area south of DC8.2W? Answer: Lies within base case circle and is less than 10' drawdown for sensitivity runs
 - Question – is this due to elevation or terrain? Answer: terrain is steep, head not lowered as much due to concentrated topography. If we showed an 8' contour compared to 10', the donut shape would not appear. The GDEs within the pocket are 6.1E and 5.1C
- Jim Wells asked the group to consider how results after the model end of 200 years will be described. The model is not at steady state yet and while model is not accurate for quantifiable results, there is still a trend that can be discussed. The EIS could discuss this point globally in text and could possibly add to GDE table.

Slide 2 – Negative Drawdown clarification

- Modeling is a snapshot of 2016 – includes 7 years of current pumping and effects of pumping since 1910s

- This is a physical reality, not just a mathematical artifact if water tables rebound. See table 2 of 8/6 report

Slide 3 - Memo Impact Discrepancy

- Sensitivity results were correct (8/31), (8/6) draft predictive modeling did not have GDEs listed as springs. The 8/6 report will be reissued with updated GDEs as springs.
- Location with most change was SK-04. Others with changes included SK02, SK03, and Bitter Springs
- GDE list is now final
- “Final Report”: WSP will reissue the October 2017 report. That will be the final report in addition to the predictive and sensitivity memos. Expect to provide end of September or early October.

GDE Tables – discussion lead by Chris Garrett

- Water quality and isotope data were best lines of evidence for pointing to a water source. After June 2018, we included “geologic common sense” as a line of evidence, i.e., if water level is 1,000 feet below a GDE nearby, then it is likely not connected.
- Grey cells/GDE = will have no impact since it is neither connected to Regional Aquifer or Apache Leap Tuff nor would be affected by SW reductions
 - Request to add another table with more clarification to water source. This table is already part of the GDE Process memo and could be added to the EIS.
- RCM suggested a single list for all sites considered and note detail on “connection”: neither, ground, or ground & surface. Greg does agree with title based on how Chris G explained terms of shallow fractures, Apache Leap Tuff, or Deep groundwater.
 - Do we call this groundwater and surface water dependent ecosystem?
 - Would it be better off with our disclosure in EIS to group stream reaches, i.e. take Queen Creek above Superior and lump the individual points together? Jim Ruff thinks it might be cleaner to take some out of this table in DEIS and keep all in process memo.
- Upper Queen Creek –
 - QC30.7C – water is coming from somewhere, but we don’t know exact water source. Upstream from disturbance but will not be affected by project.
 - Upper Carbonate 23.9C – similar as a spring near channel, SW monitoring station per Todd Keay, not a GDE
 - Request: 2 new tables – perched and regional – along with a single large classification table to characterize.
 - Since these will be lumped together there is little worry to catch every single point from Hamish SW or WSP outputs.
- Language of Impacts – Flowing Reach from 17.39 to 15.55KM pg. 2 of table. No argument, consistent approach
 - No action – reference is to drawdown. If less than 10’, “drawdown is not anticipated.” - no arguments.
 - Proposed Action = drawdown in base case modeling run minus drawdown in no action
 - Categories – less than 10’, 10’-30’, 30’-50’, greater than 50’
 - For this location and Whitlow ranch dam location – consider adding nuance on difference between regional or surface water influence.

- Cameo suggested not using “additional”, but group feels it should be used. Concern for “additional” meaning the base case had an impact. Tim thinks we could move towards using “impact” and defining it somewhere. “Impact due to block caving”. Gabi W, Jim Wells, Pat Kelley, and Mary R still want “additional” used. Chris will look at each location to see if more language could be added to clarify but will keep “additional drawdown due to block caving”. For no action – drawdown greater than 10’ “not anticipated” group feels that helps.
- DC8.8c – base case and no action are both less than 10’, sensitivity runs show over 10’.
- Group – add “additional drawdown anticipated less than 10’” in both no action and base case to be consistent. Pat Kelley likes Vicky’s suggested language that it “is the sensitivity runs pushing it over the threshold.”
- Last sentence – RCM suggested removing the “monitoring” sentence as not all rows have this text. Tim thinks it is too generic to be meaningful as currently written. Suggestion – add asterisk with footnote “see monitoring plan” and take out the sentence and instead reference section where monitoring is talked about in detail
- Pat Kelley and Jim Ruff would like LOM added back into table columns.

Mitigation

- Schedule to hold these discussions is now pushed to early 2019 after everyone has the ability to review impacts/ADEIS review period.
- Jim Ruff asked to be on water monitoring workgroup when it occurs

Climate Change – PowerPoint from Chris Garrett

- The EIS will address climate change with the best available science even though almost all agency guidance has been rescinded.
- A climate change scenario was not requested nor modeled, yet the 50%+/- brackets the possible changes for runoff and recharge
- Slide 4 incorporates Jim Ruff’s provided new data source from this morning. The data is similar to data already in use.
- Climate change estimates that can be quantified (not all can) would be less than the 50% sensitivity run that was done under for recharge.
- Quantifying is problematic due to lots of speculation on climate change and varying data sources/years.
- Mary feels there is enough information done and in ID team hands to say how climate change was looked at currently.
- Another recent Water Resources Research article from May by Kamai was brought up. The article showed evaporation from deep aquifers, even up to 300’ of groundwater depth in hyper arid environments. This effect could increase due to rising temperatures for evaporation.
- This will be the no action drawdown as mine will not impact the climate. Mary wants it addressed as a cumulative impact.

Action Items:

1. How much water comes out of the drains and how it compares to RCM dewatering – WSP can provide, memo already in progress.

- a. Will not change anything in Tim's water balance yet – Gabi to get WSP info and if discrepancies
 - b. WSP to break out of calibrated model (model before predictive runs) by individual basin. Gabi will compare this to M&A memo. If M&A requests – those will be made later
 - c. Water volumes from dewatering drains & fracture well package to compare to RCM dewatering predictions. Just LOM
 - d.
2. "Final Report"
 - a. - WSP will reissue the October 2017 report in addition to the predictive and sensitivity memos. Expect to provide end of September or early October.
 - b. WSP revise 8/6 memo
 - c.
3. SWCA – immediately – circulate GDE process memo
 4. SWCA – circulate revisions to effects table once wrapped up. Will take a while waiting for results
 5. SWCA - Consider adding GDE classification table from process memo to EIS
 6. WSP to document separate sensitivity model run & memo varying recharge +/- 50% for all zones at once.
 7. WSP to provide excel tables with hydrographs – don't need separate sensitivity run as we can pull results out on own. WSP would like to add it as a separate memo to be cleaner and still provide excel tables.
 8. Provide meeting notes and Action items to full group
 9. Tim would like to see surface water tech memo and EIS section. Tech memo can be circulated once FS review is done.
 10. GW1 - WSP will provide a better reference to "B" (McIntosh) and "C" will be Resolution internal data for pumping
 11. GW9 - M&A is working on the ESRV model and should provide later this week. Goldsim seepage modeling will also be provided later this week
 12. GW67 - should be close to complete
 13. GW 80 and 81- hopefully part of report
 14. ADWR to review language and policy in AMA discussion of EIS
 15. SWCA – Consider 2 new tables – 1 for perched and 1 for regional – and a giant classification table to characterize. Since these will be lumped together there is little worry to catch every single point from Hamish or WSP outputs.

DRAFT Agenda

To: Attendees, Project File

From: Donna Morey, SWCA

CC:

Date: 9/11/2018

Re: Resolution Copper Mine – Groundwater Modeling Workgroup Call 9/12/2018

Location:

Webinar Information:

Webinar access: [REDACTED]

USA (571) 317-3129 Access Code: [REDACTED]

CANADA (647) 497-9391 Access Code: [REDACTED]

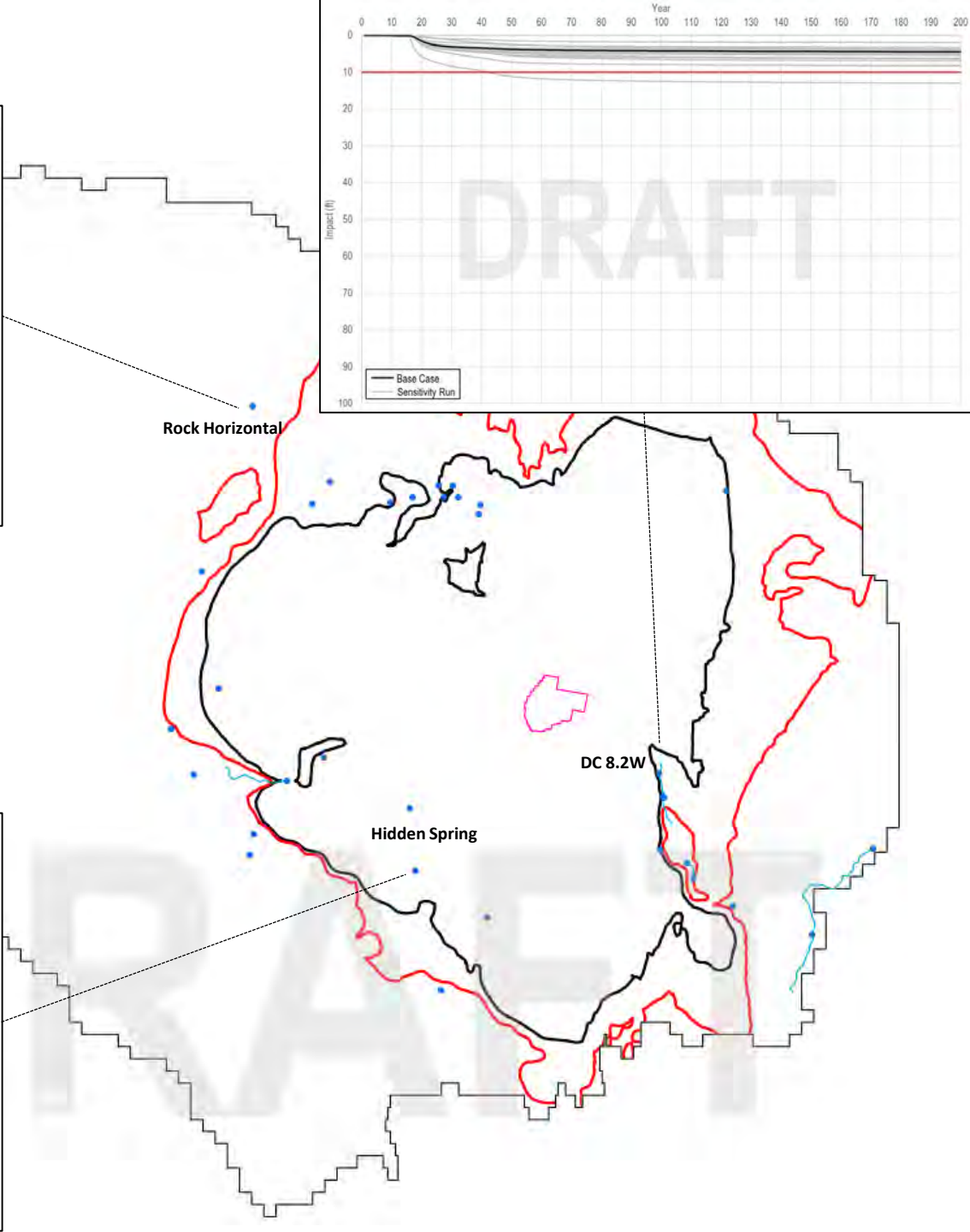
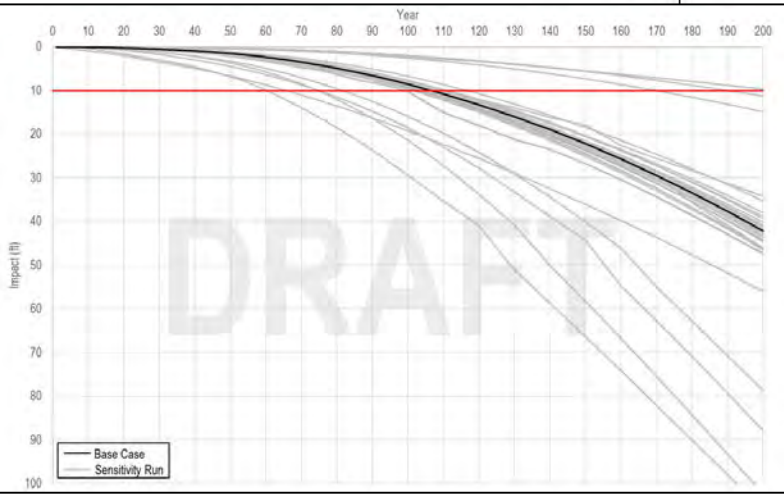
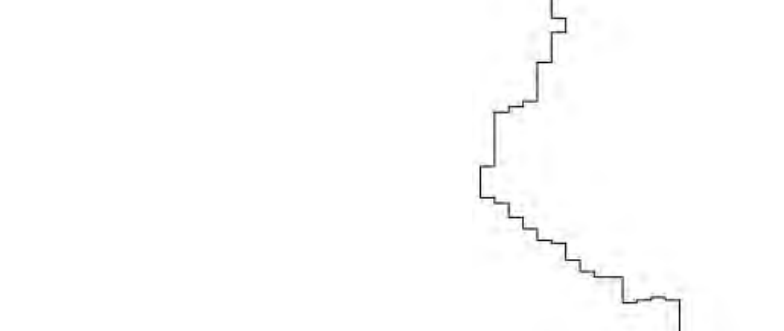
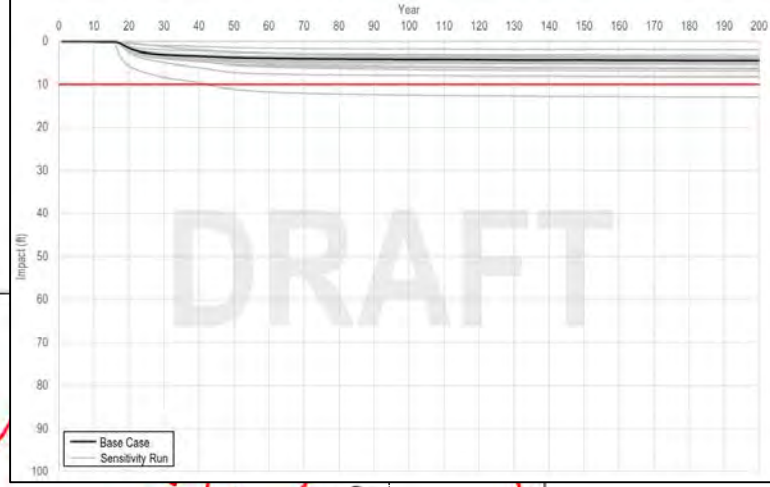
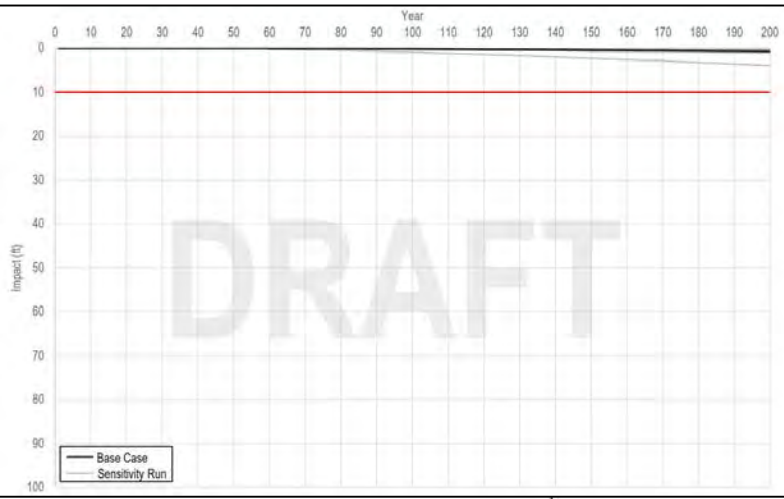
In Person:

SWCA, 20 E. Thomas Road, Suite 1700

Discussion Points:

- | | |
|---------------|---|
| 9:00 – 9:30 | WSP presentation <ul style="list-style-type: none">• Where we are and aren't seeing impacts• Nuances – negative drawdown |
| 9:30 – 10:00 | Presentation of results in DEIS <ul style="list-style-type: none">• Table X – Summary of impacts to GDEs• Table Y – Summary of impacts to water supplies |
| 10:00 – 10:20 | Climate change |
| 10:20 – 10:40 | Mitigation/monitoring <ul style="list-style-type: none">• Upcoming process• Mitigation approach in light of impact predictions |
| 10:40 – 11:00 | Final action items <ul style="list-style-type: none">• Water balance request |

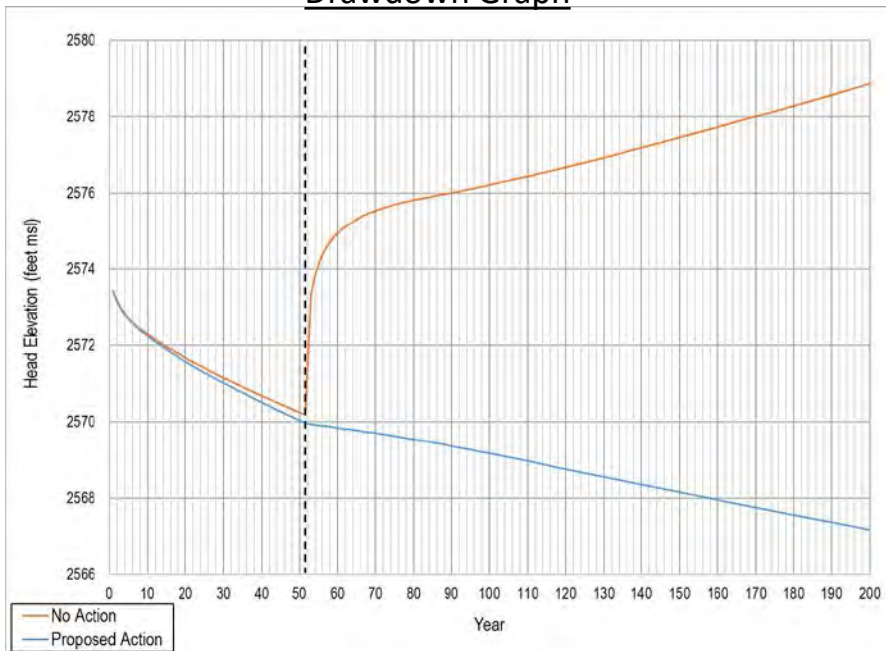
Sensitivity Superposition Run



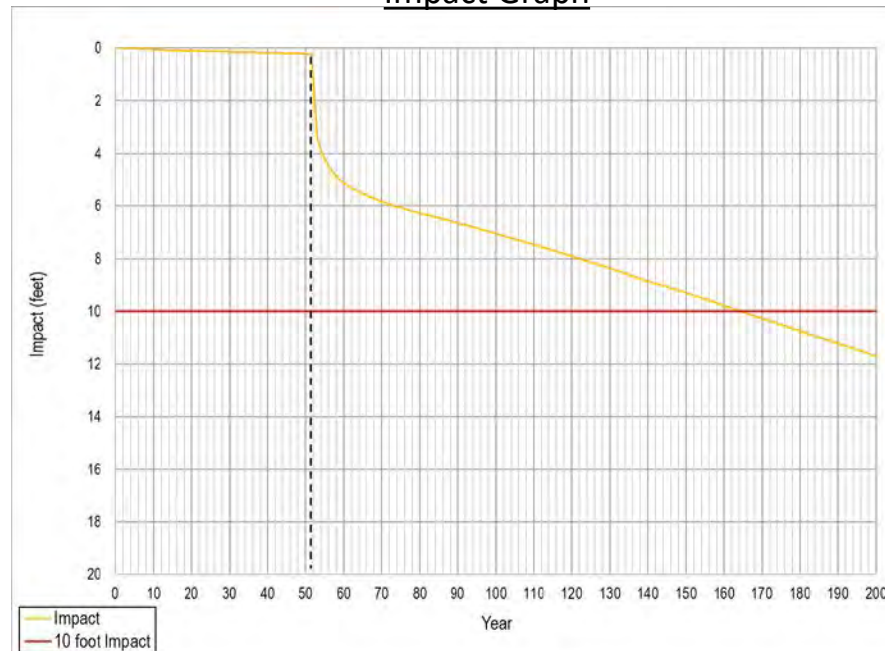
Negative Drawdown

- A question arose as to why there was seemingly higher impact than expected if we were to look at drawdown from initial head values.
- This is due to the dual model approach, where one can evaluate a no-action case where water recovers to a value greater than initially measured.
- This can be clearly seen in the hydrograph for QC17.39 below. The no-action case predicts that heads will rise higher than their values today (potentially restoring flow to Queen Creek) but the proposed action head remains lowered.
- This evaluates a “greater impact” (proposed action minus no-action) than what would simply predicted if a no-action case was not run.

Drawdown Graph



Impact Graph



Memo Impact Discrepancy

- A question arose as to why there was a discrepancy in predicted impacts between the base case predictive memo and the sensitivity memo. This is seen in the area near the Bitter Spring and SK series GDEs.
- The results in the sensitivity memo are correct and the base case memo is not.
- This is due to not having a finalized list of GDEs at the time the first memo was produced and Drain boundary conditions not being applied at these points.
- For the sensitivity memo we did include them and the head was lowered, as is shown below in cross-section view. This changes the results slightly (only in this area) and hence impacts are different.

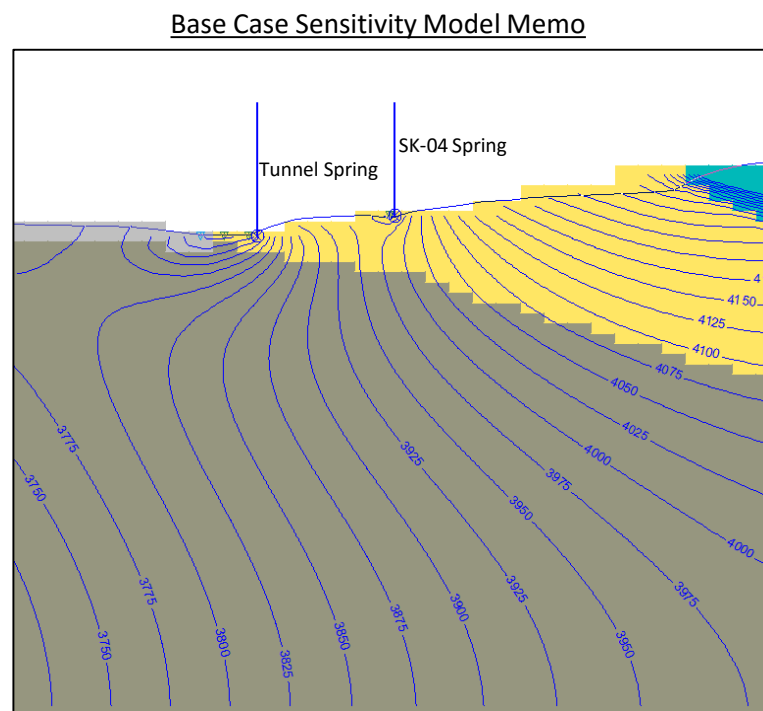
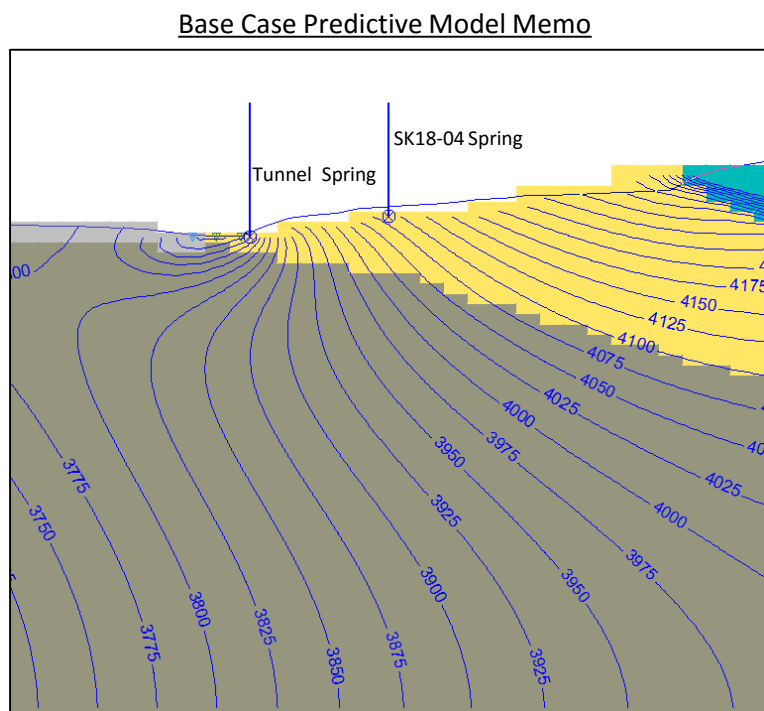


Table X. Summary of Potential Impacts to Groundwater-Dependent Ecosystems

[Note: 1) All GDE locations included for 9/12/18 groundwater meeting, but those requiring no analysis (gray highlights) would be dropped in the DEIS Environmental Consequences section; 2) yellow highlights indicate areas without specific predictions, but values shown are likely correct based on nearest predictions; 3) red highlights are outstanding clarifications needed from WSP]

Stream segment or watershed	Specific locations with monitoring conducted	DRAWDOWN (FT) UNDER NO ACTION ALTERNATIVE (200 YEARS AFTER START OF MINE)	ADDITIONAL DRAWDOWN (FT) CAUSED BY BLOCK-CAVE (200 YEARS AFTER START OF MINE)	POTENTIAL FOR GREATER DRAWDOWN BASED ON SENSITIVITY RUNS?	EXPECTED IMPACTS TO STORMFLOW FROM SURFACE DISTURBANCE IN UPSTREAM WATERSHED	SUMMARY OF EXPECTED IMPACTS TO GDE
Upper Queen Creek-Above Superior [from Magma Avenue bridge (km 21.7) to Pump Station Spring (km 30.7)]	Pump Station Spring (QC30.7C)					
	Upper Queen Creek (QC27.3C)					
	Upper Carbonate (QC23.9C)	Not applicable. Evidence indicates no groundwater connection.	N/A	N/A	Predicted 14.9% average reduction in average monthly flow rate at Magma Avenue	No Action – Reduction in surface runoff is not anticipated. Proposed Action – Reduction in surface runoff is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	Boulder Hole (QC23.6C)	Not applicable. Evidence indicates no groundwater connection.	N/A	N/A	Predicted 14.9% average reduction in average monthly flow rate at Magma Avenue	No Action – Reduction in surface runoff is not anticipated. Proposed Action – Reduction in surface runoff is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	Karst Spring (QC22.6E)	Not applicable. Evidence indicates no groundwater connection.	N/A	N/A	Predicted 14.9% average reduction in average monthly flow rate at Magma Avenue	No Action – Reduction in surface runoff is not anticipated. Proposed Action – Reduction in surface runoff is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.

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	Magma Avenue (QC21.7C)	Not applicable. Evidence indicates no groundwater connection.	N/A	N/A	Predicted 14.9% reduction in average monthly flow rate at Magma Avenue	No Action – Reduction in surface runoff is not anticipated. Proposed Action – Reduction in surface runoff is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
Queen Creek-Below Superior [from Magma Avenue Bridge (km 21.7) downstream Whitlow Ranch Dam (km 0)]	QC19.7C	Not applicable. Evidence indicates no groundwater connection.	N/A	N/A	Predicted 6.9% reduction in average monthly streamflow at Boyce Thompson	No Action – Reduction in surface runoff is not anticipated. Proposed Action – Reduction in surface runoff is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	Flowing reach from 17.39 to 15.55 km	<10	10-30	YES	Predicted 6.9% reduction in average monthly streamflow at Boyce Thompson	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is anticipated, and reduction in surface runoff is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	Whitlow Ranch Dam Outlet	<10	<10	NO	Predicted 1.8% reduction in average monthly streamflow at Whitlow Ranch Dam	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated, and reduction in surface runoff is anticipated but not substantial. Location would be monitored during operations for verification of potential impacts.

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Upper Devil's Canyon [from above Hwy 60 bridge down canyon to km 9.3]	DC15.5C					
	DC15.2C					
	DC14.7C					
	DC13.5C					
	DC10.9C					
Middle Devil's Canyon [from km 9.3 to km 6.1]	DC8.8C	<10	<10	YES	Predicted 4.0% reduction in average monthly streamflow at DC8.1C	No Action – Drawdown is not anticipated. Proposed Action – Addition drawdown due to block-caving is not anticipated with the base case model but is possible under other modeling scenarios. Reduction in surface runoff is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	DC8.2W	<10	<10	YES	Not applicable. No surface water impacts expected based on spring characteristics.	No Action – Drawdown is not anticipated. Proposed Action – Addition drawdown due to block-caving is not anticipated with the base case model but is possible under other modeling scenarios. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	DC8.1C	<10	<10	YES	Predicted 4.0% reduction in average monthly streamflow at DC8.1C	No Action – Drawdown is not anticipated. Proposed Action – Addition drawdown due to block-caving is not anticipated with the base case model but is possible under other modeling scenarios. Reduction in surface runoff is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing

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						water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	DC7.1C	<10	<10	YES	Predicted 4.0% reduction in average monthly streamflow at DC8.1C	No Action – Drawdown is not anticipated. Proposed Action – Addition drawdown due to block-caving is not anticipated with the base case model but is possible under other modeling scenarios. Reduction in surface runoff is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	DC6.6W	<10	<10	YES	Not applicable. No surface water impacts expected based on spring characteristics.	No Action – Drawdown is not anticipated. Proposed Action – Addition drawdown due to block-caving is not anticipated with the base case model but is possible under other modeling scenarios. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	DC6.14C	<10	<10	YES	Predicted 4.0% reduction in average monthly streamflow at DC8.1C	No Action – Drawdown is not anticipated. Proposed Action – Addition drawdown due to block-caving is not anticipated with the base case model but is possible under other modeling scenarios. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	DC6.1E	<10	<10	YES	Not applicable. No surface water	No Action – Drawdown is not anticipated.

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					impacts expected based on spring characteristics.	Proposed Action – Addition drawdown due to block-caving is not anticipated with the base case model but is possible under other modeling scenarios. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
Lower Devil's Canyon [from km 6.1 to confluence with Mineral Creek (km 0)]	DC5.5C	<10	<10	NO	Predicted 2.5% reduction in average monthly streamflow at Mineral Creek confluence	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated. Reduction in surface runoff is anticipated but not substantial. Location would be monitored during operations for verification of potential impacts.
	DC4.1E	<10	<10	NO	Not applicable. No surface water impacts expected based on spring characteristics.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
Mineral Creek [from Government Springs (km 8.7) to confluence with Devil's Canyon (km 0)]	Government Springs	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
	MC8.4C	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
	Upper Mineral Creek (UMC; 6.8C)	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
	MC5.2C	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated.

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						Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
	MC3.4W (Wet Leg Spring)	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
	Lower Mineral Creek (LMC; MC3.3C)	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
Arnett Creek	Arnett Creek (AC4.5C)	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
	Blue Spring	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
Telegraph Canyon	Telegraph Canyon (TC0.5C)	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
Tributaries to Devil's Canyon	Iron Canyon (IC1.0C)					
	Hackberry Canyon (H0.1C)	Not applicable. Evidence indicates no groundwater connection.	N/A	N/A		
	Rancho Rio Canyon (RR1.5C)	Not applicable. Evidence indicates no	N/A	N/A		

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		groundwater connection.				
Tributaries to Queen Creek	Number 9 Wash	Not applicable. Evidence indicates no groundwater connection.	N/A	N/A		
	Oak Flat Wash	Not applicable. Evidence indicates no groundwater connection.	N/A	N/A		
Mineral Creek Basin (Springs)	Lyons Fork (LF0.2C)					
	Patterson Spring					
Queen Creek Basin (Springs)	#5 Spring					
	Benson Spring					
	Bear Tank Canyon Spring					
	Bitter Spring	<10	10-30	YES	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	Bored Spring	>50	>50	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Proposed Action – Additional drawdown due to block-caving is anticipated, greater than the drawdown under the No Action alternative. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian

Stream segment or watershed	Specific locations with monitoring conducted	DRAWDOWN (FT) UNDER NO ACTION ALTERNATIVE (200 YEARS AFTER START OF MINE)	ADDITIONAL DRAWDOWN (FT) CAUSED BY BLOCK-CAVE (200 YEARS AFTER START OF MINE)	POTENTIAL FOR GREATER DRAWDOWN BASED ON SENSITIVITY RUNS?	EXPECTED IMPACTS TO STORMFLOW FROM SURFACE DISTURBANCE IN UPSTREAM WATERSHED	SUMMARY OF EXPECTED IMPACTS TO GDE
						vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	Conley Spring					
	Cross Canyon Spring					
	Fig Spring					
	Happy Camp Spring					
	Hidden Spring	30-50	30-50	NO	Not applicable. No upstream watershed disturbance.	<p>No Action – Drawdown is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools.</p> <p>Proposed Action – Additional drawdown due to block-caving is anticipated, greater than the drawdown under the No Action alternative. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.</p>
	Iberri Spring	<10	<10	YES	Not applicable. No upstream watershed disturbance.	<p>No Action – Drawdown is not anticipated.</p> <p>Proposed Action – Addition drawdown due to block-caving is not anticipated with the base case model but is possible under other modeling scenarios. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.</p>

Stream segment or watershed	Specific locations with monitoring conducted	DRAWDOWN (FT) UNDER NO ACTION ALTERNATIVE (200 YEARS AFTER START OF MINE)	ADDITIONAL DRAWDOWN (FT) CAUSED BY BLOCK-CAVE (200 YEARS AFTER START OF MINE)	POTENTIAL FOR GREATER DRAWDOWN BASED ON SENSITIVITY RUNS?	EXPECTED IMPACTS TO STORMFLOW FROM SURFACE DISTURBANCE IN UPSTREAM WATERSHED	SUMMARY OF EXPECTED IMPACTS TO GDE
	Kane Spring	<10	30-50	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.
	Lower Railroad Spring					
	McGinnel Mine Spring	10-30	<10	YES	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Proposed Action – Addition drawdown due to block-caving is not anticipated.
	McGinnel Spring	10-30	<10	YES	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Proposed Action – Addition drawdown due to block-caving is not anticipated.
	No Name Spring	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would be monitored during operations for verification of potential impacts.
	Perlite Spring					
	Rock Horizontal Spring	<10	<10	NO	Not applicable. No upstream watershed disturbance.	No Action – Drawdown is not anticipated. Proposed Action – Additional drawdown due to block-caving is not anticipated; location would

Stream segment or watershed	Specific locations with monitoring conducted	DRAWDOWN (FT) UNDER NO ACTION ALTERNATIVE (200 YEARS AFTER START OF MINE)	ADDITIONAL DRAWDOWN (FT) CAUSED BY BLOCK-CAVE (200 YEARS AFTER START OF MINE)	POTENTIAL FOR GREATER DRAWDOWN BASED ON SENSITIVITY RUNS?	EXPECTED IMPACTS TO STORMFLOW FROM SURFACE DISTURBANCE IN UPSTREAM WATERSHED	SUMMARY OF EXPECTED IMPACTS TO GDE
						be monitored during operations for verification of potential impacts.
	Queen Seeps	Not applicable. Evidence indicates no groundwater connection.	N/A	N/A		
	Silverado Ridge Spring					
	SK18-02 Spring					
	SK18-03 Spring					
	SK18-04 Spring					
	Tunnel Spring					
	Walker Spring	10-30	10-30	NO	Not applicable. No upstream watershed disturbance.	<p>No Action – Drawdown is anticipated. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools.</p> <p>Proposed Action – Additional drawdown due to block-caving is anticipated, greater than the drawdown under the No Action alternative. Impacts could include a reduction or loss of spring/stream flow, increased mortality or reduction in extent or health of riparian vegetation, and reduction in the quality or quantity of aquatic habitat from loss of flowing water, adjacent vegetation, or standing pools. Location would be monitored during operations for verification of potential impacts.</p>
Devil's Canyon Basin (Springs)	Gibson Well Spring					
	The Grotto					
	Rancho Rio Spring					

Table Y. Summary of Potential Impacts to Groundwater Supplies

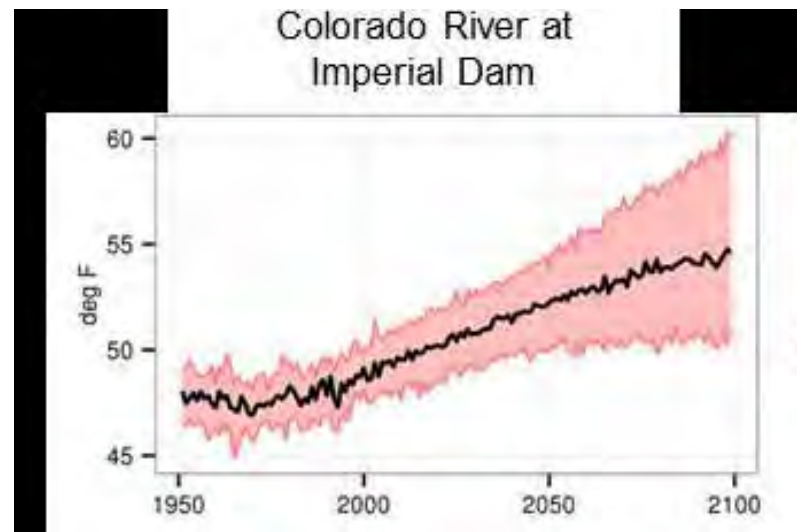
Water Supply Area	DRAWDOWN UNDER NO ACTION ALTERNATIVE (200 YEARS AFTER START OF MINE)	ADDITIONAL DRAWDOWN CAUSED BY BLOCK-CAVE (200 YEARS AFTER START OF MINE)	POTENTIAL FOR GREATER DRAWDOWN BASED ON SENSITIVITY RUNS?	SUMMARY OF EXPECTED IMPACTS TO GROUNDWATER SUPPLIES
DHRES-16_743 (Superior)	<10	10-30	NO	<p>No Action – Drawdown is not anticipated.</p> <p>Proposed Action – Additional drawdown due to block-caving is anticipated for water supply wells in this area, except for those completed solely in alluvium or shallow fracture systems. Impacts could include loss of well capacity, the need to deepen wells, the need to modify pump equipment, or increased pumping costs.</p>
Gallery Well (Boyce Thompson)	<10	<10	NO	<p>No Action – Drawdown is not anticipated.</p> <p>Proposed Action – Additional drawdown due to block-caving is not anticipated.</p>
HRES-06 (Top of the World)	<10	10-30	YES	<p>No Action – Drawdown is not anticipated.</p> <p>Proposed Action – Additional drawdown due to block-caving is anticipated for water supply wells in this area, except for those completed solely in alluvium or shallow fracture systems. Impacts could include loss of well capacity, the need to deepen wells, the need to modify pump equipment, or increased pumping costs.</p>

Climate Change and Groundwater Modeling

- Best Available Science – What are the Expected Effects of Climate Change?
 - Bureau of Reclamation, report to Congress. “SECURE Water Act Section 9503(c)— Reclamation Climate Change and Water 2016”

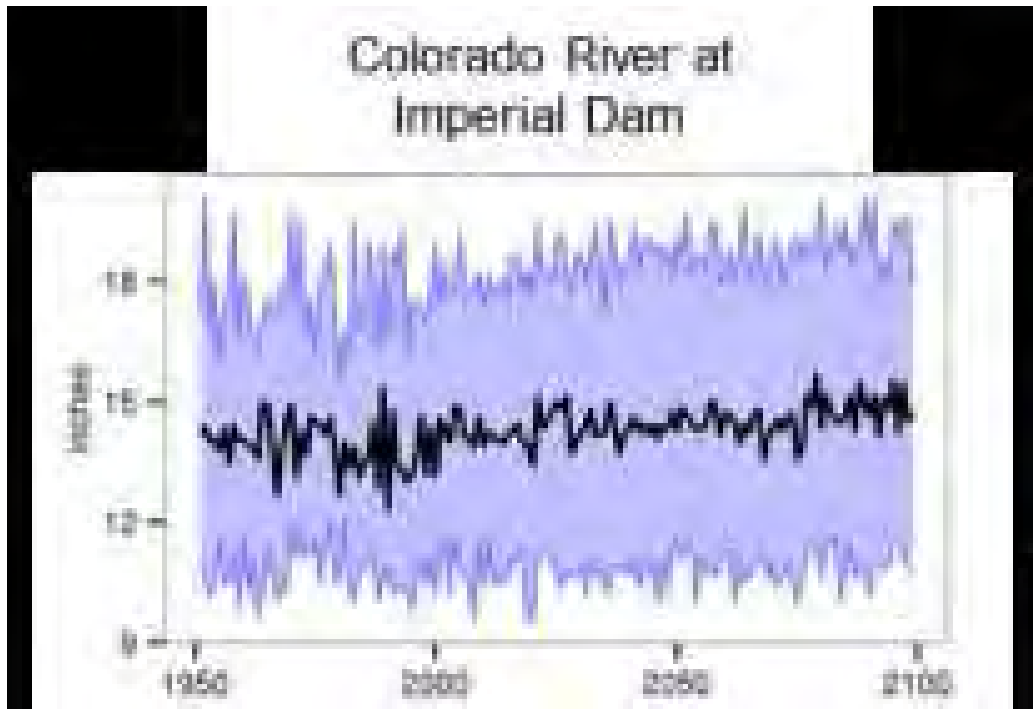
Temperatures

- “...temperatures are expected to increase in all basins by approximately 5–7 °F by the end of the century...”

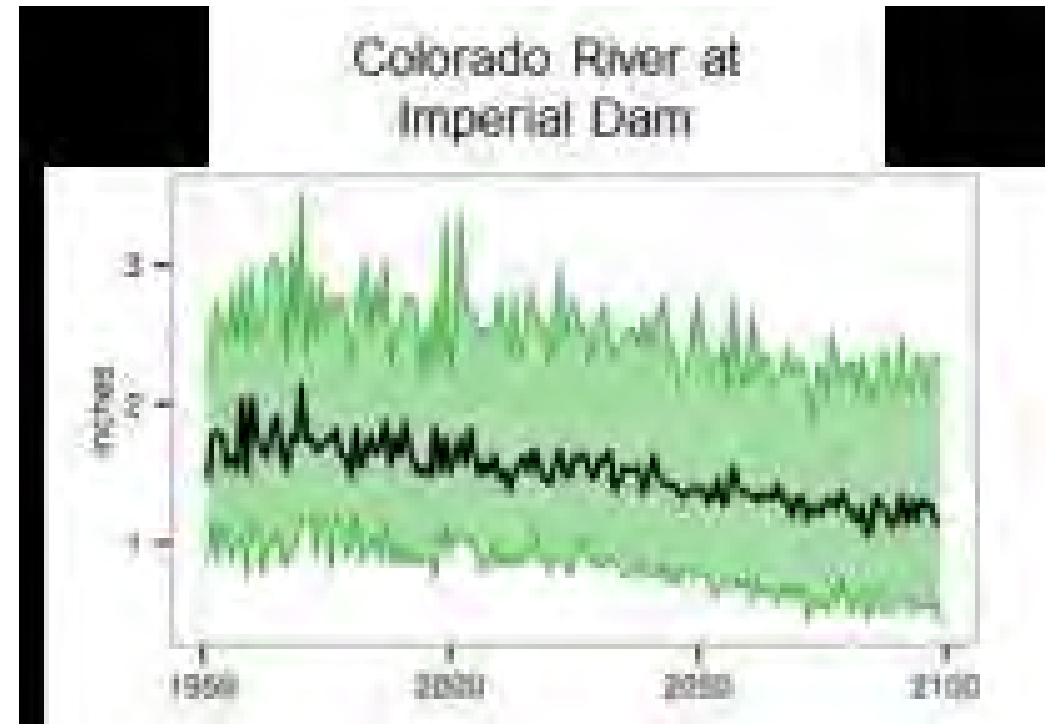


Precipitation

- “Overall precipitation is projected to remain variable with no discernable trends in most basins.”
- “In most areas, projections of future hydrology suggest that warming and associated loss of snowpack will persist over much of the Western U.S.”



Precipitation



Snowpack

Runoff

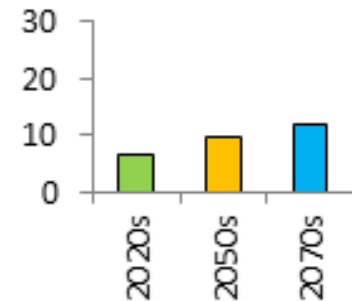
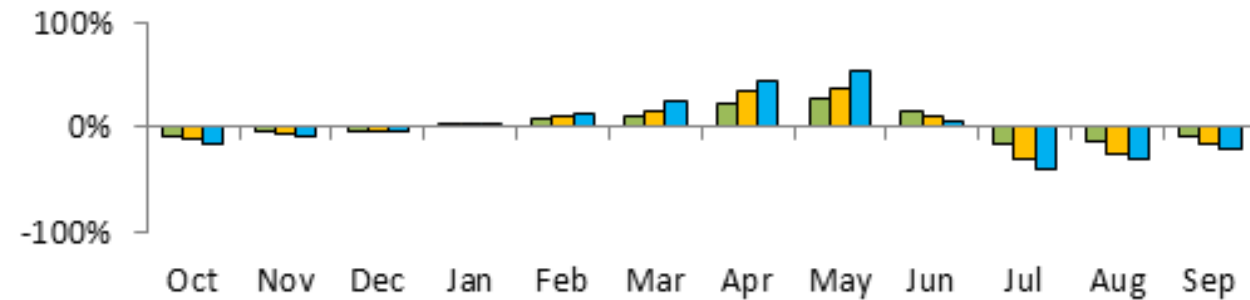
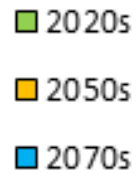
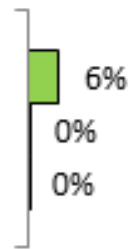
- “Colorado River Basin: Warmer conditions are projected to transition snowfall to rainfall, producing more December–March runoff and less April–July runoff. The median shift in the date of peak runoff is expected to be 12 days earlier by the end of the century.”

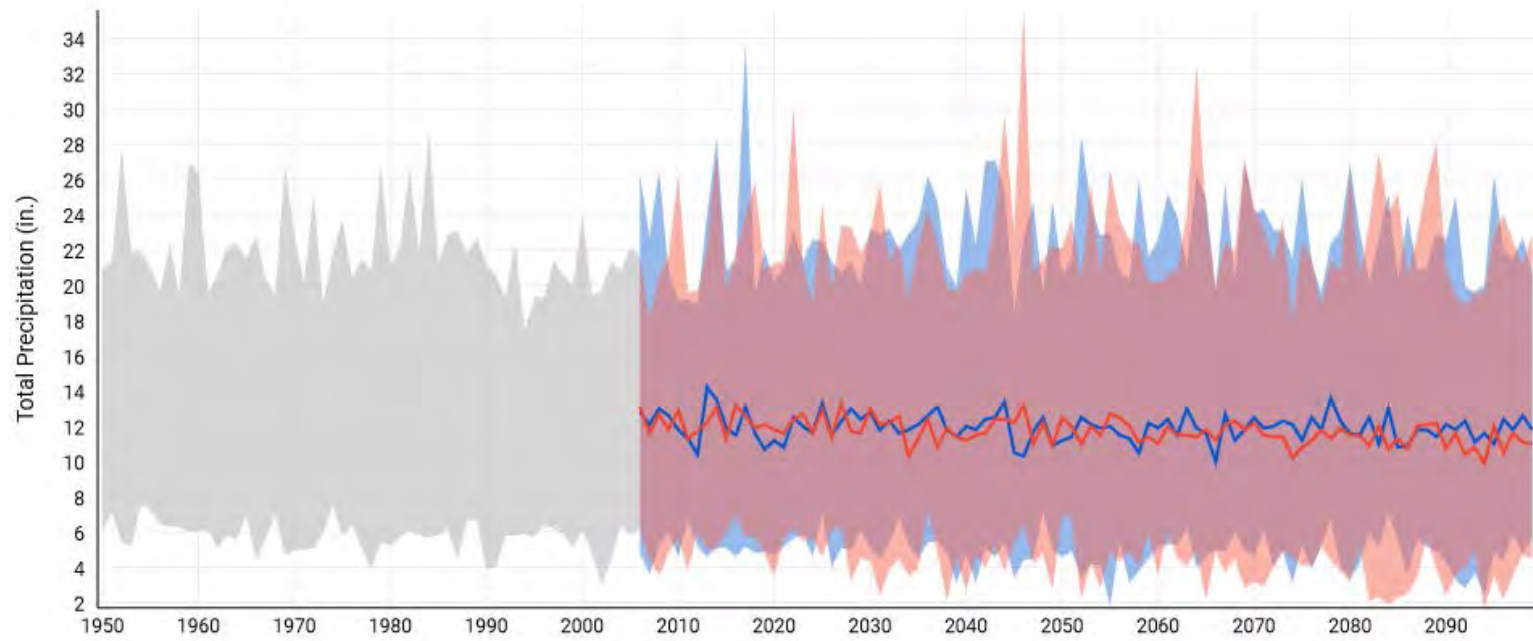
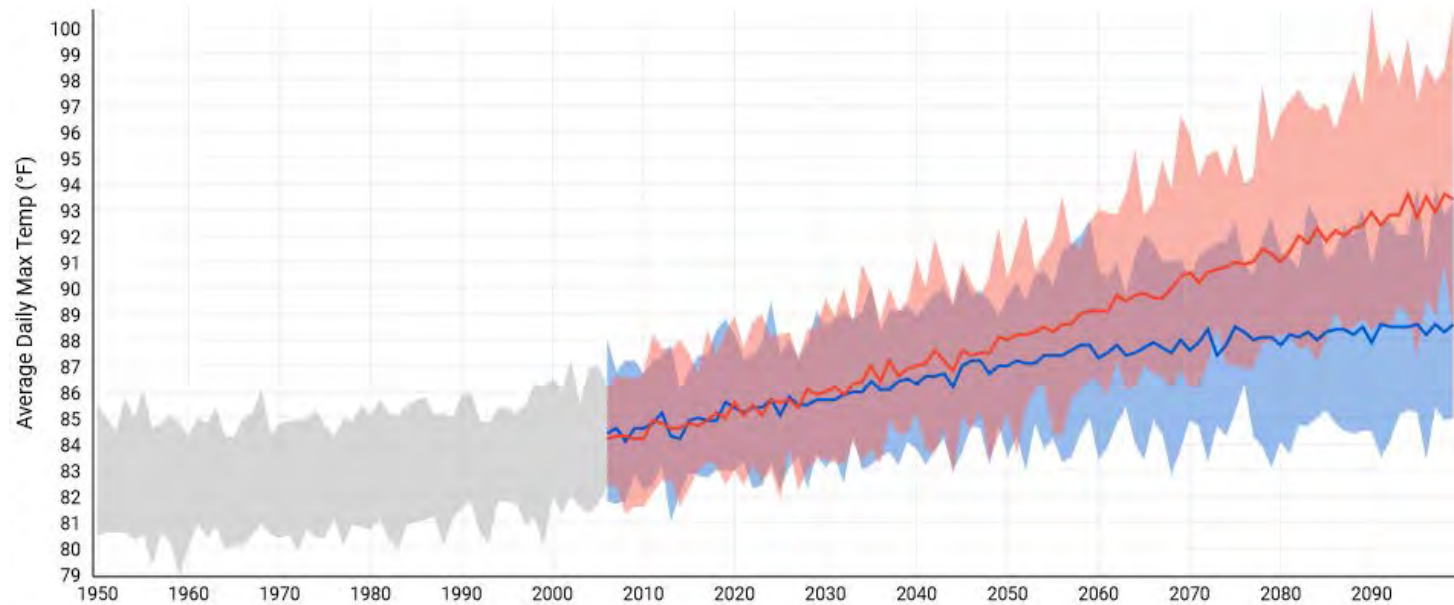
Change in Annual Runoff (%)

Change in Monthly Runoff (%)

Runoff Timing (days earlier)

Colorado River
above Imperial
Dam

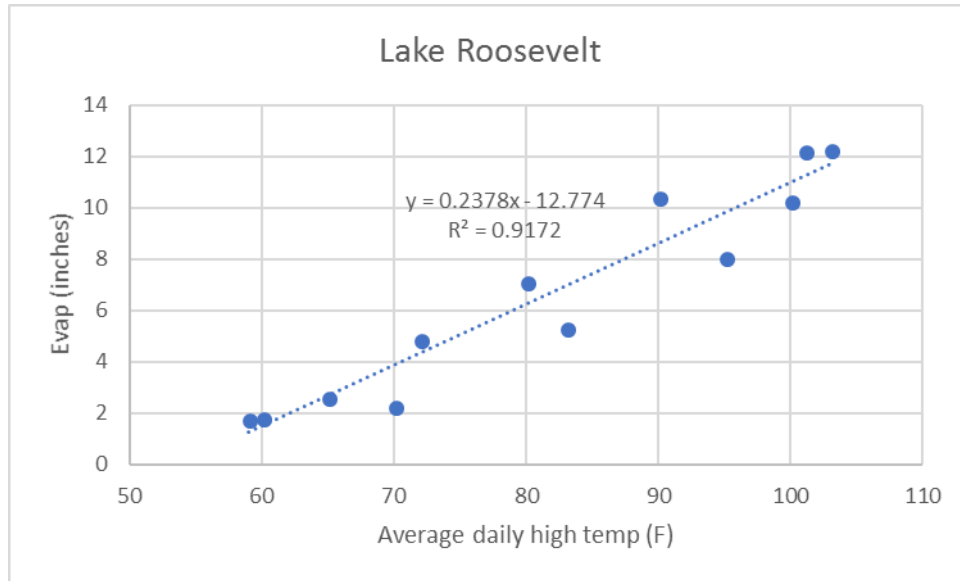




Translation of effects to groundwater model

- Higher temperatures = higher ET = less recharge
- Runoff changes = less snowpack, more winter runoff, less summer runoff. No major changes expected to recharge. If anything, suggests more recharge, not less, due to a shift to lower intensity winter flows.

How much more evaporation?



Lake Roosevelt

5-7 °F = +1.2 to 1.7 inches/month = +18% to 26% increase in evaporation

How much more transpiration by vegetation?

- Almost impossible to answer definitively
- Increased temps increase transpiration, but increased CO2 and increased humidity diminish the effect
- Some studies suggest a slight increase, some a slight decrease

Proposed Approach for Addressing Climate Change for Resolution DEIS

- Best available science indicates a possible reduction in recharge from increased ET, but no change in recharge due to precip/runoff changes.
- Quantification is difficult. We have a solid estimate of 18 to 26% increase in evaporation due to higher temps. Highly uncertain estimates of transpiration changes, but most likely remaining similar.
- WSP sensitivity runs conducted for a change in recharge +/- 50% (for Zones 4 and 6)
- Expected climate change effects likely fall in this sensitivity range. Therefore we are already assessing a scenario even more extreme than expected climate change.
- However, these results are not called out explicitly, but are lumped with all other sensitivity runs.