Lower Santa Cruz River Basin Study
Project Team Meeting #8
Notes
April 2, 2018
9:00 to 11:00 AM
Pima Association of Governments

Meeting Attendees

Name	Affiliated Organization
John McKinney	Farmers Investment Company (FICO)
Bob Hedden	Upper Santa Cruz Providers and Users' Group, Green Valley DWID
Kathy Chavez	Pima County Office of Sustainability and Conservation
Marie Light	Pima County Department of Environmental Quality
Wally Wilson	Metropolitan Water District
Kathy Jacobs	University of Arizona Center for Climate Science and Solutions
Peter Abraham	Oro Valley Water Utility
Mead Mier	Pima Association of Governments
Melanie Alvarez	Pima Association of Governments
Hsin-I Chang	University of Arizona Department of Hydrology and Atmospheric Sciences
Eve Halper	Reclamation Phoenix Area Office
Chris Castro (via phone)	University of Arizona Department of Hydrology and Atmospheric Sciences
Asia Philbin (via phone)	Town of Marana
Ken Seasholes (via phone)	Central Arizona Project
Julia Fonseca (via phone)	Pima County Office of Sustainability and Conservation
Sue Montgomery (via phone)	Pascua Yaqui Tribe
Jim DuBois (via phone)	Pima County Wastewater Department
Lindsay Bearup (via phone)	Reclamation Technical Service Center
Kip Volpe (via phone)	Vail Water Company

1. **Welcome and Introductions:** Eve Halper welcomed the Project Team. Those in attendance introduce themselves (*see above).*

   Approval of the January 19 Meeting Notes- approved without comment

2. **Study Progress, Review of Modeling Framework and Next Steps –** Eve Halper, Reclamation

   We are still in step 1 of the project timeline, projecting supply/demand imbalances, and at the same time building the modelling framework for the rest of the study. The key outcome is output from the TAMA groundwater model. A key input is climate projections, starting with emissions scenarios. The emissions scenarios provide input to the climate and surface hydrology models, producing projections of the future local climate for surface and groundwater model input. On the demand side, we are projecting socio-economic driving forces using the CAP Service Area Model (CAP:SAM).

For the climate modeling, projections are available for RCP 8.5 (worse) and RCP 4.5 (best) case. These emissions scenarios go into a global climate model and then get downscaled so they can be used as input to a basin scale surface hydrology model. The products of the downscaled climate models are time series' of precipitation and temperature through 2060.

Dr. Hsin-I Chang will be explaining the selection of climate models for the worse and best cases. Climate metrics of concern have been identified by our partners – from a longer list, five key metrics were selected:

1. Average monthly precipitation (winter vs summer);
2. Extreme precipitation by month:
3. Extreme temperatures by month;
4. Date of monsoon onset;
5. Date of last winter storm (the last two in combination allow calculation of the length of the dry season).

CAP Service Area Model (CAP:SAM) – CAP:SAM calculates demand by water provider under specific scenarios, but there is a subsequent step before this information can be used in the Study. Water providers need to specify which wells will be pumped under each CAP:SAM demand scenario to develop the pumping input files for the groundwater model.

The next steps on climate include: completion of the evaluation of climate models for best and worse cases; recommendations of which projections to use for best and worse case climates; then selection of the combinations of local climate and CAP:SAM demand scenarios for each groundwater model run. Ken Seasholes is just about ready to run the selected CAP:SAM demand scenarios for the water providers, who can then develop the groundwater model input files.

The time extension on the budget for this project has been submitted and signed by Reclamation's Lower Colorado Regional Director.

Question: What are the implications of failure to extend the project? **Answer** (Eve): The project extension takes us to September of 2020. It would end in February of 2019 if the extension didn't get approved. There is no information yet on the outcome of the budget increase request.

3. Evaluation of Climate Projections: Dr. Hsin-I Chang, University of Arizona, Department of Hydrology and Atmospheric Science

Hsin-I produces basin-scale climate projections through physics based process modeling. This process is also known as dynamic downscaling. Her research group starts with Global Climate Models (GCM) output: there are 2-3 dozen GCM simulation products to choose from: their pixel size is very coarse. They perform dynamical downscaling by using the GCM pixel as a frame, then running a regional climate model within that frame, down to 25 km resolution, through the end of 2100. This type of projection is rare, due to computing cost. The ultimate goal is to get the basin scale hydroclimate simulation to 12.5 km resolution.

Hsin-I and Chris Castro are part of a team that is coordinating dynamic downscaling of GCM's for North America, she shared a table that showed a collection of global climate products and the regional climate models that are used to dynamically downscale these products. NOAA produces collaborative data sets for many GCM's: the UK's HadGEM2, Max Planck, NCAR, GFDL, etc.

Hsin-I's group is working towards identifying the most appropriate climate projection products to use for the best case and worse case scenarios in our Study. They (and most other research groups), only use the RCP 8.5 emissions scenario (worse case) for the regional modelling (dynamic downscaling). The evaluation of the downscaled climate models is being performed using the metrics selected from partner input – including extreme events, monsoon onset (from 3 day average of dew point temperature) and pre-monsoon dry period. GCM's from the UK (HadGEM2) and Germany (Max Planck Institute, MPI) have a good representation of the monsoon for our region. Focusing on these model projections will give a better representation of our future climate in the basin.

Hsin-I's group is using the WRF regional model to dynamically downscale output from the GFDL, MPI and HadGEM2 GCMs. They are looking for historic simulations that match observed monsoon behavior. Comparing model performance to observations, these three (WRF-GFDL, WRF-MPI and WRF-HadGEM2) have the best summer precipitation increase out of seven available dynamically downscaled climate products. Also, they are not recommending averaging across multiple model outputs, rather, they are looking for models that can best simulate the historic observations.

In their evaluation of climate projections, they have looked at mean and extreme precipitation. These same three model products match mean precipitation observations reasonably well. They define "extreme" as the top 10% of average daily values over the historic period by month. For extreme summer temperatures trends, one model's (WRF-MPI) distribution shape is similar to observation, the other (WRF-HadGEM2) generated outcomes that are in contrast to observations. Both simulations are warmer than observations and will require bias correction. Extreme winter temperatures have a more consistent temperature pattern, but the WRF-HadGEM2 simulation generated categories in contrast to observation. For extreme summer precipitation events, the WRF-MPI simulation shows a similar shape distribution to observations. The other models are wetter. The shape of the curves match each other, but there is still a need for bias correction.

All products will require bias correction before they can be used in the modeling framework. In bias correction you adjust the mean, but not the frequency distribution, of the events. This corrected outcome will be fed into the weather generator.

In terms of historic monsoon onset, the average onset day is July 3, but in the WRF-MPI simulation this value is June 21; for WRF- HadGEM2 the monsoon onset date is June 19th. The models generally produced an earlier monsoon start date than what has been observed historically… so again bias correction is needed.

Question – These are just observations, and there is a need to perform bias correction to make sure that the model accurately predicts the monsoon onset date. If you don't go through this process, your future projections will not be as accurate, is that correct? In the technical team, is there already a path forward that seems most appropriate?

Answer - (Hsin-I): Their confidence is in WRF MPI simulation – but they want to verify that it is also a good match for the winter. They also need to compare the physics-based (dynamically downscaled) products with the statistically downscaled (LOCA) simulations that are being used for the best case (RCP 4.5) inputs. For the dynamically downscaled simulations, they have narrowed the model selection from 12 to 3. So far, using these metrics, the MPI looks best, HadGEM2 might be second best.

They are now waiting for concurrence from Reclamation about which climate products to use. At some point there will be a presentation by the Climate group back to the Project Team on the recommendation of climate models to use for the best and worse case climates. Should they use more than one, or is one significantly better than another? Dr. Eylon Shamir, another collaborator on this project, has conducted a similar analysis for another sub-basin and will advise on this project.

Chris Castro: If you were to ask at present which climate models he would recommend, he would suggest two models, WRF-MPI and WRF- HadGEM2…the reason is that they have the best models of seasonal precipitation. In addition, when these models are evaluated in the context of the 32 statistically downscaled (LOCA) GCM's from Reclamation, the output from the MPI and HadGEM2 models tends to be hotter and drier. For the purposes of this project, we do want to get at the higher risk futures, so using these two models for both emissions scenarios is logical even though one climate simulation is dynamical downscaled and the other one is statistically downscaled.

Lindsay Bearup: Looking at these models in the "LOCA space", there are more models to look to, all of this is working towards defining the best and worse cases. They are looking at the convergence of these two kinds of downscaling, these two models are doing the best job of meeting our needs. By way of introduction, LOCA is set statistically downscaled climate projections produced by Reclamation and other collaborators. Statistical downscaling relies on past observations. There is a potential limitation there, since historical patterns are likely to change in the future, but these simulations have a higher spatial resolution (6 km), and there are 32 different climate models available at both the RCP 4.5 and RCP 8.5 emissions scenarios. While the LOCA method is statistical, it also has some strengths…and is the best we have available that is internally consistent with CAP:SAM and the broader Colorado River Basin Study.

Chris Castro: In terms of selecting the appropriate climate models, the group is quickly coming to a point of convergence. When will they be ready to input the selected climate models into the weather generator? The two teams are interacting right now to determine what data they need to

drive the weather generator. This will happen within a month… They want to see the final statistics on the distribution, but about a month sounds right.

Mead Mier: It would be helpful to see how each of the models predict each one of these metrics… what about the dry period looking at the end of winter precipitation?.. Can we use one model for the monsoons and another for a different metric? Or is this a problem?

Hsin-I Chang: In terms of extreme frequency and intensity, they know which ones to go with. They are still working on the winter storm part… all models are a little early with monsoon… Some models do some things better than others, they are looking at the "change space" for each of the models to see how they match the different metrics. It might possible to use different models for different metrics because these projections are being fed into the weather generator.

Question: does this cause some kind of internal inconsistency in the analysis? **Answer** (Hsin-I): No it doesn't, because this is actually just an intermediate step in the climate modeling process.

The Project Team expressed confidence with the climate team selecting the appropriate models to use in developing climate projections for the best and worse case climates.

4. CAP-SAM Results, Ken Seasholes, Central Arizona Project

For supply and demand modelling, the intent is to take complicated phenomena and identify core variables that can be modeled. In defining CAP:SAM scenarios, we have selected the rate of growth, growth patterns, and levels of Colorado River shortages. The output from CAP:SAM gives an idea of the reliance on groundwater as a supply. The model can use the High, Medium or Low population series from Arizona Department of Administration. The current growth rate for the entire service area is on the low side, even the Low population series is likely on the upper side of what we will see, but it is good to look at a range of options.

The location of growth matters quite a bit – there are differences among the providers in terms of the character of the water use. Analysis is based on Transportation Analysis Zones (TAZs), since that is how population projections are done. CAP:SAM can perform analysis around land use choices, e.g. the impact of infill or sprawl on water demand. Demand factors are differentiated between new and existing demand, as well as conservation and climate effects.

The Colorado River shortage pattern is a critical factor – impacts of shortages to the CAP supply need to be modeled in the Study. A primary output of all of this work is the groundwater flow model. Due to the complexity of developing input files, a much smaller number of runs are possible on the groundwater model than for the CAP:SAM model alone. Ken has developed representative sequences of future reductions to the CAP supply, with and without considering climatic factors. Both sequences take into account build-out in the Upper Colorado Basin. Ken shared two potential shortage sequences, one that is representative of the historic climate, the other of a dry climate.

The first year of possible shortage has been updated to 2019. The chart on the left of the slide shows the periodicity and depth that could occur using the observed hydrology, even with the historic climate there is still more shortage in later decades due to gradual increase in Upper Colorado Basin development. On the right side of the slide what CAP shortages might look like under a dry climate – it has a greater depth of shortage… up to 2/3 of the supply is wiped out, and there are persistent levels of shortage. The specific timing is there to test the resilience of the system.

Groundwater dependence is assessed overlaying housing density within Transportation Analysis Zone projections on water provider boundaries and projected service territories. This is important because there are areas outside of the existing or anticipated water provider service areas where new housing is expected. A key assumption is which water provider will serve these newly developed areas, and what supply will be used to meet their demand.

In the lower risk case, we are proposing that existing providers expand their territory to adjacent areas to meet the demand. In the higher risk case, new developments would be entirely groundwater dependent. Even though the water providers serving these areas would have to replenish their pumping somewhere within the Tucson Active Management area, this would increase the stress on the aquifer where these supplies would be pumped from. This assumption has been an important point of discussion at the demand sub-team meetings. We are now closer to deciding which providers would serve which TAZs under the high and low risk scenarios.

The scenario matrix is a way to "mash up" the dimensions of the drivers of demand… for a low risk situation, we have matched slower growth with compact form; on the higher risk end of the spectrum, there is more rapid growth and more of this growth is groundwater dependent. It is riskier in terms of local water supplies being more highly stressed when there is direct reliance on groundwater.

Ken has run draft versions of the highest and lowest risk scenarios for individual water providers. For Tucson Water – with slow compact growth (infill), the CAP:SAM model output shows flat water demand because some new demand is offset by reduced usage rates. On this chart, light blue represents the CAP supply held by the city… only in the last two years of the projection do you see full utilization of the city's CAP sub-contract. For Marana, the pattern looks very different because their CAP allocation is not as large as their demand, especially in the higher growth scenario.

Question: What is the definition of replenished groundwater… is it paper water? **Answer** (Ken): The baseline assumption is that the CAGRD actually does the replenishment but we don't say where it will take place. Later in the study, we can look at where the credits that will allow replenishment come from and alternative approaches to meeting this demand. The starting place is a groundwater based assumption. All the CAP:SAM model output charts have the CAP shortages in them. In Marana's chart, the darker blue shows the use of their long term storage

credits due to shortages. Asia Philbin pointed out that Ken needs to modify Marana's chart because they will also be using effluent credits. Ken said that he would do this.

FICO has a different growth pattern as well as a different portfolio of supplies. The last chart Ken shared is for Lago del Oro, which serves the Saddlebrooke community. In the low risk scenario, their demand is very manageable, but in the higher risk scenario, water use accelerates in the last couple of decades.

Question: When will we see the impacts on the groundwater itself? Answer: not until the end of the modeling process. Mead Mier requested that the green label that says "Replenished Groundwater" on Ken's chart legend be made clearer, it should be called "Groundwater to be replenished," or "Legally required to be replenished." Ken agreed that this would more clearly communicate that this is water that the CAGRD would need to acquire in the future.

5. Supply - Demand Scenarios – Kathy Chavez

We are projecting water supply and demand using scenario planning because we want to look at a range of futures. We decided on the climate scenarios in November, 2016; best and worse case, base case…

Comment: Important to use worse rather than worst, and better rather than best? We don't want to mislead people…(this comment was due to a typo in the presentation, corrected in the version of the presentation on the website.)

The draft CAP:SAM scenarios include slow compact growth, slow outward, rapid outward, rapid growth plus mining without replenishment. The latter is the most risk, with pumping from the proposed Hudbay mine but assuming no replenishment by the mine. There was much discussion of whether the replenishment should be viewed as an adaptation or a base assumption. It was decided to table this discussion until the next meeting when there would be sufficient time to go into the details of plans for mine replenishment in the Green Valley area.

Now we are trying to figure out which demand scenarios should be matched with each of the climate scenarios, we can't test an infinite number of combinations. The same options presented at the last Project Team meeting were presented to the Stakeholder Advisors for input and today's presentation reflects their suggestions. In the proposed scenario chart, the four x's on the top would allow a comparison of growth affects groundwater without climate considerations. The chart also proposed running a slow compact growth scenario with the worse and best case climate (green column).

There was a lot of discussion at the Stakeholder Advisor meeting about whether to keep the "Baseline Growth" because it can be considered the "No Action Alternative", representing the official state projections. "Baseline Growth" is really medium growth, so the Stakeholder Advisors recommended that it be moved from the left side to the middle of the chart, between

slow and rapid growth. Rapid outward growth is almost the same as Rapid outward growth without mine replenishment, the replenishment could be considered an adaptation measure.

Summary of recommendations from the stakeholder advisor meeting: eliminate the rapid outward growth "with replenishment of mining" option. Can always add back in this pumpage as an adaptation later. Baseline growth scenario should be renamed Official Projections, Relocate official projections to middle column, add a scenario combining official growth projections with worse case climate future. Eliminate slow outward growth scenario. This leaves: A – official projections, B – slow compact growth and best case climate; C – rapid growth and best climate; D – slow, compact growth and worse case climate, E – Medium growth and worse climate, and F Rapid outward (highest risk).

There was continued discussion of exactly how much replenishment is likely to take place in Green Valley by Hudbay. HudBay hasn't purchased all of the CAP water that they need yet, our modeling could start with what they have already purchased as the baseline assumption. However, all their projections are based on a 15 year mine life and now it is likely that it will go longer. With 7,000 acre-feet a year of demand… perhaps a better baseline scenario would be the differential between what they have bought and what they need.

In each of the scenarios, we are stressing the level of groundwater dependence. It is important to remember the purpose of the study is to identify where infrastructure is needed. The scenarios should include varying levels or risk.

Question: Does CAP:SAM consider the permitted capacity of underground storage facilities?
Answer (Ken): In CAP:SAM the permitted capacity is extended according to current plans.

The Project Team agreed that additional discussion is needed to understand replenishment in Green Valley.

6. Outreach & Communications Update – Marie Light

The March 12th Public Meeting was well attended. Attendees were interested in safety and health, the impact of water conservations and adaptation strategies. Input provided on comment cards is being summarized. Notes of the meeting are being finalized.

7. Basin Study Sub-Team Updates

a. Demand Sub Team – Wally Wilson

The Demand Sub Team met in February to discuss CAP:SAM as described earlier. The format and data to be included in projected pumpage files for each provider was agreed upon. This data will be used in the groundwater model. Wally has provided an example to the water providers and will be reaching out to them.

b. Environmental Sub Team – Mead Mier

The Environmental Sub Team has been meeting regularly to review recent studies on riparian areas, how the modeling framework will be used to assess impacts to riparian areas and how adaptation strategies for the environmental component of the study will be developed.

8. Next Meeting Date

The next meeting will be held on May 8 at 9:30 am at the PAG Conference Room. It will focus on scenario selection and Green Valley replenishment.