Lower Santa Cruz River Basin Study
All Teams Webinar
NOTES
December 4, 2018, 10:30 am to 12:30 pm

1. Welcome & Introductions

Peter Abraham, Town of Oro Valley	Bob Hedden, Upper Santa Cruz/Providers and Users' Group
Lindsay Bearup, Reclamation	Kathy Jacobs, University of Arizona /CCASS
Gita Bodner, The Nature Conservancy	Bailey Kennett, Arizons Land & Water Trust
Evan Canfield, Pima County Regional Flood Control District	John McKinney, Farmers Investment Company
Austin Carey, Central Arizona Project	Christina McVie, Community Water Coalition
Chris Castro, University of Arizona	Jeff Odefey, American Rivers
Hsin-I Chang, University of Arizona	Asia Philbin, Town of Marana
Kathy Chavez, Pima County	Greg Saxe, Pima County Pima County Regional Flood Control District
Luke Cole, Sonoran Institute	Ken Seasholes, Central Arizona Project
Lee Comrie, Pima Assoc. of Governments	Jeff Tannler, Arizona Department of Water Resources
Jim DuBois, Pima County Regional Wastewater Reclamation Department	Amanda Smith, Sonoran Institute
Catherine Evilsizor, Citizen	Valerie Swick, Reclamation
Doug Greenland, Cortaro-Marana Irrig. District	Selso Villegas, Tohono O'odham Nation
Neha Gupta, University of Arizona	Kip Volpe, Vail Water Company
Julia Fonseca, Pima County Office of Sustainability and Conservation	Wally Wilson, Metro Water
Eve Halper, Reclamation	Claire Zugmeyer, Sonoran Institute

2. Climate Time Series Projections for Input to the Weather Generator – Eve Halper and Lindsay Bearup

Eve Halper, Reclamation Phoenix Area Office, provided background on the LSCR Basin Study's decision process regarding climate projections and supply-demand scenarios. The Basin Study is benefitting from the University of Arizona's dynamically downscaled climate projections.

- Water supply and demand is driven by climate and socioeconomic forces (pumping, recharge, growth, etc.)

- Global climate models (GCMs) generate projections of temperature, precipitation and other variables. A key input to a Global Climate Models is an assumption about the level of greenhouse gasses that will be emitted worldwide in the future. The Intergovernmental Panel on Climate Change (IPCC) has developed standardized emissions scenarios for Global Climate Models called Representative Concentration Pathways. Climate projections are available for two emissions scenarios, described below.

  - RCP 4.5 – in this scenario, there is active reduction in the rate of carbon emissions, resulting in a stabilization in carbon dioxide concentrations towards the end of the century. Within the Basin Study, it represents a "best case", or "lower risk" scenario.

  - RCP 8.5 – in this scenario, the greenhouse gas emissions increase considerably over time. This is sometimes referred to as "a business as usual" scenario (the trajectory we are currently on). It represents a "worse-case", "higher risk" scenario. We deliberately use the term "worse case" to denote a high-risk future, but one that can still be adapted to. We recognize that it does not represent the "worst" case.

- Outputs from global climate models are too coarse for basin-scale hydrologic modeling, so they are *downscaled* to increase spatial resolution. The downscaled climate projections can then provide input into a surface hydrology model.

- Two main types of downscaling:
  - Statistical (SD) - develops relationships between outputs of GCMs and observed variables, and assumes these relationships remain constant through time. Widely used, easy to do, inexpensive, for many GCMs statistical downscaling is the only type of downscaling available. Disadvantages: the assumption that these statistical relationships remain constant through time may not be realistic; this approach does not explicitly model many atmospheric processes important to the Southwest U.S. climate.

  - Dynamical (DD) - Uses a global climate model as input to a regional climate model, explicitly models the physical processes that take place in the atmosphere at a medium scale, including convective storms and monsoonal rainfall. Also, does not assume a constant relationship of climatic variables in the future. Therefore, DD can forecast a wider range of outcomes than the historical record. Colleagues at UA have developed DD projections for models that perform well in the Southwest U.S. Disadvantage: expensive and time consuming to do this kind of modelling and thus not available for all GCMs.

- Reasons for including DD: can physically reproduce seasonal precipitation patterns, and there is local interest in dynamics of monsoonal rainfall.

- There was discussion regarding Slide 7. There was a question about why the best case requires minimal adaptation. It is confusing, especially as it relates to the "worse case" scenario, which also requires adaptation. It was agreed that a better definition or explanation of "best case" is needed.

  Upon further discussion, it was concluded that this slide erroneously suggested that the "Best Case" emissions scenario implied a future with minimal adaption and the "Worse Case" implied a serious, but still adaptable future. The slide was revised to note this error.

- The climate scenarios focus on risk: base case (no climate change), best case (RCP 4.5, SD), worse case (RCP 8.5, DD). Dynamically downscaled projections are not available for the RCP 4.5 emissions scenario, only the RCP 8.5 scenario.

- In previous meetings, study partners expressed interest in understanding projected changes in specific climate metrics:
  - Extreme temperature and precipitation events (frequency and intensity)
  - Monsoon onset timing
  - Timing of pre-monsoon dry period

Lindsay Bearup, Reclamation Technical Services Center (TSC), explained how the groundwater modeling will incorporate input from the climate models and the socio-economic model (CAP:SAM)

- Downscaling captures finer scale variability (e.g. in California, if we do not downscale, we miss the Sierras)

- We are downscaling the LSCR Basin Study area because it is relevant to local surface water modeling and local decision making

- After downscaling, will use a *weather generator* (WG) to get temperature and rainfall inputs for surface water model.

- The weather generator reproduces the range of variability (based on climate projections) around daily patterns/seasonality that will drive range of streamflows

- The WG ingests "training data" from historical weather patterns. These patterns are categorized within the climate states/seasons
    - The calibration dataset will then get modified by future climate scenarios
    - State: any grouping of weather (e.g. seasons; wet vs. dry days)

- Using the assumptions about either the "best case" or "worse case" climate, the WG outputs large numbers, or ensembles, of future precipitation and temperature time series. These ensembles provide inputs to the SAC-SMA surface water model. The product is a probability distribution of streamflows.

- Model selection for future projections:
    - RCP 8.5 + DD: WRF MPI for "*worse*" case scenario
        - The WRF MPI model was chosen by UofA because it simulates monsoon timing well, which is important in this region
        - The WRF (Weather Research and Forecasting) regional climate model provides dynamic downscaling of MPI global climate model
        - U of A and Reclamation researchers evaluated other DD models, did not meet study needs.
        - Additional details below
    - RCP 4.5 + SD:LOCA – MPI for "*best*" case scenario
        - SD: MPI was chosen to match choice of WRF MPI for DD
        - LOCA: standardized method of statistical downscaling, has been through rigorous quality control
        - Additional details below

- Worse case (WRF MPI RCP 8.5) – Dynamically Downscaled Projection
    - Preferred by U of A for analysis because it captures monsoon dynamics in the study area well (simulated monsoon timing in study area)
    - Other DD models were inconsistent in projected changes, or required additional data screening.

- Best case (LOCA-MPI RCP 4.5) - SD
    - Using physically consistent data source and underlying global climate model to worse case model (WRF-MPI RCP 8.5)
        - MPI climate model was determined to perform well for DD scenarios
        - Based on all the plots of precipitation and temperature it is still somewhat conservative and not the most optimistic scenario

- Future climate periods
  - Historical: 1970-1999, consistent with the SAC-SMA calibration period
  - Near Future (“2030s”): 2020-2049
  - Far Future (“2060s”): 2050 - 2079
    - Aligns with CO River Basin Study analysis through 2060
    - 2060”s is period where emissions scenarios diverge

- Hybrid Delta Ensemble method was used to model changes in magnitude of future climate
  - Based on monthly changes of precipitation and temperature from climate models, at every quantile (percentage of data)
  - Change in cumulative probability distribution (at each quantile) used to “perturb” data
    - Illustrated on graph
    - Looking at change at every quantile: can adjust “low” rainfall events and “high” rainfall events separately, allows to better capture changes in extreme events
  - Uses modeled historical data, to offset any bias inherent in model. For example, any bias present in the modeled historical data will also be present in the projected data. When the difference between the two is calculated, the effect of systematic model bias is reduced.

- Climate metrics (chosen by the LSCRBS participants)
  - Extreme events: intensity (accounted for in HDE) and frequency (accounted in weather generator wet/dry day sampling) of temperature and precipitation
  - Timing: Monsoon onset was defined as the first 3 consecutive days with temperature dew point above threshold
  - Timing: Dry period was defined as the last day of winter storm to first day of spring, basin averaged rainfall less than 0.1 inches over 2 weeks
  - Temperature and precipitation results are available for twelve months, but for simplicity, results were shown for a dry month (May), wet winter month (December) and monsoon month (August)

- Results
  - Dry Month (May):
    - LOCA-MPI RCP 4.5: Rainfall events are few and small, so changes are small. Temperature consistently increases
    - WRF - MPI RCP 8.5: Rainfall events are few and small, so changes are small. Temperature consistently increases
    - Looking at 95th percentile as extreme, things change a little more for larger events.
    - Overall: not much precipitation since it is the dry season

  - Monsoon Month (August)
    - LOCA-MPI RCP 4.5: Reductions in precipitation in far future, near future does not see much change in rainfall. Consistent increasing trend in temperature over time.
    - WRF - MPI RCP 8.5: Larger decreases in large rainfall events. 95th percentile storms decreasing over 0.1’’ per day. Some of the more extreme events are increasing. Consistent increasing trend in temperature over time, more extreme changes in temperature than changes in RCP 4.5 (“hot gets hotter”)

  - Wet Winter month (December) -- Hard to choose one month for winter. LOCA saw an increase in extreme events in October

        - LOCA-MPI RCP 4.5: Rainfall changes are inconsistent, for larger events. Temperature consistently increases, but the changes are smaller. Temperature changes could alter snowpack.
        - WRF - MPI RCP 8.5: Increases in extreme precipitation, but temperature changes limited after the "near period"

- Next steps:
    - Prepare climate scenarios as weather generator inputs
    - Run Weather generator
    - Run SAC-SMA Surface water model
    - Run Groundwater model

- Questions:

  Evan Canfield: Does the increased precipitation in fall reflect an increase in tropical storms? Chris Castro responded that the changes are not likely representative of tropical cyclones in the southwest US, as the DD model at this scale cannot resolve tropical cyclone features. The extreme winter events are more likely to be the result of mid-lateral atmospheric rivers, which are more extreme in intensity in the projections.

  Julia Fonseca: The start of dry season does not seem conceivable. Lindsay Bearup replied that this threshold is being refined. There is no definitive metric for start of dry period. They will address the "drizzle" effect in models that can influence dry season onset with use of weather generator.

  Kathy Jacobs commended Reclamation for their collaborative work with the UA and the clarity of Lindsay's presentation given how complex the processes and data are. Both Reclamation and UA have done a good job. Chris Castro recognized collaboration with Reclamation in developing new and different methodologies to assess climate, these are significant contributions to future studies.

3. **Overview of Adaptation Objectives – Kathy Jacobs, CCASS/UA** reviewed the overall basin study process. Outcomes of the modeling will include changes in water supply and demand throughout the basin, but what do those changes mean and to whom? How will we select adaptation strategies to test, how will we assess them and how will we conduct the required trade-off analysis? Key considerations are:

    - Evaluating the implications of imbalances: what are the risks to what and whom? We will need an initial screening to describe options to be evaluated, since we can't evaluate an unlimited number.

    - Some questions to consider:
        - Must adaptation strategies have minimal support among the project partners to be analyzed? How do we select the strategies to analyze, given cost and time constraints and the multiple perspectives of project partners?
        - How can we perform a trade-off analysis without ranking projects? Challenge is collective decision-making, especially since this project is not intended to lead to specific recommendations about which projects should be implemented.
        - Should each sub-team discuss adaptation strategies, or should it be an overall Project team discussion?
        - The Environmental Sub-Team has been discussing strategy objectives; their approach could be shared with other sub-teams for discussion.

- Suggestions for next steps:
  Wally Wilson: Next steps may require a level of subjectivity. It will help to look at water accounting areas individually. In each case, we have two major choices for dealing with imbalances, reduce demand or import water? And, how can we achieve that? When we have water level changes, we focus on areas of declining groundwater, geospatially. We should concentrate on areas that need help (areas where imbalances occur). A map of Water Accounting Areas exists (see Figure 1). There is agreement that we want to start with that map. Then we will need a map showing water levels for the near future and another map for the far future using a "color flood" – areas of groundwater decline color-coded. It should have contour lines showing area where groundwater is 1,000 feet below land surface because it has assured water supply implications. The Environmental Sub-team should consider contour lines at a groundwater level needed to support large trees. Kathy Jacobs noted the Environmental Sub-team has done some work on thinking about thresholds like this.

  Julia Fonseca liked the idea of using water accounting areas for the analysis but does not solely want to look at groundwater levels. Changes in recharge and changes in surface water are also important for riparian areas. Kathy Jacobs added the intensity of storms and managing floods needs to be considered, not just groundwater overdraft. Evan Canfield added that he is looking for priority areas to maintain floodplain function and watershed function as part of Pima County's Santa Cruz River Management Plan and hopes this study will be useful in that regard.

  Greg Saxe: We need to encourage natural infiltration and identify areas where we can enhance artificial recharge. Lindsey Bearup then explained changes in streamflow can be identified through this process, but not changes in floodplain explicitly. Chris McVie asked if we will evaluate impacts to upstream tributaries, in addition to main-stem streams. Lindsay replied that upstream tributaries can be evaluated.

  Kathy Jacobs observed that we should develop the approach to identifying adaptation options and evaluating them collectively.

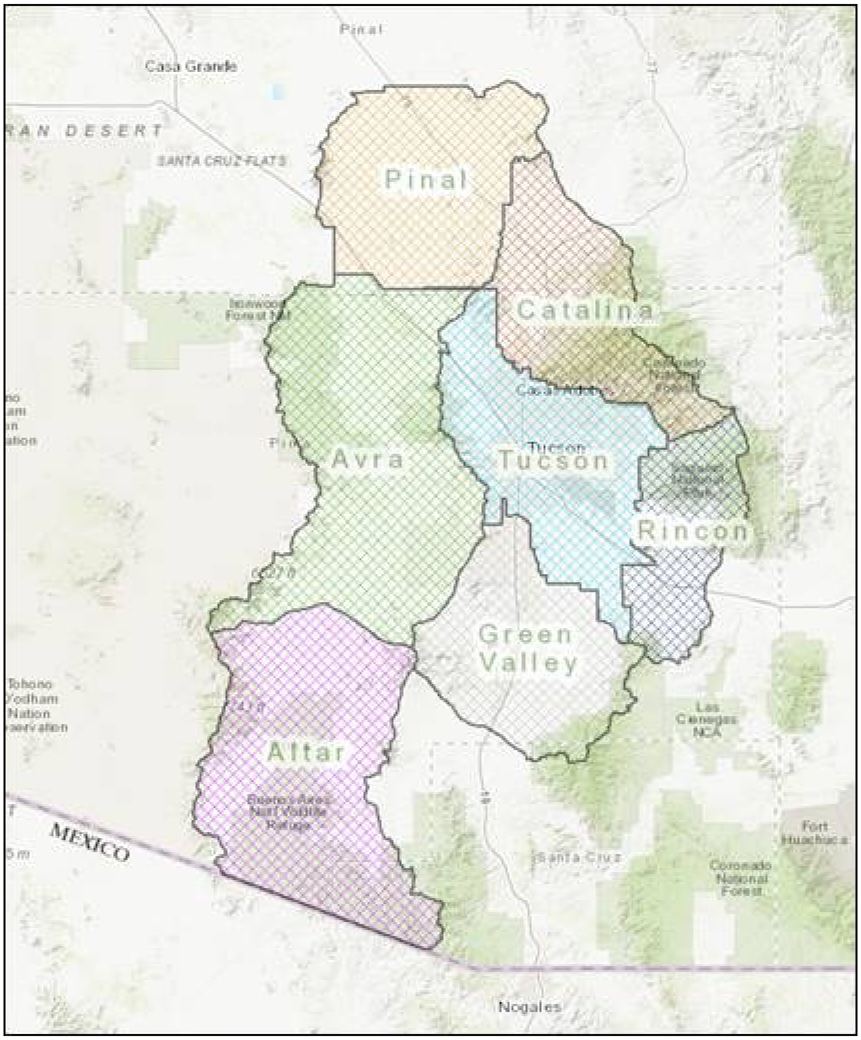

Figure 1 - Tucson Active Management Area Water Accounting Areas

4. **GIS Map Preview – Eve Halper, Reclamation –** deferred to future meeting.

5. **Basin Study Updates – Kathy Chavez, Pima County, on behalf of Eve Halper**
   a. Supply/Demand Assessment: Project Team has recommended six supply/demand scenarios that will be evaluated in the groundwater model. They include four variables: climate, population growth, density and CAP shortage futures. The CAP Service Area Model output has been completed and the Demand Sub-team is preparing a spreadsheet of current and future groundwater pumping locations (in consultation with the water providers) for use in the groundwater model.

   b. Outreach: A Stakeholder Advisors meeting was held in February and a Second Public meeting was held in March 2018. The meeting covered the modeling framework, supply/demand scenarios, climate scenarios and the CAP:SAM model.

   c. Adaptation Strategies: The Environmental Sub-Team has been developing objectives for adaptation for riparian impacts resulting from supply/demand and climate imbalances. These criteria will be considered in the risk analysis phase of the study.

d. Project Management: Reclamation approved a time extension and budget increase in August. The study timeline was extended to September 2020 and the budget increased to $1.4 million. The local cost share is $718,000 and the Federal share is $717,750. Reclamation is finalizing the memorandum of agreement for time extension and budget increase.

6. **Next Steps** – Kathy Chavez, Pima County concluded the meeting saying the Basin Study Co-managers will prepare a summary of the webinar and discuss the best ways to move forward. The meeting was adjourned.