Lower Santa Cruz River Basin Study
Adaptation Workshop One

November 21, 2019 | Pima Association of Governments, Tucson AZ

Workshop Summary

Table of Contents

Study Description

The goal of the Lower Santa Cruz River Basin Study is to identify where physical water resources are needed to mitigate supply-demand imbalances due to climate change and other factors and develop strategies to improve water reliability for municipal, industrial, agricultural, cultural and environment sectors in the Lower Santa Cruz River Basin.

Water supply-demand projections were developed for six scenarios using three growth scenarios and two climate scenarios. The study plan calls for running the Arizona Department of Water Resources' groundwater model to evaluate the effects of these scenarios on groundwater levels, the development of reliability metrics to address infrastructure vulnerabilities and the formulation of adaptation strategies to address water supply vulnerabilities and preserve groundwater dependent ecosystems.

The purpose of Workshop One was to begin brainstorming a wide variety of adaptation strategies using existing knowledge, obtain stakeholder feedback on screening criteria and prepare to apply strategies to forthcoming groundwater model results. Strategies were based on areas known to be vulnerable to declining groundwater levels. An additional workshop will be held to refine these strategies consistent with results of the groundwater evaluation. Selected strategies will undergo a trade-off analysis to provide an objective and transparent evaluation and comparison. The resulting analysis will be a range of strategies that can be considered to adapt to future conditions.

Participants invited to the workshop were representatives of the Basin Study local cost share partners, subject experts who contributed to technical sub-teams and stakeholder advisors who expressed interest in study participation.

Setting the Stage: Mini-Presentations

Overview of the Lower Santa Cruz River Basin Study, - *Eve Halper*, Reclamation
See presentation here: Lower Santa Cruz River Basin Study Website

- While the Tucson Active Management (TAMA) has an overall abundance of renewable water supplies, there are supply-demand imbalances within the TAMA
- The improvement in the Tucson area's groundwater levels is apparent by comparing two maps developed by Tucson Water. The first shows the groundwater declines between 1940 and 1998, while the second shows how water levels have improved with the recharge of Central Arizona Project water.
- The Lower Santa Cruz River Basin Study is a partnership between the Bureau of Reclamation and state and local partners to identify where physical water resources are needed to mitigate supply-demand imbalances and to develop strategies to improve water reliability for the municipal, industrial and environmental sectors
- This workshop addresses the third element of the Basin Study, the development of adaptation strategies. Although we are not completely finished with the projection of future supply and demand imbalances, we want to identify strategies ahead of time using existing knowledge.
- The study is using a "risk-management framework". Climate change is one of many risks to a reliable water supply in the Tucson area. This study has developed state-of-the-art information on the range of climate impacts to the basin. What can be done to address these anticipated risks?
- Our first objective today is to start the brainstorming process using available information and prepare to look more closely at these strategies when the groundwater results are available.
- The workshop will examine water use in the Tucson area from geographic and sectoral perspectives
- Adaptation strategies can be large or small, address single or multiple risks, structural or non-structural, etc.
- A second objective is to identify criteria for screening which strategies will be examined in more depth. The number of strategies to be investigated depends on the type and number selected.

History of Aquifer Change (video) - *Beth Scully, Tucson Water*
See video here: Lower Santa Cruz River Basin Study Website
This Tucson Water video shows the history of decline in certain areas, and subsequent recovery of the aquifer following the introduction of Colorado River water from the Central Arizona Project (CAP).

Overview of risk-based framing and metrics – *Kathy Jacobs, University of Arizona*
See presentation here: Lower Santa Cruz River Basin Study Website

- Adaptation is iterative risk management; we need to be prepared for things to change over time and evaluate our goals and capacity to meet them on an ongoing basis.
- The process starts with defining what you are trying to achieve, how the climate is changing, and actions that will get you closer to your goal or mitigate adverse impacts. Then you can evaluate to see if you're making progress towards your goal.
- Surprises will happen since climate change affects multiple systems simultaneously.
    - Electric grid, ecosystem, transportation, etc., potential for cascading effects

    - Small, subtle changes and their intersections can add up to something important
- As managers of risk, we need to be prepared for the "worst or worse case conditions" that can be dramatic and/or problematic.
- Need to think about range of futures via scenarios, in our case we are using the highest and the next to lowest greenhouse gas emission scenario from the Intergovernmental Panel on Climate Change (IPCC).
    - There is no intrinsic reason a "mid-range" scenario is more likely than a higher/lower one. A risk-based approach does not involve using a median approach
    - Lower scenario establishes a "minimum requirement" for adaptation
- Adapting to climate change involves acting to reduce vulnerability, enhance preparedness, and overall responsible risk management and common-sense planning to protect health/safety/prosperity.
- There are still issues that need to be addressed: unmet infrastructure needs, environmental resources are still at risk, capacity to solve problems is different in different parts of the basin.
    - There is no guarantee that we will have existing riparian habitat/biodiversity into the future given climate impacts
- Simplified climate impacts: we know things will be hotter, streamflow is likely to be reduced, it will be drier on average, evapotranspiration will generally increase, imported CAP supply is at risk, and there will be serious implications for ecosystems/human health/historically disadvantaged populations.
- Can link objectives/desired conditions to climate impacts and climate metrics to evaluate risks to objectives/desired conditions.

Climate and Surface Water Analyses Summary – *Lindsay Bearup, Bureau of Reclamation*
See presentation here: Lower Santa Cruz River Basin Study Website

- Overview of emission scenarios Representative Concentration Pathway (RCP) RCP4.5 (best case) and RCP8.5 (worse case)
- We are essentially already within the "2030s" projected future; also preparing a set of projections for "2060s" time frame
- We see an increase in precipitation variability and temperature across scenarios
    - Magnitude of change varies across scenario (best = minimal change, worse = drier, hotter)
- The worse-case scenario is consistently hotter and drier than the best-case scenario
- Increase in "no flow" days with regards to streamflow – more per month in worse-case scenario
- Soil moisture decreases across the board in months before monsoon season (April) but evapotranspiration (ET) also decreases due to soil moisture limitation (if there is not enough moisture in the soil then higher temperatures do not increase ET as much)

Questions and comments:

- Are the projections used by CAP consistent with predictions made by Udall and Overpeck in their 2017 paper? How do these projections stack up against the Udall/Overpeck predictions for the Colorado Basin?
    - This work was done on the Santa Cruz, rather than the entire Colorado River Basin – we used the best available data and downscaling method that we could, and it is consistent with Reclamation's Colorado River Basin Study
    - CAP is using Reclamation's modelling of the Colorado River warming impacts, and their CAP-SAM model takes those inflows and projects deliveries to its customers.

Overview of Historic Areas of Concern – *Wally Wilson, Metro Water*

- The two Tucson Water maps from the introductory presentation were displayed again Tucson area groundwater level changes from: 1940-1998 and from 2000-2016, emphasizing the point that long-term planning was necessary to achieve the level of sustainability the Tucson area enjoys today.
- The hydrogeologic setting can make the locations of groundwater declines hard to predict. This is also true for responses to recharge.
- Green Valley's challenge is not limited aquifer capacity but a combination of industrial, municipal, and agricultural water use
    - Hydrogeologically, that aquifer can take and give water easily.
- When Tucson Water did its second long-range plan in 2004, they had the goal of stabilizing water levels in existing well fields using Avra Valley as "the bank" in which to store water.
- Multiple model runs with changing pumping in well fields zeroed in on a couple of conclusions:
    - The southeast Tucson area:
        - does not have groundwater underflow like the west part of the valley
        - does not have significant mountain front recharge
        - does not respond well to any level of groundwater pumping – we will see water level declines if there is additional pumping in area
        - is "just storage" – old groundwater that is not receiving mountain front recharge
    - The Canyon Del Oro (CDO) "lobe":
        - is dependent on mountain front recharge/snowpack/runoff out of the Catalinas
        - comprises a set of hydrogeological pockets that need to get filled
        - changes from year to year based on high/low winter precipitation
    - The entire Avra Valley area is essentially rising
        - large amounts of CAP recharge
        - the narrowest part of the aquifer is backing water up to the south
- Potential future areas of concern:
    - Northwest, Northeast (Oro Valley) and Green Valley areas
    - There is not much planned for the southeast area yet; this could be a good place for adaptive strategy work group
    - In the future there will be two recharge/replenishment projects close to Marana airport (Marana is working with Metro Water on one closer to Oro Valley)

Questions and comments

- Is the rise in groundwater in central Tucson due to natural replenishment because wells were turned off?
    - Yes, from natural recharge and underflow from the southern part of aquifer (B zone)
- For the southeast sector with the South Houghton Area Recharge Project (located just west of Houghton and Drexel, owned by Tucson Water) and Vail wheeling through intergovernmental agreements (IGA), how will that impact groundwater with new development coming online?
    - Won't see as much decline, but recharge will be smaller than other areas
- What are some the areas you're watching and/or important projects coming online?
    - Marana – The northwest replenishment area.
    - Water may be pumped from storage areas someday due to Colorado River shortages, but that is a question of pipes and pumps available by that time
- We who live in Central Tucson basin have a distinct local focus, but the AMA Is bigger than this picture. We have the potential for significant declines in the Saddlebrooke area and Arivaca – make sure that as we go forward that we don't forget to consider these areas.
- What about northeast side stresses, particularly Pinal County in the Tucson AMA?

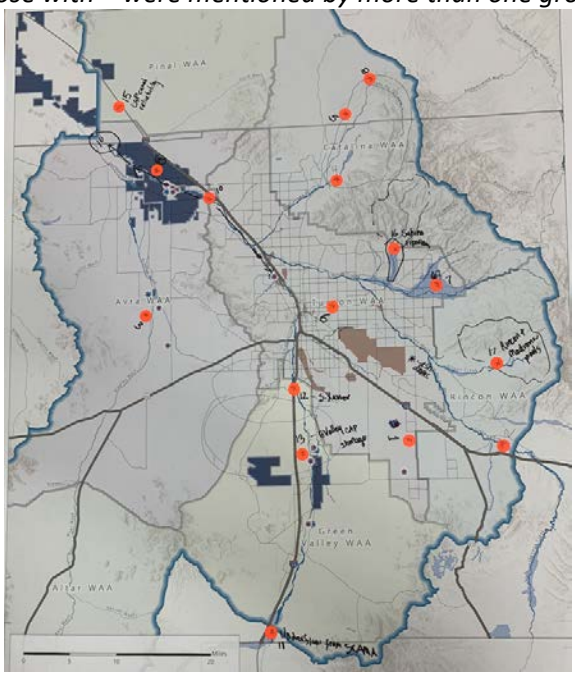
- That area is predominantly undeveloped desert. Water use includes an approximately 4 square mile area of farming near Picacho Peak, and a smaller area of farming to the east of Red Rock. They are not getting much mountain front recharge in that area.

Geographic Areas of Concern (Small group work)

In small groups, participants worked to identify specific areas of concern for water availability into the future. Participants indicated areas of concern with small orange sticky dots on maps of the study area. Photos of all maps are in Appendix B.

Following is first a synthesis of all areas mentioned. Notes from each group discussion are included with more context about why *areas were identified.*

Synthesized list (combined from all groups)
*Those with * were mentioned by more than one group*



Geographic areas of concern for all groups
(Maps for individual groups are in Appendix B.)

- South Houghton corridor*
- Saddlebrooke area*
- Rincon Creek/Madrona pools*
- Lower Santa Cruz River*
- Tanque Verde/Agua Caliente Park/Sabino Canyon*
- Cienega Creek /Davidson Canyon*
- Vail
- Tucson (mid-town, southwest and southeast)
- Oro Valley
- Town of Oracle
- CAP Canal
- Canada Del Oro Wash (CDO)
- San Xavier District
- Tortolita Mountains
- Ajo Way Corridor
- Green Valley/Pima Mine Road
- Arivaca
- Marana area
- I-19 Bridge at the Santa Cruz River

Blue Group – Facilitated by Tahnee Robertson

Numbers correspond to Blue group map (orange dots) which can be found in Appendix B.

1. South Houghton corridor
2. Cienega Creek and Davidson Canyon – desiccation of a riparian area. Exempt wells, Vail wells, Rosemont Mine surface water diversions and groundwater draw toward open pit.
3. Avra Valley – eventual recovery of restored water, potential contamination of supply with proposed Interstate 11
4. Canada Del Oro/Sutherland Wash – potential effects of natural recharge by changing conditions and forest fires, expanded groundwater pumping, aquifer stress
5. Saddlebrooke Ranch – residential demand. Concern that much of the area to the south contributes to Pima County Regional Wastewater Reclamation Department-not locally recharged.
6. Tucson center – potential future reduction of Colorado River could result in additional groundwater pumping
7. Tanque Verde/Agua Caliente – riparian areas
8. Town of Oracle – physically outside of the AMA, but pumping from inside the AMA in an area with little recharge
9. Marana area – future reduction of CAP deliveries could cause problems with supply - demand balance
10. Lower Santa Cruz River (from Roger Road past Trico Road) – effluent dependent riparian/wetland area would lose water if effluent used elsewhere.
11. Green Valley – dependent on underflow, possible impacts from Santa Cruz County effluent flows
12. I-19 Bridge at Santa Cruz River – groundwater levels support surface flow
13. Green Valley/Pima Mine Road – potential future CAP shortages. Cone of depression.
14. Arivaca Valley – riparian issues
15. CAP Canal – limits to canal capacity; potential future reliability issues due to single siphons
16. Sabino Canyon - desiccation of a riparian area. No nearby recharge.
17. Rincon Creek/Madrona pools – risks to natural riparian area. Is SHARP (South Houghton Area Recharge Project) recharge close enough or large enough?

Green Group – Facilitated by Colleen Whitaker

- Cienega Creek/Davidson Canyon
- Santa Cruz River, west of I-10 - effluent dependent flows, increased water demand
- Green Valley
- Arivaca
- Sabino/Tanque Verde Creeks
- Saddlebrooke - anticipated growth area
- Oro Valley
- Santa Cruz River effluent flows
- Flowing Wells – perhaps increased demand
- Southeast Tucson (south of airport) – targeted industrial growth area
- Rincon Creek – loss of surface water; conservation opportunity in Rincon
- Flowing Wells Irrigation District – heat island demand

Yellow Group – Facilitated by Julia Sittig

- Urban corridor - urban flooding and Marana flooding
- Saddlebrooke and Catalina

- Green Valley – cone of depression on the border of the Tucson and Santa Cruz Active Management areas; as well as the pecan orchards owned by FICO pushing/pulling in and out of this cone due to seasonal irrigation
- Rincon East, Cienega Creek/Rillito Creek
- Canada Del Oro and areas that rely on mountain front recharge
- Southeast area - large number of private wells
- San Xavier - CAP may be threatened
- Tortolita Mountains – potential for wells to go dry
- Rising water levels downtown (near river) - proximity to landfills; contaminants may be mobilized if levels get too high
- If CAP supplies decrease in areas with strong ag presence, there could be a strong reliance on groundwater
- Riparian areas - particularly the intersection of pumping, declining recharge from precipitation, and proximity to shallow groundwater
- Reduced flood-carrying capacity in main channel from Martinez Hill to Marana, as its been highly channelized – at risk for flash flood
- CAP water – Tucson area should be using/storing its allocated amount (CAP water belonging to the Tohono O'odham Nation is recharged in the Phoenix and Pinal AMAs).
- Large capacity for recharge on the Tohono O'odham Nation is not being utilized

Red Group – Facilitated by Jessica Olson

- Saddlebrooke
- Vail (served by CAP)
- Green Valley, south (lots of housing and limited infrastructure)
- Southwest Tucson
- Ajo Way Corridor and South Houghton (limited infrastructure)

Climate Change Impacts by Sector: Mini Presentations

Municipal Water Supplies - *Wally Wilson, Metropolitan Water District*

- Climate change impacts on the Colorado River will have the greatest impact to water use in this region because the majority of our water use is dependent on Central Arizona Project (CAP) water.
    - Vulnerability of the entire Colorado River Basin, and negotiations of the 2007 guidelines, adds some risk.
    - We have the lowest priority on the Colorado River System; will likely just have water for municipal and tribal from CAP now. If the agricultural allocations are cut, agriculture can choose to pump groundwater.
    - If we retreat to using more groundwater, there will be more impacts to mountain front streams and riparian areas;
    - Fires that increase runoff rates/sedimentation could also have an effect
- Average use per household will depend on landscaping
    - We could see an impact from increased water use, but the cost of the water is going to go way up, especially with shortages on CAP. The cost per acre foot will go up and could significantly affect demand.
    - In some cases, we will see no outdoor water use. New developments are moving toward "hardscaping"

    - New houses will be more efficient
- We are now in surplus but that may not last.

Local Environmental Conditions/Riparian Areas - *Julia Fonseca, Pima County*

See presentation here: Lower Santa Cruz River Basin Study Website

- Value of riparian areas - wildlife, recreation, quality of life, housing prices.
- For the Sonoran Desert Protection Plan (SDCP) they looked at the historic losses - 3,000 acres lost, 32% now in protected status.
- 2004 bonds have been used to preserve bosques
    - 200 acres of the 1000-acre restoration goal have been restored
    - 3373 acres of bosque have been acquired since 2001.
- Threats - water table changes, soil moisture changes, erosion and deposition (has had the least attention so far, but this study won't address this).
- The SDCP proposed infrastructure solutions that could reduce stress on aquifers – advocated extensions of the reclaimed system to 49ers, Rocking K and Del Lago
    - Tanque Verde Creek now flows more frequently due to extension of the reclaimed system to the Forty-niners area.
- Tucson Water's "last on, first off policy" has been successful – the method allows for avoiding pumping in areas where natural recharge restores the aquifer; need to do the restoration in places where there is underground perching if possible.
- San Xavier District recharge - limits on groundwater pumping around San Xavier have resulted in enhancement of riparian
- Can also increase soil moisture by lowering the floodplain – harvesting water off the Oro Valley Marketplace has resulted in enhanced restoration
- Wild card is erosion and deposition – it affects riparian areas and infrastructure. Where will the sediment wind up? Will we have more riparian areas or more incision?
- There will be a continued need for floodplain management – more options are needed.
- We also need to look at the forest watersheds (Saguaro National Park partnerships).
- Our basin has around 50,000 AF of natural recharge – is there a bigger role for uplands?

Agriculture - *Brian Wong, BKW Farms*

- Pinal County farmers are reliant on Central Arizona Project Non-Indian Agricultural pool water; this will be a problem as the supply decreases into the future.
- Agriculture in Pima County is lucky to have ability to be on renewable supply and avoid groundwater pumping through partnerships with municipal entities.
- BKW farm has stopped all groundwater pumping since the late 1990s. In combination with use of renewable water, the aquifer has risen about 100 feet.
- All agriculture in the area is dependent on irrigation.

Questions/comments

- What about switching to lower water use crops?
    - The question with this is always - is there a market? There is a current demand for cotton and alfalfa. BKW has tried to switch over to niche markets of organic crops and heritage varieties that are more suited to the desert.
- How many heritage crops is BKW cultivating?
    - In total BKW farms has 4,500 acres of irrigated agricultural land. Approximately 100-150 acres of this is heritage crops.

- Do you have ideas of switching to something that could use drip irrigation?
    - All land is on furrow/flood irrigation now. There are other, more advanced forms (sprinklers and drip). The biggest problem is that the majority is of the land is leased from the Arizona State Land Department. These technologies have long pay-back horizons. It's hard to justify investing in water conservation infrastructure when the land could be auctioned at any time.
- If there was a community effort to support getting a longer lease on the land, would BKW consider that type of irrigation infrastructure?
    - Yes. But even if the local community is supportive, the biggest question is whether the State of Arizona will support it. At this point the leases are only 5 years.
- What percentage of your water is reclaimed, as part of the M&I (Municipal and Industrial) partnerships?
    - The majority is raw CAP water. No reclaimed water is used.
    - Treated wastewater from the prison does go to fields, but it's an extremely small percentage of overall use
- How does climate change affect your energy sources? Are there issues related to reliability or cost?
    - The majority of our pumps are on natural gas – it's more efficient than electricity.

Livability - *Mead Mier, Pima Association of Governments*

The Pima Association of Governments is run by the Regional Council, leadership from each jurisdiction in Pima County. Will highlight here what local governments are responsible for regarding water – public health, safety, welfare, healthy economy and quality of life.

- Economy – industrial demand for water; need to consider additional demand of new sectors.
- Safety – we've discussed flooding; some neighborhoods have no emergency access during a rainstorm – this is a future concern as flooding may increase.
- Water quality – in today's Workshop maps we've included the groundwater contamination areas.
- Subsidence – Caused by groundwater depletion, can affect the integrity of all infrastructure in our communities. Is recharge occurring in key areas to help with this? Does development need to avoid areas of future risk?
- Social - Need to consider disadvantaged populations – increased heat in the models we're using, less access to cooler green space in impoverished areas. Consider this when looking at distribution of projects for water in the environment and public landscape efforts that may be impacted by drought ordinance adaptations. Also consider cultural and heritage values of maintaining historic flows.
- Small private wells on the urban edge may not have access to renewable supply. Although they use a small amount, there are thousands of households that rely on these small wells (may need to be drilled deeper or bring in new renewable supplies). Also need to think about proximity of wells to shallow groundwater dependent ecosystems as we consider risks and adaptation strategies.

Other perspectives – open comments from participants

- At UA we hear about agro-voltaics. As we think about energy distribution, what does the water use look like for that?
- The Altar Valley Conservation Alliance is working on a watershed-wide plan. The overarching goal is to increase infiltration, which will have effects on other downstream areas. Anyone can participant in the Watershed Working Group (contact Julia Sittig).

Adaptation Strategies (Small Group Work)

Participants worked in small groups to brainstorm potential adaptation strategies for future areas of concern identified in an earlier session. In this session, the four groups were consolidated into three.

Note: Due to the early departure of some attendees, the remainder of participants were re-distributed into three groups: Blue, Red and Yellow.

Green Group - Facilitated by Colleen Whitaker

Note: This group developed strategies based on geographic area. Small numbers in parentheses refer to yellow sticky dots on blue group map (see Appendix B).

1. **Oro Valley area** (includes Saddlebrooke)
   - Issue: This area has groundwater level declines because that is the only source of water. Plans to try and get CAP water in that area to combat declines, but not sure if that will happen. Could Oro Valley wheel some water to Saddlebrooke?
     - **Strategies:**
       - Develop ordinances for new development [38]
       - Wastewater recharge and reuse facility (Saddlebrooke) [37] (*Note: Saddlebrooke Ranch already uses the reclaimed water from its treatment plant for golf course irrigation*)
         - There could be recharge but that would just be a portion.
         - Could capture and treat rainwater and stormwater.
         - Forest Service as a whole could do more to enhance infiltration.
   - Issue: Fire risk issue and increased flood risk
     - **Strategy:** Prescribed fire and thinning in Coronado National Forest [36]
2. **Summerhaven**
   - Issue: Wastewater is drained to San Pedro watershed. Need renewable supply.
     - **Strategy:** More storage (tanks); reclaimed; surface water runoff; wastewater treatment; rainwater collection [35]

- **Strategy:** change through Arizona Department of Environmental Quality Triennial Review to allow treated wastewater to flow down Sabino Creek, unless redefinition of WOTUS (Waters of the U.S.) passes [39]

3. Sabino/Tanque Verde

- Issue: Reliability of water supply: seasonal stress; fire risk; shallow ground water supplies
  - **Strategy:** Have a designated augmentation; partner sharing of water providers; expand definition of emergency to include environmental factors [34]
  - Potential issue: water quality
  - Potential benefit: "water security fund" (surcharge); could wheel water to different areas
- Issue: streamflow, dry days
  - **Strategy:** Doing in-channel recharge of reclaimed water during cool season (using existing infrastructure) [33]
  - Potential concern: Would be a managed recharge and earn 50% credit for the amount of reclaimed water infiltrated under current state law.
  - Potential benefit: recharge in higher portion of the watershed; supporting riparian systems
- Issue: Energy use/ consumption, dewatering of certain areas.
  - **Strategy:** Decentralized wastewater treatment and recharge [32]

4. Agua Caliente

- Issue: Spring dry; pumping water and lining ponds – tremendous economic cost
  - **Strategy:** Water harvesting (low-tech above spring), or use reclaimed water [28]

5. Vail

- Issue: Cienega Creek is diverted to a Del Lago golf course ponds creating invasive bullfrog habitat, impacting the environment and reducing natural recharge. There are risks to the golf course if Cienega Creek dries up.
  - **Strategy:** Supply Del Lago golf course with water from new wastewater reclamation plant (distributed decentralized wastewater recharge) to recover effluent, reuse and recharge here; or extended reclaimed infrastructure to match the standard used across the region [40]. Let Cienega Creek flow in river channel for riparian use and recharge of Vail wellfield.

6. Cienega Creek Preserve

- Issue: Increased water use in drought by wells plus surface water diversion; impacting groundwater dependent ecosystems, including perennial and intermittent surface water and wells nearby. Could become exacerbated because although currently Vail Water is getting CAP water wheeled, the group was concerned about times of CAP shortage. In addition, the Rosemont Mine would impact contributing runoff and groundwater levels.
  - **Strategy:** Manage underflow storage: Instead of diverting Cienega Creek to the Del Lago golf courses in Vail, remove the flumes that divert water and let flows stay in the channel. Del Lago golf course can then recover naturally recharged water through a well closer to Vail. To maintain the wetland, managers may want to maintain the dam which is holding sediment detaining shallow groundwater;[41]
  - Potential benefit: improves local recharge, allows water to flow through Cienega Creek Preserve; riparian benefits: The extended creek flows will have higher habitat value for endangered species and higher (free) access for recreators than the golf ponds which house invasive species (bullfrogs). The extended creek flows will also infiltrate to replenish the aquifer.
  - **Strategy**: Land acquisition along Davidson Canyon to reduce future pumping, work with Rosemont Mine owners to supply water (CAP, water harvesting, earthworks for natural

stormwater recharge, effluent reclamation efforts) within the Cienega basin since open pit would divert groundwater and surface flow to Cienega/Davidson Canyon.

7. **Sopori Wash**
   - Issue: Historically an area of groundwater pumping; no longer farming there but perhaps in future; area had riparian vegetation at one time, but has been ephemeral for quite some time
     - **Strategy:** Land acquisition (SDLP) [43]
     - **Strategy:** Lowering flood plain for restoration [44]
     - **Strategy:** Beavers in Las Cienegas Preserve [45]

8. **Agricultural areas**
   - Issue: Weather concerns - higher temperatures, more storms
   - Issue: State land tenure – lack of security
     - **Strategy:** Address state land tenure; support more long-term Groundwater Savings Facilities (GSF) partnerships [46]
     - Amount of GSF water could be reduced in CAP shortages; unmaintained wells, no plan B
     - **Strategy:** Well maintenance [47]
     - **Strategy:** Fallow land, perhaps in south (must be rotational, or will result in potential dust storms)

9. **Central Arizona Groundwater Replenishment District**
   - Issue: Disconnect between wet water and paper rights; costly, water quality, supply
     - **Strategy:** Replenish credits in area of withdrawal/use; could accomplish this through policy at state level; more wheeling agreements could be a solution [26]

10. **General (non-location specific)**
    - Issue: Enhancing infiltration to improve riparian habitats
      - **Strategy:** Water-harvesting along Catalina mountain front, and/or other mountain fronts along shallow mountain areas [27]
    - Issue: How to provide conservation incentives to those using groundwater – who would fund these incentives (or range of incentives)?
      - **Strategy:** Residential efficiencies (conservation and/or education for those users)'; Could target areas where there's a particular imbalance [48]
      - **Strategy: Meter all wells (exempt or non-exempt)**
        - Potential concern: there would be a lot of push back in rural areas regarding non-exempt wells
      - **Strategy:** Need reporting outside AMA [31]
      - **Strategy:** County could apply for Adequate Water Supply rules to be adopted
      -

Red Group – Facilitated by Jessica Olson

A full-list of strategies developed is presented here, with further detail below on strategies #1-3.

1. **CAGRD reform** (Central Arizona Groundwater Replenishment District) – allows recharge in one area of the Active Management Area to offset development in other areas. Focus on multiple areas including north Marana and outlying communities. Strategy could include policy change and new infrastructure.
2. **Infrastructure improvements for recharge** at Saddlebrooke, Ajo Way Corridor Way, southwest area. Example: wheeling water for recharge (shared distribution).
3. **Rebuild habitat on the Santa Cruz and recharge river corridors** – expand credits for effluent reallocated into Santa Cruz River and Rillito confluence.

4. **More infill development** – reduces the need for outer area water development; designated water providers. Would include development policies, zoning changes, permitting solutions. Consideration - What would happen to all the places already slated for development outside centers?
5. **Green infrastructure in neighborhoods everywhere.** Prioritize areas with low canopy, flood risk, and low income areas. Will likely only see benefit in more densely developed areas.
6. **Large-scale restoration of riparian areas and flood plains, for recharge, community amenities, and stormwater capture.** Areas include: Airport Wash, Christmas Wash, BKW Farms, southern part of Tucson. Requires larger properties and low-density development.
7. **Use the Conservation Effluent Pool -** moving effluent where it's needed. Restructure the existing program to be more useful and user-friendly. May require a hydro study. Source is Santa Cruz River. Key players - Tucson Water and Pima County.

<u>More detail on specific strategies</u>

1. **Central Arizona Groundwater Replenishment District (CAGRD) Reform**: Need policy change to limit potential for offsite uses, require direct delivery infrastructure (developer pays), restrict depletions, and allow wheeling.
    - *Where?* Existing and future CAGRD subdivisions. Only 8-10 providers who don't have this issue.
    - *Why?* Policies are currently unsustainable, groundwater is decreasing, reliability issues.
    - *When?* Attention is focused NOW, solutions can be phased, legislative timing is important to consider.
    - *Who pays?* Now the homeowners pay, but this could be shifted to developers.
    - *Who has more details?* Kyle Center at ASU – Kathy Ferris and Sarah Porter; Robert Glennon; Representative Kristin Engel; Arizona Department of Water Resources; CAP
    - *Cons?* Politics, cost

2. **Infrastructure improvements for treated and untreated water.** Improve direct delivery, upgrade existing infrastructure to allow wheeling (immediate opportunity)
    - *Where?* Saddlebrooke, Saddlebrooke Ranch, Town of Oracle, pipeline for potable water, golf courses?
    - *When?* Immediate – pipeline to Oro Valley proposed
    - *Who pays?* Saddlebrooke, Saddlebrooke Ranch
    - *Who has more details?* Arizona Water Company, Saddlebrooke developers, Tucson Water, Metro Water, Oro Valley, Marana
    - *Cons?* Enormous cost. Does this drive development? Takes water from population cores.

3. **Rebuild habitat on the Santa Cruz,** other rivers and tributaries and improve reclaimed water opportunities past Drexel Road. Ties into restoration, green infrastructure, and capture recharge.
    - *Where?* Focus on visibility, biggest benefit south of town
    - *When?* Learning from Heritage project now. Plan ahead for ESA, NEPA, and other compliance and permitting; consider timing based on water levels
    - *Who?* Sonoran Institute, Julia Fonseca
    - *Cons?* It costs water to do this, balancing environmental and human values, benefits exported out of town, one size does not fit all.
    - *Who pays?* Taxpayers, rate payer

Yellow Group - Facilitated by Julia Sittig

1. **Recharge San Xavier District Arizona Water Settlements Act CAP water in the District-** 30,000 acre-feet/year project on San Xavier Reservation
    - Currently the 30,000 acre-feet (af) is being recharged in Maricopa and Pinal counties, not in Pima County.
    - Could consider Avra Valley as an alternative recharge area

2. **Maximize use of full allocated CAP water (250,000 acre feet) in basin**
    - Purpose: Build capacity to store groundwater for later use
    - Aim for 50,000 acre feet of storage, including water allocated under the Arizona Water Settlements Act (AWSA)
    - The City of Tucson, Arizona Department of Water Resources (ADWR), and Central Arizona Water Conservation District (CAWCD) are aware of the water-related numbers in this area. Reclamation would also have more details.
    - Groups that would benefit: municipalities, agriculture, Tohono O'odham Nation (TON) - AWSA water would go to the TON.
        - One of the TON's key goals is aquifer restoration. This project would also repair riparian habitat and mesquite bosques.
    - This strategy fulfills a AWSA water right, maximizes the value of the CAP system itself, and minimizes evapotranspiration losses.
    - Challenges: lack of funding, establishing trust with TON and San Xavier District, Santa Cruz wellfield might start getting pumped again, if it happens.
    - Suggested next steps: Form a collaborative group of everyone who has entitlements (to balance various interests): Reclamation, CAWCD, City of Tucson, Tohono O'odham, San Xavier, ADWR, etc.

3. **Local food production to address unstable situation** (have 3 days of storage)
    - Would require tens of thousands of acre-feet/year to devote to it.

4. **Harvest 65 billion gallons (20,000 acre-feet) of rainwater per year**
    - Use for tree canopy cover and water storage through network of dry wells (green infrastructure)
    - Dry wells are great but not necessarily sustainable
    - 65 billion gallons (20,000 af) uses runoff as well, not just green infrastructure harvesting. 4.5 billion (13,800 is what could be harvested from rooftops, according to Brad Lancaster. Rooftop harvest retains 50-80% of the water.
    - City of Tucson requires runoff from the road be directed into basin before it goes into a wash
    - Below-ground cisterns that are well-maintained for potable water use
    - Scales of rainwater harvesting:
        - Small-scale - active harvesting
        - Neighborhood scale - passive harvesting (street trees and landscapes, green infrastructure; high-volume in-ground storage (e.g., dry wells)
        - Above-ground and below-ground are possible with all scales
    - Use pre-development water for riparian and natural uses.
    - Enact legislation encouraging indoor non-potable water use for new commercial buildings.
        - Examples: City of Scottsdale uses toilet to tap. *(Note: Scottsdale was issued a permit for direct potable reuse by the Arizona Department of Environmental Quality but does not use recycled water in its drinking water system.)* The City of Austin, Texas requires rainwater harvesting for toilet flushing, irrigation, etc.

5. **Build new developments with rainwater storage as an integral component of the infrastructure**
    - Build new homes in developments with rainwater storage as part of lot design and common areas with below ground storage interconnected to new home rainwater storage. Scale rainwater storage to supply non-potable and/or potable demand. Contract with a well owner to supply water that could be trucked to the development during extended drought conditions.
    - At commercial scale it might work, but residential will be more difficult. Also need non-potable water storage.
    - Who pays? Homeowners? Developers? When you do the analysis for cost at micro level, it becomes very difficult. Is it still worth it if we run out of water and are last priority? Cost is really still unknown. If it's sufficiently integrated, it might be doable.
    - Suggested actions:
        - Link to someone who has a well so the water can be delivered from cistern to well (a micro-water grid). It could be within or without a service area as long as there was a contract.
        - Develop policies and incentivize to capture rainwater for home use in new developments as a backup during drought.
        - Get more info from City of Tucson, Austin, Milagro co-housing

6. **Use technology to address in-system water** (transparent interfaces)
    - Purpose: This strategy provides incentive to save water
    - Where: Golf courses, feedback from sensors that takes evapotranspiration into account, etc.
    - Example: Conflict of interest group in Phoenix for Home Owner Associations who have little incentive to save water.
    - Utilize more reclaimed water instead of giving it back to riparian area
    - Use county lines as the barrier to focus recharge?
    - Next steps: Study to assess how much water is available ("post-development water")

7. **Indirect potable re-use**
    - "recycled" water with advanced treatment

8. **Use wet water**
    - Holistic water use: stop recharging where you don't pump it
    - Pair recharge with recovery
    - Requires reworking of groundwater code, specifically recharge rules

9. **Characterize cost and value of water**
    - CAP has capital cost and delivery cost
    - CAGRD cost of water is over $700 acre-feet
    - California's cost of municipal water is over $1000 acre-feet
    - Quantify long-term Operations and Maintenance cost

10. **Dealing with flooding**
    - There are more intense rainstorms predicted in the future, even if fewer events
    - SHADE Tucson is trying to double the tree canopy; with green infrastructure (like Watershed Management Group), it can relieve some of the potential flooding.
    - Installing 100,000 check dams/erosion control structures high up in watershed could attenuate flood flows effectively (rather than downstream only)

- Important consideration: What scale event are you preparing for or could you experience?

11. Minimize impacts of pumping in areas prone to subsidence

- Where: southeast area near I-10 may have subsidence; little recharge. Also southwest of Tucson and north of Ajo Way Corridor.
- Keep water levels high
- Phase 2 will look at which areas are most affected.

12. Encourage a flowing river in Green Valley

- Green Valley has a drawdown problem.
- Increase in-channel Santa Cruz recharge.
- Avra Valley has room for recharge basins. But then you have to get it back to Tucson. 120,000 acre feet that Tucson Water is recharging; 30,000 for the Arizona Water Rights Settlements Act (AWSA);
- We get 180,000 acre feet in CAP water - 30,000 of it is for AWSA, another 40,000 is available.

<u>Discussion notes on CAP water allocations</u>

Numbers reported are in acre-feet

- The Tohono O'odham Nation is entitled to 66,000 acre-feet per year from the United States as part of the Arizona Water Settlements Act. Reclamation pays for delivery. Recharge credits from 28,200 acre-feet of Tucson area effluent helping pay for the delivery costs. The recharge credits generated by this treated effluent represents Tucson's portion of the settlement with the Tohono O'odham Nation.
- 38,800 acre-feet of this 66,000 is for the San Xavier District within the Tohono O'odham Nation
- The City of Tucson's allocation is about 144,000 acre-feet.
- The Town of Oro Valley has an allocation of 10,305 acre-feet per year and the Metropolitan Domestic Water Improvement District (Metro) has an allocation of 13,406 acre-feet per year
- Tucson is currently storing water for Phoenix. We have the capacity to store more. There are three recharge projects possible, all upgradient of where there are wells. But there may not be recharge capacity in Tucson Basin.
- State Land in the Tucson area has a separate allocation of 28,000 acre-feet.
- Reclamation is paying for the Tohono O'odham Nation's water to be recharged in Maricopa and Pinal Active Management Areas. We should be storing it here.

Appendix A: Workshop Agenda

Time	Activity
9:00 am	**Registration and coffee**
9:15	**Welcome and introductions** *Mead Mier, Pima Association of Governments & Marie Light, Pima County*
9:25	**Overview of Lower Santa Cruz River Basin Study and** **Purpose of Today's Meeting** *Eve Halper, Bureau of Reclamation & Kathy Chavez, Pima County*
9:45	**Setting the stage: Historic areas of concern and future projections** Mini-presentations followed by brief Q&A ● Overview of risk-based framing and climate metrics - *Kathy Jacobs, University of Arizona* (5 min) ● Review of range of climate projections, general trends and scenarios- *Lindsay Bearup, Bureau of Reclamation* (10 min) ● History of Aquifer Change - *Beth Scully, Tucson Water* (5 min) ● Overview of historic areas of concern - *Wally Wilson, Metropolitan Water District* (10 min)
10:20	**Small group discussion: Geographic areas of concern**
10:35	**Sharing back and break**
11:00	**Climate Change Impacts by Sector** Mini-presentations on the current status of: 1. Problem areas/risks/stressors 2. Objectives/ Desired Conditions (where developed) General Sector Impacts (5 min each): ● Municipal Water Supplies - *Wally Wilson, Metropolitan Water District* ● Local Environmental Conditions/Riparian Areas - *Julia Fonseca, Pima County* ● Agriculture - *Brian Wong, BKW Farms* ● Livability - *Mead Mier, Pima Association of Governments*
11:45	**General identification of problem areas** *Plenary Discussion*
12:30 pm	**Lunch** *Provided by Tucson Water*
1:15	**Small group work: Adaptation Strategies** In mixed groups participants will brainstorm potential solutions to identified geographic and sectoral problem areas
2:15	**Break**
2:30	**Sharing back from small group work and discussion**
3:15	**Criteria for selecting strategies for further evaluation** *Plenary Discussion*
3:45	**Next steps and closing** - *Eve Halper, Bureau of Reclamation & Kathy Chavez, Pima County*
4:00 pm	**Adjourn**

Appendix B: Participant Names and Affiliations

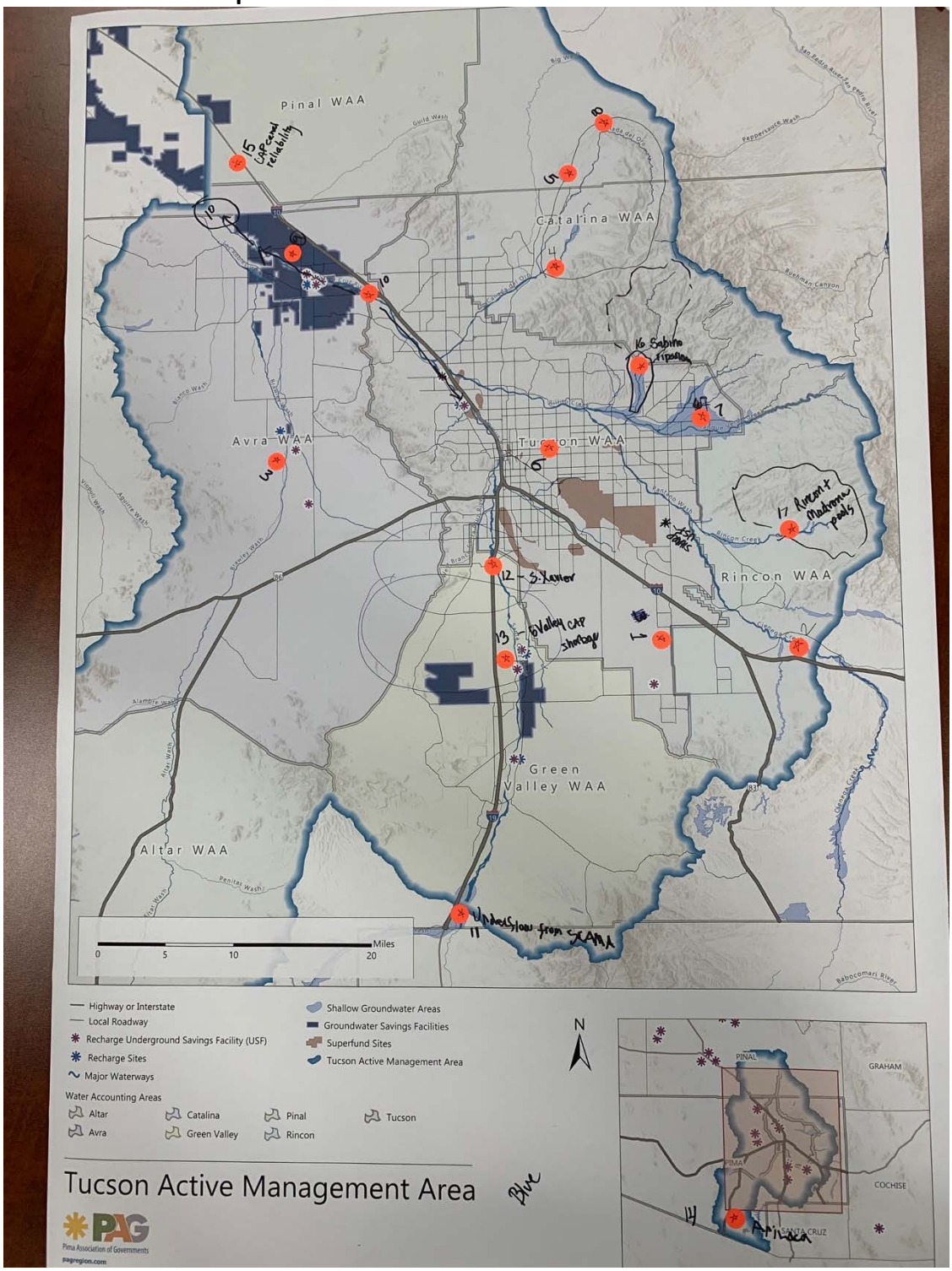
Name	Affiliation
Melanie Alvarez	Pima Association of Governments
Brittney Bates	E.L. Montgomery
Lindsay Bearup (remotely)	Reclamation Technical Service Center
Bruce Caris	Farmers Investment Company (FICO)
Kathy Chavez	Pima County Office of Sustainability and Conservation
Luke Cole	Sonoran Institute
Lee Comrie	Pima Association of Governments
Tres English	Sustainable Tucson
Catherine Evilsizor	Resident
Julia Fonseca	Pima County Office of Sustainability and Conservation
Jaimie Galayda	Tucson Water
Neha Gupta	University of Arizona - Hydrology and Atmospheric Sciences
Eve Halper	Reclamation - Phoenix Area Office
Eric Holler	Private Citizen
Kathy Jacobs	University of Arizona - Ctr for Climate Adaptation Science and Solutions
Bailey Kennett	Arizona Land and Water Trust
Marie Light	Pima County Department of Environmental Quality
Melodee Loyer	Tucson Water
Juliet McKenna	Montgomery and Associates
Mead Mier	Pima Association of Governments
Monica Pickenpaugh	University of Arizona - Civil Engineering
Lisa Rivera	Reclamation - Phoenix Area Office
Beth Scully	Tucson Water
Catlow Shipek	Watershed Management Group
Valerie Swick	Reclamation - Phoenix Area Office
Renee Tilstra-Mann	Colorado State University
Kip Volpe	Vail Water Company
Wally Wilson	Metro Water District
Brian Wong	BKW Farms

Facilitation and documentation
Southwest Decision Resources - Tahnee Robertson, Colleen Whitaker, Julia Sittig and Jessica Olson

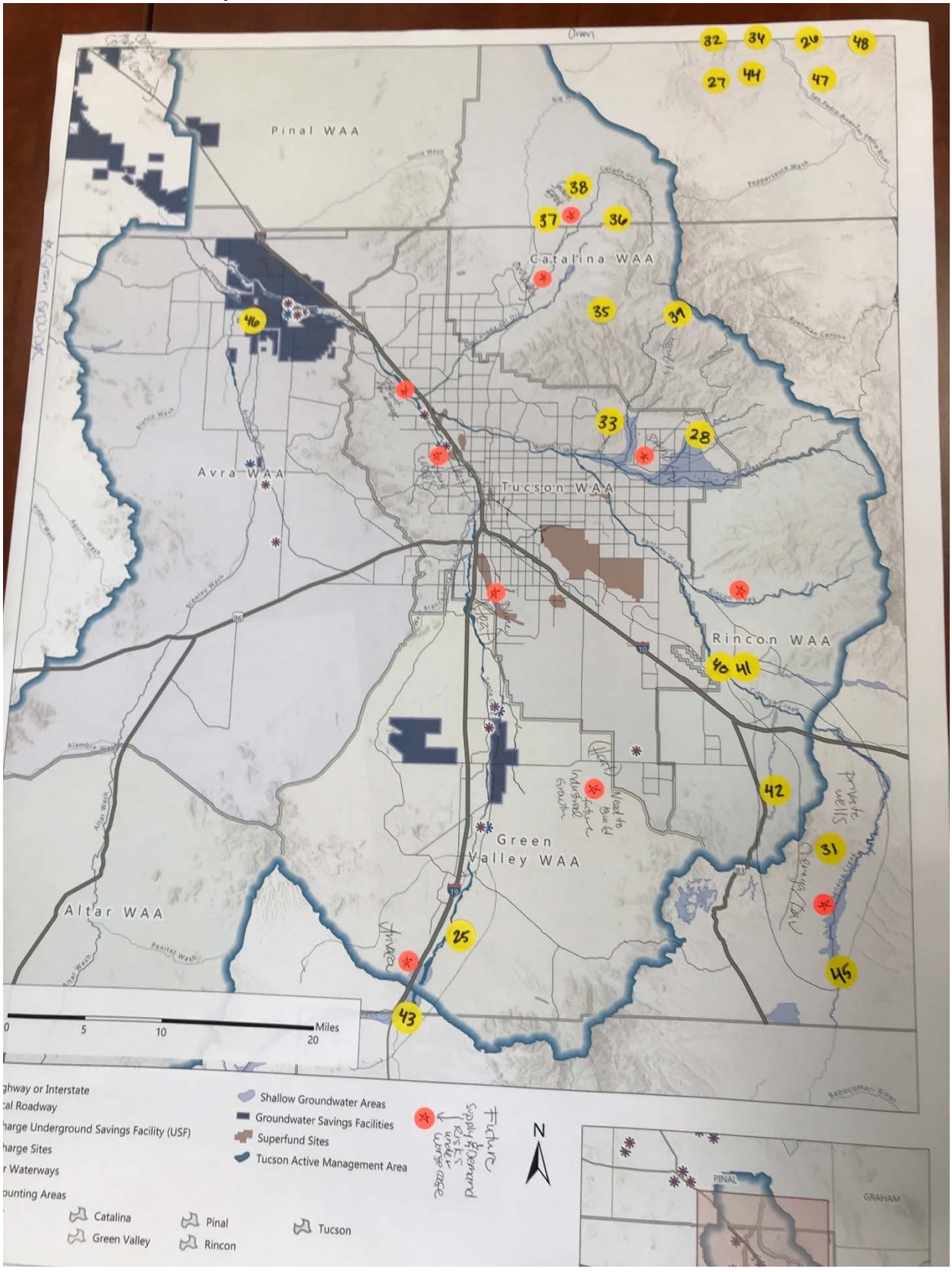
Appendix C: Small Group Maps – Areas of Concern & Strategies

Orange dots indicate areas of concern (from morning small group work). Yellow dots represent suggested adaptation strategies (afternoon small group work).

Blue Group



Green Group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Catalina WAA
Avra WAA
Tucson WAA
Rincon WAA
Green Valley WAA
Altar WAA
32
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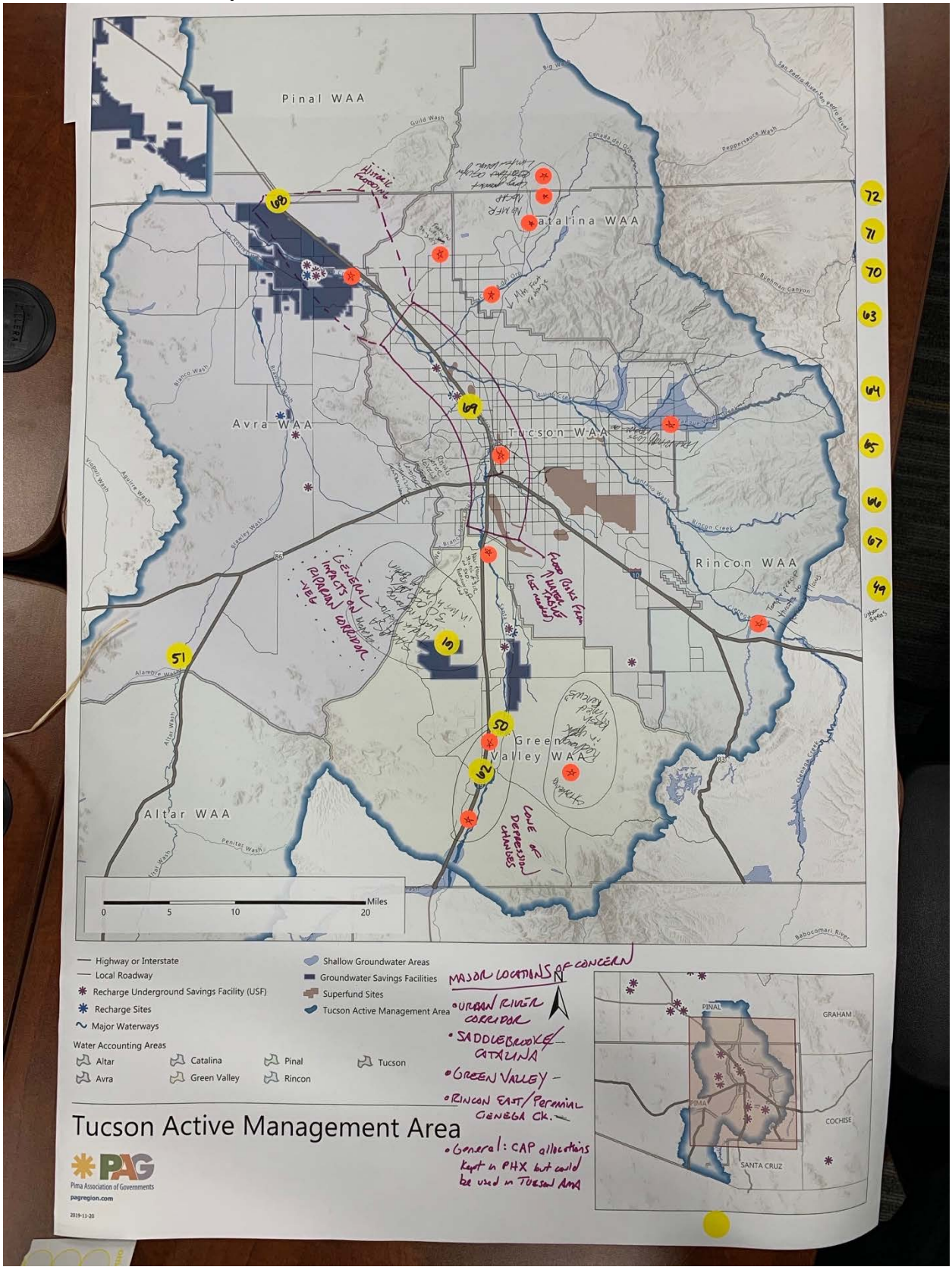
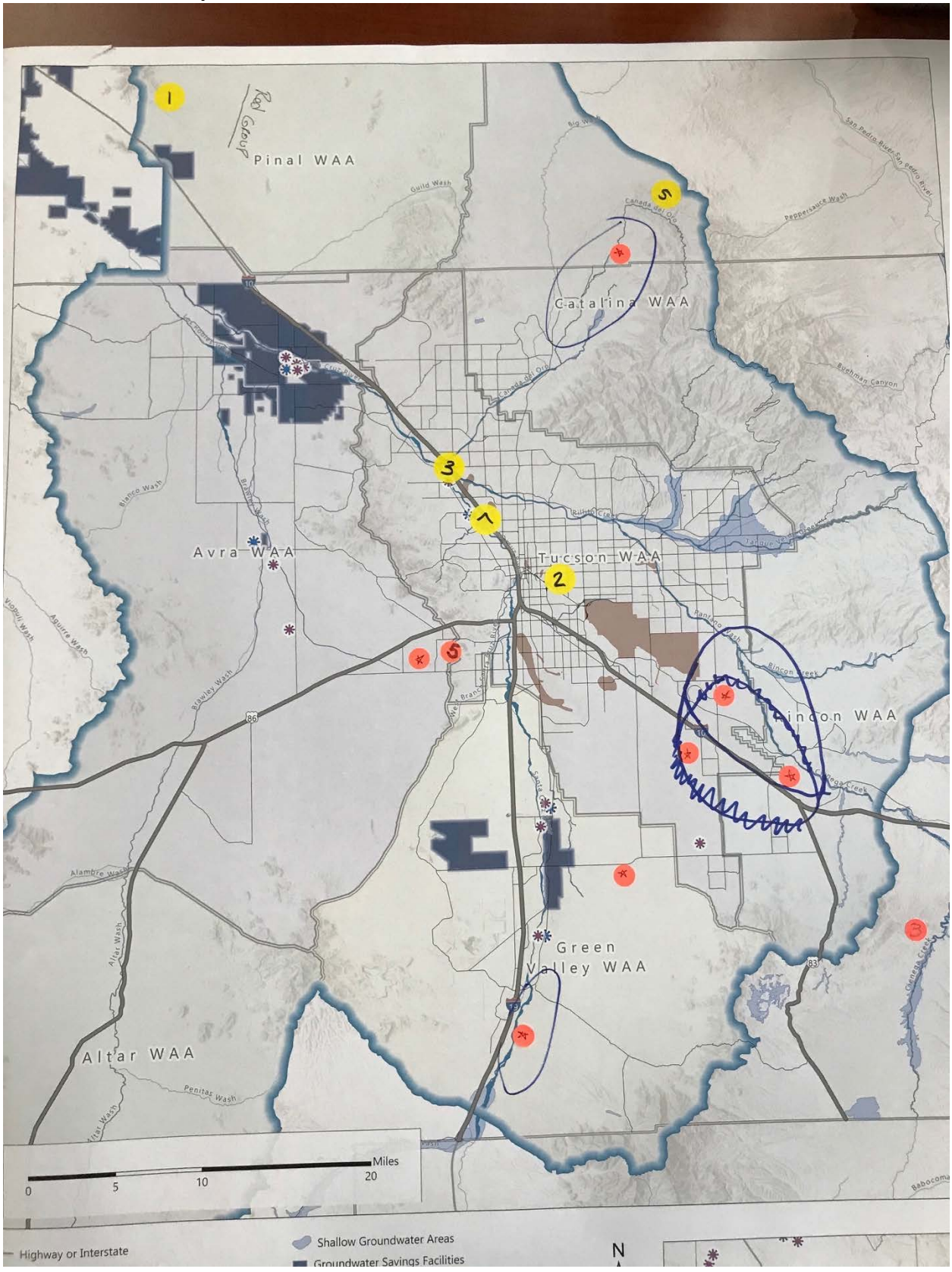
40
41
42
31
25
43
45
0
5
10
Miles
20
Shallow Groundwater Areas
Groundwater Savings Facilities
Superfund Sites
Tucson Active Management Area
Catalina
Green Valley
Pinal
Rincon
Tucson
N
PINAL
GRAHAM

Yellow Group



Red Group


Pinal WAA
Catalina WAA
Avra WAA
Tucson WAA
Rincon WAA
Green Valley WAA
Altar WAA
Miles
0
5
10
20
Highway or Interstate
Shallow Groundwater Areas
Groundwater Savings Facilities
N

Appendix D: Feedback on Initial Adaptation Strategy Screening Criteria

Criterion	**# of participants considering criterion important**
Addresses multiple adaptation objectives/sectors	12
Builds on existing resources and projects	10
Responds to urgent concern	9
Addresses vulnerable water accounting areas	9
Addresses multiple risks	9
Provides benefits to a large population	7
Addresses a priority risk	6
Promotes long-term resiliency / sustainability	3
Addresses a large geography	2
Feasibility	2
Promotes sustainable economic growth	2
Cost effective/high return on investment	2
Infrastructure availability and/or costs for improvements	1
Provides benefit to existing population	1
Deals with food stability	1
Restricts/reduces exempt wells	1
Does not support sprawl/ promotes infill and preservation of open space	1
Preserves or restores a natural system	1
Has committed, active leaders/champions	1
Address long-term impact/benefits over short-term objectives	1
Benefits long term water security and resilience across triple bottom line	1