Vulnerability Assessment Components and Approaches

Vulnerability assessments can help water managers understand what aspects of their system are at risk due to climate change and formulate a plan to manage those risks. The Academy's September 20, 2012 webinar with guests Amy Snover, Co-Director of the Climate Impacts Group at the University of Washington and Charlie Ester, Manager of Water Resource Operations at Salt River Project moved the discussion beyond assessment of the general risk of reduced water supplies and increased demand due to climate change.

Why assess vulnerability? Vulnerability assessment can help us understand climate change impacts and is an early step in preparing for those impacts by:

- Providing a "no action" benchmark for evaluating response options
- Helping to develop a risk assessment and identify priority areas for action
- Identifying adaptation options based on an understanding of the causes of potential future problems

A Simple Approach to Vulnerability Assessment

There are three components of vulnerability: exposure, sensitivity, and adaptive capacity. The first two determine the potential impact of climate based on its interaction with the system being considered. The third combines with those impacts to determine overall vulnerability.
Amy Snover of the Climate Impacts Group shared a simple definition of vulnerability. Vulnerability is equal to exposure times sensitivity, minus adaptive capacity.

The steps in a vulnerability assessment are:
1. Frame the assessment: decide the scale and focus of the assessment
2. Evaluate each component of vulnerability in turn: exposure, sensitivity, adaptive capacity
3. Evaluate overall vulnerability
4. Use results to inform risk assessment and adaptation planning

**Framing** is essential for a quality vulnerability assessment. It requires taking a step back before getting started. Framing asks three questions:
1. **Vulnerability of what?** Most water utility efforts have focused on water supply and timing. Fewer have identified all the pathways that climate change will impact water systems. Good ways to identify more pathways include looking at your entire system from different perspectives, such as utility planning areas, business lines, management objectives, regulatory requirements, facilities and operations, and geographic zones.
2. **Vulnerability to what?** You may want to consider not just projected changes in local and regional climate, but the primary impacts of those changes, such as fire risk and sediment transport. Other drivers of change may be important, too, such as population growth or regulatory changes.
3. **Vulnerability when?** What is the time period of assessment? Climate change projection information is often presented for specific times such as 2020, 2040, or 2070, but results are increasingly available for many time periods. The time scale may be set by your
mandated planning horizon, or farther out when you are concerned about longer-term impacts.

**Exposure assessment** addresses the degree to which a system experiences changing climate conditions. Depending on the scope determined in the framing step, this component considers various impact pathways, such as through the amount and timing of managed flows, water supply facilities, or changes in water quality. The goal is to identify those environmental conditions affected by climate change that are relevant and important for the outcome variables that you care about. Once you have identified the things you are managing for, then you want to assess the vulnerability of each, asking which changes in environmental conditions need to be considered?

**Sensitivity assessment** addresses the degree to which a system changes in response to changing climate conditions. A useful chain of questions to answer may be: How big is the projected change in climate or other forces? For each environmental condition considered, how much does the system change? How large is the initial impact, if we don’t implement any potential adaptive response? How close is our system to any threshold? Do we have any system buffers, such as water leasing arrangements?

For some system elements, qualitative assessments may be the only practical approach. In that case, it helps to consider how current problems are experienced, such as from weather extremes, and then logically track whether climate changes are likely to make these problems better or worse.

**Adaptive capacity assessment** addresses the degree to which a system component can adjust in response to changing climate conditions by asking, will adaptation occur automatically, or does it require some sort of intervention? For example, reservoir operation rule curves and continuous monitoring allow automatic adjustment to climate variation within pre-determined limits. But changing water pricing policies or developing new water supply sources require intervention. This component looks at the flexibility of current policies and practices, what jurisdictions control any decisions about changes (such as local, state, or federal), how much time would be needed to implement changes, and how often planning allows revisiting the process.

Putting all these steps together produces the vulnerability assessment. This often consists of qualitatively screening for situations where there is exposure, high sensitivity, and low adaptive capacity. These situations are what you focus on in the decision making phase – they are your priority planning areas.
It's important to remember that vulnerability will change over time as preparedness actions are implemented, as regulations change, and as the understanding about climate change and impacts evolves and is experienced.

**Vulnerability Assessment: A New Method of Water Resource Planning at Salt River Project**

Roosevelt Lake and Dam – one of the four reservoirs Salt River Project manages on the Salt River. *Photo: Salt River Project.*

The Salt River Project (SRP) manages a complex water supply system that includes reservoirs, groundwater pumping, and conveyance to deliver about 1 million acre-feet of water/year to the Phoenix metro area in the face of large climate variability. SRP has experienced a sustained drought, beginning in 1995, which is longer than the longest drought (1898-1904) they had considered in their planning. In the process of responding to this sustained drought, SRP realized that it was a good opportunity to also consider climate change adaptation. Their focus question was “What is the minimum annual inflow that allows SRP to maintain carryover storage in perpetuity?”, reflecting the importance of their reservoir system to provide water supply reliability during multi-year droughts. They considered the historical instrumental record (110 years), the tree-ring record (1000 years), and global climate model scenarios of future climate change.

A major finding, based on the tree-ring record, was that a key assumption about regional drought was incorrect. Past assumptions were that the Upper and Lower Colorado River Basin climates operated in opposite phase: when one was experiencing drought, the other would be experiencing surplus. The implication of this assumption was that the regional diversity would provide management flexibility. The tree-ring research showed this assumption was incorrect.
While storage in the large Colorado River Basin reservoirs (Lakes Mead and Powell) may provide a buffer to future climate stresses, Arizona droughts are unlikely to be offset by excess water from the Upper Colorado River Basin. Increasing water demands in the Upper Basin and climate warming may exacerbate a basin-wide drought. With this new information, SRP took a closer look at their local water sources.

Institutional knowledge at SRP developed during a time of extreme wetness that wasn’t acknowledged as being so unusual; from 1975-1995, flows were 25% greater than the long-term average. From the tree-ring record, they used an extreme dry period (1575-1585, which had 70% of long-term average flows), and found that the SRP reservoir system would have been completely drained under existing management plans. Under a revised simulated water allocation and pumping plan, the reservoirs went very low, but not completely dry. However, this simulation did not consider climate change.

A sensitivity analysis showed that as temperatures increase, SRP could be facing a 20-50% runoff reduction in the next several decades. Considering climate change and increased population, SRP will need to find additional supplies to maintain the same level of service. The sensitivity analysis also provided some idea of how much time SRP has to plan for those resources to be available. This lead time is an important concept because some options will take decades to put into place.

The Board of Directors has signed off on a proposed adaptive capacity analysis for SRP that would identify the timing and volume of additional supplies needed to meet customer demands and all other obligations, including regulatory requirements. The analysis will evaluate whether different management options can provide less than a 1% risk of not being able to meet their Sustainable Storage Target. If the risk is higher than 1%, SRP will need to develop additional water supplies.

SRP also identified future assessment needs, including more research on water demand, especially how to track, project, and affect it; the integration of piecewise water management into a comprehensive plan; and keeping an eye on climate change projections as the science evolves, especially changes in the essential messages, increases in spatial resolution, and effectiveness in modeling the summer monsoons.

The Bottom Line
Vulnerability assessment can be done at a variety of scales and levels of effort. SRP took about five years total to complete their assessment. The first phase took 4 people working ½ time for 3-4 months to complete, while a larger effort (6 people, ~1 year) was needed to develop the management plan in the second phase. However, the approach is amenable to whatever you
have to commit to the process, and drives home the benefit of addressing vulnerability assessments iteratively. You can start now and add to the analysis over time. If you are starting small, think through the qualitative assessment first, and then you can identify where quantitative analysis will be most helpful.

But the vulnerability assessment isn’t the end-all. It’s important to move to the next step. The vulnerability assessment provides the foundation for identifying your priority planning areas. Then, you have to keep moving and actually get something going on the ground to reduce your vulnerabilities. Just like in the assessment process, there are three ways to reduce your vulnerability: reduce exposure to climate change, reduce sensitivity to climate change, and increase adaptive capacity. Which combination of these approaches will be the best course of action for reducing your organization’s climate change vulnerability?

**Tools**

Guide Tool:
The whole guidebook is very helpful. Vulnerability assessments are covered in Chapter 8.

Data Tool:
**WEAP: Water Evaluation and Planning Tool.** This is a powerful tool, but requires $3000 for a 2-year license and some substantial learning time. Because of this, WEAP would be an ideal tool for a regional approach where utilities are working together, or for a larger utility. There are written tutorials, user manuals, and an online training program for the user community. It also allows modeling the water-energy nexus. [http://www.weap21.org/](http://www.weap21.org/)