Global Institute of Sustainability
Arizona State University

WaterSim: Supply and Demand Simulation Model for Metropolitan Phoenix

DCDC
Decision Center for a Desert City

Teacher's Guide to Using WaterSim on the Web

http://watersim.asu.edu

Introduction: WaterSim on the Web

The Decision Center for a Desert City has created WaterSim on the Web, an interactive tool that brings science to the general public. It allows you to explore future water scenarios for metropolitan Phoenix in an easy-to-understand format. With Water Sim at your command, you can gauge water availability in response to changes in climate conditions, drought, population growth, urbanization, land use, and technological innovation, as well as test various policy decisions.

The lesson outlined here was developed for use in AP or introductory college-level Geography or Environmental Science classes. Students are encouraged to explore different scenarios using the WaterSim Scenario Builder where they can compare, side-by-side, two different scenarios. WaterSim also includes historical and geographical background on water supply and demand in the Phoenix metropolitan area. All these features on WaterSim provide one location for students to learn about the complexity of decisions facing water providers here in the Phoenix area, especially as we look to the future and possible climate changes in the Southwest.

Lesson Objectives

Upon completion of this lesson, students will be able to:

- Explain where the Phoenix Metropolitan area gets its water supply and how it is currently used.
- Compare best, moderate, and worst case scenarios for water supply and demand in the Phoenix Metropolitan area
- Assess the relationship between regional climate variation and water supply
- Assess the relationship between population growth and water demand
- Assess the relationship between land use and water demand
- Assess the impact of water shortage policies upon water demand
- Explain how the county could plan to conserve water resources

Background Information

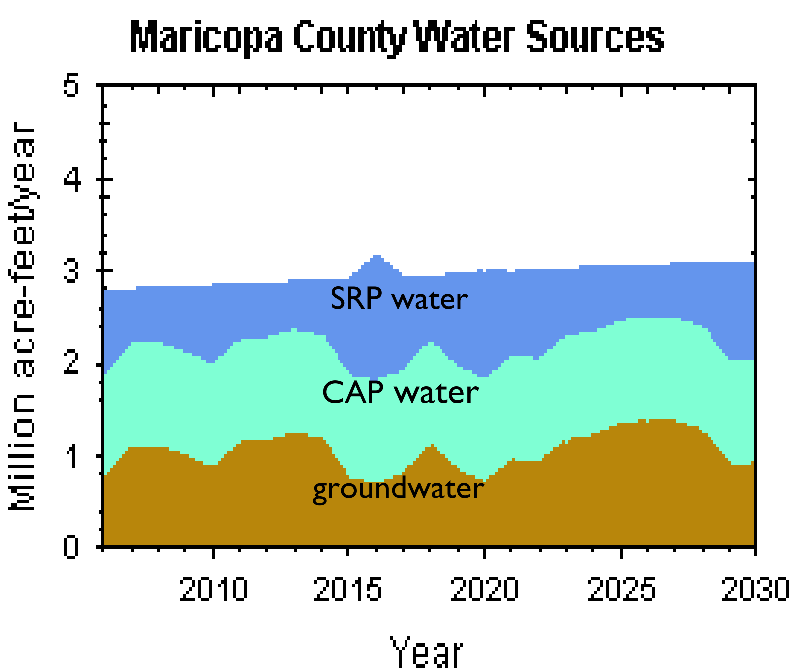
WaterSim on the web can be found at: http://watersim.asu.edu/

WaterSim is a computer simulation of water supply and demand for the Phoenix Metropolitan area that integrates information about climate, land use, population growth, and water policy. WaterSim contains multiple submodels; these submodels work together to simulate the future of our water. Some of the submodels, like the Colorado River shortage sharing agreement, are unchangeable because of legal or natural constraints. You and your students will be adjusting other submodels to see what effect they have on water supply and demand.

This first page includes a map of the major rivers and their watersheds that supply the Phoenix metropolitan area with water. Also included on the map is the Central Arizona Project canal which brings Colorado River water to Phoenix. Other background information on the Colorado River and the Salt and Verde Rivers can be found at this link: http://watersim.asu.edu/WaterSimBackground.aspx

At the bottom of this page, students can choose to select several options. We recommend having the students begin with the WaterSim Tutorial as this gives a good overview of the program. This lesson will focus on using the WaterSim Scenario Builder.

Note: unfamiliar terms used on this web site are underlined with blue dots—a question mark followed by a definition will appear if you hold your mouse over the underlined area.



Example of a graph showing the total amount of water from various water sources to Maricopa County

WaterSim on the Web: Student Handout—Teacher Version

The following pages include the text from the student handout. A separate PDF for the students can be found at: http://

WaterSim is a simulation of water supply and demand for the Phoenix Metropolitan Area that integrates information about climate, land use, population growth, and water policy. You will be using this simulation to learn about future water supply conditions in response to climate change, drought, population growth, and land use. You will be able to see what effect various water policy decisions might have on the Phoenix area water supply and water use.

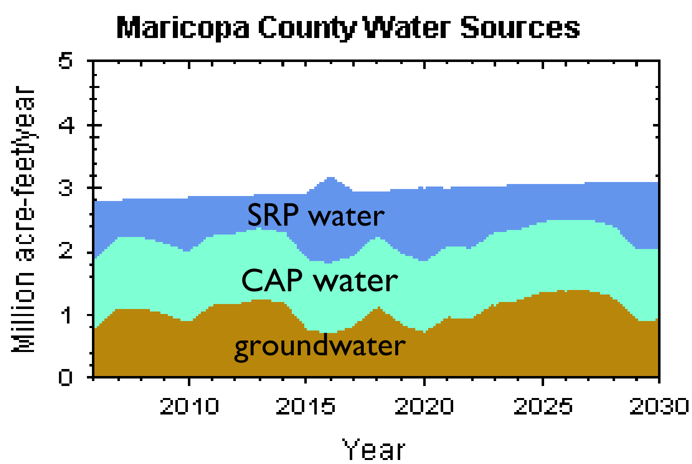
Note: unfamiliar terms used on this web site are underlined with blue dots—a question mark followed by a definition will appear if you hold your mouse over the underlined area.

Water Supply

1. Go to http://watersim.asu.edu/. After reading the introductory material and going through the tutorial at the link, click on **WaterSim Explorer**.

The first chart that appears on the WaterSim Explorer webpage represents water sources for the Phoenix Metropolitan area projected to the year 2030. *Click on the chart to obtain more information.*

Notice that there are three major water sources for the region: Salt River Project (SRP) surface water represented in blue, Central Arizona Project (CAP) surface water in turquoise, and groundwater in brown.



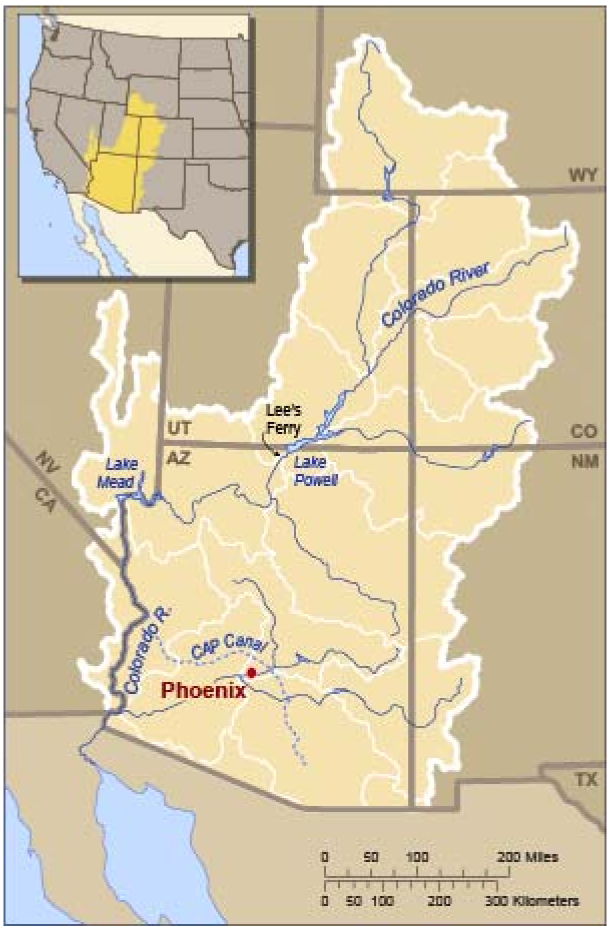
Question:

1. Groundwater is water that lies below the surface of the earth. In many cases this water has been undisturbed for thousands of years. Why are some scientists and policy makers concerned about overuse ("overdraft") of groundwater?

Water Supply cont'd.

Salt River Project water represents surface runoff from the Salt and Verde River watersheds (map on right). These watersheds, located in the central highland region of Arizona where some elevations exceed 10,000 feet, are larger than the states of Connecticut and Massachusetts combined.

Central Arizona Project (CAP) water represents surface runoff from the Colorado River watershed. This water, originating as Rocky Mountain snowfall, is shared by seven U.S. states plus Mexico. It is transported to Phoenix and Tucson via the 336 mile-long CAP canal (map on left).

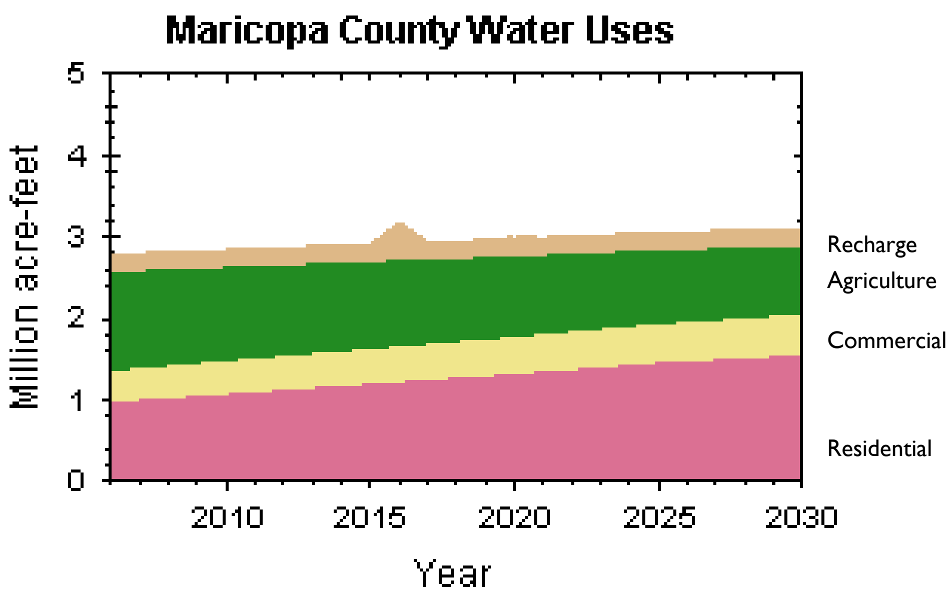


Colorado River Watershed: showing CAP canal

Salt-Verde Watersheds: source of SRP water

Water Demand

The second chart on the WaterSim website represents projected water demand for various uses in Maricopa County to the year 2030. *Click on the chart to view additional information.*



Questions

2. Notice that residential and commercial water use (represented in pink and yellow, respectively) are projected to increase steadily. Why?

3. Would you expect all types of development to consume an equal quantity of water? If not, describe characteristics that might influence the quantity of water consumed.

4. Agricultural water use in Maricopa County (represented in green on the graph) is projected to decline. Why? Major crops grown in the area include cotton and alfalfa. In an effort to reduce water demand, should agricultural land use be restricted? Why or why not?

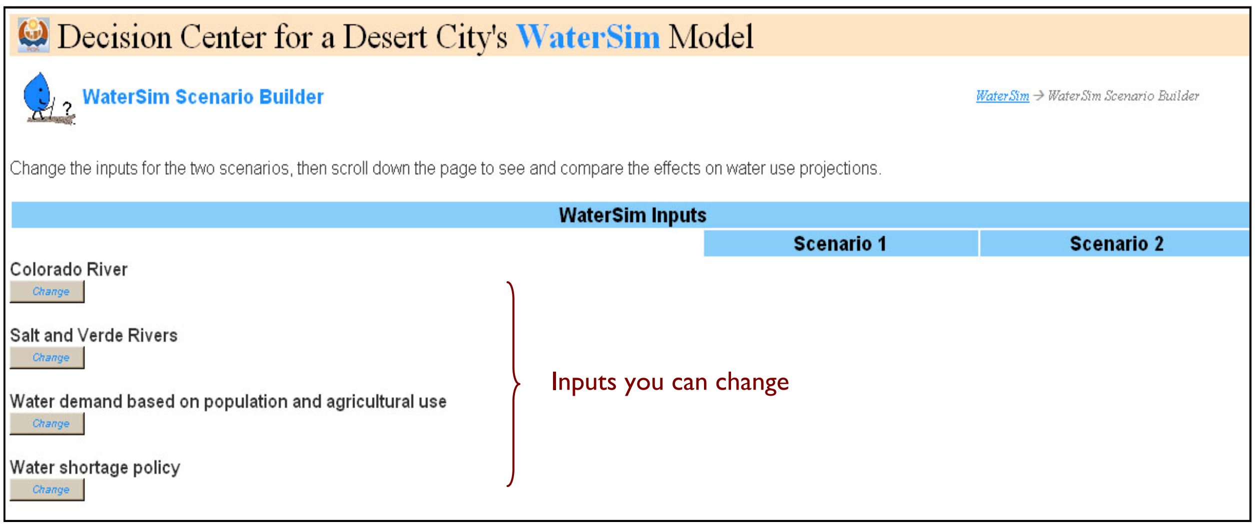
5. Recharge (represented in brown) is water that is pumped into aquifers below ground to be stored for future use. Why is this considered to be a "water demand"?

WaterSim Scenario Builder Inputs

Now that you have some familiarity with water supply and demand in the Phoenix metropolitan area, let's experiment with some water scenarios.

Return to http://watersim.asu.edu/ and scroll down to **WaterSim Scenario Builder**. This tool allows you to create and compare water scenarios for Maricopa County. We will select hypothetical population growth rates, climate trends, and policy decisions, then compare water supply and demand results in side-by-side displays.

- Click on **WaterSim Scenario Builder**. On the left side of the page are 4 inputs that you can adjust.
- Click on "Change" under the Colorado River heading. Two scenarios are now visible on the right side of the page.
- For Scenario 1 let's simulate average conditions, while Scenario 2 will simulate a drought. Enter the values from the table below to the WaterSim Inputs for the Colorado River.



Colorado River Inputs	Scenario 1 – Average	Scenario 2 - Drought
Start of the Colorado River historical flow record to use to project future flows in the basin	1970	1970
Simulated runoff conditions for the Colorado River as a percent of normal runoff	100%	60%
Start year for simulated runoff conditions for the Colorado River	Now	Now
Duration of simulated runoff conditions for the Colorado River in years	15	15

Questions: (answers in bold)

6. Look at the graph entitled "Colorado River Flow Through Lee's Ferry". Notice that Scenario 2 flows (representing drought conditions) are significantly lower than Scenario 1. How might lower flows affect plants and animals along the Colorado River? Be specific in your response.

7. Look at the Scenario 2 graph entitled "Colorado River Total Storage". Under drought conditions, total storage reaches a low of approximately 5 million acre-feet of water in 2014 (an acre-foot is the volume of water that will cover an acre to a depth of one foot – approximately 325,000 gallons).

a. What percent of total storage capacity in Lake Powell and Lake Mead is reached in 2014? **(10%)**

b. Discuss the impact of drought upon recreation (such as boating) in Colorado River lakes.

c. Both the dams that create Lakes Powell and Mead also generate hydroelectric power. Discuss the impact that drought might have upon power generation from these dams.

Now let's select variables for the Salt & Verde Rivers.

- Click on "Change" under the Salt & Verde River heading. Once again, two scenarios are visible on the right side of the page.
- Scenario 1 will again simulate normal conditions, while Scenario 2 will simulate a drought. Enter the highlighted values from the table below into the WaterSim Inputs.

Salt & Verde Inputs	Scenario 1 – Average	Scenario 2 - Drought
Start of the Salt & Verde Rivers historical flow record to use to project future flows in these basins	**1970**	**1970**
Simulated runoff conditions for the Salt & Verde Rivers as a percent of normal runoff	**100%**	**60%**
Start year for simulated runoff conditions for the Salt & Verde Rivers	**Now**	**Now**
Duration of simulated runoff conditions for the Salt & Verde Rivers in years	**15**	**15**
Climate Scenario for the Salt & Verde Rivers	**Average Scenario**	**Most Pessimistic Scenario**

Notice that Salt-Verde River annual runoff declines significantly in the drought scenario. Similarly, Salt-Verde River System Storage falls significantly below capacity.

Finally let's look at the effect of *Population* and *Agricultural* variables upon our scenarios.

- Click on "Change" under the "Water demand based on population and agricultural use" heading.
- Enter the highlighted values from the table below into the WaterSim Inputs.

Population & Agriculture Inputs	Scenario 1 – Average	Scenario 2 - Drought
Adjustment to model's use of the Department of Economic Security's projected population growth	**As Projected**	**Double Projected Growth**
Year in which the last of the agricultural land in the metropolitan area is projected to be converted to another use	**2070**	**2070**

Questions: (answers in bold)

8. A Maricopa County Population graph displays the Department of Economic Security population projection as a red line. Population is represented by a light beige color.

a. According to the graph, what is the current county population? (**~ 4 mill.**)

b. In Scenario 1 (average conditions), what is the 2030 projected population? (**6 mill.**)

c. In Scenario 2 (double projected growth), what is the 2030 population (light beige color)? (**>10 mill**)

The last variable to be defined is **Water Shortage Policy**. Policymakers must make decisions in the event that there is insufficient water supply to meet demand. In this scenario, policy options include:

- restricting use of groundwater through laws prohibiting overdraft
- satisfying demand through unrestricted pumping of groundwater
- placing limits on the maximum number of gallons of water used (per capita daily)
- restricting agricultural water use during times of shortage

Set the policy for both Scenario 1 (average) and Scenario 2 (drought) to "**Satisfy Demand**".

WaterSim Scenario Builder Outputs

Now let's look at the Scenario 1 (average) and Scenario 2 (drought with double population growth rate) results based on our inputs to the model. Scroll down to WaterSim outputs.

Questions: (answers in bold)

9. Between the average- and worst-case scenarios, what is the difference in total water use (not counting recharge) by the year 2030 ("Maricopa County Water Uses"graph)? **(1.3 to 1.5 maf)**

10. Which group accounts for the majority of this increase? **(residential)**

11. What is/are the primary source(s) of water for Maricopa County in the average-case scenario? **(groundwater and Central Arizona Project (CAP))**

12. What is/are the primary source(s) of water in the worst-case scenario? **(groundwater by far)**

13. How much groundwater would be pumped from the ground in 2025 in both the average- and worst-case scenarios? **(average – 1.4 to 1.6 maf, worst – ~3.6 maf)**

14. By the year 2030, what is the difference in the groundwater deficit between the average- and worst-case scenarios? **(30 to 40 maf)**

15. The Arizona Groundwater Management Code specifies that the Phoenix Active Management Area (AMA) achieve "safe yield" of groundwater by 2025, where "safe-yield is defined as a long-term balance between the annual amount of groundwater withdrawn in the AMA and the annual amount of natural and artificial recharge." Under this law, groundwater could only be used sustainably. Under Water Shortage Policy, change the Water Policy to "**No groundwater overdraft**" with the Year to implement policy left at **2025**, keep "**proportional shortage sharing**" What happens? (see Fig. 2) **(the county would face a massive water shortage)**

16. What is the effect upon agriculture in the two scenarios when "**Agriculture loses water first**" is selected as a water shortage policy? Try it!

17. How might an "**Agriculture loses water first**" policy affect the daily lives of Maricopa County residents, including you?

18. Now, under Water Shortage Policy, change the Water Policy to "Fixed residential GPCD". Restrict gallons per capita per day (GPCD) to 200 gallons (residential) and 225 gallons (total) beginning in 2015.

a. What happens to Maricopa County water uses in 2015 in Scenario 1? Why?

b. What happens to water uses after 2015 in Scenario 2? Why?

c. Look at the change in groundwater supply. The brown color represents a decrease in groundwater in millions of acre-feet. Is the groundwater supply sustainable (no overdraft) under the conditions we have selected?

e. What recommendations do you have for reducing gallons of water per capita per day used in Maricopa County?

19. Which water shortage policy is:

a. most effective in preserving groundwater?

b. least effective in preserving groundwater?

New Scenario: Comparing average vs best

Although all of the climate change scenarios suggest that we will have higher temperatures here in the Southwest, one or two of the models do predict slightly higher precipitation. So go ahead and see what happens with a "best" scenario. Leave Scenario 1 as "average" and change Scenario 2 as follows:

Colorado River Inputs	Scenario 1 – Average	Scenario 2 - Best
Start of the Colorado River historical flow record to use to project future flows in the basin	**1970**	**1970**
Simulated runoff conditions for the Colorado River as a percent of normal runoff	**100%**	**130%**
Start year for simulated runoff conditions for the Colorado River	**Now**	**Now**
Duration of simulated runoff conditions for the Colorado River in years	**15**	**15**

Salt & Verde Rivers Inputs	Scenario 1 – Average	Scenario 2 - Best
Start of the Salt & Verde Rivers historical flow record to use to project future flows in these basins	**1970**	**1970**
Simulated runoff conditions for the Salt & Verde Rivers as a percent of normal runoff	**100%**	**130%**
Start year for simulated runoff conditions for the Salt & Verde Rivers	**Now**	**Now**
Duration of simulated runoff conditions for the Salt & Verde Rivers in years	**15**	**15**
Climate Scenario for the Salt & Verde Rivers	**Average Scenario**	**Most Optimistic Scenario**

Other Inputs	Scenario 1 – Average	Scenario 2 - Best
Adjustment to model's use of the Department of Economic Security's projected population growth	**As Projected**	**Half of Projected Growth**
Year in which the last of the agricultural land in the metropolitan area is projected to be converted to another use	**2070**	**2070**
Water Shortage Policy	**Satisfy Demand**	**Satisfy Demand**

Questions: (Answers in Bold)

20. How did storage for the Colorado and Salt and Verde Rivers systems change between the best and average-case scenarios (second graph under "Colorado River" section and second graph under "Salt and Verde Rivers" section, respectively, down the page on the right)? **(much more storage, the Colorado River storage is even above capacity between 2020 and 2025)**

21. How many more million acre feet are available in storage for the Colorado River system in 2015 between the best- and average-case scenarios? **(~ 15 maf)**

22. How many more million acre feet are available in storage for the Salt/Verde system in 2015 between the best- and average-case scenarios? **(0.1 to 0.3 maf)**

23. Generally, water managers for the Salt River project (which manages the Salt-Verde river reservoirs) are more interested in winter precipitation than summer precipitation. In terms of the water cycle, why does winter precipitation lead to more runoff than summer precipitation? (**(Winter ppt. results in increased runoff due to the ground being saturated and snowmelt being a slower process— not so with summer rain due to high rates of evaporation and evapotranspiration.)**

24. Scroll to the graphs at the bottom of the page. When there is more water available to Maricopa County from the Colorado and Salt and Verde Rivers systems, what happens to that water? **(used to recharge groundwater)**

25. What is the difference in overdraft of groundwater ("Change in Groundwater Supply" graphs) between the two scenarios by 2030? **(14 to 16 maf)**

26. If you switch the policy to "no groundwater overdraft" and "agriculture loses water first" What happens to agriculture in the two scenarios? (**no ag after 2025 in normal, ag persists in best**)

27. Which of these three scenarios (best, average, worst), if any, do you think will eventually require consumers to ration their water use? Why?

Conclusions:

Are you likely to alter your personal water consumption based upon what you have learned from this exercise? Why or why not? Please explain your response in some detail.

Acknowledgements:

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