FREE WATER

An analysis of potential impacts of large-scale residential rainwater harvesting

College of Architecture, Planning & Landscape Architecture
THE UNIVERSITY OF ARIZONA GRADUATE COLLEGE
Peace Corps Coverdell Fellows
Watershed Management Group

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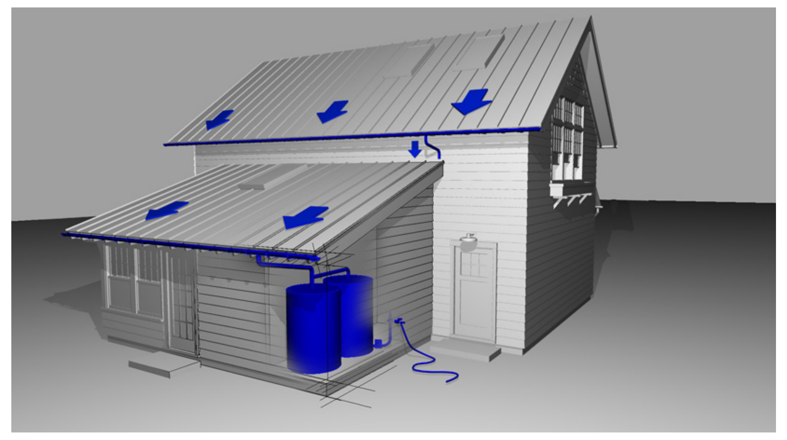
Master of Landscape Architecture '22

Special thanks to:
Dr. Philip Stoker, CAPLA & Lisa Shipek, Watershed Managment

INTRODUCTION

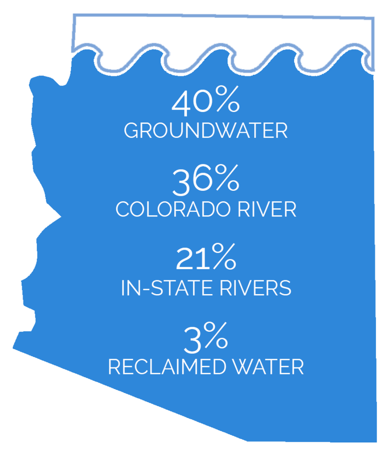
The following document will attempt to calculate the potential impacts of residential rainwater harvesting if implemented across the Tucson city limits. As this precious renewable resource becomes ever more precarious, this study aims at providing a case that municipal programs aimed at making rainwater harvesting accessible to all Tucsonans is environmentally, socially, and economically viable.



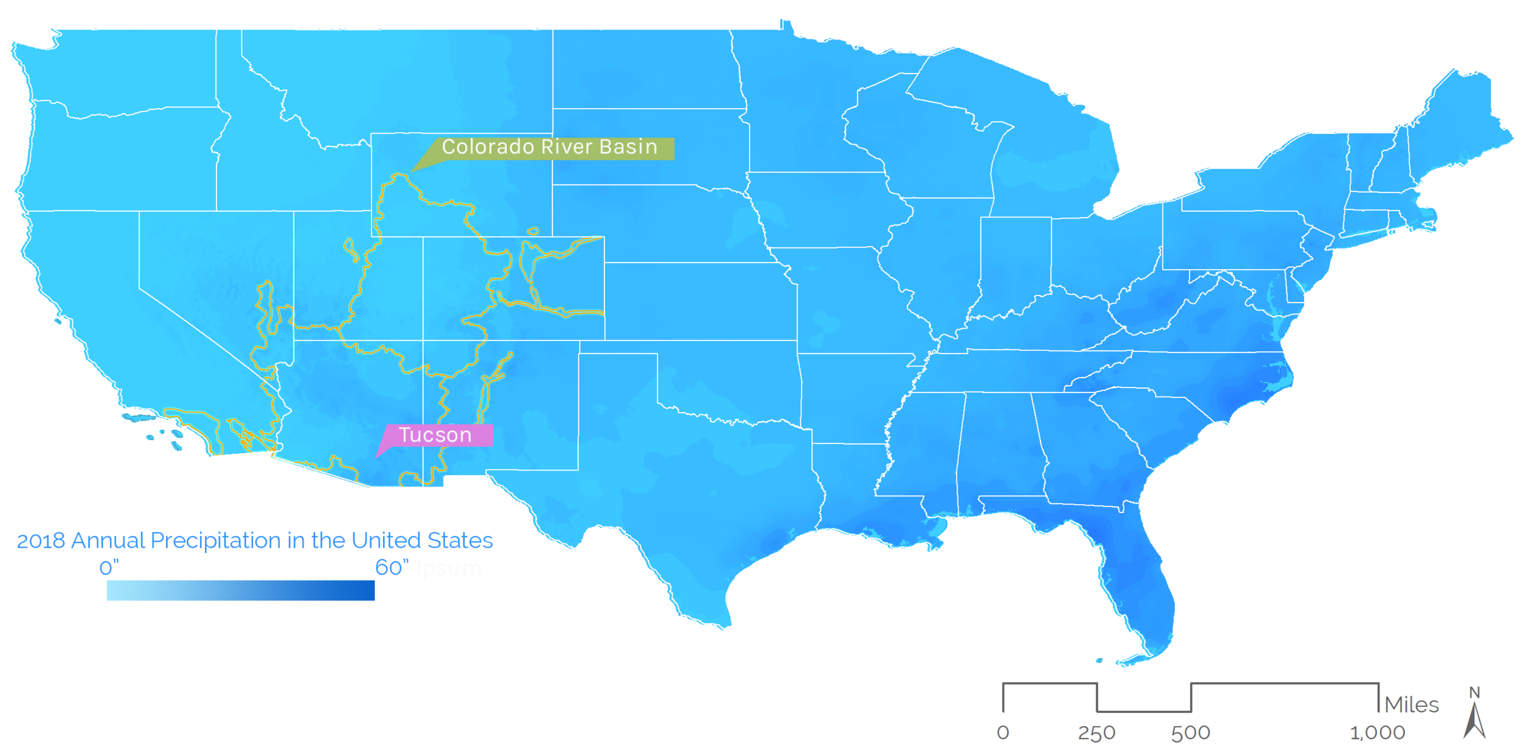
AN EXAMPLE OF A RESIDENTIAL RAINWATER HARVESTING SYSTEM

REVIEW OF WATER SOURCES

The majority of Arizona's water is sourced from underground aquifers. The State of Arizona estimates 2.8-million acre-feet of water is pumped annually. Because the recharge of groundwater can take many tens to hundreds of years, Arizonans are now more conscious of this dwindling resource. As climate models predict Arizona's weather to increase in heat and drought, state officials have begun to preemptively store unused portions of the Colorado River water. Currently, the Arizona Water Banking Authority estimates the state has stored over 3 trillion gallons of water, enough to supply the city of Phoenix for 30 years.



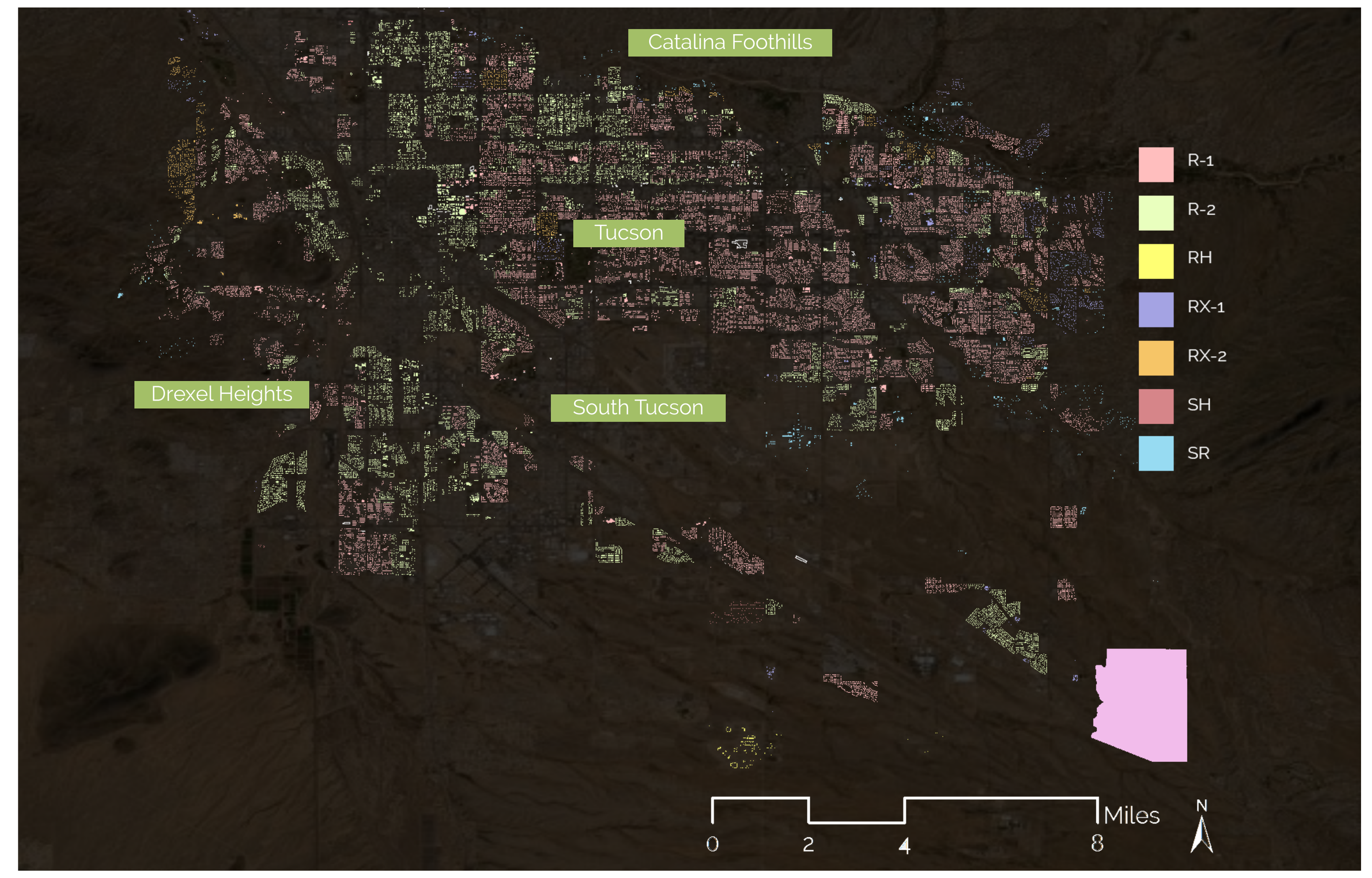
KEY SOURCES OF ARIZONA'S WATER



The Colorado River is Arizona's second largest water source. The Colorado River Compact of 1922 allocated 50% of the river's water to both the Upper and Lower Colorado Basins.

Arizona initially refused the compact due to fears of California receiving the majority of the Lower Colorado Basin's allotment. In 1944, Arizona would increase their allotment to 2.8-million acre feet under the condition that California's allotment of 4.4-million acre feet allocation was prioritized during years with drought.

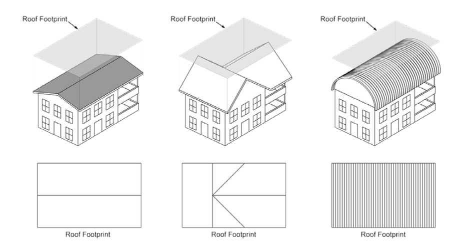
Today, between 36 and 40 million people in the United States are reliant upon the flow of the Colorado.



SINGLE-FAMILY HOMES LOCATED WITH TUCSON CITY LIMITS

METHODOLOGY

For this study, we isolated 119,859 building footprints within low-medium density zoning, calculated the area of the roofs, and multiplied the total area by the total amount of annual rainfall in Tucson.



7,472 ACRES
TOTAL AREA
X
0.99 FEET
ANNUAL RAINFALL
=
7,472 ACRE FEET
RAINWATER HARVESTED

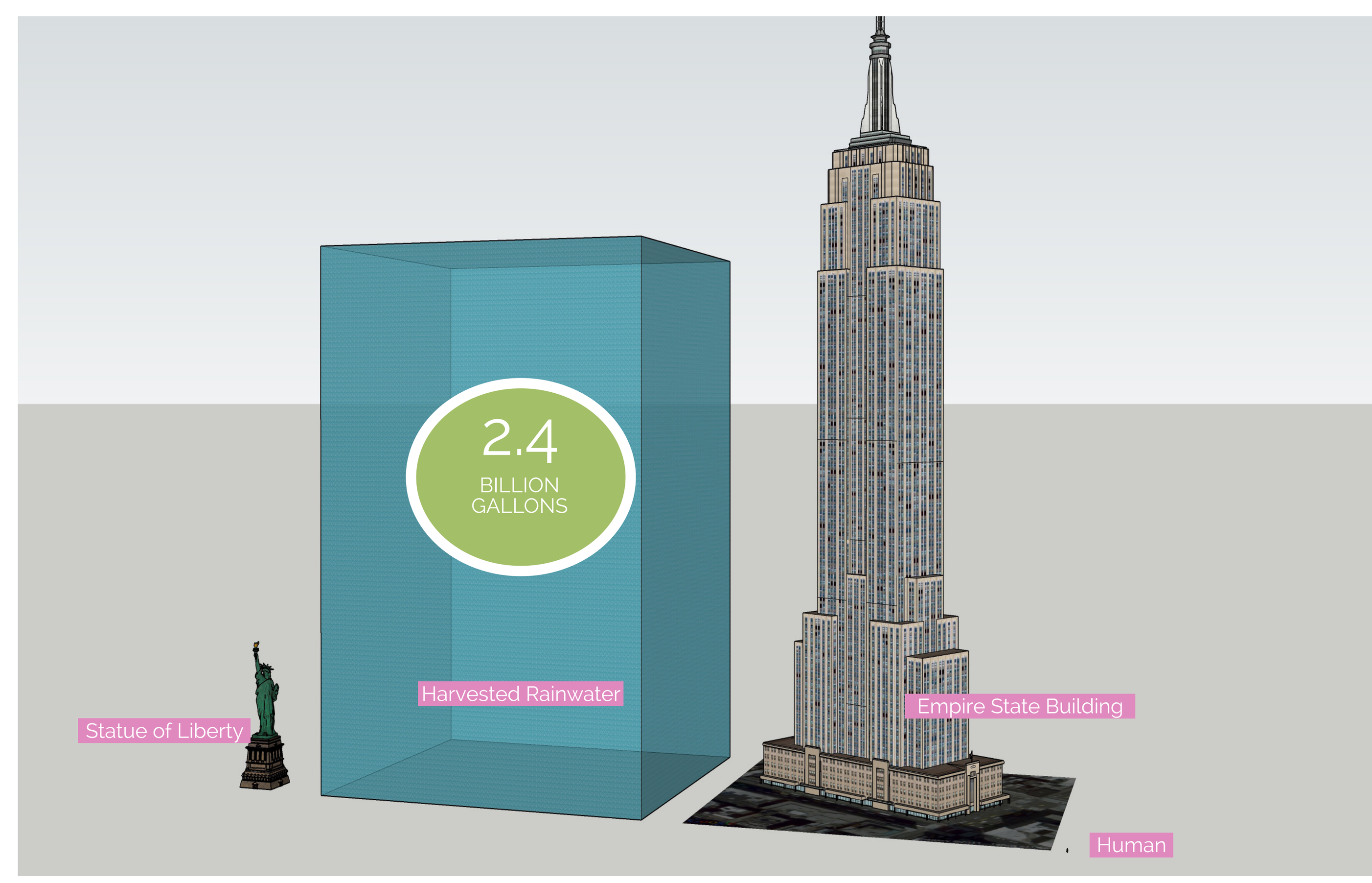
RESULTS

It is difficult to imagine the size of 2.4-billion gallons of water. If the Empire State Building was completely empty, it would not be able to store the amount of rainwater harvested.

A family of three in Tucson uses approximately 112 gallons of water per day. This amount of water could provide 58,188 families a year supply of water.

325
MILLION CUBIC FEET

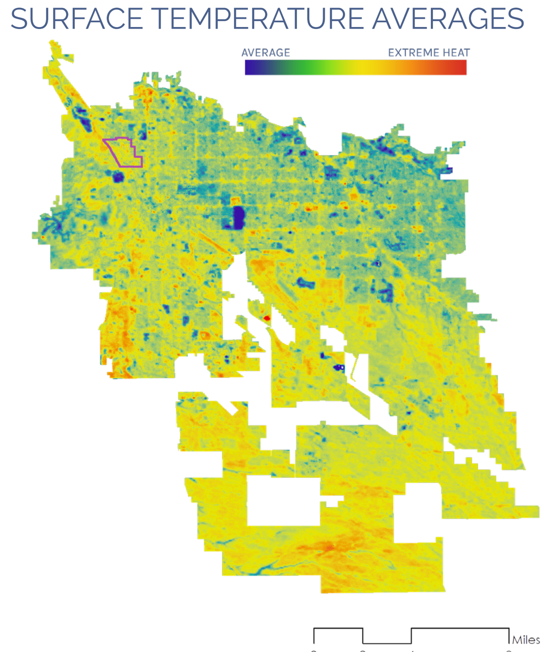
5.5%
OF TUCSON'S ANNUAL COLORADO RIVER WATER



APPLICATION

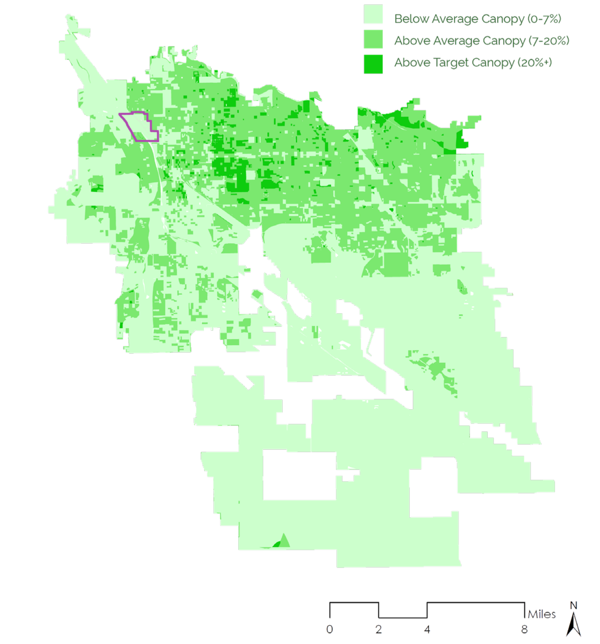
There is a link between poverty, health, and urban heat island effect.[1,2,3] People that live below the median income in Tucson are more likely to live in a neighborhood with low tree canopy and higher surface temperatures. These factors have a wide variety of effects such as worsening health outcomes, lack of exercise, and overall discomfort.

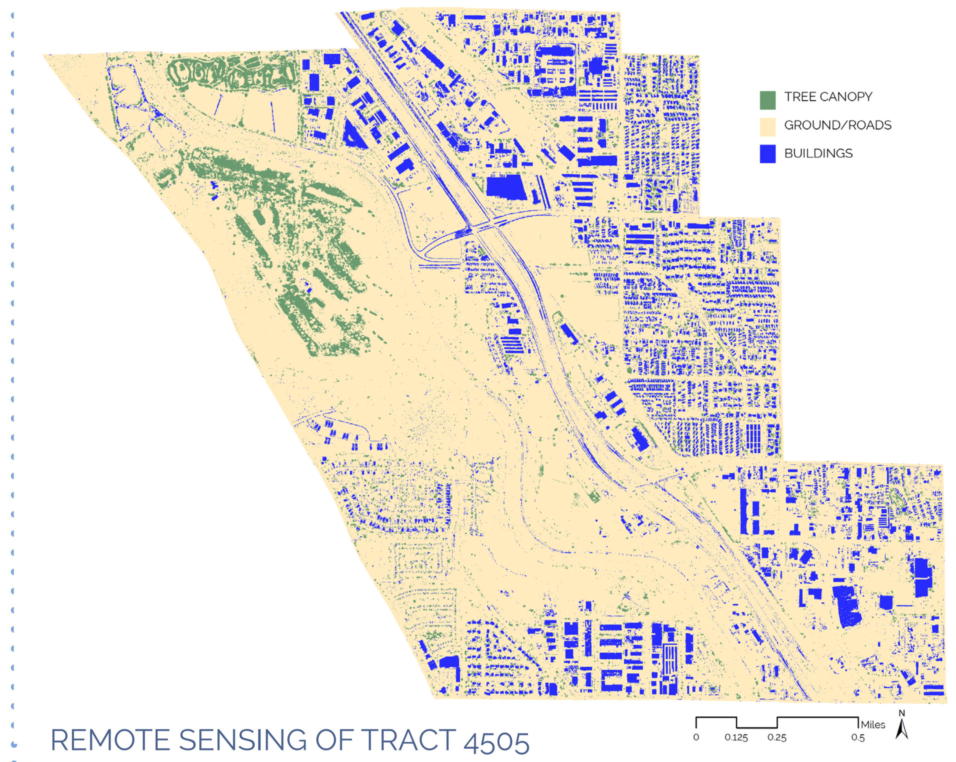
SURFACE TEMPERATURE AVERAGES



For further analysis, surface heat temperature and tree canopy were analyzed in order to locate a census tract that had below average tree canopy (0-7%) and above average surface temperature. CENSUS TRACT 4505, located in the Flowing Wells neighborhood, was selected.

TREE CANOPY COVER





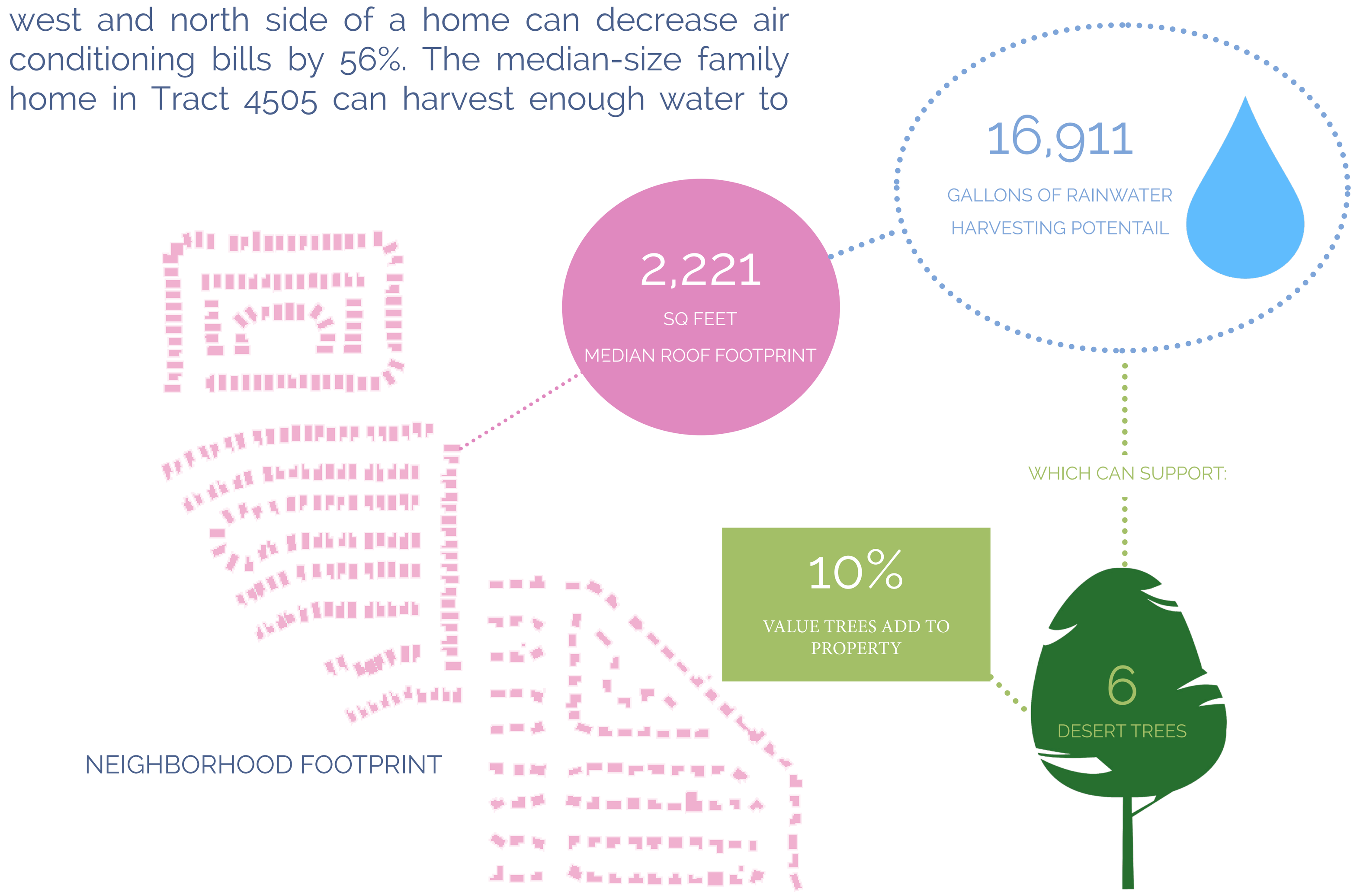
REMOTE SENSING OF TRACT 4505

With remote sensing imagery, it is easy for us to determine the amount of tree canopy in an area. Within Tract 4505, a golf course provides most of the tree canopy. The canopy remarkably decreases near residential development, sparking concern for aging residents, those with underlying health conditions, and the very young.

Without any nearby public parks, the residents of Tract 4505 have little opportunity to enjoy spending time outside during the hot summer months.

IMPACTS

At the neighborhood scale, it is clear what immediate impact could be made. Well-placed trees on the west and north side of a home can decrease air conditioning bills by 56%. The median-size family home in Tract 4505 can harvest enough water to



NEIGHBORHOOD FOOTPRINT

CONCLUSION

With simple area and volume calculations, it is apparent each single-family home in Tucson carries the potential to harvest thousands of gallons of water per year.

As the scientific community continues to produce research that confirms the relationships between health, urban heat island,, and tree canopy, further research is required to fully realize the economic value of rainwater harvesting and tree canopy in arid climates.

The City of Tucson's One Million Trees Initiative to increase tree canopy should consider incorporating a residential rainwater harvesting programs in order to meet this goal. If all harvested rainwater was used for the planting of native trees, Tucson could sustain 850,00 new trees on residential properties alone.

*Please see REPORT for METADATA and DATA ACKNOWLEDGMENTS.

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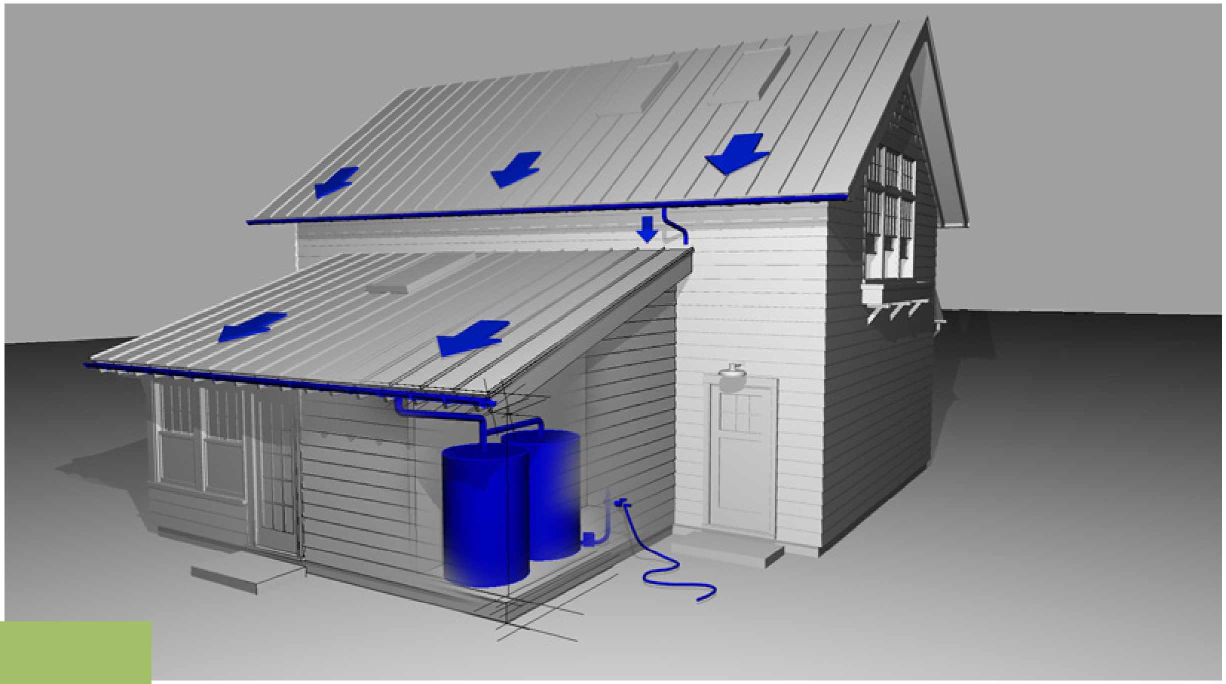
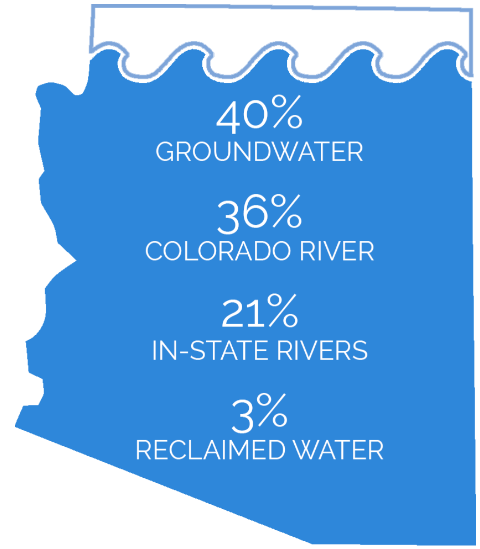


An example of a residential rainwater harvesting system

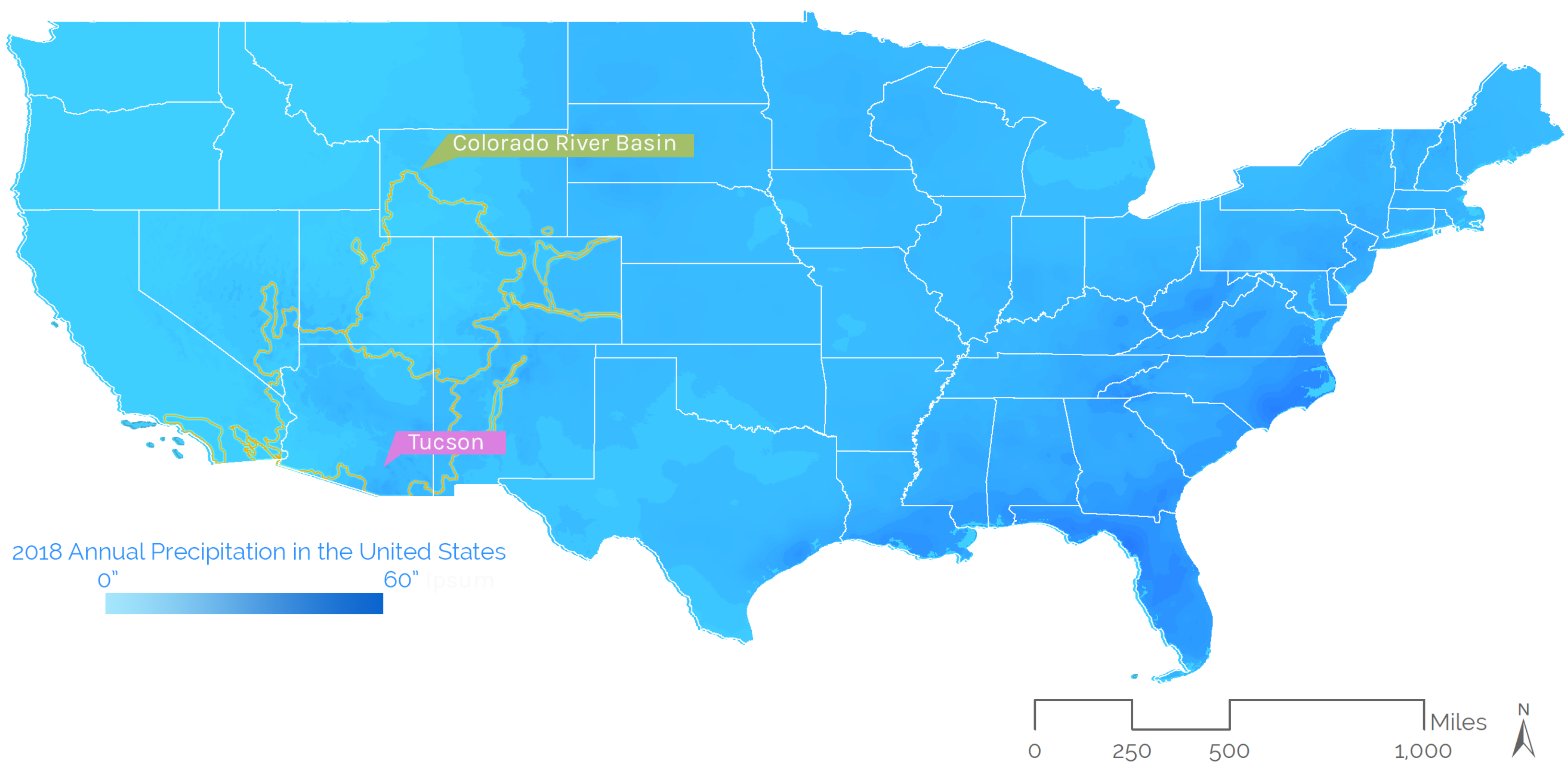
CONTENTS:

WHERE DOES ARIZONA'S **WATER** COME FROM?

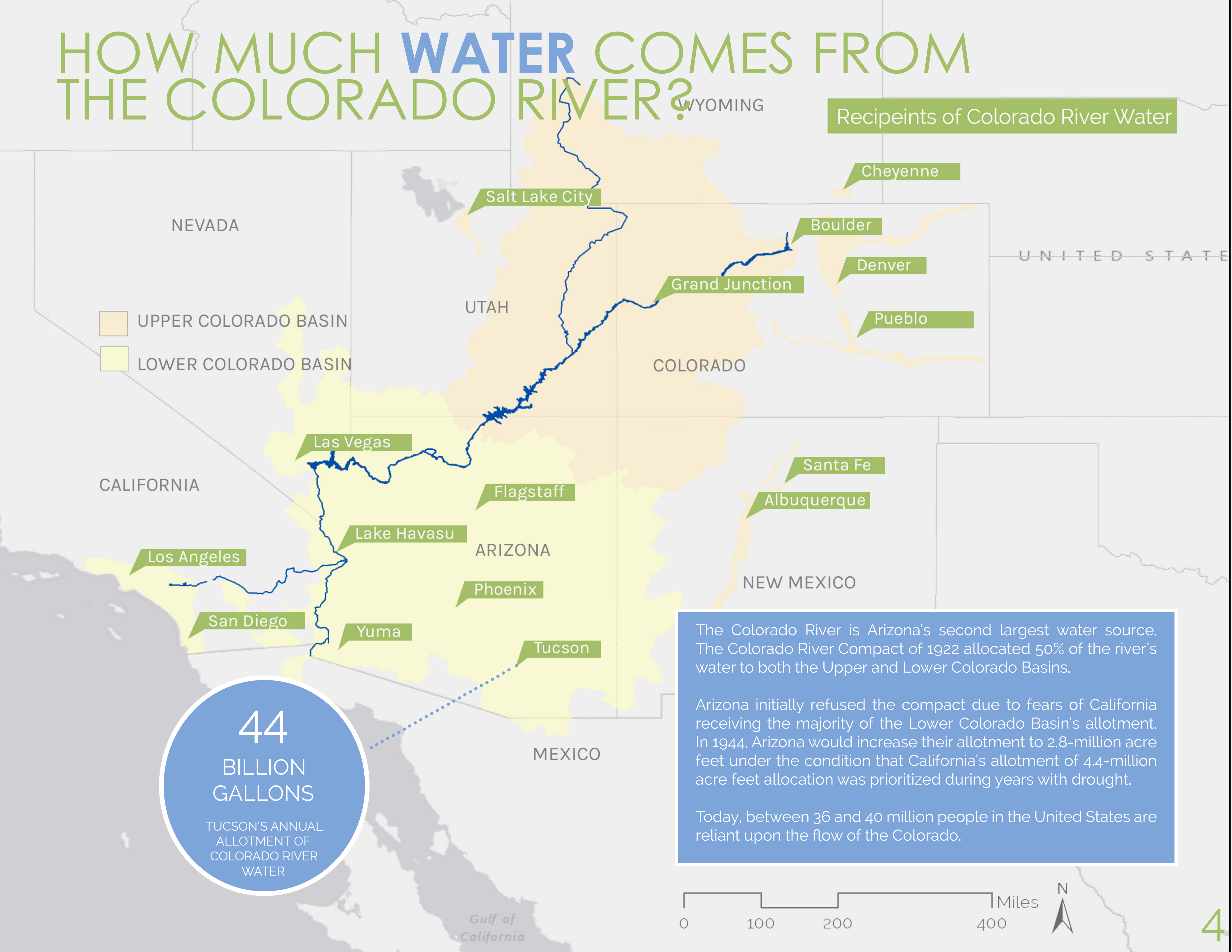
The majority of Arizona's water is sourced from underground aquifers. The State of Arizona estimates 2.8-million acre-feet of water is pumped annually. Because the recharge of groundwater can take many tens to hundreds of years, Arizonans are now more conscious of this dwindling resource. As climate models predict Arizona's weather to increase in heat and drought, state officials have begun to preemptively store unused portions of the Colorado River water. Currently, the Arizona Water Banking Authority estimates the state has stored over 3 trillion gallons of water, enough to supply the city of Phoenix for 30 years.



Key Sources of Arizona's Water Suppy



HOW MUCH **WATER** COMES FROM THE COLORADO RIVER?



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HOW MUCH **WATER** CAN BE HARVESTED ANNUALLY?

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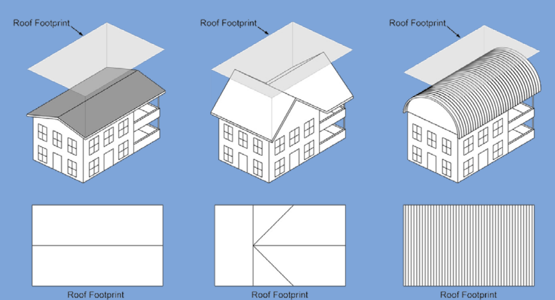

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HOW MUCH **WATER** IS THAT?

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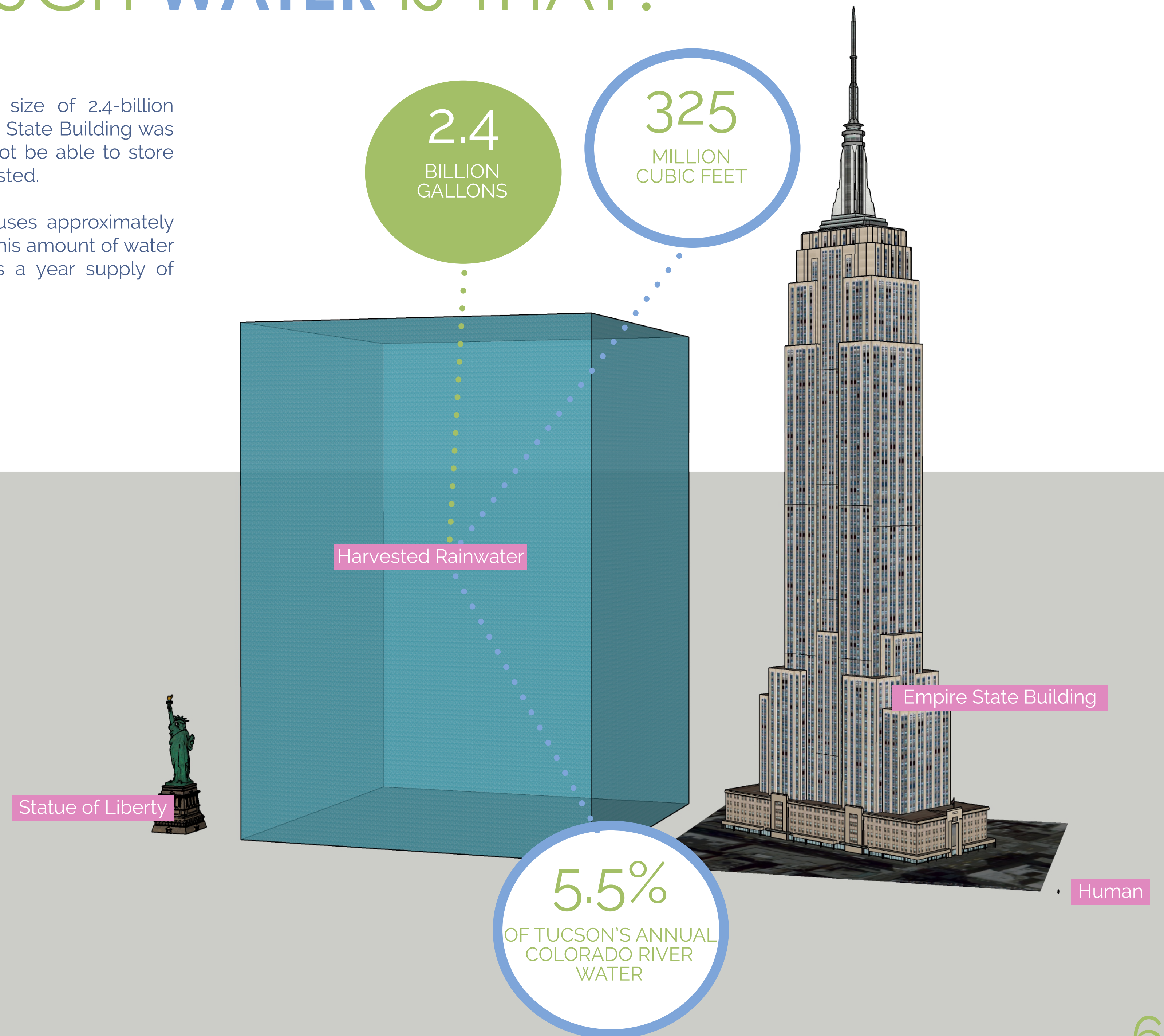

WHO WOULD BENEFIT FROM **WATER** HARVESTING?

There is a link between poverty, health, and urban heat island effect.[1,2,3] People that live below the median income in Tucson are more likely to live in a neighborhood with low tree canopy and higher surface temperatures. These factors have a wide variety of effects such as worsening health outcomes, lack of exercise, and overall discomfort.

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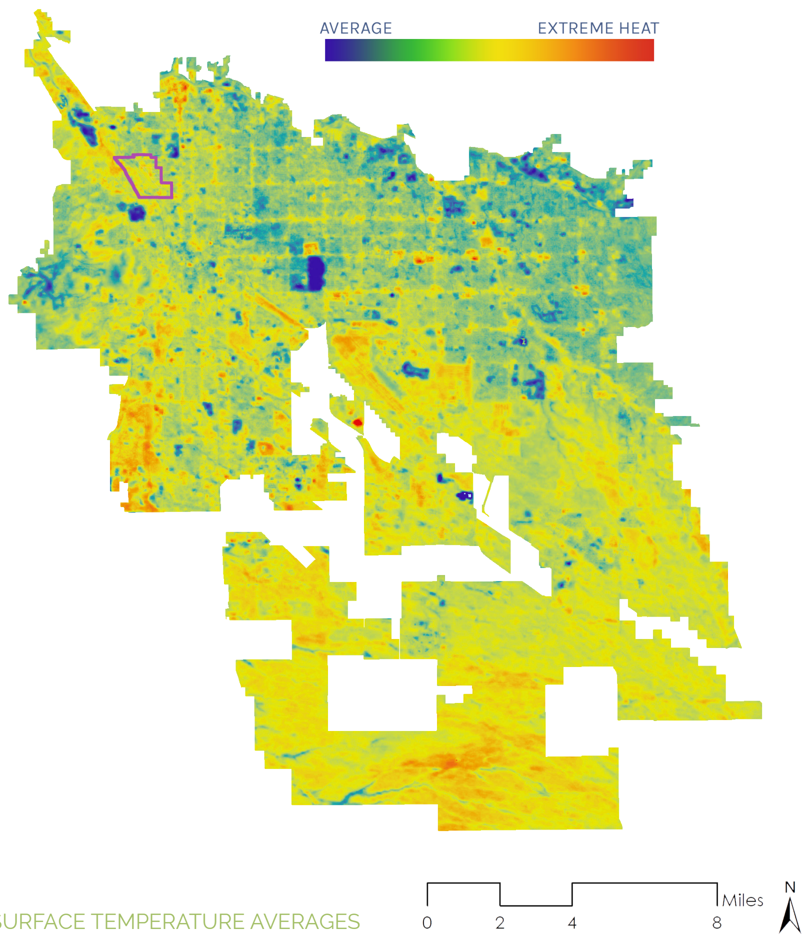
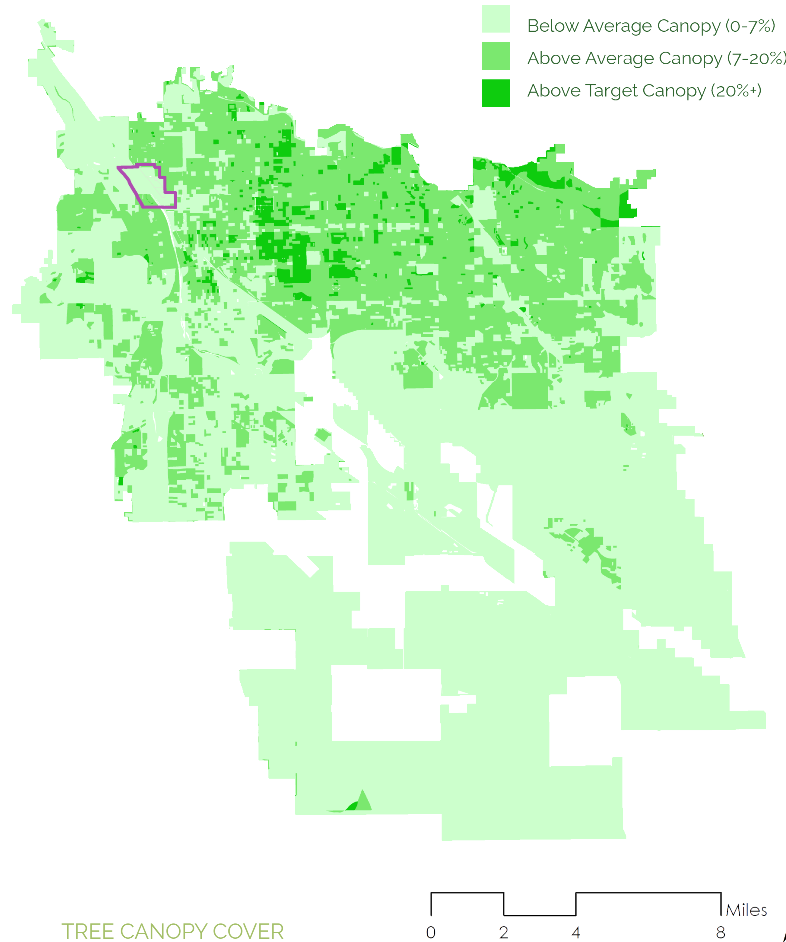


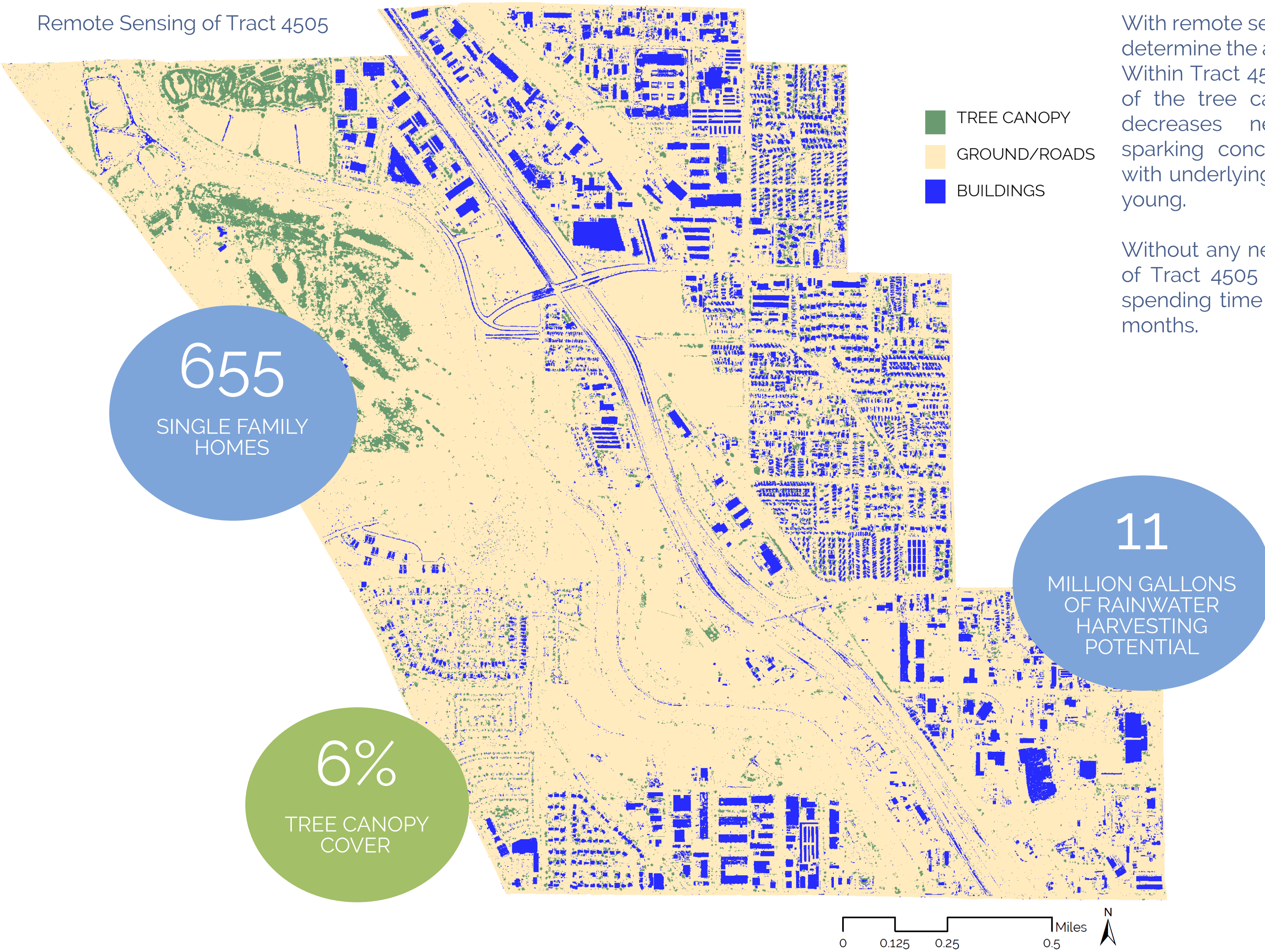
SURFACE TEMPERATURE AVERAGES



TREE CANOPY COVER

A CLOSER LOOK AT **TRACT 4505**

Remote Sensing of Tract 4505



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IMPACT ON **TREE CANOPY**

At the neighborhood scale, it is clear what immediate impact could be made. Well-placed trees on the west and north side of a home can decrease air conditioning bills by 56%. The median-size family home in Tract 4505 can harvest enough water to support the planting of six trees.

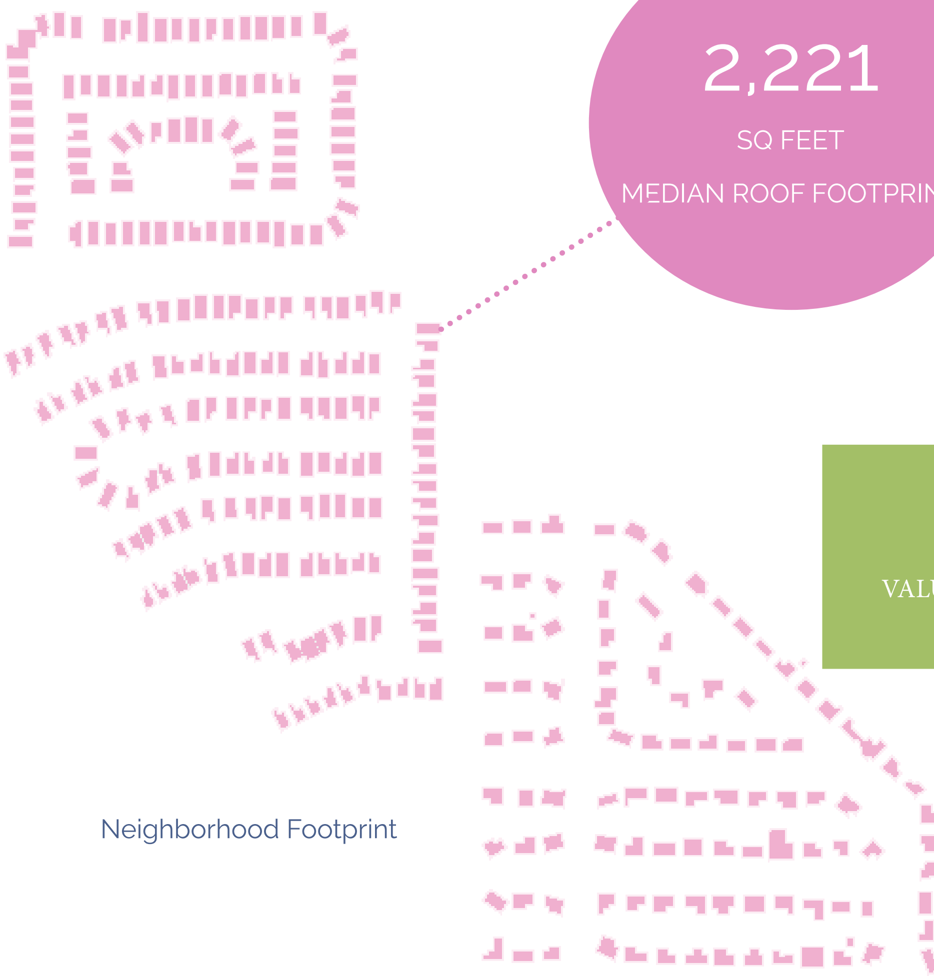
16,911

GALLONS OF RAINWATER HARVESTING POTENTAIL

2,221

SQ FEET

MEDIAN ROOF FOOTPRINT



Neighborhood Footprint

WHICH CAN SUPPORT:

10%

VALUE TREES ADD TO PROPERTY

6

DESERT TREES

CONCLUSION

With simple area and volume calculations, it is apparent each single-family home in Tucson carries the potential to harvest thousands of gallons of water per year.

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METADATA

Metadata for ResidentialRainwater									
Attribute Label	**FID**	**Footprint_Acres**	**Parcel_ID**	**Parcel_Area**	**FCV**	**Zoning_Code**	**CensuBlockGRP**	**TractCE10**	**TreeCanopy**
Description	Unique ID	Building Footprint Area	Unique ID	Parcel Area in Sq. Ft.	Current Value	R-1, R-2, RH, RX-1, RX-2, SH, SR	Census Block ID	Census Tract ID	Percent Tree Canopy
Data Source	-	Microsoft	Pima County	Pima County	Pima County	City of Tucson	US Census Bureau	US Census Bureau	USGS
Methods	-	Calculated geometric area	Spatial Join	Spatial Join	Spatial Join	Spatial Join	Spatial Join	Spatial Join	Remote Sensing, calculated geometric area

ACKNOWLEDGMENTS

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Page 2	Image courtesy of PatioProductions.com
Page 3	Data courtesy of World Climate Research Program, Arizona Water Banking Authority, and Tucson Water
Page 4	Data courtesy of Colorado Division of Water Resources, Babbit Center for Land and Water Policy, Lincoln Institute of Land Policy, and Arizona Water Facts
Page 5	Data courtesy of City of Tucson, Pima County, and Microsoft Diagram courtesy of Texas A&M
Page 6	Image generated with SketchUp
Page 7	Data courtesy of Pima County and Pima Association of Governments

1. Heaviside, C., Macintyre, H. & Vardoulakis, S. The Urban Heat Island: Implications for Health in a Changing Environment. Curr Envir Health Rpt 4, 296–305 (2017).

2. Johnson, D.P., Wilson, J.S., The socio-spatial dynamics of extreme urban heat events: The case of heat-related deaths in Philadelphia, Applied Geography,Volume 29, Issue 3, 2009, Pages 419-434, SSN 0143-6228.

3. Gronlund, C., Racial and Socioeconomic Disparities in Heat-Related Heath Effects and Their Mechanisms: a Review. Curr Epidemiol Rep 1, 165-173 (2014).

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