Tracking wetland conditions of an effluent-dependent river: Lower Santa Cruz Living River Project

Claire Zugmeyer

Contributors: Ed Curley, Evan Canfield, Akitsu Kimoto, Julia Fonseca, Brian Powell, Ian Dowdy

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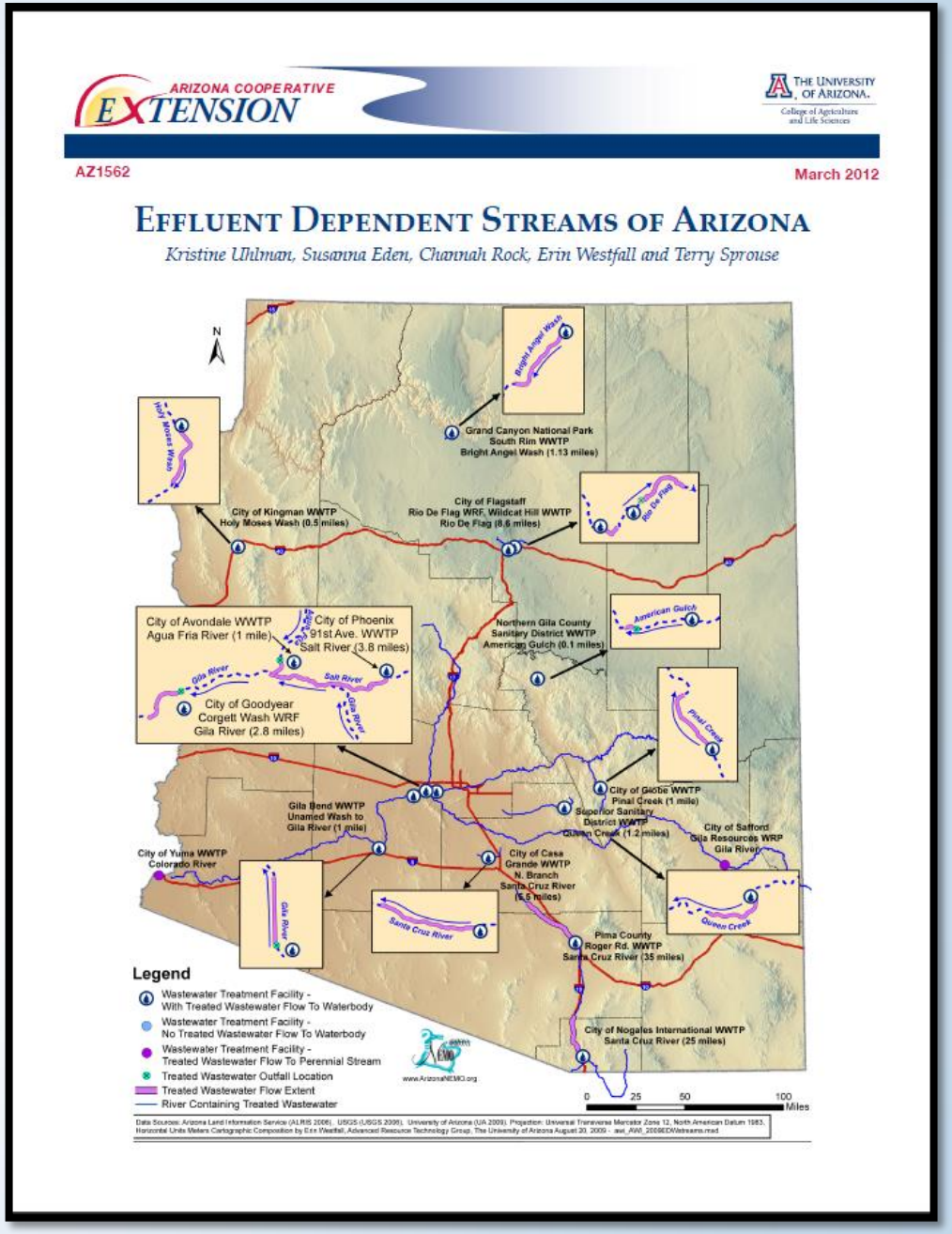
PIMA COUNTY

WRRC Brown Bag – October 29, 2014

Outline

- Upper Santa Cruz River
- Lower Santa Cruz Living River Project

Over 91 miles of Arizona rivers flow with effluent



ARIZONA COOPERATIVE EXTENSION

THE UNIVERSITY OF ARIZONA. College of Agriculture and Life Sciences

AZ1562

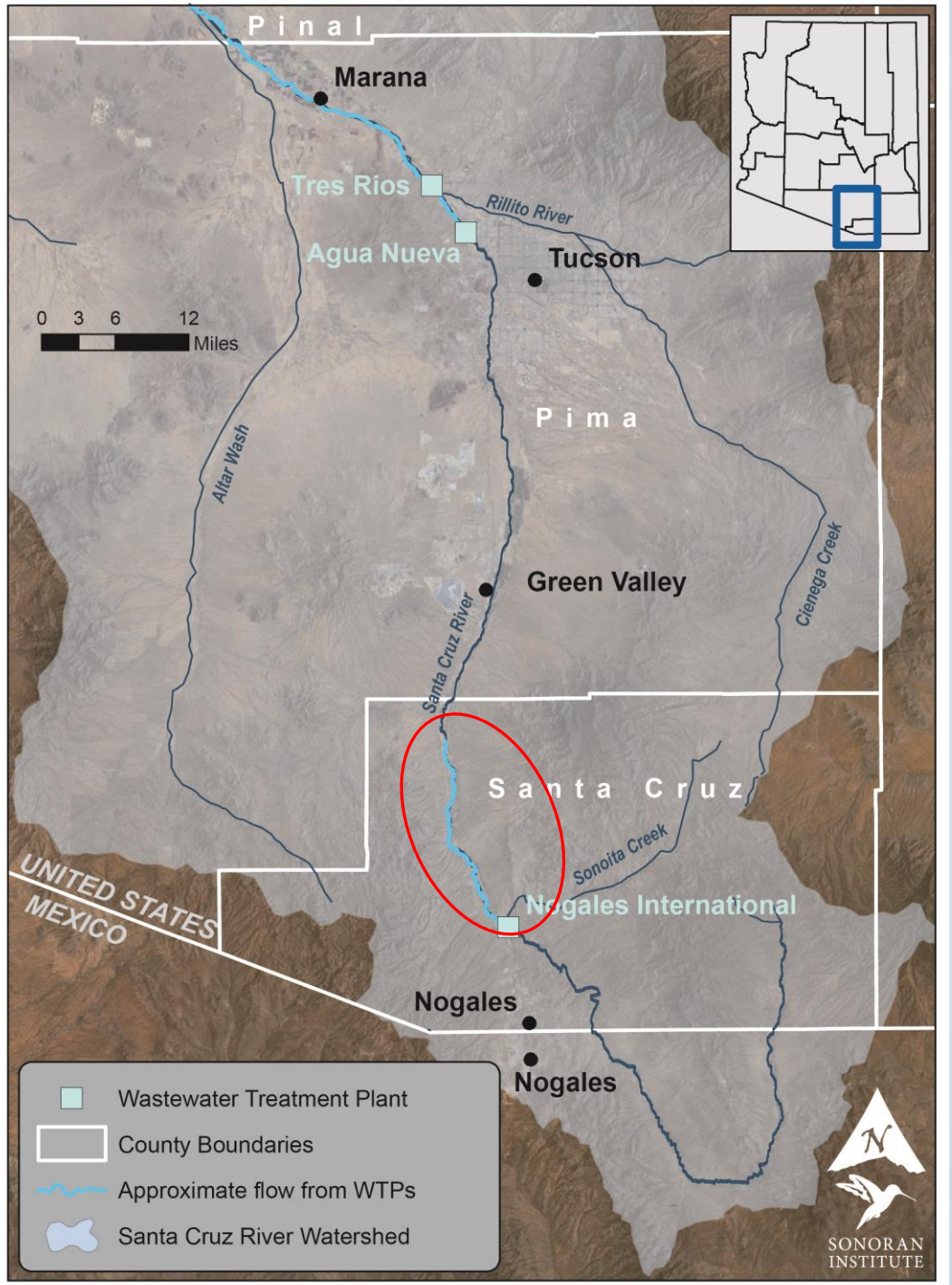
March 2012

EFFLUENT DEPENDENT STREAMS OF ARIZONA

Kristine Uhlman, Susanna Eden, Channah Rock, Erin Westfall and Terry Sprouse

http://extension.arizona.edu/pubs/effluent-dependent-streams-arizona

Living River
Tracking the Health of the Santa Cruz River



Upper Santa Cruz Living River Project

Santa Cruz River near Tubac

Upper Santa Cruz Living River Project

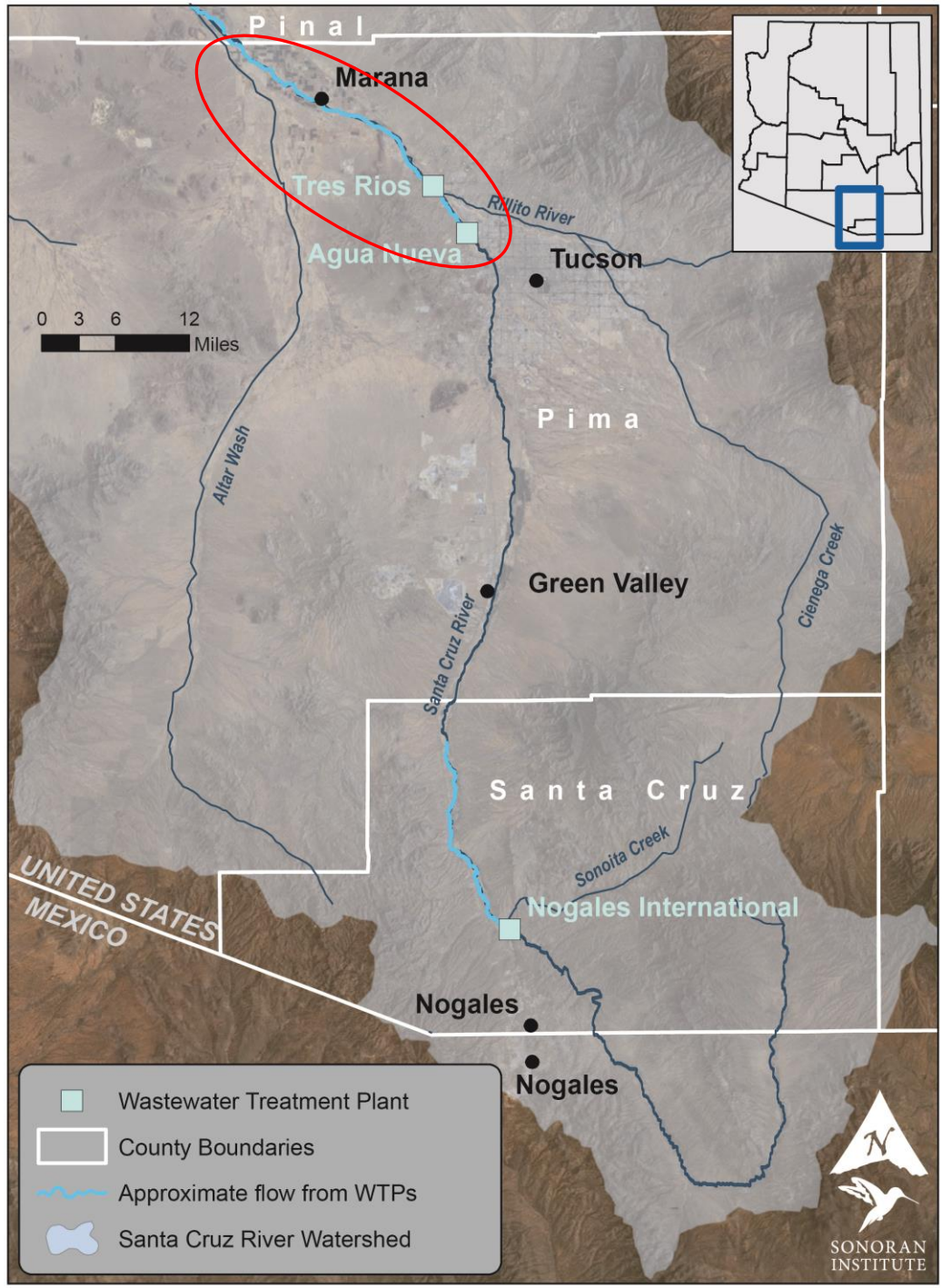
Santa Cruz River near Rio Rico, 2005

Santa Cruz River near Tubac

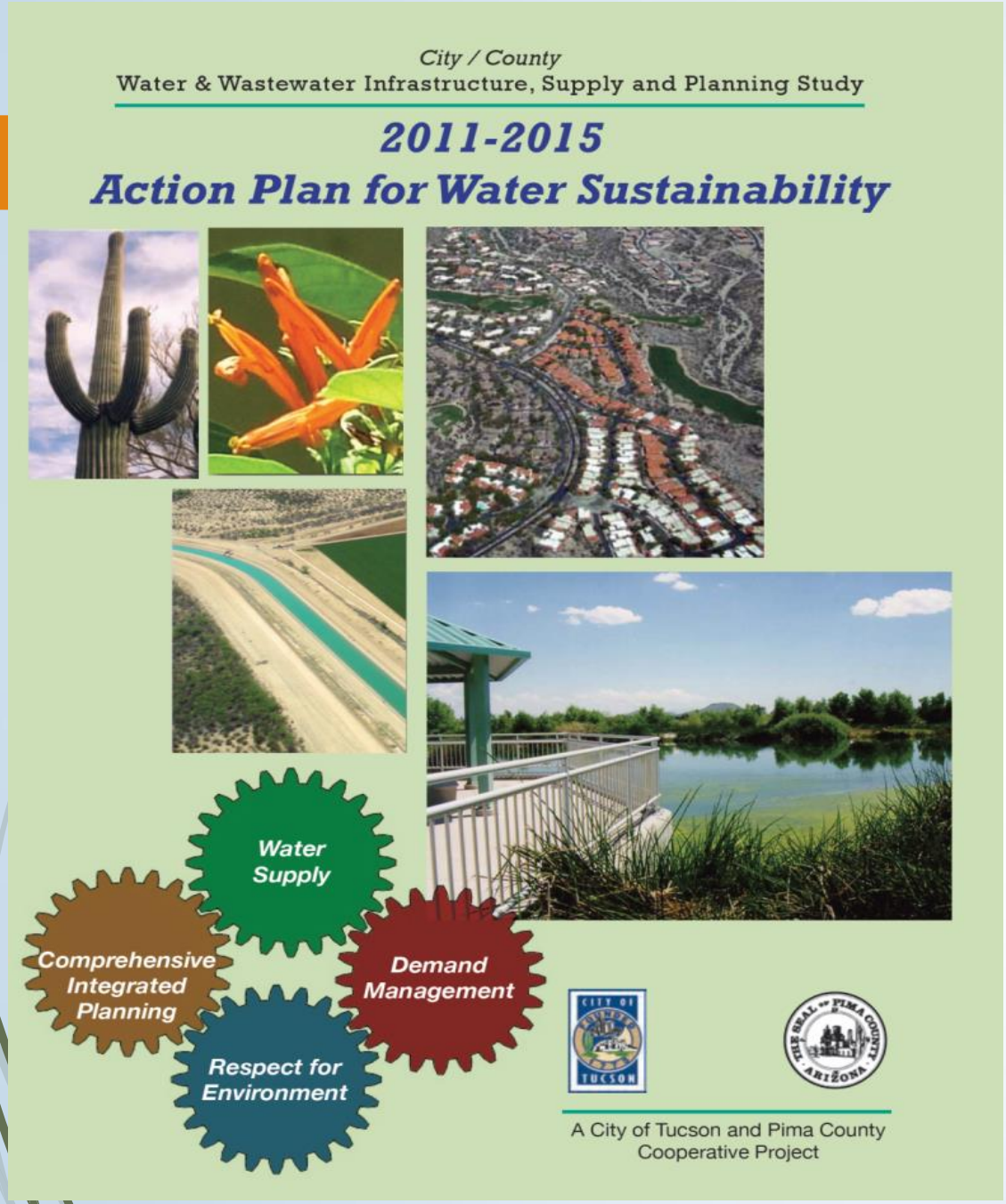
Upper Santa Cruz River Improves

- Fish returning
- Water quality improving
- River not flowing as far
- Metals & *E. coli* still of concern

Living River
Tracking the Health of the Santa Cruz River



T. Moody



Demand Management Goal #4:
Ensure the future of riparian and aquatic habitat along the effluent-dependent reach of the Santa Cruz River.

Expected water quality changes from upgraded reclamation facilities

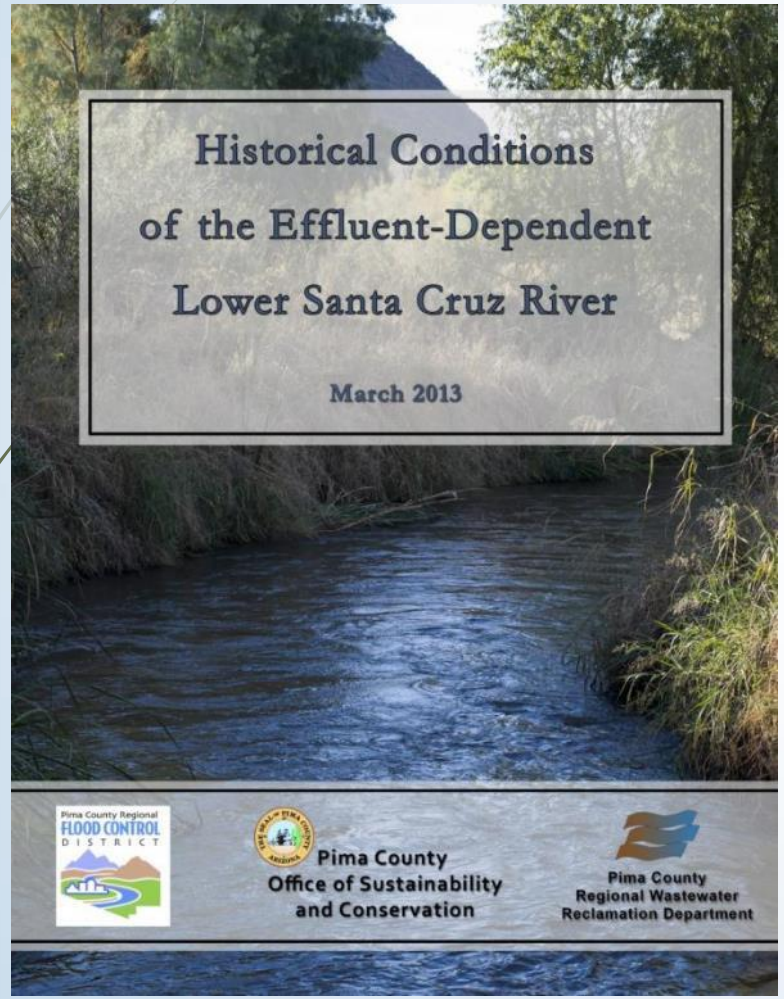
	Before Upgrade Concentration (mg/liter)		Anticipated Concentration (mg/liter)	
	Tres Rios WRF	Agua Nueva WRF	Tres Rios WRF	Agua Nueva WRF
Nitrogen	26	31	2.5	2.3
Phosphorus	3.4	4	< 1	< 1
Biochemical oxygen demand	12	10	2.4	2.7
Total suspended solids	7	16	3.1	3.3

Data Source: RWRD, Compliance and Regulatory Affairs Office, April 2011

Living River Project

- **Summarizing past wetland conditions**
- Selecting new indicators of river health
- Developing a new annual report series

Historical Conditions Report – conditions through 2012

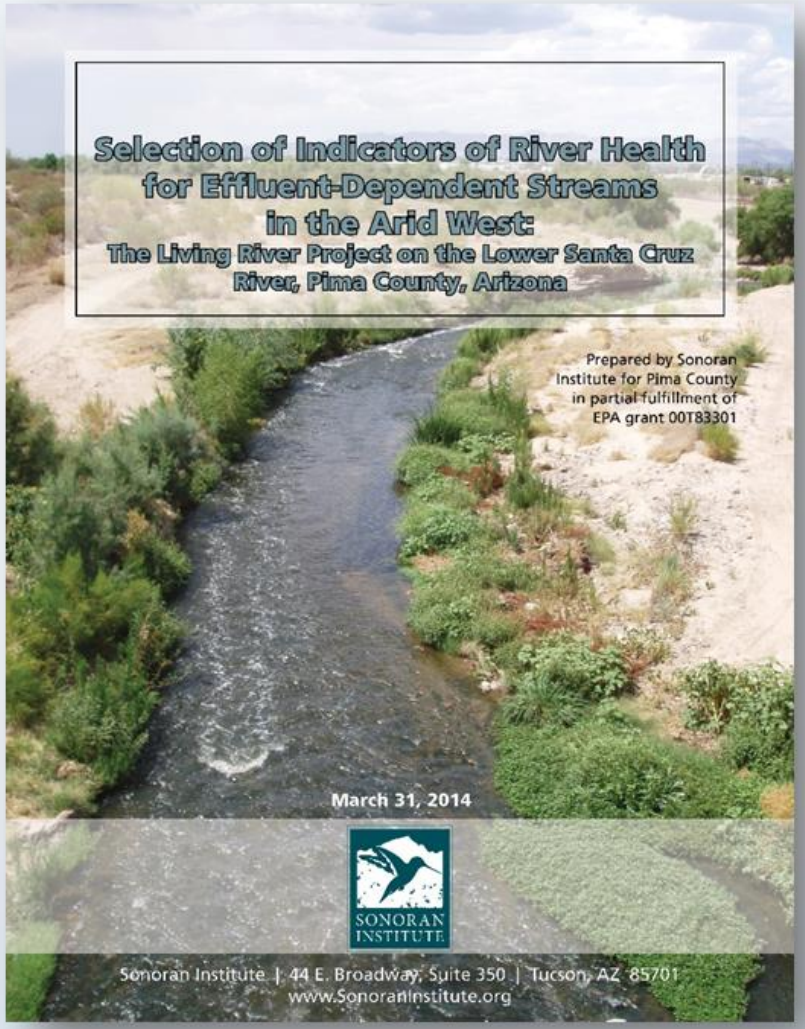


- Water & Infiltration
- Geomorphology
- Vegetation
- Water Quality
- Macroinvertebrates
- Expected changes due to facility upgrades

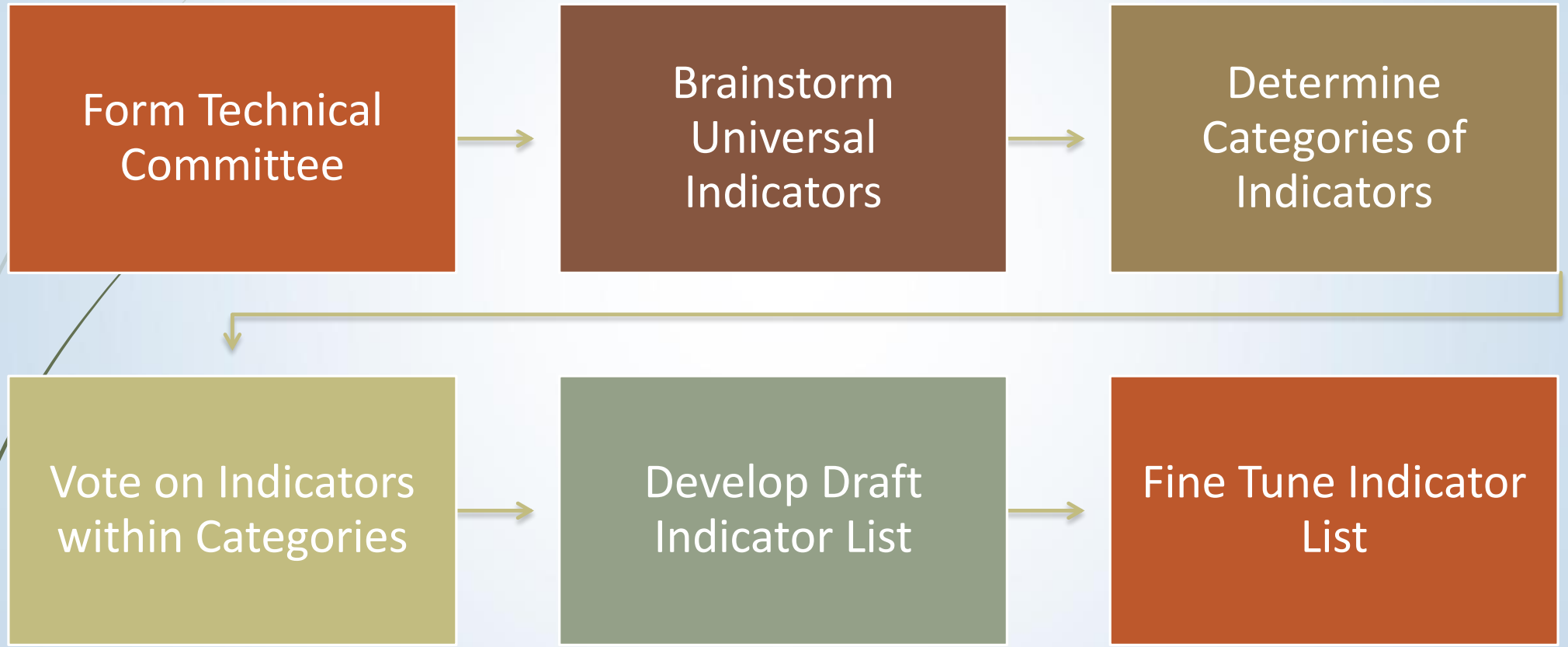
Living River Project

- Summarizing past wetland conditions
- **Selecting new indicators of river health**
- Developing a new annual report series

Selection Process Report: How we got to 16 indicators



What Indicators Should We Use?



Living River Technical Committee

- **Jennifer Duan** – *University of Arizona*
- **Juliet Stomberg** – *Arizona State University*
- **Robert Webb** – *University of Arizona*
- **Patrice Spindler** – *Arizona Department of Environmental Quality*
- **Kendall Kroesen** -*Tucson Audubon Society*
- **John Kmiec** – *Town of Marana*
- **Akitsu Kimoto** – *Pima County Regional Flood Control District*
- **James DuBois** – *Pima County Regional Wastewater Reclamation Department*
- **Brian Powell** – *Pima County Office of Sustainability and Conservation*
- **Claire Zucker** – *Pima Association of Governments*
- **Michael Liberti** - *Tucson Water*
- **Eve Halper**– *Bureau of Reclamation*
- **Jean McClain** – *UA Water Resources Research Center*
- **Linwood Smith** - *Ecologist*
- **Placido dos Santos** – *Westland Resources Inc.*

Indicator "Brainstorm"

High Level Categories	Brainstormed Indicators
Groundwater	• Depth to water in 100yr floodplain • Variability of depth to water over time
Surface/Groundwater Interactions	• Streambed infiltration • Source composition of surface/groundwater • Unsaturated at depth • Schmutzdecke presence + infiltration
Surface Water Quantity	• 7 day minimum flow • Presence/Absence of water • Distance of flow • Base flow • Peak flows
Water Quality	• Ammonia • Macro invertebrates • E. coli • Polychlorinated hydrocarbons • Dissolved oxygen • Water temperature • Heavy metals • Other water quality toxins • Algal productivity • C-N-P

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High Level Categories	Brainstormed Indicators
Physical Factors	• Ratio of width to depth in channel
Terrestrial Plants	• Suite (diversity of native plant species present • Extent exotic species present • Land use and land cover • Stand diversity • Age structure of riparian vegetation • Recruitment of native plants • Continuity of vegetation
Terrestrial Animals	• % native biota diversity (birds & herps) • Mammals – keystone species
Aquatic Critters	• Native fish species present • % native biota diversity (birds & herps) • Non-native fish & herps • Large woody debris • Macro invertebrates
Human Disturbance	• Land use and land cover • Grazing intensity • Trash • % of people who get drinking water from stream • Human perceptions of river • Fire • Landscape disturbance (mines, dumps, roads) • Amt. of impervious surfaces

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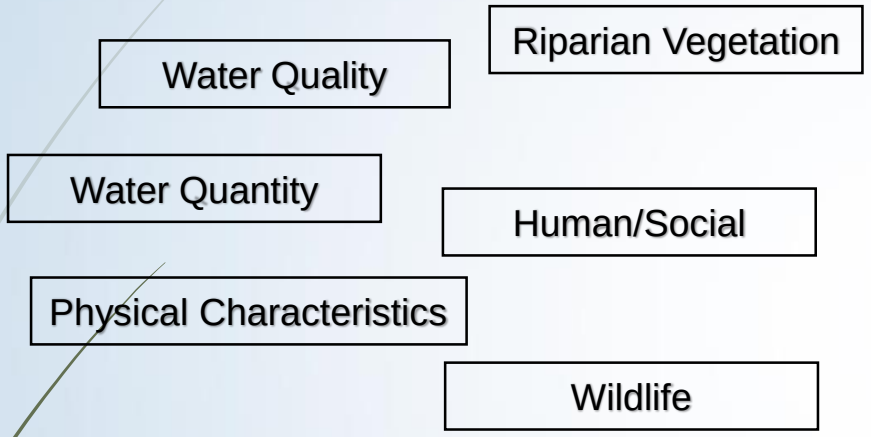

Pima County Wetland Monitoring Program
(ie. EPA approved data collection/acquisition plan)

Annual Report Indicators
(ie. public communication tool)

Weeding Out Indicators

Final List of 16 Indicators

Category	Indicator	Sampling Locations	Monitoring Frequency
Riparian Vegetation	Wetland indicator status	8	Annual
	Riparian tree cover	8	Every 3 years
	Nitrogen affinity score	8	Annual
Social Impacts	Odor at treatment plant[1]	2	Daily
Flow Extent	Miles of flow at start of monsoon (June 14)[2]	3	Annual
	Number of dry days at Trico stream gauge	1	Daily
Sediment Transport	Total suspended solids	4	Quarterly
	Percent fines	4	Annual
	Turbidity	4	Quarterly
Aquatic Wildlife	Macroinvertebrates	4	Annual
	Fish	4	Annual
Water Quality	Dissolved oxygen	4	Quarterly
	Biological oxygen demand	4	Quarterly
	Total dissolved solids	4	Quarterly
	Metals (combined score for copper, lead, zinc, mercury, selenium, arsenic, cadmium, chromium)	4	Quarterly
	Ammonia	4	Quarterly

[1] Data observed at treatment plants used to create a map of worst possible odor effects

[2] Report Miles of Flow in Each of the three "Reporting Reaches"

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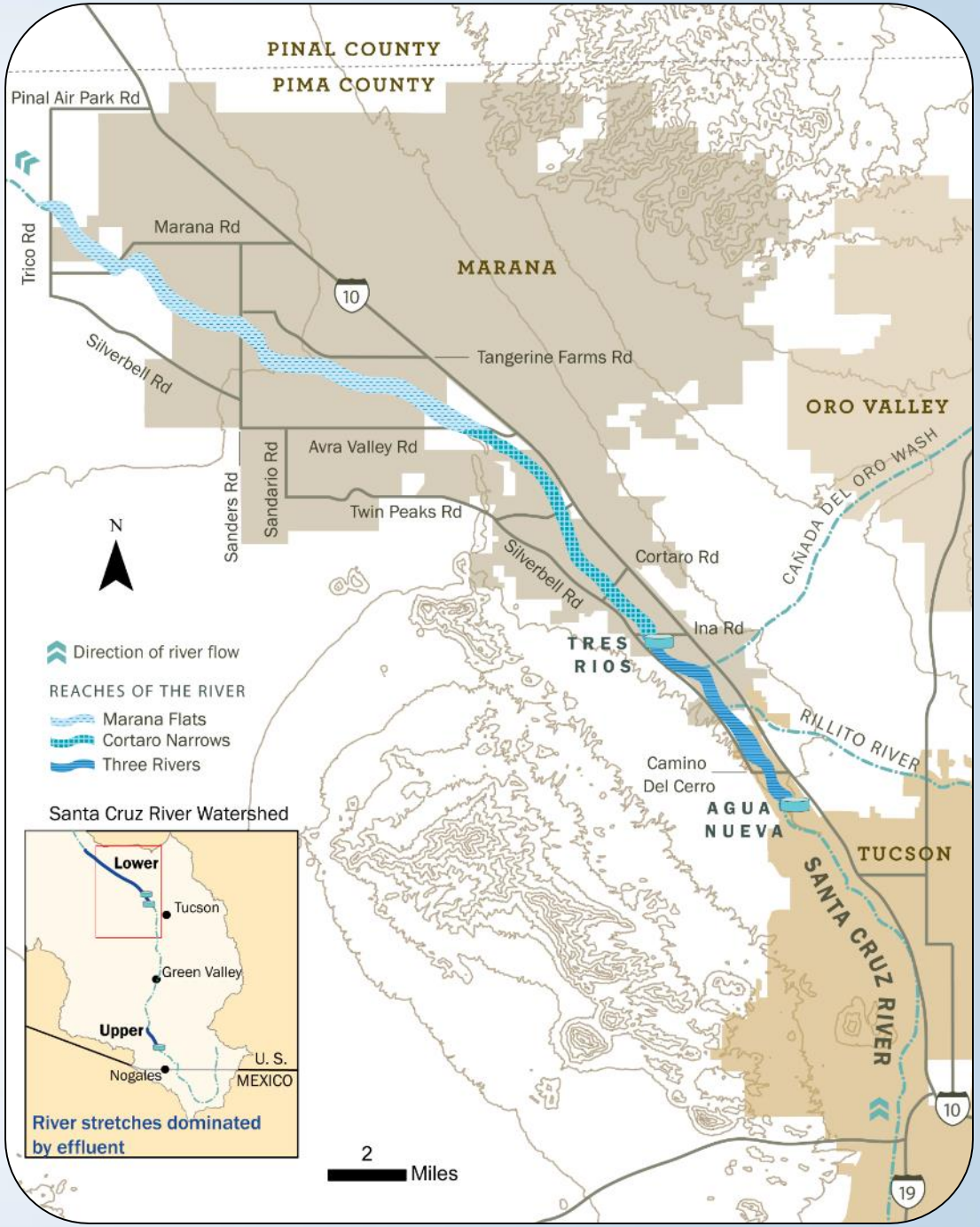
Additional Supplemental data

Three Reporting Reaches

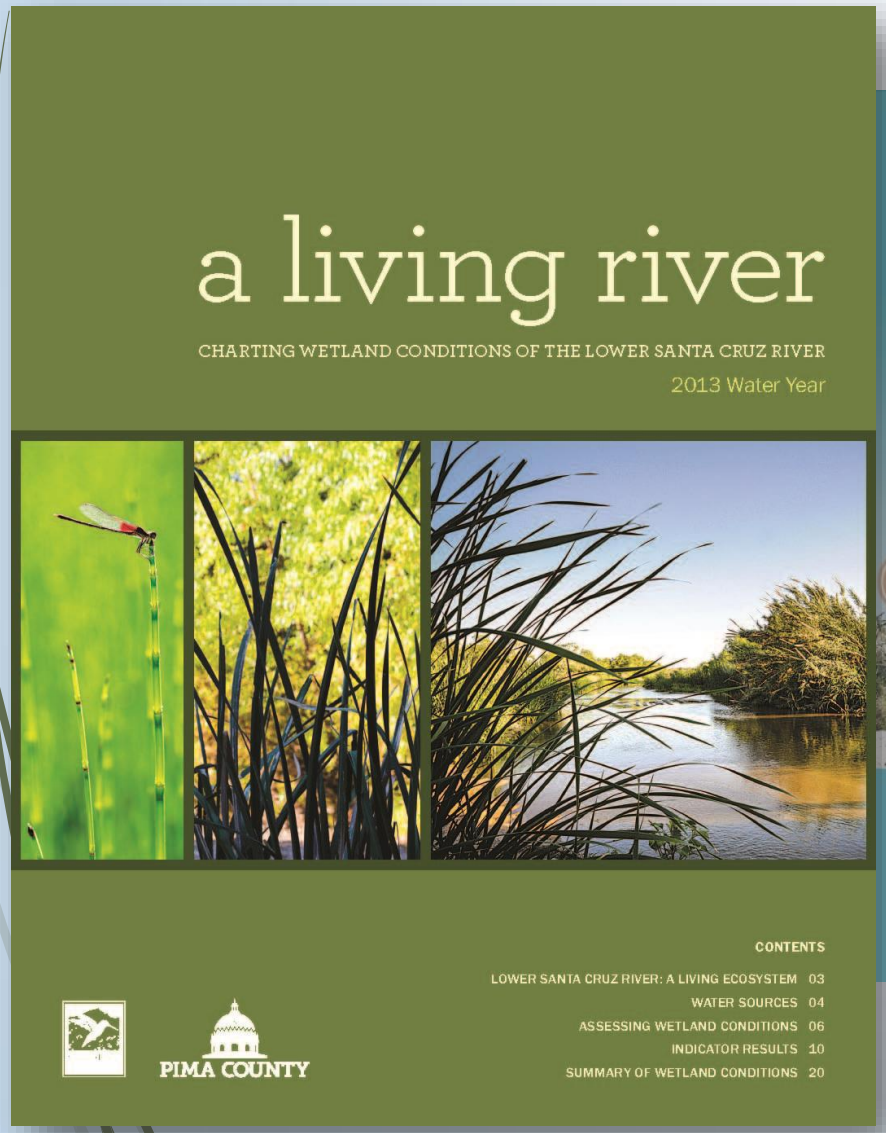
- Three Rivers (Agua Nueva to Tres Rios)
- Cortaro Narrows (Tres Rios to Avra Valley Rd)
- Marana Flats (Avra Valley Rd to Trico Rd)

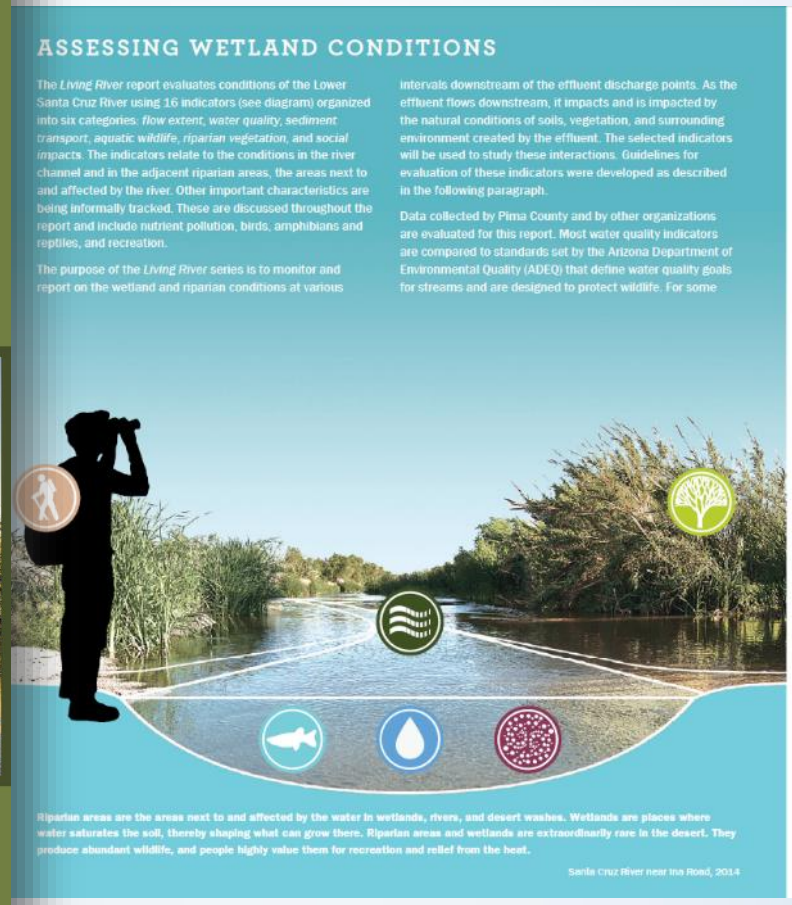


Living River Project

- Summarizing past wetland conditions
- Selecting new indicators of river health
- **Developing a new annual report series**

Baseline report released October 2014





ASSESSING WETLAND CONDITIONS

The *Living River* report evaluates conditions of the Lower Santa Cruz River using 16 indicators (see diagram) organized into six categories: *flow extent, water quality, sediment transport, aquatic wildlife, riparian vegetation,* and *social impacts*. The indicators relate to the conditions in the river channel and in the adjacent riparian areas, the areas next to and affected by the river. Other important characteristics are being informally tracked. These are discussed throughout the report and include nutrient pollution, birds, amphibians and reptiles, and recreation.

The purpose of the *Living River* series is to monitor and report on the wetland and riparian conditions at various intervals downstream of the effluent discharge points. As the effluent flows downstream, it impacts and is impacted by the natural conditions of soils, vegetation, and surrounding environment created by the effluent. The selected indicators will be used to study these interactions. Guidelines for evaluation of these indicators were developed as described in the following paragraph.

Data collected by Pima County and by other organizations are evaluated for this report. Most water quality indicators are compared to standards set by the Arizona Department of Environmental Quality (ADEQ) that define water quality goals for streams and are designed to protect wildlife. For some standards, ADEQ defines goals for streams whose waters are dominated by effluent. However, for indicators where there are no such standards, data are evaluated with reference values established by historical data or other sources. For indicators without a clear reference value or standard, the 2013 *Living River* assessment becomes the baseline for tracking future change. Additional information about historical conditions along the river is summarized in *Historical Conditions of the Effluent-Dependent Lower Santa Cruz River*, available online at **www.tiny.cc/lscr**.

The following pages present the data collected in the 2013 water year (October 1, 2012–September 30, 2013), prior to reclamation facility upgrades. For the purposes of this report, the 23-mile stretch of river is divided into three sections, or reaches: Three Rivers, Cortaro Narrows, and Marana Flats. These reaches differ in geology, hydrology, and adjacent land use. To review all the data in more detail and see additional charts from the 2013 water year, please visit the Sonoran Institute website at **www.tiny.cc/lscr13**.

IMPORTANT NOTE: Facility upgrades at the Tres Rios WRF came online in phases between Fall 2012 and Fall 2013. However, the Agua Nueva WRF upgrades did not come online until December 2013. Therefore, the cumulative effect of all the upgrades is not reflected in the baseline information in this report. As this report was sent to the press, casual observation of the river suggests that the upgrades will significantly impact wetland conditions and flows in the Lower Santa Cruz River.

Riparian areas are the areas next to and affected by the water in wetlands, rivers, and desert washes. Wetlands are places where water saturates the soil, thereby shaping what can grow there. Riparian areas and wetlands are extraordinarily rare in the desert. They produce abundant wildlife, and people highly value them for recreation and relief from the heat.

Santa Cruz River near Ina Road, 2014

CATEGORY	PURPOSE	INDICATORS
FLOW EXTENT	General measure of water flowing in and out of the system, recharge, and available aquatic habitat.	• Miles of flow in each reach • Flow at Trico Road
SEDIMENT TRANSPORT	Measure of solid particles moving through the system, which can impact habitat and conditions for aquatic plants and animals.	• Total suspended solids • Turbidity • Percent fines
WATER QUALITY	Measure of chemical conditions necessary for sustaining the river's animal and plant communities.	• Total dissolved solids • Ammonia • Dissolved oxygen • Biochemical oxygen demand • Metals
AQUATIC WILDLIFE	Direct measure of river's wildlife which integrate many factors of the surrounding environment.	• Fish • Aquatic invertebrates
RIPARIAN VEGETATION	Direct measure of river's plant communities which reflect changes in water quantity and quality.	• Wetland indicator status • Nitrogen affinity score • Riparian tree cover
SOCIAL IMPACTS	Measure of aesthetic factors that directly impact people living or recreating along the river.	• Odor at reclamation facilities

Results summarized visually

WATER QUALITY

Aquatic ecosystems, such as streams, depend on particular water quality conditions (chemical, physical, and biological properties) to sustain plant and animal communities. Five indicators help track changes in water quality in the river: total dissolved solids, ammonia, dissolved oxygen, biochemical oxygen demand, and metals.

Many of the dissolved solids are essential nutrients for plants and animals, but when too abundant they can produce unhealthy conditions for aquatic life and riparian vegetation. Thus, measuring **total dissolved solids** (TDS) is commonly used to monitor excess salts in the water. TDS in the effluent has been rising with increased use of Colorado River water in the Tucson area. The Colorado River has greater TDS, mostly in the form of dissolved salts, than the local groundwater. Because there is no standard for TDS (often standards are for individual elements that contribute to TDS), the results from the 2013 water year will serve as a baseline.

Nitrogen is an essential nutrient for plant and animal life, but too much can contribute to nutrient pollution. **Ammonia** (NH_3) is one form of nitrogen that can be toxic to fish. Even at low concentrations, ammonia can reduce hatching success, among other impacts. ADEQ's chronic wildlife standard for ammonia levels in rivers dominated by effluent varies with pH (level of acidity) and temperature. As pH and temperature increase, the toxicity of ammonia increases, thus the acceptable level of ammonia decreases with high pH and temperature. During the 2013 water year, water temperature ranged from 62.6° F in the winter to nearly 92° F in the summer; pH was between 7.4 and 8.0. Based on the range of temperatures and pH in the reaches, the maximum amount of ammonia during the 2013 water year should be less than 0.9 to 2.5 milligrams per liter (mg/L) for ecosystem health.

Fish and other aquatic animals need **dissolved oxygen** to survive. Rivers absorb oxygen from the atmosphere, and aquatic plants and algae produce oxygen. Natural causes of variability in dissolved oxygen levels include nutrient levels, shading, water temperature, and time of day. ADEQ sets the minimum standard for dissolved oxygen in effluent-dependent streams at 3 milligrams per liter (mg/L) during the day.

Biochemical oxygen demand (BOD) is an estimate of how much dissolved oxygen is being used. Microorganisms in the river consume dissolved oxygen as they break down and use organic materials, such as leaves and woody debris, dead plants and animals, and animal wastes. If there are a lot of organic materials in the water, these microorganisms become so numerous that they consume a lot of dissolved oxygen and deprive other aquatic animals of the oxygen they need to survive. Though there are standards for BOD in the wastewater reclamation process, there is no standard for BOD in rivers. The results from the 2013 water year will serve as a baseline.

Metals in high concentrations endanger wildlife in aquatic ecosystems by lowering reproductive success, interfering with growth and development, and, in extreme cases, causing death. Most metals build up in aquatic food chains and may pose long-term threats to all organisms in the aquatic environment. Rivers are exposed to pollutant metals through numerous sources, including mine drainage, roadways, and by the release of metals naturally occurring in near-surface rocks and sediments. ADEQ has set standards for the protection of aquatic wildlife. Results for the following metals are compared to their appropriate standard: arsenic, cadmium, chromium, copper, lead, mercury, selenium, and zinc.

2013 RESULTS

Measures of water quality were collected at several locations throughout the year. Total dissolved solids were similar across all reaches. With the exception of Marana Flats, ammonia levels were high and did not meet the ADEQ standard. Dissolved oxygen levels met the ADEQ standard. Biochemical oxygen demand tended to increase as the river flowed through the reaches. All the metals tested met the appropriate standard. View all the data online at www.tiny.cc/wq13.

Data source: Pima County Regional Wastewater Reclamation Department

NUTRIENT POLLUTION

Nutrient pollution, such as high levels of nitrogen and phosphorus, enters the river from air pollution, fertilizer, surface runoff, and release of effluent from wastewater treatment plants. While elevated nutrient levels can benefit growth of riparian plants, they can also lead to problems such as low levels of oxygen in the water (dissolved oxygen) and associated declines in fish habitat. High nutrient levels can also increase the number of microorganisms that break down and use these nutrients. These organisms live in the spaces between the sand and gravel in the streambed, and can become so numerous that they create an impermeable "clogging" layer that can reduce the amount of water that moves through the streambed, thereby decreasing infiltration of water into local aquifers. Under such conditions and without seasonal floods to scour the streambed and flush out the microorganisms, streamflow may continue without riparian plants being able to access water flowing in the river.

Supplemental data summaries online

WATER QUALITY: Dissolved Oxygen

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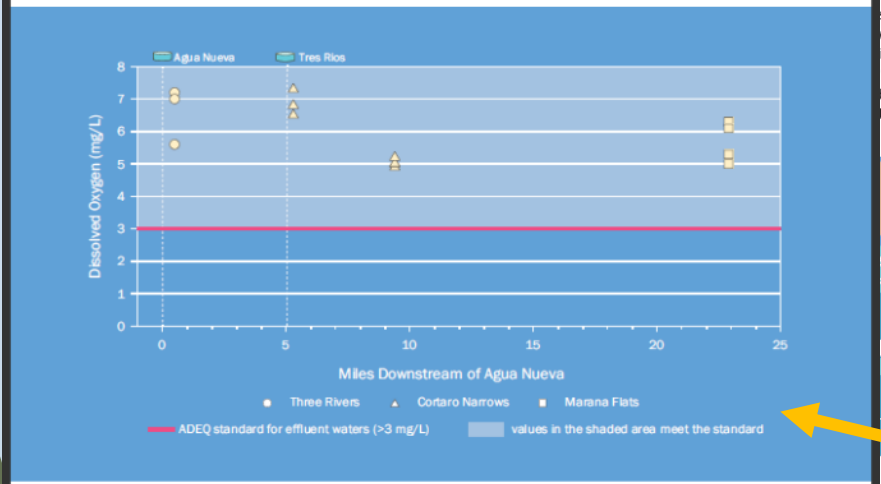

2013 RESULTS

Dissolved oxygen was measured 15 times. All of the 15 samples met the standard for dissolved oxygen (100 %).

- Three Rivers — 4 of 4 samples met the standard (100%).
- Cortaro Narrows — 7 of 7 samples met the standard (100%).
- Marana Flats — 4 of 4 samples met the standard (100%).

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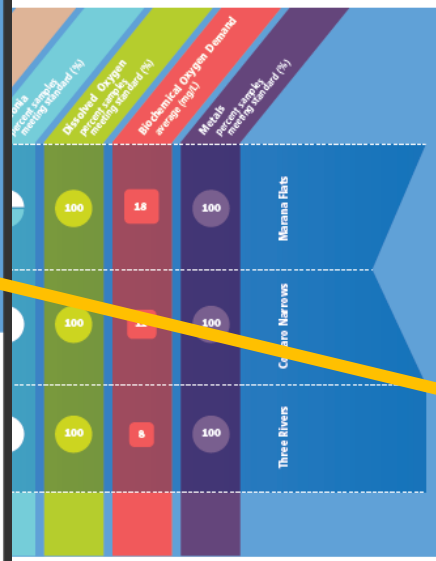

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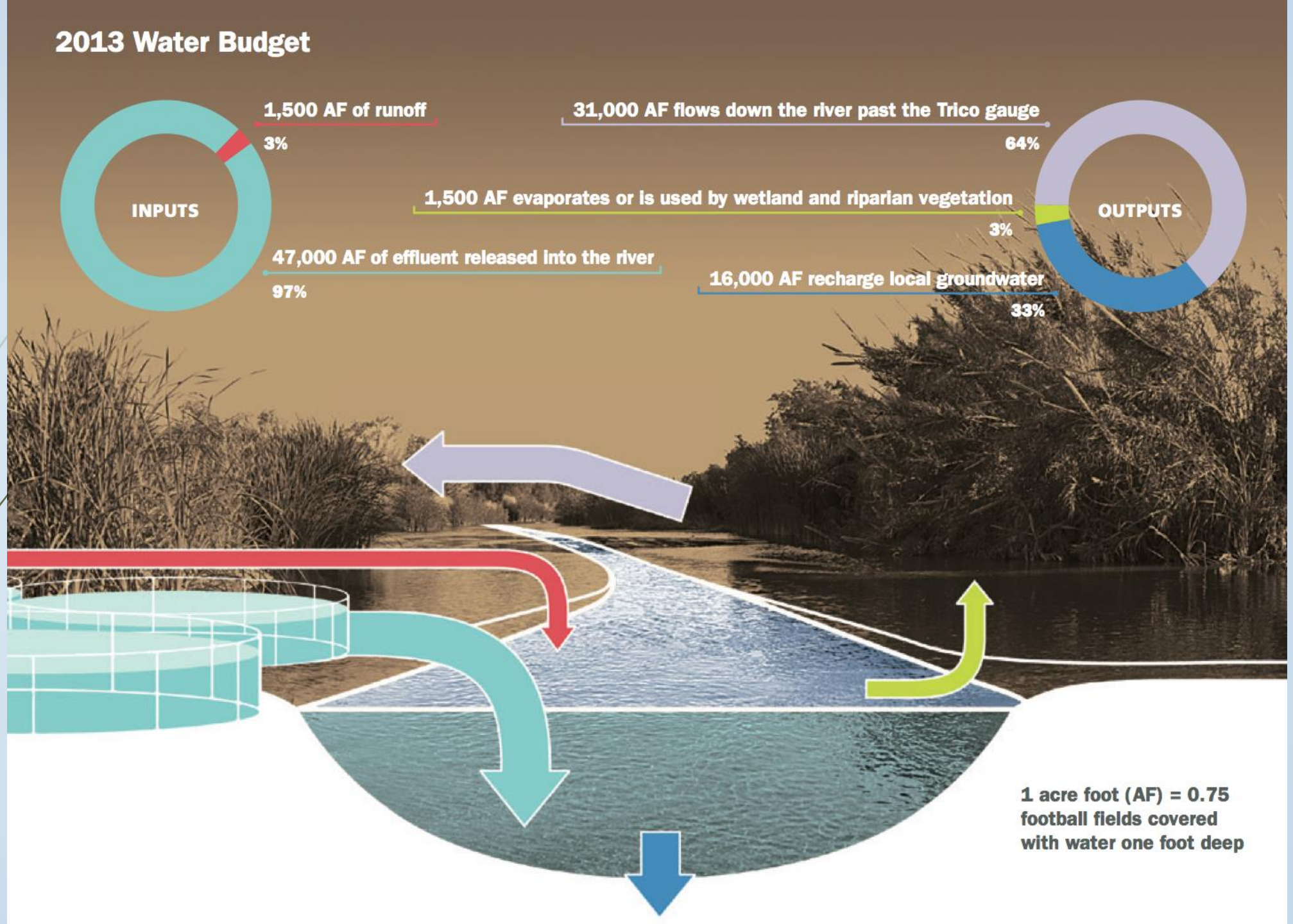
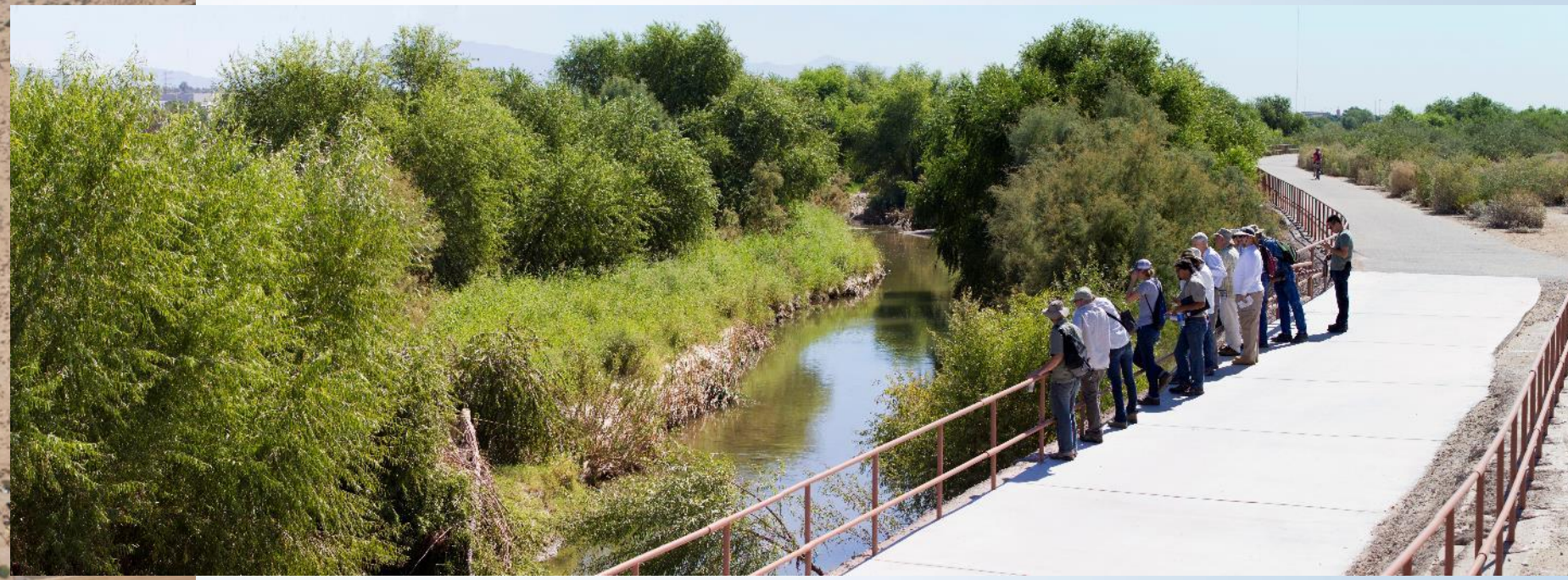
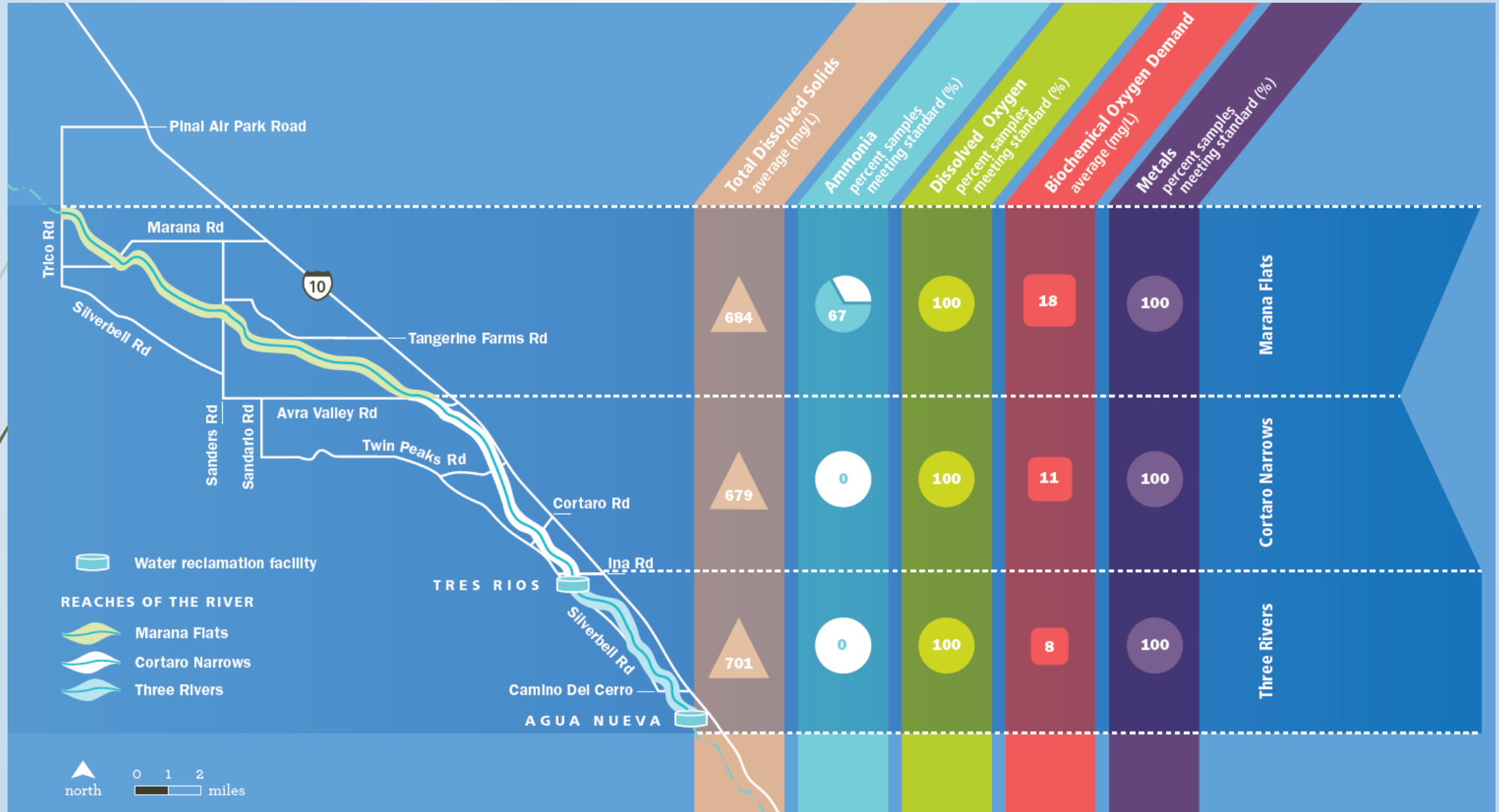

2013 Water Budget
INPUTS
1,500 AF of runoff
3%
47,000 AF of effluent released into the river
97%
OUTPUTS
31,000 AF flows down the river past the Trico gauge
64%
1,500 AF evaporates or is used by wetland and riparian vegetation
3%
16,000 AF recharge local groundwater
33%
1 acre foot (AF) = 0.75 football fields covered with water one foot deep

Flow extent – 23 miles flowing year round

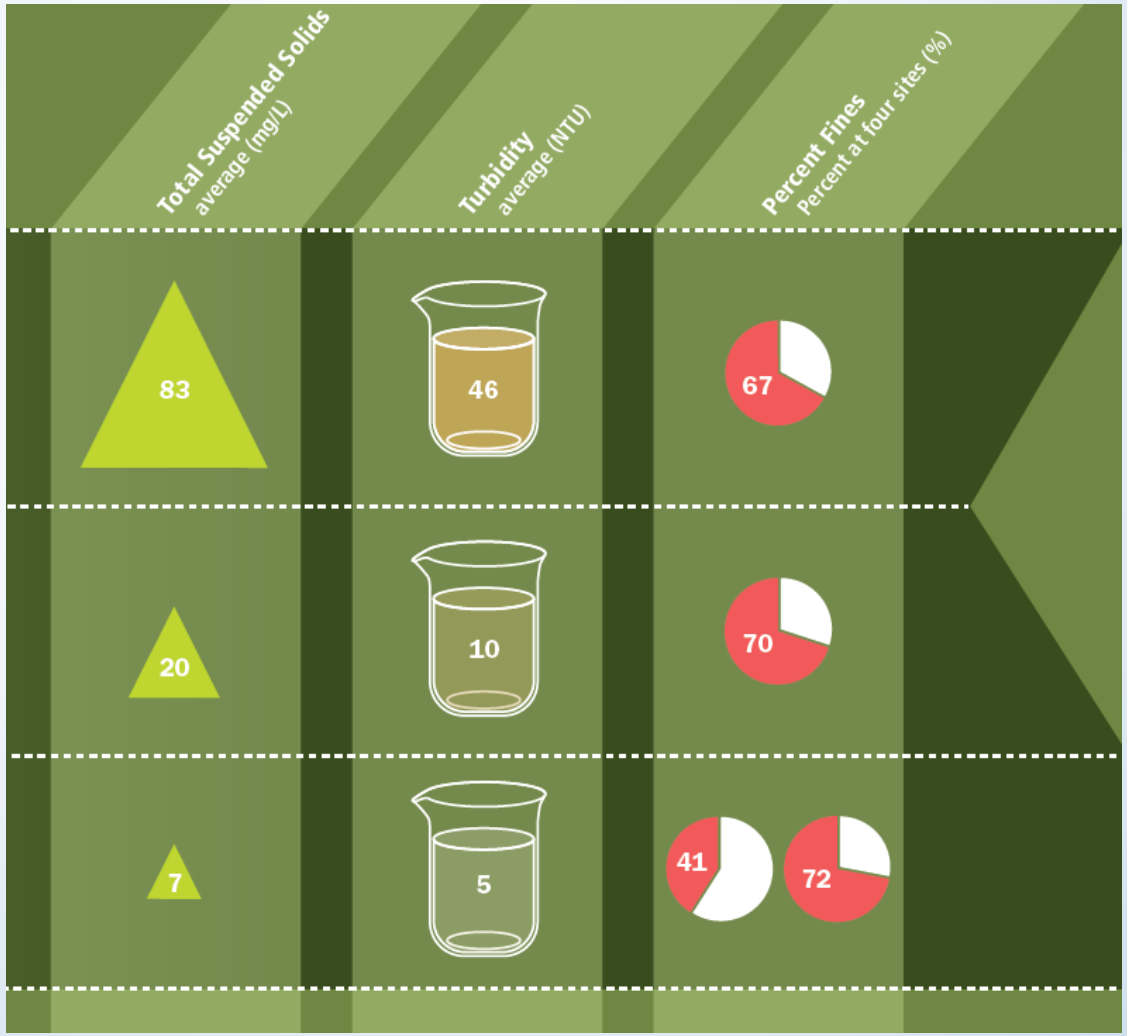


D. Knuth

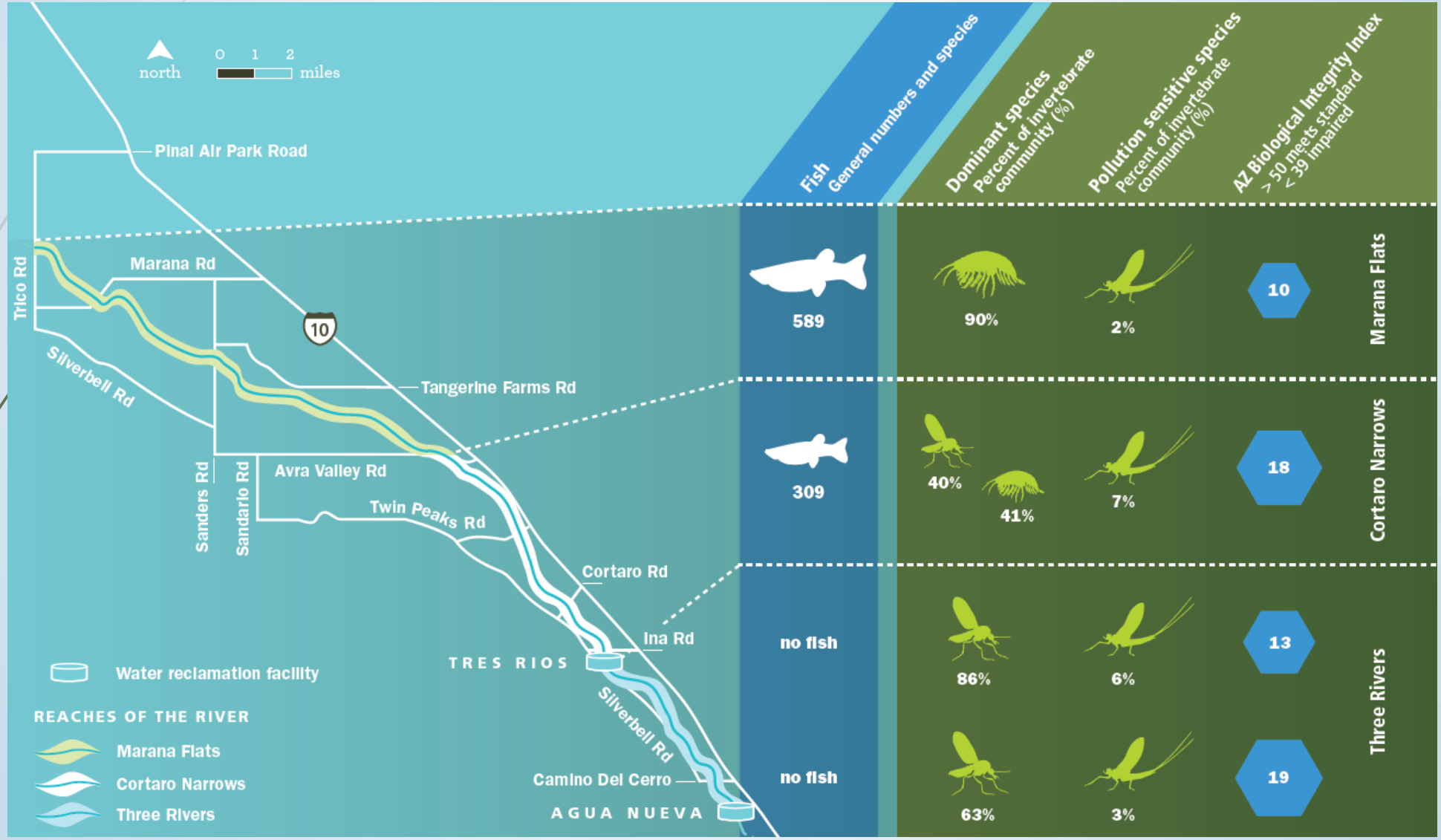
Water Quality – high ammonia a risk to wildlife



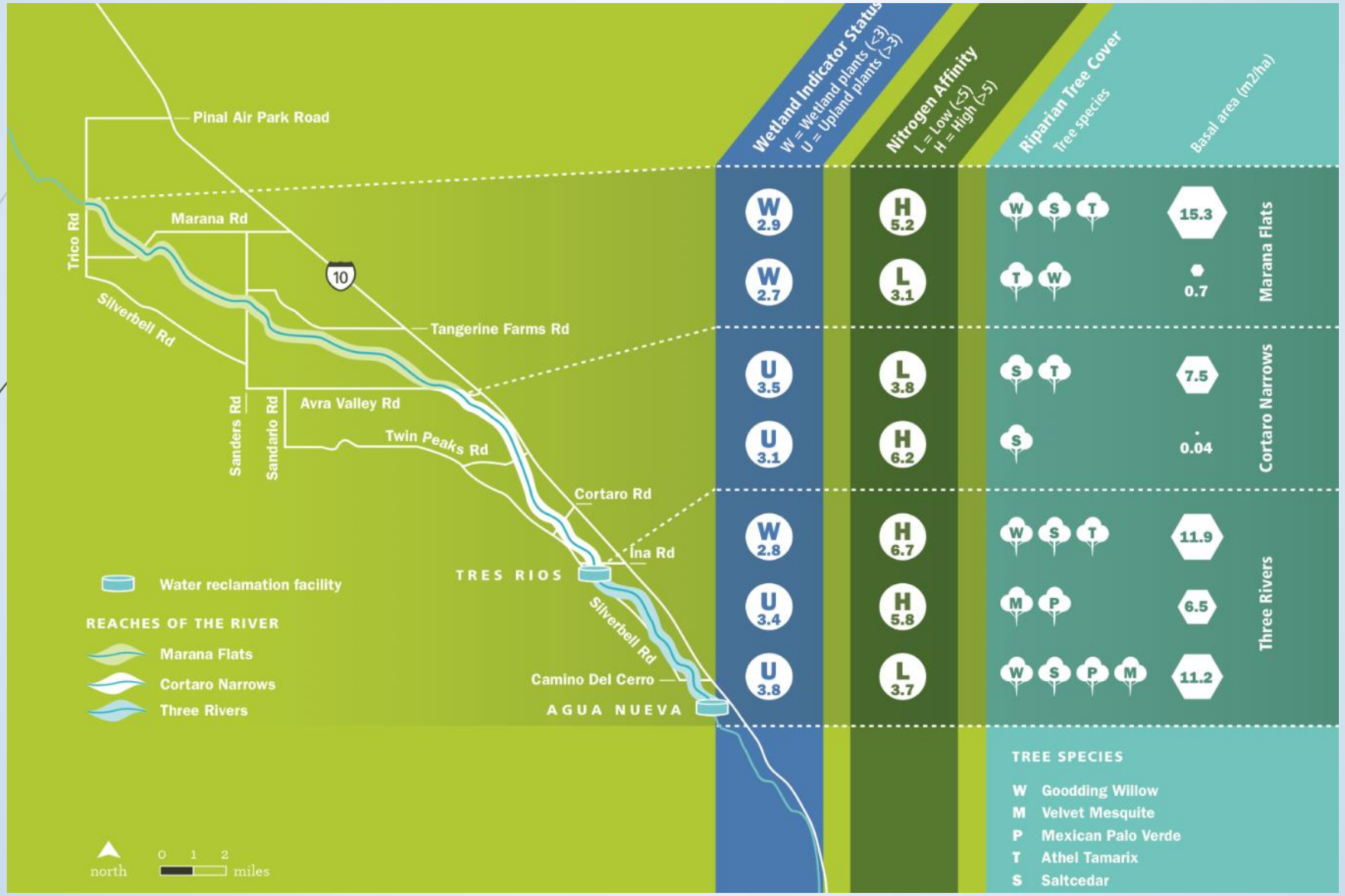
Sediment Transport – high amount moving during non-flooding conditions



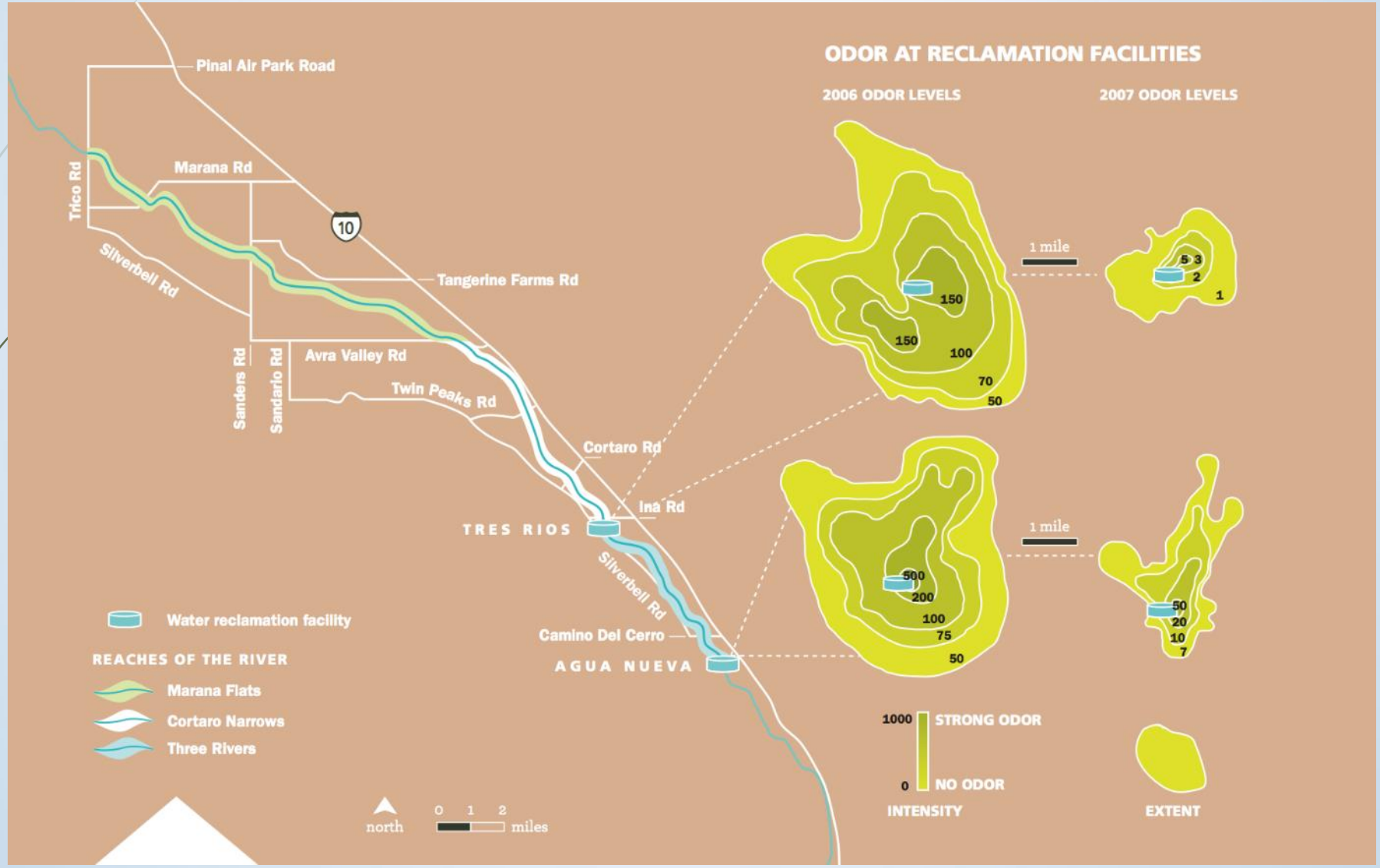
Aquatic Wildlife – low abundance and diversity



Riparian Vegetation



Social Impacts – Odor at facilities reduced!



Supplemental information

B. Powell

P. Rosen

D. Knuth

Living River series gives annual snapshot

- Highlight amenity that preserves a piece of our region's river heritage
- First report gives baseline for tracking changes
- Initial observations have seen a lot of changes in the 2014 water year
- Stay tuned for the next report in June 2015

Acknowledgements

- Huge thanks to:
  - Environmental Protection Agency
  - Pima County Regional Flood Control District
  - Pima County Regional Wastewater Reclamation Department
  - Members of the Technical Committee

Questions?

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Learn more at: **www.tiny.cc/lscr**