a living river

CHARTING THE HEALTH OF THE UPPER SANTA CRUZ RIVER

2010 Water Year

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THE UPPER SANTA CRUZ RIVER A LIVING ECOSYSTEM

For thousands of years, rivers in the arid Southwest have sustained people and supported an abundance of plants and wildlife. Though at times unnoticed, the numerous services that these rivers perform provide substantial benefits to the people living near them. For example, the plants growing along the river naturally slow flood flows, improve air quality, and provide shade. Soils in the floodplain, meanwhile, filter and clean the river water as it recharges the groundwater aquifer that supports local residents.

The Upper Santa Cruz River supports a culturally and ecologically diverse region, from its headwaters in Arizona's San Rafael Valley, through Mexico, and back into the United States through Santa Cruz County, Arizona. Santa Cruz County highlighted the importance of the Upper Santa Cruz River in its 2004 Comprehensive Plan, stating that *"the Santa Cruz River and its watershed should be conserved and managed as a Living Ecosystem."*

How do we know if this important regional resource is a healthy living ecosystem? Numerous groups conduct research and monitoring to track conditions along the Upper Santa Cruz River. The annual *Living River* reports build on these ongoing efforts, with the goal of promoting a better understanding of the health of the river among watershed residents, land managers, and policymakers. By documenting how elements of the system are changing from year to year, we gain insight into how the river is functioning and what stewardship efforts are needed to help the ecosystem stay healthy so the river continues providing valuable services.

The *Living River* series began with a baseline study in the 2008 water year (October 1, 2007–September 30, 2008) to assess the health of a 20-mile stretch of the river in Santa Cruz County, Arizona, from Rio Rico to Amado. This third-annual *Living River* report summarizes results from the 2010 water year (October 1, 2009–September 30, 2010). All *Living River* reports and associated documents are available for download at **www.sonoraninstitute.org** (Where We Work > Southwest > Santa Cruz River).

NOTABLE FINDINGS FOR 2010 WATER YEAR

- Improved water quality with reduced nutrient pollution (page 12)
- Increased number of fish (page 10)
- E. coli and heavy metals remain a challenge (page 14)
- Likely increase in water infiltration due to reduced nutrient pollution (pages 9/10)

ASSESSING THE HEALTH OF THE UPPER SANTA CRUZ RIVER

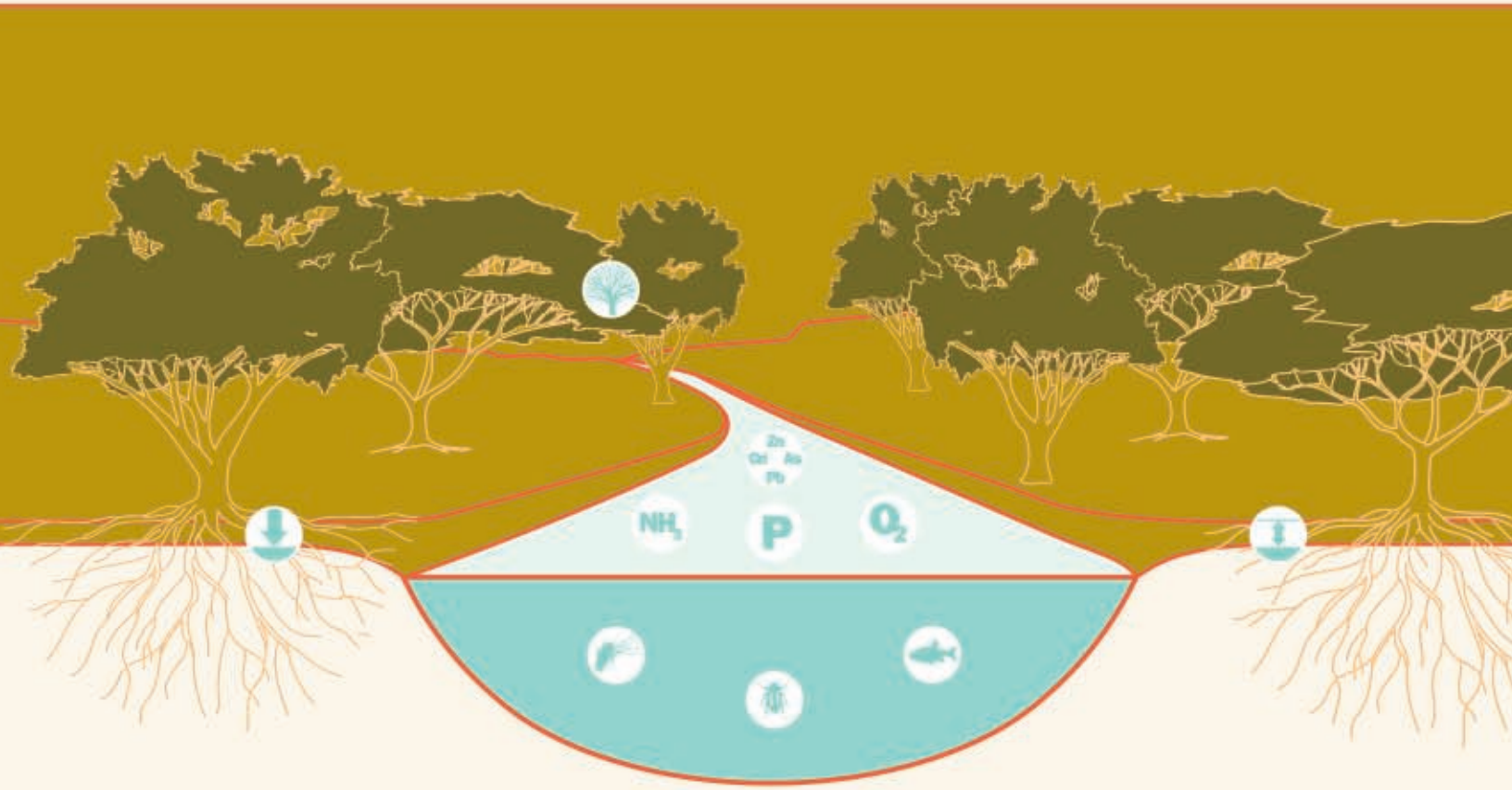
A healthy river maintains its plant, animal, and physical composition, as well as its function. A healthy river also sustains human communities by supplying ecosystem services—the benefits that people obtain and receive from natural systems such as rivers, forests, and grasslands.

Ecosystem services supplied by the Santa Cruz River include:

- ***Provisioning*** services, or "goods" received, such as fresh water, crops, and livestock.
- ***Regulating*** services, or benefits from the natural regulation of water flows and the reduction of hazards related to water flows. These include flood and erosion control, groundwater infiltration, and improvement of water quality.
- ***Cultural*** services, or benefits received from our recreational, aesthetic, and spiritual interaction with nature.
- ***Supporting*** services, or elements that contribute to ecosystem function. These include habitat (providing plants and animals with necessary resources for survival), and processes such as nutrient cycling (transfer of nutrients from one place to another).

The *Living River* report tracks the health of the Upper Santa Cruz River using 10 indicators (see diagram) organized into two categories: *aquatic* and *riparian*. Aquatic indicators relate to the water and the health of the plants and animals living in the river. Riparian indicators convey the health of the plant and animal communities in areas next to and affected by the surface water or groundwater of the river. The indicators also relate to ecosystem services—the presence of fish indicates good water quality conditions for aquatic animals, while the presence of cottonwood forests indicates the availability of these iconic trees as habitat for birds and for our aesthetic enjoyment.

Monitoring data from many organizations are evaluated against standards set by state agencies or the scientific



community. 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 and human health. For some standards, ADEQ defines goals for streams that are dominated by treated wastewater or effluent, such as the Upper Santa Cruz River from Rio Rico to Amado in Santa Cruz County, Arizona. For some indicators, scientists have determined scientific standards or benchmarks. Other indicators, such as aquatic animals and riparian vegetation, do not have defined standards. For these indicators, the 2008 *Living River* assessment provides baseline data to track change.

We divide the 20-mile stretch of river from Rio Rico to Amado into three reaches (stretches of river): Rio Rico, Tubac, and Amado (see map on page 2). These reaches differ in geology and hydrology, with portions of the reaches alternating between *gaining* and *losing* stream conditions (see Water Sources section for gaining/losing explanation). There is a close connection between surface water and groundwater that can influence the aquatic and riparian ecosystems in these reaches.

The following pages summarize data collected for the 10 indicators. Information about precipitation, streamflow, and other aspects of the aquatic and riparian ecosystems is also included. For each indicator, a brief summary of results is provided, along with a chart of the data from the 2010 water year (October 1, 2009–September 30, 2010). Results from the 2009 water year are provided as a reference, but there is not enough data for a formal statistical comparison. For a side-by-side comparison of data from previous water years, please visit the Sonoran Institute website at **www.sonoraninstitute.org** (Where We Work > Southwest > Santa Cruz River).

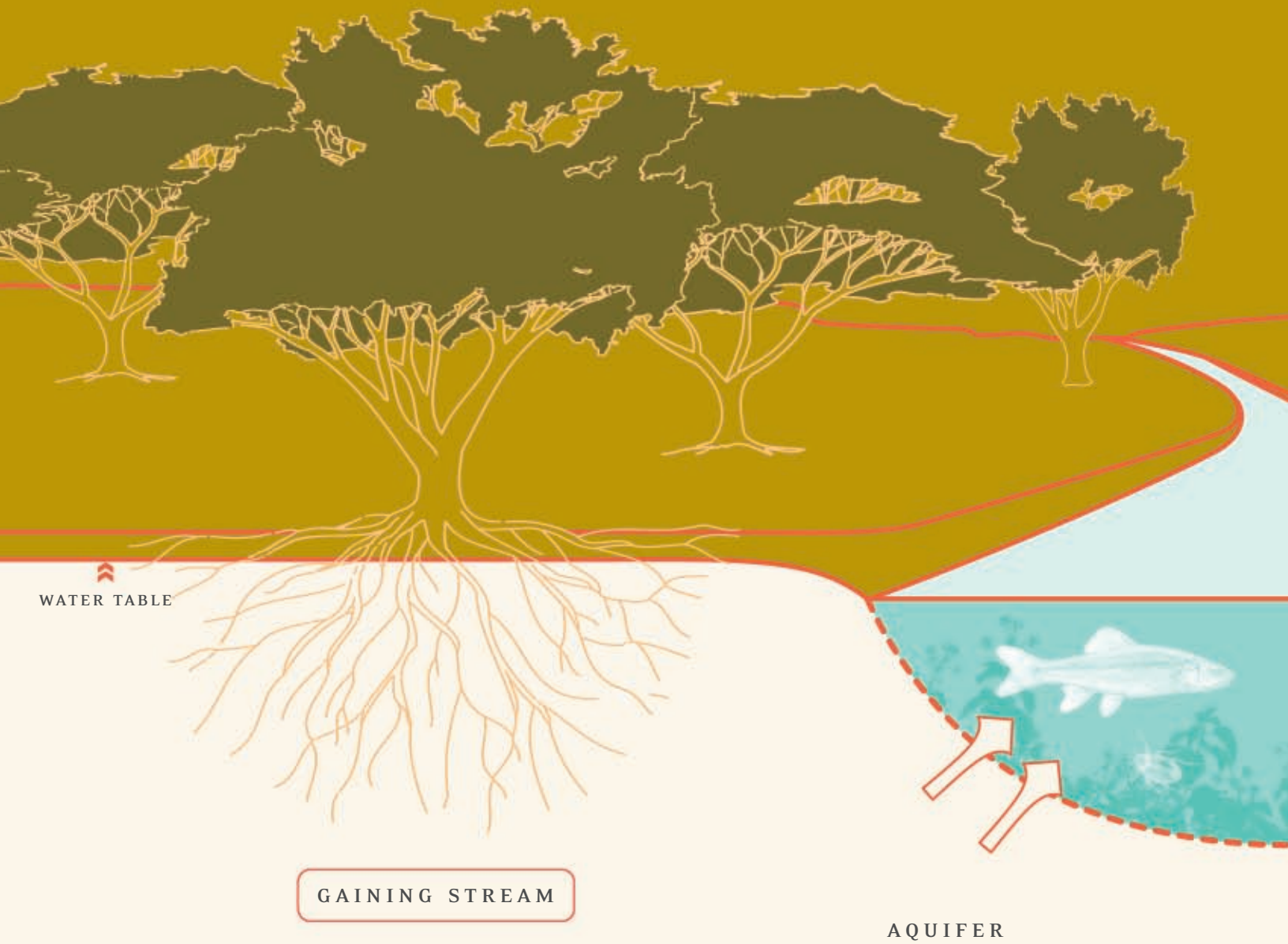
Category	Indicators and Standards	Standard Source and Type
aquatic	**Dissolved oxygen:** > 1 mg/L	**ADEQ:** standard for wildlife in effluent[1]
	Ammonia: varies with temperature & pH	**ADEQ:** standard for wildlife in effluent[1]
	Total phosphorus: < 5 mg/L	Historical (1992–1999 median)[2]
	E. coli: < 235 CFU/100mL	**ADEQ:** standard for human health[1]
	Metals: varies by specific metal	**ADEQ:** standard for wildlife[1]
	Aquatic invertebrates: baseline	2008 Baseline information
	Fish: baseline	2008 Baseline information
riparian	**Depth to groundwater:** < 5.1 m	Scientific standard[3]
	Groundwater variability: < 0.8 m/yr	Scientific standard[3]
	Riparian vegetation: baseline	2006 Baseline information

1 Arizona Administrative Code. (2008).
2 Friends of the Santa Cruz River. Unpublished data.
3 Lite, S. J., and J. C. Stromberg. (2005).

WATER SOURCES

A finite amount of water supports human and natural environments along the Upper Santa Cruz River. This water comes from two natural sources: precipitation and groundwater. A third source of water, effluent, is water that has been pumped from one location, used by people, treated in a wastewater facility, and returned to the river in a new location. Thus, effluent is really the movement and use of water, and represents an important human "source" of water. While effluent presents a suite of challenges for riparian areas, research at Arizona's universities and agencies has shown that effluent can be an important additional water source for rivers. In the Upper Santa Cruz River, all three sources of water contribute to streamflows, help the river function, and thereby offer numerous ecosystem services that people value.

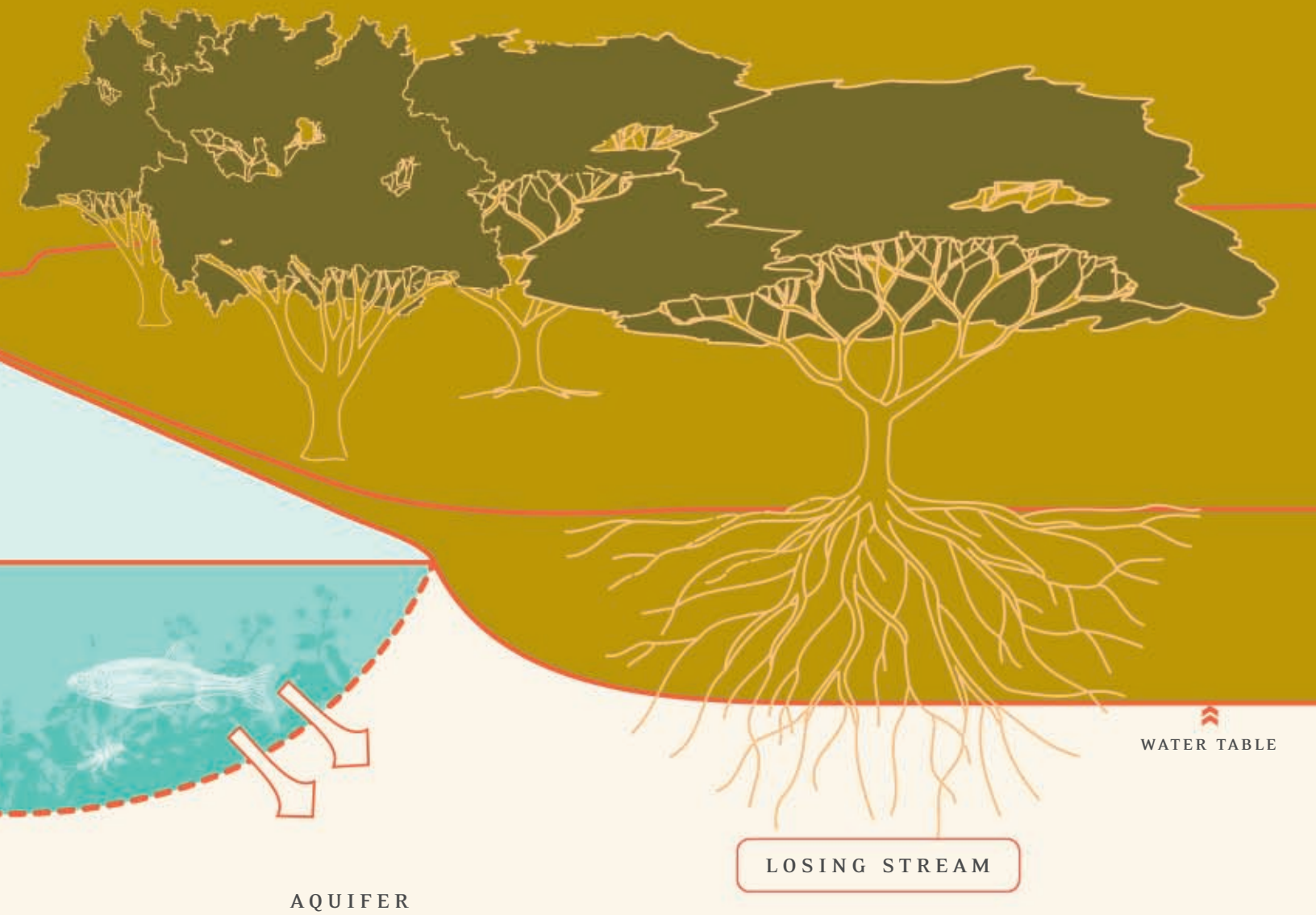
Streamflow is influenced by both precipitation and groundwater levels. Effluent released into the stream can increase streamflow and replenish local aquifers (layers of rock or earth that contain groundwater) as the water infiltrates through the streambed. As a general rule, when the water table in the aquifer is above the level of the stream, groundwater will emerge or discharge from the aquifer into the stream channel and increase flow. A stream that receives groundwater from the aquifer is referred to as a gaining stream. If the water table is below the level of the stream, water from the stream will infiltrate through the streambed to



raise the water table in local aquifers, consequently lessening flow. A stream that loses water to the aquifer is referred to as a *losing stream*.

Historically, streamflow in many stretches of the Upper Santa Cruz River was perennial (year-round). As the human population grew, the demand for water resulted in increased pumping of groundwater. As pumping lowered the water table, groundwater discharge to the stream decreased and streamflow became more dependent on effluent and precipitation.

Currently, upstream of the Nogales International Wastewater Treatment Plant (NIWTP) located in Rio Rico, Arizona, precipitation is the primary source of streamflow in the river. In contrast, effluent provides the majority of the flow downstream of the NIWTP in the Rio Rico, Tubac, and Amado reaches, according to the Arizona Department of Water Resources. Effluent is released from NIWTP into the streambed at a rate of up to 15 million gallons per day (9.9 million gallons per day from Nogales, Sonora, Mexico; and 5.1 million gallons per day from Nogales, Arizona). Upgrades to the NIWTP were completed in summer 2009. As reported in the *Living River*—2009 water year, the upgraded treatment process has significantly decreased levels of nitrogen in the released effluent (see nutrient pollution in Aquatic section).



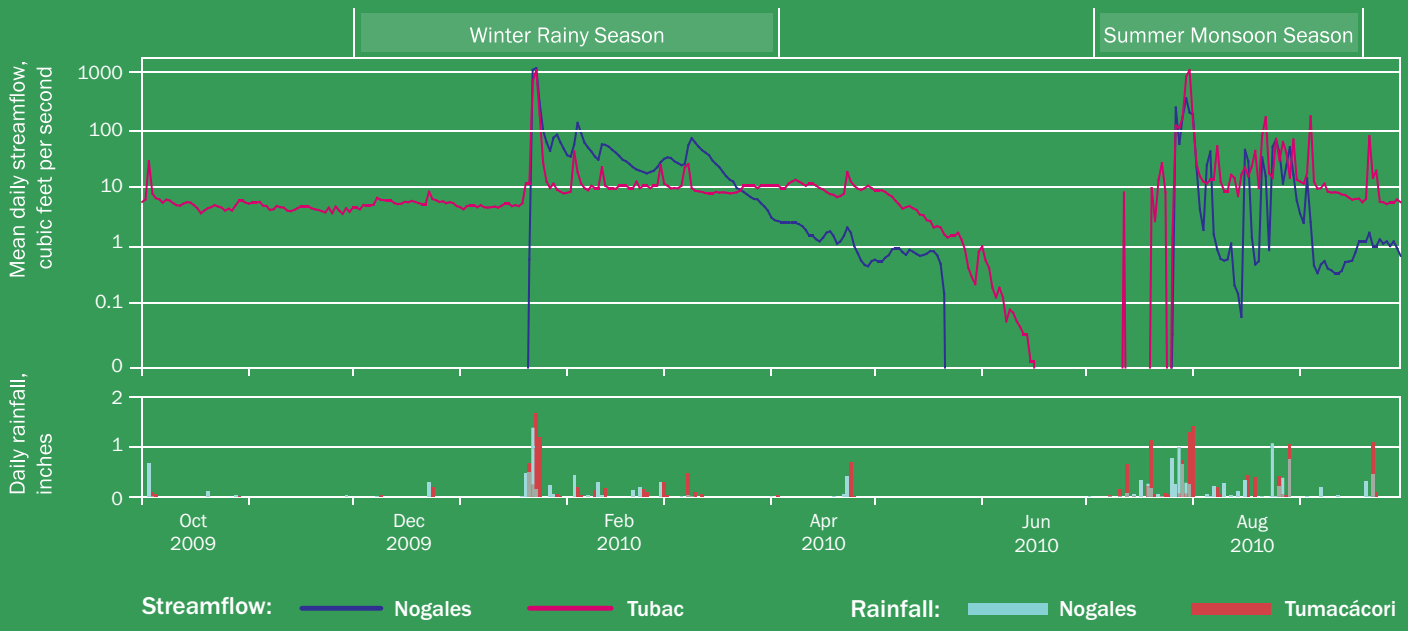
PRECIPITATION AND STREAMFLOW

The "water year" (October 1 to September 30) is linked to annual precipitation patterns. Precipitation typically falls during two seasons. The *winter rainy season*, which lasts from December to March, brings the occasional gentle and widespread rain. Frequent but locally violent thunderstorms occur during the *summer monsoon season*, which typically lasts from July to mid-September. The two rainy seasons do not occur completely within one calendar year, thus the water year starts during the dry season before the winter rains and ends during the dry season after the summer monsoon.

The variability of streamflow (i.e., flood peaks) is influenced by precipitation events throughout the watershed. The Santa Cruz River watershed includes any land that water runs over, under, or through on its way to the river. Seasonal floods are important for recharging aquifers, dispersing seeds, inducing seed germination, and clearing natural debris from the riparian forest floor.

Precipitation and streamflow provide context for the results of the indicators in the following pages. Therefore we include precipitation patterns and streamflow monitoring during the 2010 water year.

CUBIC FEET PER SECOND 1 cubic foot per second = 7.48 gallons per second



Data Source: National Weather Service and U.S. Geological Survey

2010 Precipitation

Weather is monitored at the Nogales International Airport near Nogales, Arizona, and at the Tumacácori National Historical Park, near Tubac, Arizona.

The Nogales station recorded 15.1 inches of rain. Rainfall was slightly above this station's recent average (13 inches from 2002 to 2010), and higher than the 9.7 inches that fell in the 2009 water year.

- The winter rainy season brought over 4.7 inches of rain—the wettest winter at this station in 10 years.
- The summer monsoon brought over 8 inches of rain.

The Tumacácori NHP station recorded 16.6 inches of rain. Rainfall was similar to this station's historical average (17 inches from 1971 to 2000) and higher than the 12.2 inches that fell in the 2009 water year.

- The winter rainy season brought over 5.8 inches of rain—the wettest winter at this station in 12 years.
- The summer monsoon brought over 8.6 inches of rain.

2010 Streamflow

Streamflow is measured with gages upstream of the NIWTP as the river returns to the United States near Nogales, Arizona, and downstream of NIWTP at Tubac, Arizona. Streamflow, measured in cubic feet per second (cfs), is the volume (cubic feet) of water flowing past a fixed point in a specific period of time (1 second).

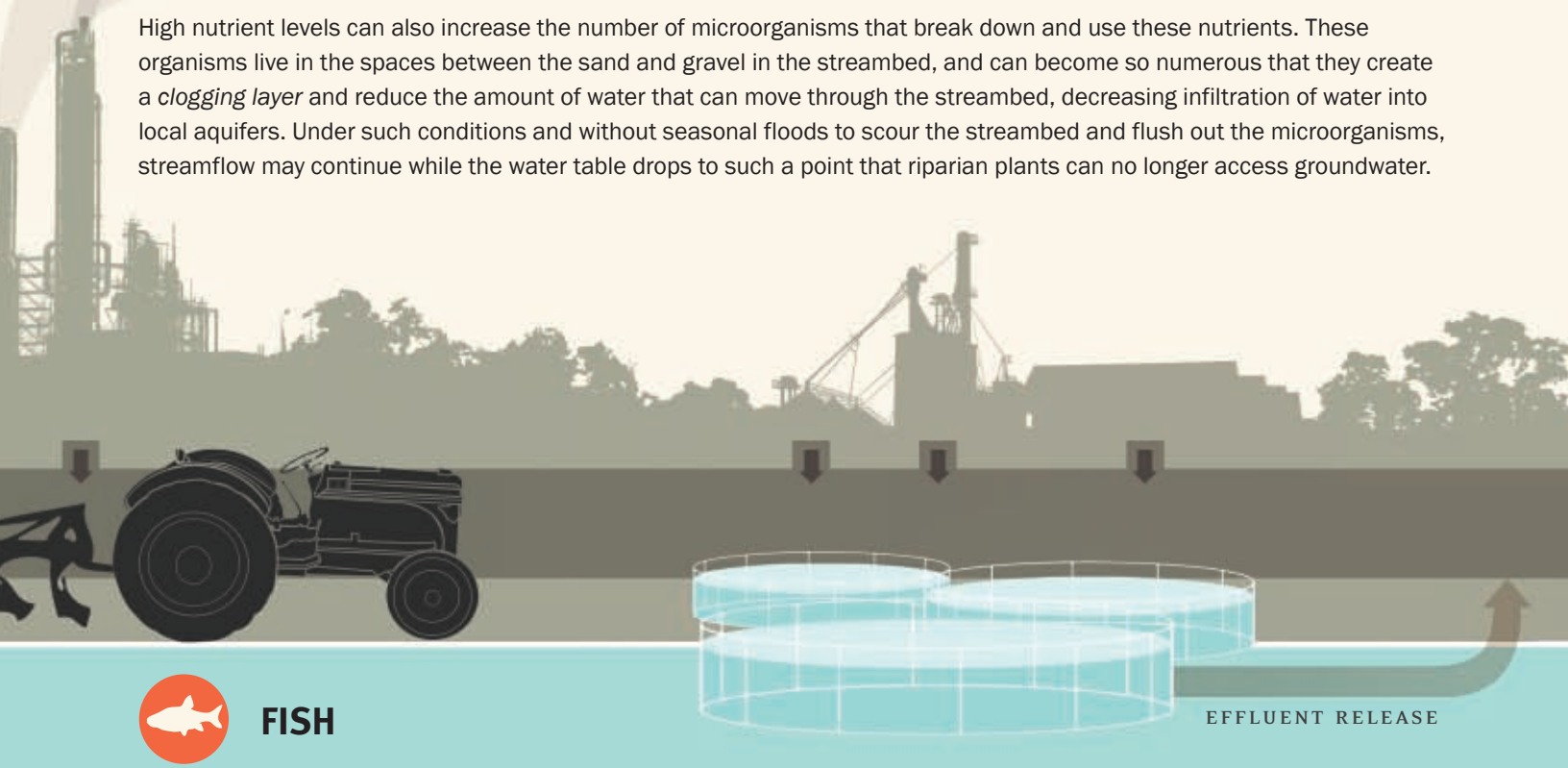
- Mean daily streamflow averaged 19 cfs near Nogales, peaking at 1180 cfs on January 23, 2010. Streamflow was high compared to the 2009 water year when mean daily streamflow averaged 0.5 cfs.
- Mean daily streamflow averaged 21 cfs at Tubac, peaking twice at 1090 cfs on January 23 and July 31, 2010. For several days in June and July, the Tubac gage recorded zero flow, a state not seen since July 2003. Several factors likely contributed to reduced streamflow. These include changing weather patterns, floods, and reduced nutrient pollution which may have increased infiltration (see nutrient pollution in Aquatic section).

aquatic

Aquatic ecosystems, such as streams, depend on particular water quality conditions (chemical, physical, and biological properties) to sustain plant and animal communities. Water temperature and pH (level of acidity) provide important context for river conditions. During the 2010 water year, water temperature ranged from 42.8° F in the winter to nearly 81.5° F in the summer; and pH was between 7.2 and 8.5 most of the year.

Nutrient pollution, such as high levels of nitrogen and phosphorus, enters the river from air pollution, fertilizer, overflow from septic systems, 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 a *clogging layer* and reduce the amount of water that can move through the streambed, 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 while the water table drops to such a point that riparian plants can no longer access groundwater.



FISH

Fish can serve as effective indicators of river health because they live for several years and differ from species to species in their tolerance to pollution. Historically, the Upper Santa Cruz River supported several native fish species: Gila Topminnow, Desert Sucker, Sonora Sucker, and Longfin Dace. Long-term monitoring has shown a decline in the number of native fish species present and the number of individual fish in the river. Three nonnative fish species—the Western Mosquitofish, Green Sunfish, and Largemouth Bass—were found in Tumacácori National Historical Park between 2001 and 2002. The 2008 baseline documented only Longfin Dace, in very low numbers (2 individual fish caught).

2010 Results

A fall 2010 fish survey of the Upper Santa Cruz River determined presence and general numbers of fish, but did not estimate total population numbers. Notably more fish were caught and observed in 2010 than in 2009.

- **Rio Rico:** 66 Longfin Dace. *2009 = 70 Longfin Dace*
- **Tubac:** 257 Longfin Dace and over 800 Western Mosquitofish. *2009 = 46 Longfin Dace and 109 Western Mosquitofish*
- **Amado:** 266 Longfin Dace and 455 Western Mosquitofish. *2009 = 26 Longfin Dace and 47 Western Mosquitofish*

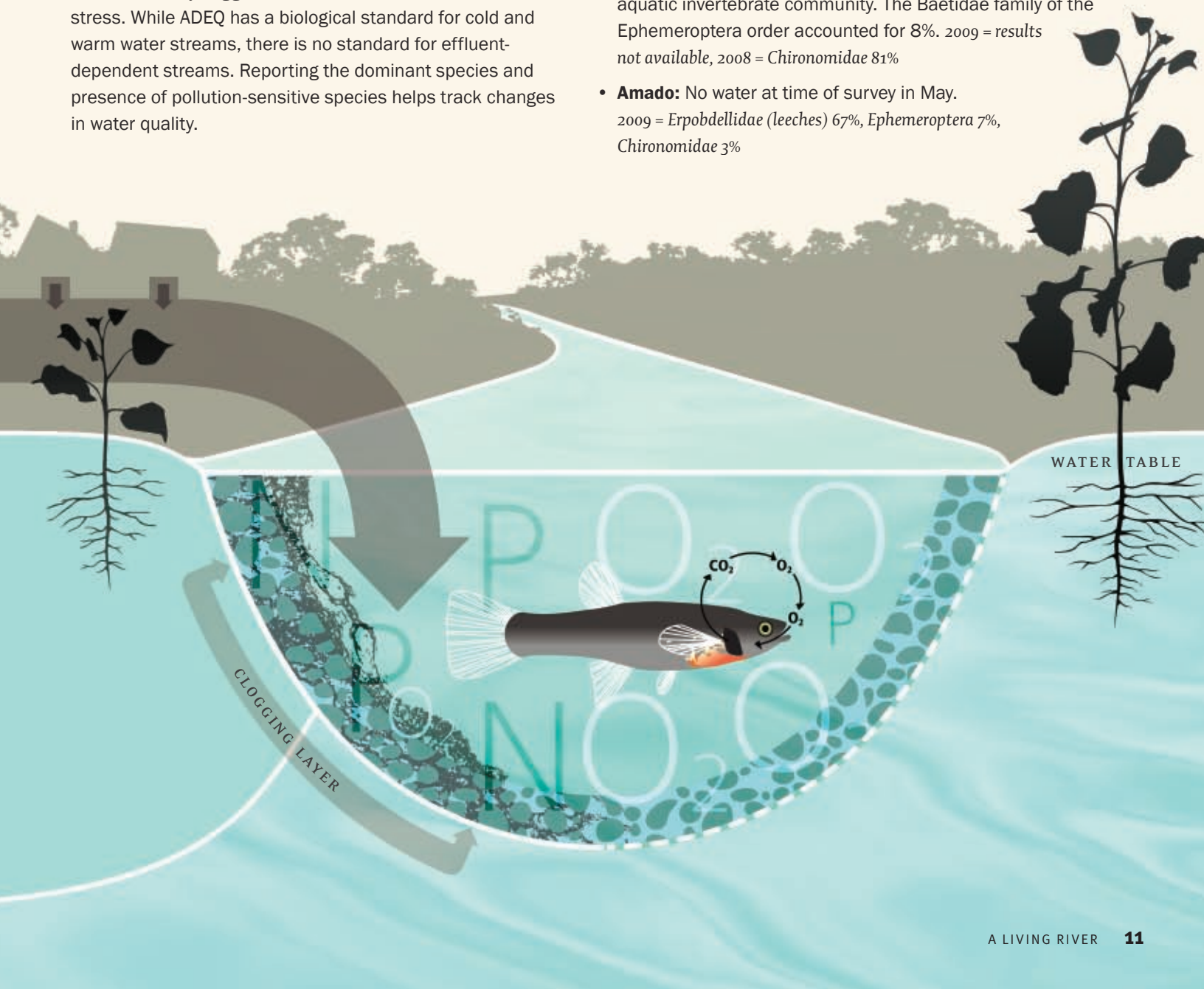
AQUATIC INVERTEBRATES

Aquatic invertebrates (aquatic animals that lack a spinal column or backbone) are an important biological component in streams and an indicator of river health because they differ in their tolerances to pollution and typically live for more than a year. In general, aquatic invertebrates with high tolerances to pollution, like those in the Chironomidae family (midges), are found in higher numbers in polluted streams. In contrast, Ephemeroptera (mayflies) is an order (group of families) of aquatic invertebrates that is sensitive to pollution and found in lower numbers in polluted streams. Regardless of sensitivity to pollution, if a single species or group accounts for more than 50 percent of the invertebrate community, this lack of diversity suggests a stream is under environmental stress. While ADEQ has a biological standard for cold and warm water streams, there is no standard for effluent-dependent streams. Reporting the dominant species and presence of pollution-sensitive species helps track changes in water quality.

2010 Results

There was no water in the Amado reach at the time of the survey. A Sonoran Institute sample within the Tubac reach in 2010 found that the Tubac reach was dominated by one family, suggesting that this reach is under environmental stress. However, Ephemeroptera were observed in 2010 while not in 2008, suggesting some improvement in water quality. Data from another location in the Tubac reach were not available at press time.

- **Rio Rico:** No samples were collected. *2009 = No data*
- **Tubac:** The Chironomidae family accounted for 77% of the aquatic invertebrate community. The Baetidae family of the Ephemeroptera order accounted for 8%. *2009 = results not available, 2008 = Chironomidae 81%*
- **Amado:** No water at time of survey in May. *2009 = Erpobdellidae (leeches) 67%, Ephemeroptera 7%, Chironomidae 3%*



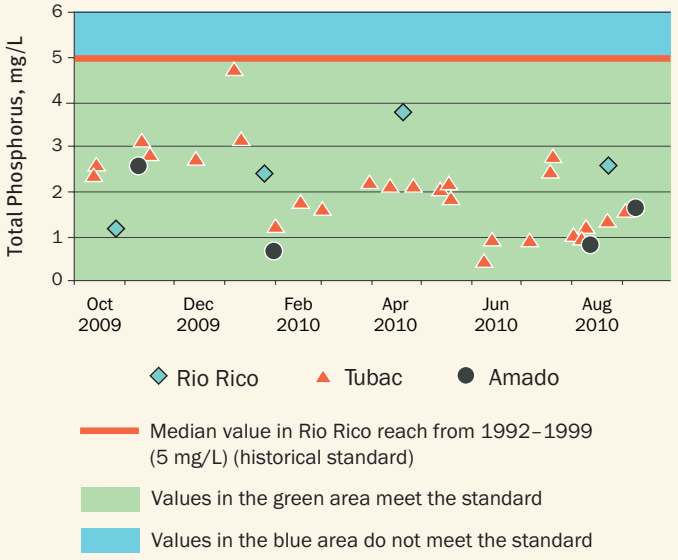
AMMONIA

Nitrogen is an essential nutrient for plant and animal life, but too much can lead 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. The toxicity of ammonia varies with several factors such as pH, temperature, and dissolved oxygen. ADEQ's standard for ammonia varies by pH and temperature. As pH and temperature increase, the toxicity of ammonia increases, thus the acceptable level of ammonia decreases with high pH and temperature. Based on the range of temperatures and pH in the reaches, the maximum amount of ammonia during the 2010 water year should be less than 0.64 to 5.08 milligrams per liter (mg/L) for ecosystem health.

Data Source: Arizona Department of Environmental Quality, Friends of the Santa Cruz River, National Park Service Sonoran Desert Network, Sonoran Institute, and U.S. Geological Survey

TOTAL PHOSPHORUS

Phosphorus is an essential nutrient for plant and animal life. However, too much phosphorus can reduce the quality of aquatic habitat. Elevated levels of phosphorus can accelerate plant growth. As plants decay in the river, dissolved oxygen decreases and aquatic animals can die. The median amount of total phosphorus monitored in the Rio Rico reach from 1992–1999 was approximately 5 mg/L. Because ADEQ does not have a standard for total phosphorus in this stretch of the Upper Santa Cruz River, this assessment uses the 1992–1999 median of 5 mg/L as the historical standard.

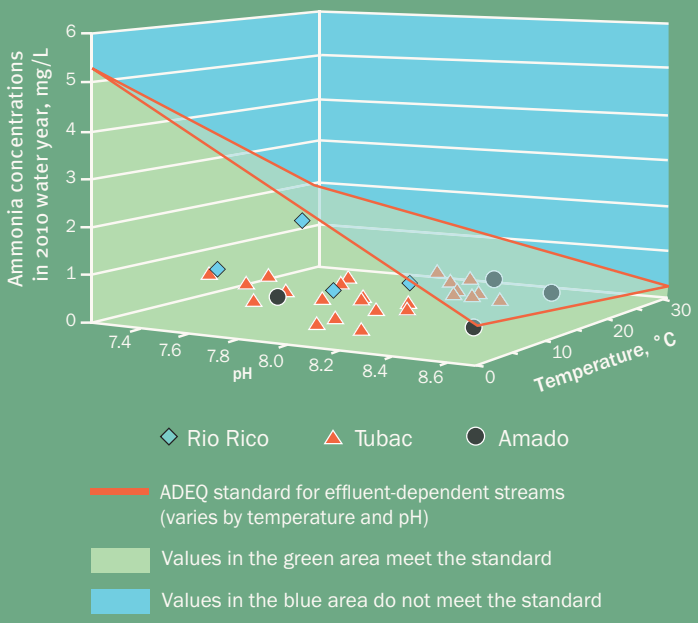


2010 Results

Phosphorus was monitored a total of 34 times. All 34 samples met the historical standard (100% standard attainment). Overall, levels of total phosphorus decreased since the 2009 water year.

- **Rio Rico:** 4 of the 4 samples met the historical standard (100% attainment). *2009 = 20% attainment*
- **Tubac:** 26 of the 26 samples met the historical standard (100% attainment). *2009 = 86% attainment*
- **Amado:** 4 of the 4 samples met the historical standard (100% attainment). *2009 = 100% attainment*

Data Source: Arizona Department of Environmental Quality, Friends of the Santa Cruz River, National Park Service Sonoran Desert Network, Sonoran Institute, and U.S. Geological Survey



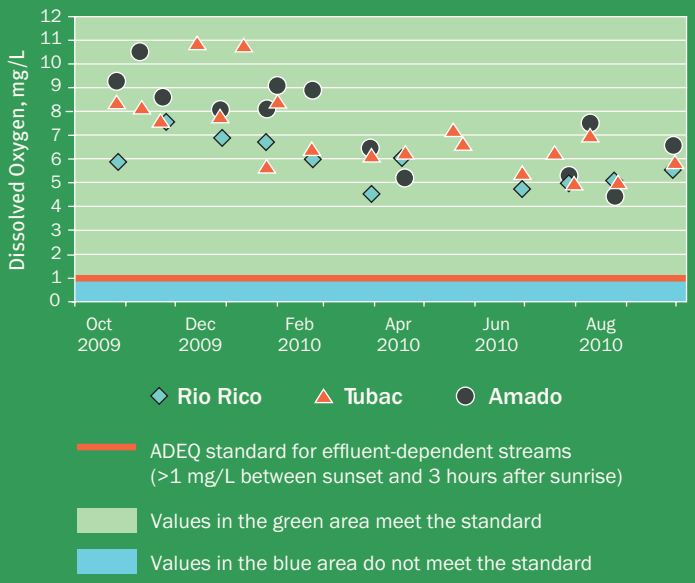
2010 Results

Ammonia was monitored a total of 32 times, and the ADEQ standard was met in all 32 samples (100% standard attainment). Overall, levels of ammonia are lower than in the 2009 water year.

- **Rio Rico:** 4 of the 4 samples met the standard (100% attainment). *2009 = 40% attainment*
- **Tubac:** 24 of the 24 samples met the standard (100% attainment). *2009 = 57% attainment*
- **Amado:** 4 of the 4 samples met the standard (100% attainment). *2009 = 100% attainment*

O_2 DISSOLVED OXYGEN

Fish and other aquatic animals need oxygen to survive. Rivers absorb oxygen from the atmosphere and aquatic plants produce oxygen. Natural causes of variability in dissolved oxygen levels include nutrient levels, groundwater discharge, shading, water temperature, and time of day. ADEQ sets the minimum standard for dissolved oxygen in effluent-dependent streams at 1 milligram per liter (mg/L) measured between sunset and three hours after sunrise, and 3 mg/L at other times. All data in this report was measured within three hours after sunrise, thus measures of dissolved oxygen that are greater than 1 mg/L meet the standard.



2010 Results

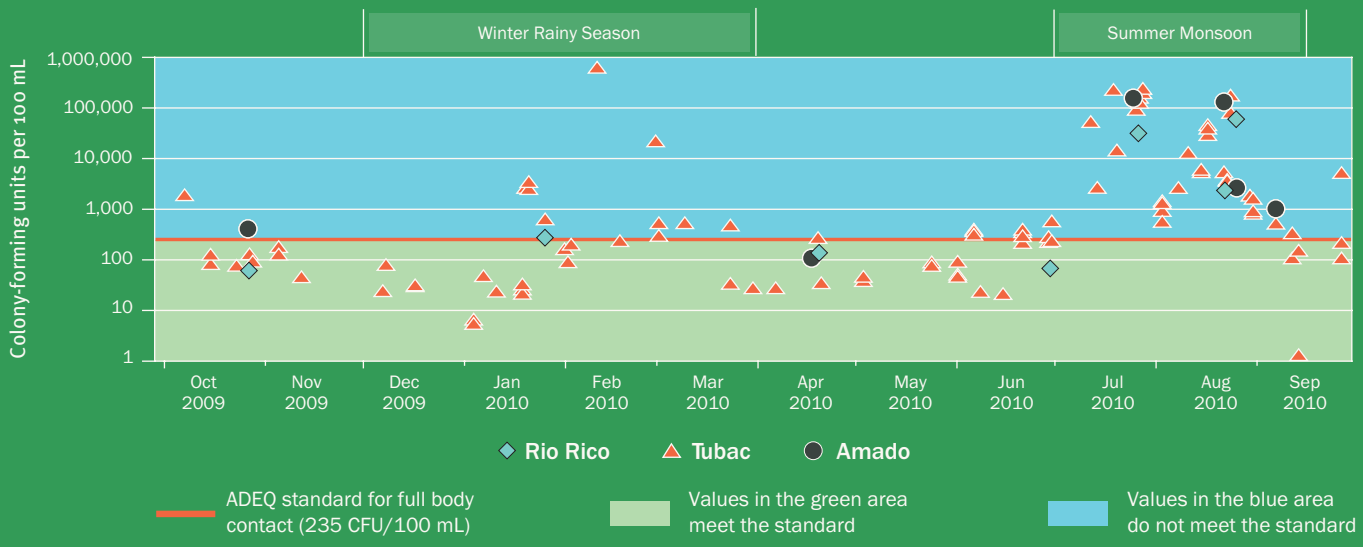
Dissolved oxygen was measured a total of 43 times. All of the 43 samples met the standard (100% standard attainment). Although there was no difference from the 2009 water year in overall percent attainment, data from all sites tended to have higher levels of dissolved oxygen in the 2010 water year.

- **Rio Rico:** 11 of the 11 samples met the standard (100% attainment). *2009 = 100% attainment*
- **Tubac:** 19 of the 19 samples met the standard (100% attainment). *2009 = 100% attainment*
- **Amado:** 13 of the 13 samples met the standard (100% attainment). *2009 = 100% attainment*

Data Source: Friends of the Santa Cruz River, Sonoran Institute, and U.S. Geological Survey

E. COLI

Escherichia coli (E. coli) is one of the common species of bacteria living in the lower intestines of mammals, and its presence in water is an indication of fecal contamination. The discovery of *E. coli* indicates the potential presence of other pathogenic microorganisms such as bacteria and viruses that might be a health risk to people swimming or wading in the river. The ADEQ standard for a single sample maximum for full body contact (swimming) is 235 colony-forming units per 100 milliliters of water (CFU/100mL). For partial body contact (wading), the single sample maximum is 576 CFU/100mL. The results are compared to the stricter standard, thus samples with greater than 235 CFU/100mL do not meet the standard.



Data Source: Arizona Department of Environmental Quality, Friends of the Santa Cruz River, National Park Service at Tumacácori National Historical Park, National Park Service Sonoran Desert Network, and U.S. Geological Survey

METALS

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. The Upper Santa Cruz River is exposed to pollutant metals through numerous sources, including industrial wastewater discharge, 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 wildlife standard: arsenic, cadmium, copper, lead, selenium, and zinc.

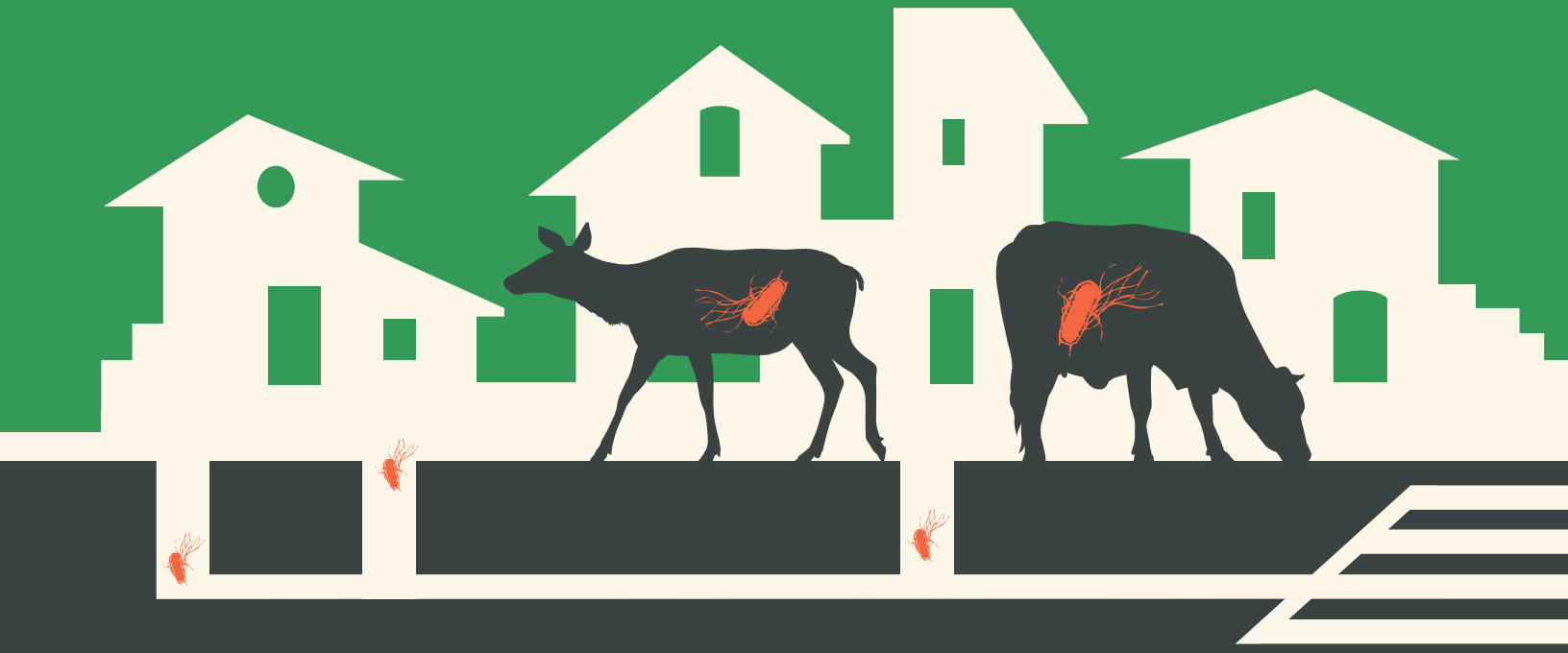
2010 Results

During the 2010 water year, most of the samples met the appropriate standard. However, samples measured for cadmium in the Rio Rico reach were above the standard. Cadmium is lethal to aquatic wildlife at relatively low concentrations and comes from numerous human produced sources such as electroplating processes, fertilizers, pesticides, coal combustion, and mine wastes.

2010 Results

E. coli was monitored a total of 112 times across the three reaches, with most of the monitoring in the Tubac reach conducted by staff at Tumacácori National Historical Park. Overall, the ADEQ standard was met 48 out of the 112 times (43% standard attainment). *E. coli* levels continued to exceed the standard, especially during the rainy seasons. High levels during the rainy season suggest that rain is washing fecal contamination into the river from multiple sources within the watershed. Preliminary research identifies humans, livestock, and wildlife among the sources of contamination.

- **Rio Rico:** 3 of the 7 samples met the standard (43% attainment). *2009 = 50% attainment*
- **Tubac:** 44 of the 99 samples met the standard (44% attainment). *2009 = 61% attainment*
- **Amado:** 1 out of 6 samples met the standard (17% attainment). *2009 = 67% attainment*



- **Rio Rico:** Overall 20 of the 22 samples tested for metals met the standard (91% attainment). *2009 = 88% attainment*
  - Standards met: Arsenic (4 of the 4 samples), Copper (4 of the 4 samples), Lead (4 of the 4 samples), Selenium (4 of the 4 samples), and Zinc (4 of the 4 samples).
  - Standards not met: Cadmium (0 of the 2 samples met the standard; exceedances were 0.003 and 0.008 mg/L above the standard).
- **Tubac:** Overall, 7 of the 7 samples tested for metals met the standard (100% attainment). *2009 = 80% attainment*
  - Standards met: Cadmium (1 of 1 sample), Copper (3 of the 3 samples), Lead (1 of 1 sample), and Zinc (2 of the 2 samples).
  - Standards not met: none
- **Amado:** No samples were tested for metals. *2009 = No data*

Metals Data Source: Friends of the Santa Cruz River and National Park Service Sonoran Desert Network

riparian

DEPTH TO GROUNDWATER

The interactions between vegetation, surface water, and groundwater are important factors in overall riparian health. As with other Southwestern rivers, cottonwoods and willows dominate the native riparian forests along the Upper Santa Cruz River and depend on surface water and groundwater to survive.

Several scientific studies have investigated the maximum depth to groundwater required to sustain mature Fremont cottonwood trees. Scientists estimate that this depth ranges from 2.5 to 5.1 meters (approximately 8 to 16 feet).

We compare maximum depths to groundwater to the upper end of the cottonwood range, thus locations with maximum depths less than 5.1 meters meet the scientific standard. It is important to note that areas with greater maximum depths to groundwater may support other types of riparian vegetation, such as mesquites.

2010 Results

A total of 17 wells within and near the 100-year floodplain were monitored at least once during the 2010 water year. Depth to groundwater measurements are determined relative to areas that may support cottonwoods and are displayed on the map on the page 19.

- **Rio Rico:** Maximum depths to groundwater in seven wells were: 1.45 m, 2.06 m, 2.06 m, 3.28 m, 3.46 m, 4.95 m, and 8.02 m (86% attainment). *2009 = 86% attainment*
- **Tubac:** Maximum depths to groundwater in six wells were: 1.23 m, 1.36 m, 2.68 m, 2.83 m, 3.42 m, and 4.25 m (100% attainment). *2009 = 100% attainment*
- **Amado:** Maximum depths to groundwater in four wells were: 2.97 m, 6.11 m, 7.15 m, and 10.56 m (25% attainment). These depths are within the historical range for the Amado reach which is dominated by other riparian vegetation. *2009 = 25% attainment*

GROUNDWATER VARIABILITY

Variability in groundwater levels affects the growth and survival of riparian plants. There are several natural and human causes of groundwater variability. Naturally, groundwater levels decline after the winter rainy season ends and increase once the summer monsoons begin. Studies on the San Pedro River in Arizona indicate that cottonwood trees can withstand declines in groundwater levels up to 0.8 meters (2.6 feet) from January to June. Wells with groundwater levels that decline no more than 0.8 meters between January and June met this scientific standard.

2010 Results

Due to reductions in groundwater monitoring, groundwater variability from January to June 2010 could only be calculated for 4 wells that were monitored throughout the year (see graph for annual variability in each well). All 4 wells met the scientific standard (100% attainment). Groundwater increased from January to June in the single well in Rio Rico. This is likely due to high winter streamflow upstream of Rio Rico that helped replenish the aquifer (see Streamflow section). Note

Groundwater Data Source: Arizona Department of Water Resources

BIRDS

According to the Tucson Audubon Society and the National Park Service, the birds of the Upper Santa Cruz Valley attract thousands of visitors each year. Birds are influenced by many factors at various locations that may or may not reflect what is happening at a site-specific level. Therefore, birds are not an indicator for this assessment. However, because of their importance to the region, bird monitoring information is summarized below.

In 1997, the National Park Service began to collect data at Tumacácori National Historical Park as part of the Monitoring Avian Productivity and Survivorship (MAPS) program. The MAPS program has recorded a total of 172 species over the past 14 years. In addition to the MAPS program, the National Park Service surveys resident birds at Tumacácori National Historical Park during the breeding season. The Tucson Audubon Society uses similar methods to monitor birds at the Esperanza Ranch in the Amado reach.

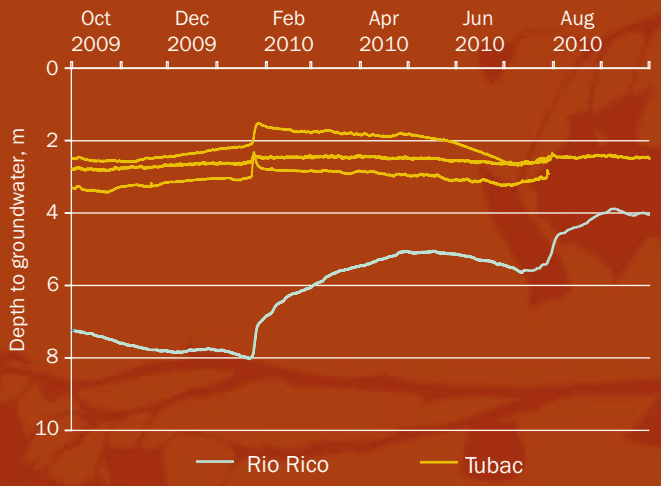
2010 Results

Surveys in the Tubac and Amado reaches found a total of 82 species, of which 36 were found in both reaches.

- **Rio Rico:** Birds were not monitored.
- **Tubac:** Surveys detected 62 native and 1 non-native species (House Sparrow) at the Tumacácori National Historical Park.
- **Amado:** Surveys detected 54 native and 1 non-native species (Eurasian Collared-Dove) at the Esperanza Ranch.

that the change in percent attainment for Rio Rico is due to having fewer wells with data. With small amounts of data, the gain or loss of a well can cause large changes in attainment values.

- **Rio Rico:** Groundwater increased 2.37 m in one well (100% attainment). *2009 = 50% attainment*
- **Tubac:** Groundwater declined 0.18 m and 0.35 m in two wells and increased 0.01 m in one well (100% attainment). *2009 = 100% attainment*
- **Amado:** No wells with enough data. *2009 = 100% attainment*



RIPARIAN VEGETATION

Riparian vegetation represents a small percentage of the land cover in the Upper Santa Cruz watershed, but it provides important benefits to the region. Riparian vegetation's many ecosystem services include removing contaminants before effluent-dominated water infiltrates into groundwater drinking supplies, slowing flood waters, reducing erosion potential along stream banks, increasing groundwater recharge, providing habitat for wildlife, and providing recreational and spiritual enjoyment.

In 2006, Santa Cruz County, Friends of the Santa Cruz River, the University of Arizona, and the Sonoran Institute mapped the riparian vegetation along the Upper Santa Cruz River. Though there is no scientific standard quantifying the amount of riparian vegetation necessary to maintain a healthy river, a simplified version of the 2006 map establishes a baseline useful for measuring future changes in extent or composition of vegetation.

Types of vegetation and land use within the river's 100-year floodplain are divided into five categories: cottonwood forests and woodlands; mesquite forests and woodlands; other riparian vegetation; human infrastructure; and agriculture and pasture. Forests and woodlands have more than 10 percent cottonwood or mesquite tree cover. Other riparian vegetation includes areas not dominated by cottonwood or mesquite trees. Human infrastructure includes areas with roads, railroads, and housing. Agriculture and pasture include crop fields and pasture land. The 2006 baseline map is updated annually using hundreds of aerial photos to identify large changes (>1 acre) in these five categories. The results of the updated vegetation map for the 2010 water year are shown on the opposite page.

Since the 2006 baseline, about 100 acres (1.5%) of the area within the 100-year floodplain had changes in vegetation type and landcover. During the 2010 water year, a small decrease (0.2%) in the extent of mesquites resulted from the clearing of 10 acres for human infrastructure. However, overall there were no major changes in extent of riparian vegetation, with over 1,000 acres (16%) dominated by cottonwoods; nearly 1,400 acres (20%) dominated by mesquites; about 2,000 acres (31%) dominated by other riparian vegetation; over 500 acres (8%) used for human infrastructure; and 1,700 acres (25%) used for crops or pastures. Of the area in the 100-year floodplain, the Tubac reach has the largest percentage dominated by cottonwoods (26%), while the Rio Rico reach has the largest percentage dominated by mesquites (28%).

The following legend corresponds to well monitoring, displayed on the map at right. Wells that met the scientific standard are shown in light green and grey. Wells that did not meet the scientific standard are shown in yellow-green.

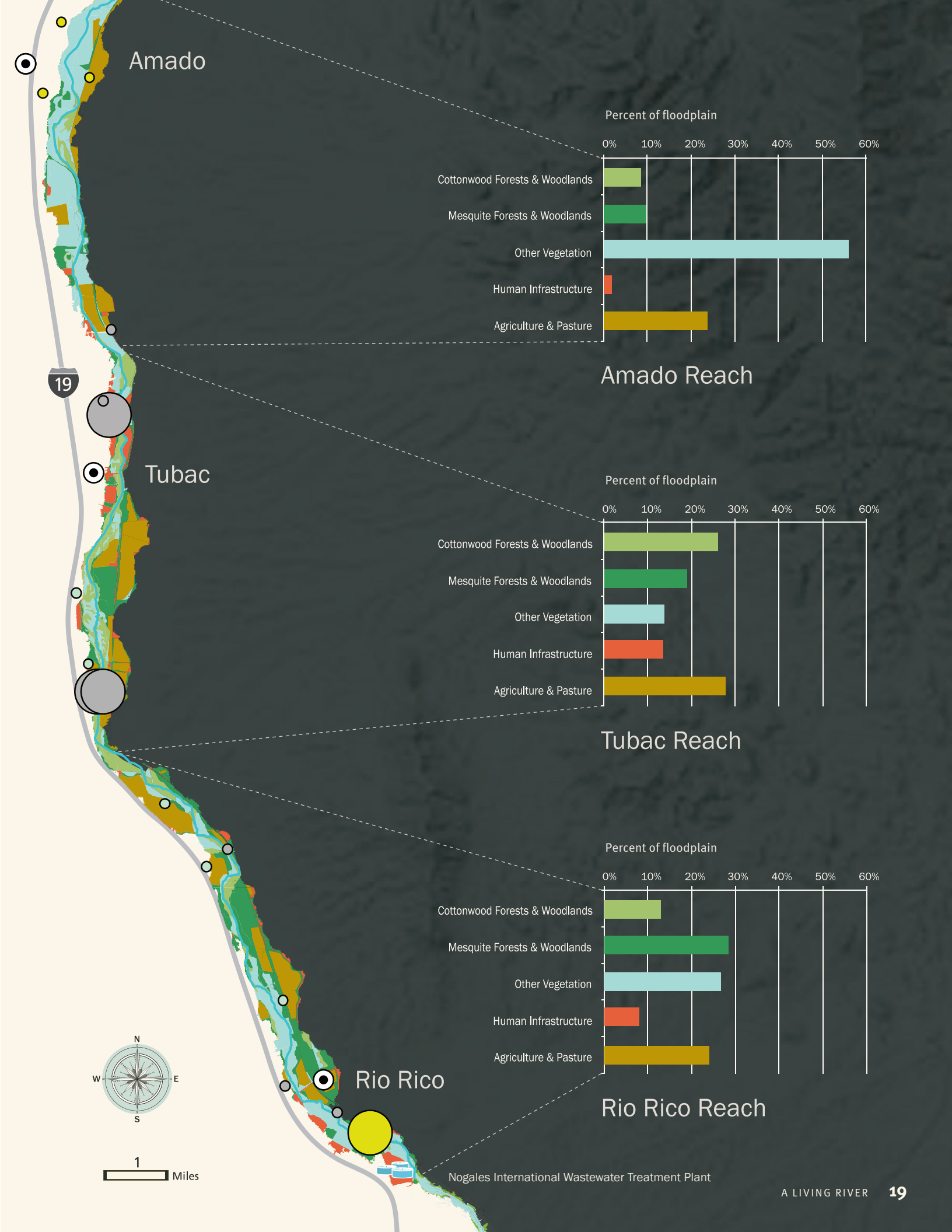
Maximum depth

- < 2.5 m
- 2.5 – 5.1 m
- > 5.1 m

Number of measurements

- 1
- 2 – 12
- Continuous

Annual overflight for photography of riparian vegetation generously provided by Lighthawk (www.Lighthawk.org)


Amado
Percent of floodplain
0%
10%
20%
30%
40%
50%
60%
Cottonwood Forests & Woodlands
Mesquite Forests & Woodlands
Other Vegetation
Human Infrastructure
Agriculture & Pasture
Amado Reach
19
Tubac
Percent of floodplain
0%
10%
20%
30%
40%
50%
60%
Cottonwood Forests & Woodlands
Mesquite Forests & Woodlands
Other Vegetation
Human Infrastructure
Agriculture & Pasture
Tubac Reach
Percent of floodplain
0%
10%
20%
30%
40%
50%
60%
Cottonwood Forests & Woodlands
Mesquite Forests & Woodlands
Other Vegetation
Human Infrastructure
Agriculture & Pasture
Rio Rico
Rio Rico Reach
N
W
E
S
1
Miles
Nogales International Wastewater Treatment Plant

ECOLOGICAL HEALTH SUMMARY

The 2010 water year data indicate continued improvement for the aquatic ecosystem and relative stability in the riparian ecosystem on the Upper Santa Cruz River. This suggests that the Upper Santa Cruz River continues to supply important ecosystem services (to compare data from previous reports, visit **www.sonoraninstitute.org**: Where We Work > Southwest > Santa Cruz River).

During the 2010 water year, levels of ammonia and phosphorus met the standard in all reaches. These results were found after the upgrade to the Nogales International Wastewater Treatment Plant was completed in March 2009.

Reduced nutrient pollution has likely increased infiltration of water into local aquifers.

As in the 2009 water year, *E. coli* levels and concentrations of metals caused some concern. Fecal contamination continues to pose a risk to humans, as indicated by *E. coli* levels exceeding the swimming (full body contact) standard. Most exceedances occurred during the rainy seasons, suggesting that there are multiple sources of contamination. Preliminary research identifies humans, livestock, and wildlife among the sources of contamination. Levels of cadmium were above the wildlife standard in the Rio Rico reach and posed

Category	Indicators and Standards	% Attainment of Standard*					
		Rio Rico		Tubac		Amado	
		2009	2010	2009	2010	2009	2010
aquatic	**Dissolved oxygen:** > 1 mg/L	100%	100%	100%	100%	100%	100%
	Ammonia: varies with temperature & pH	40%	100%	57%	100%	100%	100%
	Total phosphorus: < 5 mg/L	20%	100%	86%	100%	100%	100%
	E. coli: < 235 CFU/100mL	50%	43%	61%	44%	67%	17%
	Metals: varies by specific metal	88%	91%	80%	100%	no data	no data
	Aquatic invertebrates: 2008 baseline	no data		+		no data	
	Fish: 2008 baseline	+		+		+	
riparian	**Depth to groundwater:** < 5.1 m	86%	86%	100%	100%	25%	25%
	Groundwater variability: < 0.8 m/yr	50%	100%	100%	100%	100%	no data
	Riparian vegetation: 2006 baseline	no change		no change		no change	

*For indicators lacking a standard whose data is compared to a baseline in order to track change, direction of change is summarized with: "+" increase, "–" decrease, or "no change" for indicators that have not significantly changed over the past year.

a risk to aquatic organisms. ADEQ has worked with the cities of Nogales, Arizona, and Nogales, Sonora, as well as with the U.S. International Boundary and Water Commission to mitigate metals in the binational wastewater treated by NIWTP. Cadmium levels decreased between August 2009 and October 2010. Ongoing monitoring will help confirm the success of actions taken to reduce cadmium.

Fish surveys in the fall of 2010 found 589 native Longfin Dace compared to 142 in the fall of 2009. In addition, higher numbers of non-native Western Mosquitofish were found in the Tubac and Amado reaches. Information on the aquatic invertebrate population remains limited. There was no water in the Amado reach at the time of the survey and some data for the Tubac reach were not available at press time. The pollution-tolerant family Chironomidae dominated the one sample from the Tubac reach, suggesting that this reach is under environmental stress. However, Ephemeroptera, a family sensitive to pollution, was observed in small numbers in 2010 while not in 2008, suggesting some improvement in water quality.

Maximum depth to groundwater levels remained consistent between the 2010 and 2009 water years, meeting the scientific standard for sustaining cottonwood forests in the Rio Rico and Tubac reaches. While the maximum depths to groundwater in the Amado reach did not meet the scientific standard, depths were within the historical range of data, and cottonwood forests were not historically found in this reach. Groundwater variability in 2010 was similar to the results in 2009. The increase in percent attainment for Rio Rico is likely a result of having fewer wells with data. With small amounts of data, the gain or loss of a well can cause large changes in attainment values.

There was little change in the extent of riparian vegetation within the 100-year floodplain, with nearly 2,500 acres (36%) dominated by cottonwoods and mesquites, about 2,000 acres (31%) dominated by other vegetation, and over 2,200 acres (33%) used by humans for infrastructure, crops, and pastures. The Tubac reach still has the largest percentage (26%) dominated by cottonwoods, while the Rio Rico reach still has the largest percentage (28%) dominated by mesquites.

ONGOING EFFORTS

This report builds on numerous research and monitoring efforts to track conditions along the river. The following organizations collected data that contributed to this assessment of conditions along the Upper Santa Cruz River during the 2010 water year:

- Arizona Department of Environmental Quality—water quality monitoring as part of the Monitoring and Assessment Program which ensures that water quality standards are being met.
- Arizona Department of Water Resources—monitoring of groundwater levels.
- Friends of the Santa Cruz River—monthly water quality monitoring by trained volunteers as part of RiverWatch, and annual fish surveys conducted with the Arizona Game and Fish Department, Sonoran Institute, University of Arizona, and the U.S. Fish and Wildlife Service.
- National Park Service—monitoring of birds, water quality, and macroinvertebrates within the Tumacácori National Historical Park.
- National Weather Service—continuous monitoring of precipitation and weather.
- Sonoran Institute—monitoring of water quality and macroinvertebrates in the Tubac and Amado reaches and the extent of riparian vegetation along the Upper Santa Cruz River from the international border to Amado.
- Tucson Audubon Society—monitoring of birds in the Amado reach.
- U.S. Geological Survey—water quality monitoring and continuous monitoring of streamflow.

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The Sonoran Institute convened a Science Advisory Committee of ecology, hydrology, and wildlife experts to bring the best available science to bear on the development of the *Living River* health assessments.

The Committee provided scientific guidance on: identifying indicators of riparian health, establishing standards for ecological health, aggregating indicators to quantify riparian health, and reviewing this report. The information presented in this report grew out of discussions involving these experts and represents the product of a collective effort; it does not reflect the opinions or viewpoints of any individual member of the technical team. The viewpoints and opinions expressed in the discussions of the group and captured in this report also do not reflect the opinions or viewpoints of the agencies, institutions, or organizations with whom the technical team members and external reviewers are associated or employed. Any errors or omissions contained herein are solely those of the Sonoran Institute.

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University of Arizona — Rosalind Bark
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SONORAN INSTITUTE MISSION AND VISION

The Sonoran Institute's mission is to inspire and enable community decisions and public policies that respect the land and people of western North America. Facing rapid change, communities in the West value their natural and cultural resources, which support resilient environmental and economic systems.

Founded in 1990, the Sonoran Institute helps communities conserve and restore those resources and manage growth and change through collaboration, civil dialogue, sound information, practical solutions and big-picture thinking.

Our passion is to help shape the future of the West with:

- **Healthy Landscapes** that support native plants and wildlife, diverse habitat, open spaces, clean energy and water, and fresh air.
- **Livable communities** where people embrace conservation to protect quality of life today and in the future.
- **Vibrant economies** that support prosperous communities, diverse opportunities for residents, productive working landscapes and stewardship of the natural world.

The Sonoran Institute is a nonprofit organization with offices in Tucson and Phoenix, Arizona; Bozeman, Montana; Glenwood Springs, Colorado; Sheridan, Wyoming; and Mexicali, Baja California, Mexico. For more information, visit **www.sonoraninstitute.org**

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GET INVOLVED

If you would like to contribute to research, monitoring, or conservation efforts along the Upper Santa Cruz River, here are some actions you can take:

- Reduce your use of the region's limited water supply by harvesting rainwater and gray water to irrigate outdoor landscapes. Learn more at Watershed Management Group: ***www.watershedmg.org***.
- Join Friends of the Santa Cruz River and volunteer with RiverWatch to monitor water quality. Sign up at: ***www.friendsofsantacruzriver.org***.
- Volunteer with Tucson Audubon Society to conduct bird surveys or help with habitat restoration along the Upper Santa Cruz River. Sign up at ***www.tucsonaudubon.org***.
- Visit Tumacácori National Historical Park and Sonoita Creek State Natural Area to learn more about the plant and animal life in riparian systems.
- Visit the Sonoran Institute website for digital copies of Living River reports, comparisons of data from previous years, and other project updates: ***www.sonoraninstitute.org (Where We Work > Southwest > Santa Cruz River)***.

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