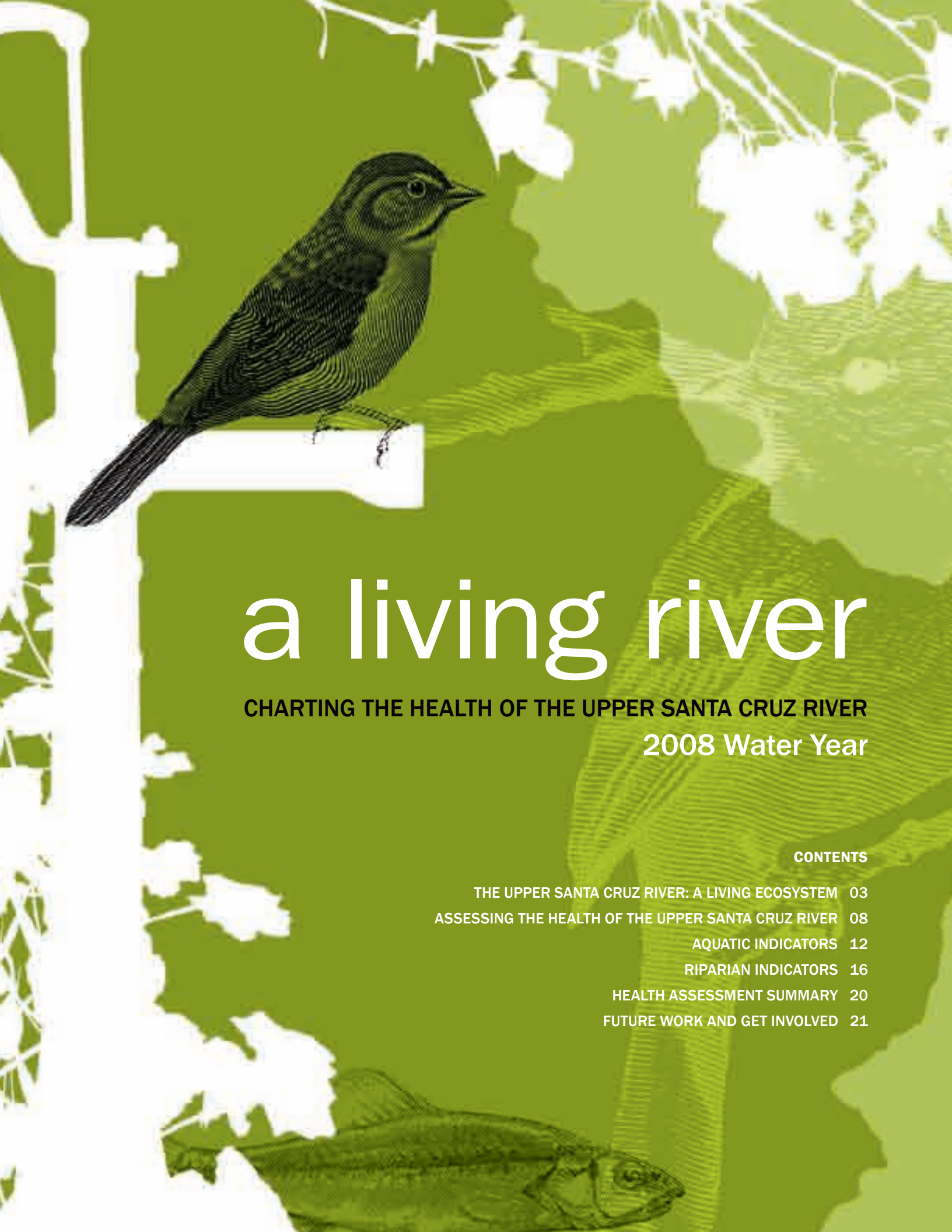


a living river

CHARTING THE HEALTH OF THE UPPER SANTA CRUZ RIVER

2008 Water Year

CONTENTS

THE UPPER SANTA CRUZ RIVER WATERSHED

THE UPPER SANTA CRUZ RIVER A LIVING ECOSYSTEM

For thousands of years, people in the arid West have built their communities near rivers that supply drinking water, serve as navigation corridors, and support hundreds of plant, fish, and wildlife species. The Upper Santa Cruz is such a river, having sustained human communities for more than 3,500 years. From its headwaters in the San Rafael Valley in Arizona, the Upper Santa Cruz River flows south into Mexico where it completes a 25-mile U-turn and flows north back into the United States through Santa Cruz County, Arizona.

In recent years planning and research efforts have focused on understanding and conserving the Upper Santa Cruz River. Locally, Santa Cruz County identified the Santa Cruz River as an important resource and specified in the 2004 Comprehensive Plan that *"the Santa Cruz River and its watershed should be conserved and managed as a Living Ecosystem."*

On a national level, legislation is pending in Washington D.C. to designate the Santa Cruz River Valley as a National Heritage Area. These efforts augment a long-term water quality monitoring effort by Friends of the Santa Cruz River, and the 2002 expansion of Tumacácori National Historical Park to include a one-mile stretch of the Upper Santa Cruz River.

These efforts also demonstrate the importance of the river to the history, culture, and quality of life in Santa Cruz County, and provide a valuable foundation of information on the health and changing conditions of the river. This report builds upon that foundation by identifying and tracking elements of river health on an annual basis. Understanding how the river is changing over time is essential to ensuring that the Upper Santa Cruz River continues to play an important role in the future of the region.

A HEALTHY SANTA CRUZ RIVER BENEFITS THE REGION

Stewardship that helps maintain a healthy river ecosystem strikes a balance between the ecological and societal aspects of the river system. River health can be defined as a system that persists in a stable and sustainable state. A healthy river maintains its plant, animal, and physical composition, organization, and function, while sustaining human communities through the provision of **ecosystem services**. Rivers provide many ecosystem services that benefit human communities. While humans often rely on costly engineered infrastructure for protection from floods, erosion, and water contamination, riparian vegetation works naturally to slow flood flows. Tree roots also work to control erosion along stream banks, while floodplain soil filters water as it percolates into groundwater tables. The riparian area also provides important wildlife habitat and contributes to the culture and heritage of the region.

Blue-eyed Darner

Ecosystem Services

BENEFITS OF A HEALTHY ECOSYSTEM

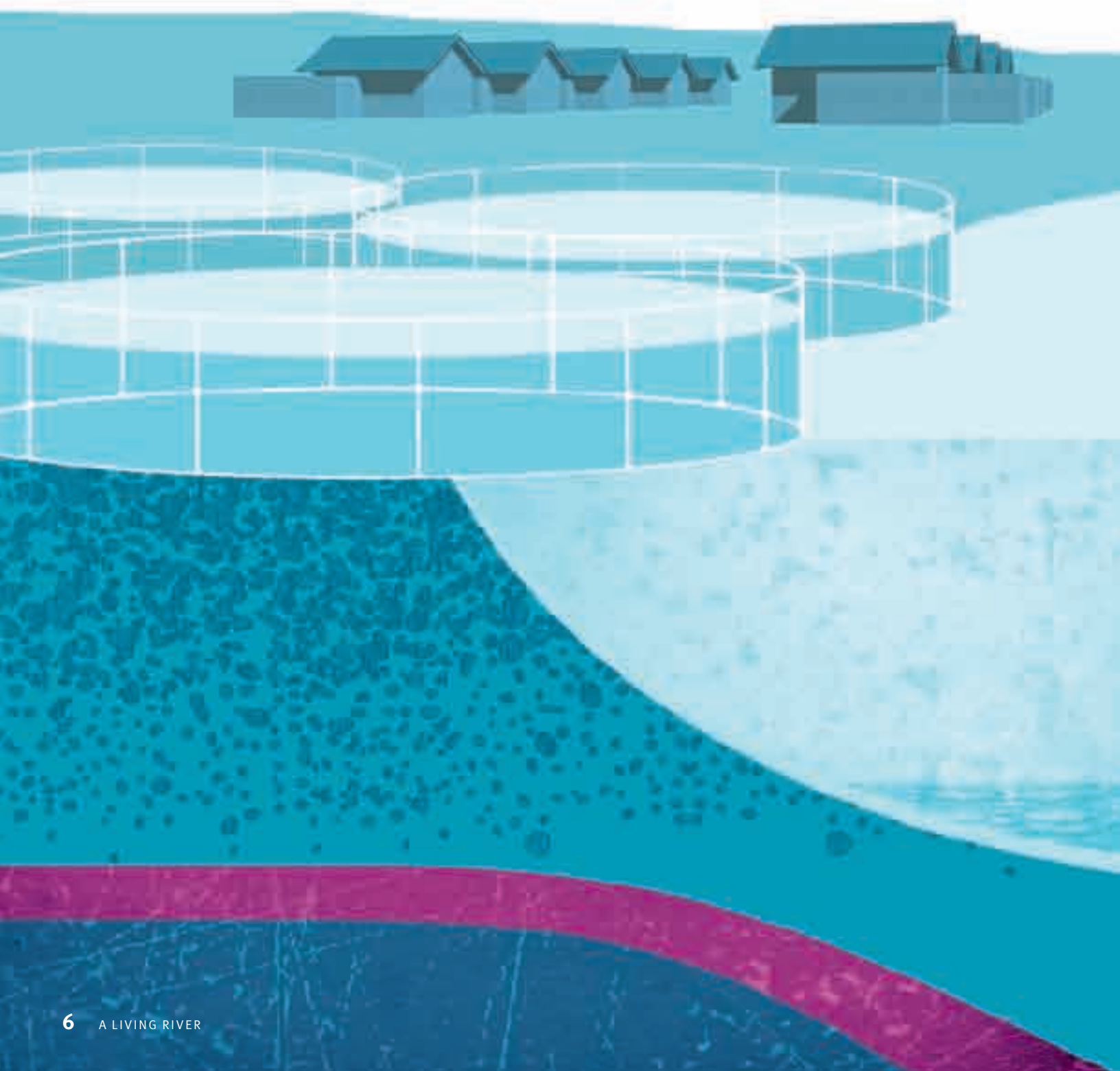
Ecosystem services are the benefits that people obtain and receive from natural systems such as rivers, forests, and grasslands.

Ecosystem services can be broadly organized into four categories:

- ***Provisioning services*** provide goods such as food, fresh water, timber, and fiber for direct human use.
- ***Regulating services*** maintain processes that ensure the survival of life such as pollination of crops, flood mitigation, erosion control, groundwater recharge, and climate stabilization.
- ***Cultural services*** provide recreational, aesthetic, and spiritual benefits.
- ***Supporting services*** are the underlying processes that produce the direct services above, such as soil formation, photosynthesis, and nutrient cycling.

Water Sources

Three sources of water contribute to flows in the Upper Santa Cruz River: precipitation, groundwater discharge, and treated municipal effluent. Treated effluent is discharged into the streambed of the Upper Santa Cruz River at the rate of 15 million gallons per day from the Nogales International Wastewater Treatment Plant (NIWTP) located in Rio Rico, Arizona. According to the Arizona Department of Water Resources, about 70 percent of the effluent is comprised of water pumped from Upper Santa Cruz River groundwater basins located on either side of the international border. The effluent is essentially Upper Santa Cruz River water that has been withdrawn from the groundwater aquifers beneath the river, used in households and businesses, and returned to the river in a different location. The remaining 30 percent of the effluent is comprised of water originally pumped from the Los Alisos watershed in Sonora, Mexico.



While there are many uncertainties regarding the ecological benefits and challenges of effluent, recent research at Arizona's universities and agencies has shown that effluent can augment groundwater recharge and provide additional water to support riparian vegetation growth. Daily effluent flows can be an important additional water source that help sustain riparian vegetation. However, high levels of nitrogen in effluent can degrade the quality of surface water and groundwater and decrease the diversity of aquatic animals. Nitrogen also fosters algae growth that can form thick mats on the bottom of the stream channel. In the absence of seasonal floods, the algae mats can seal the bottom of the stream channel, decreasing infiltration and groundwater recharge. As a result, water can continue to flow in the stream channel even as groundwater tables drop to the point that riparian plants can no longer access groundwater and thus begin to suffer from lack of water.

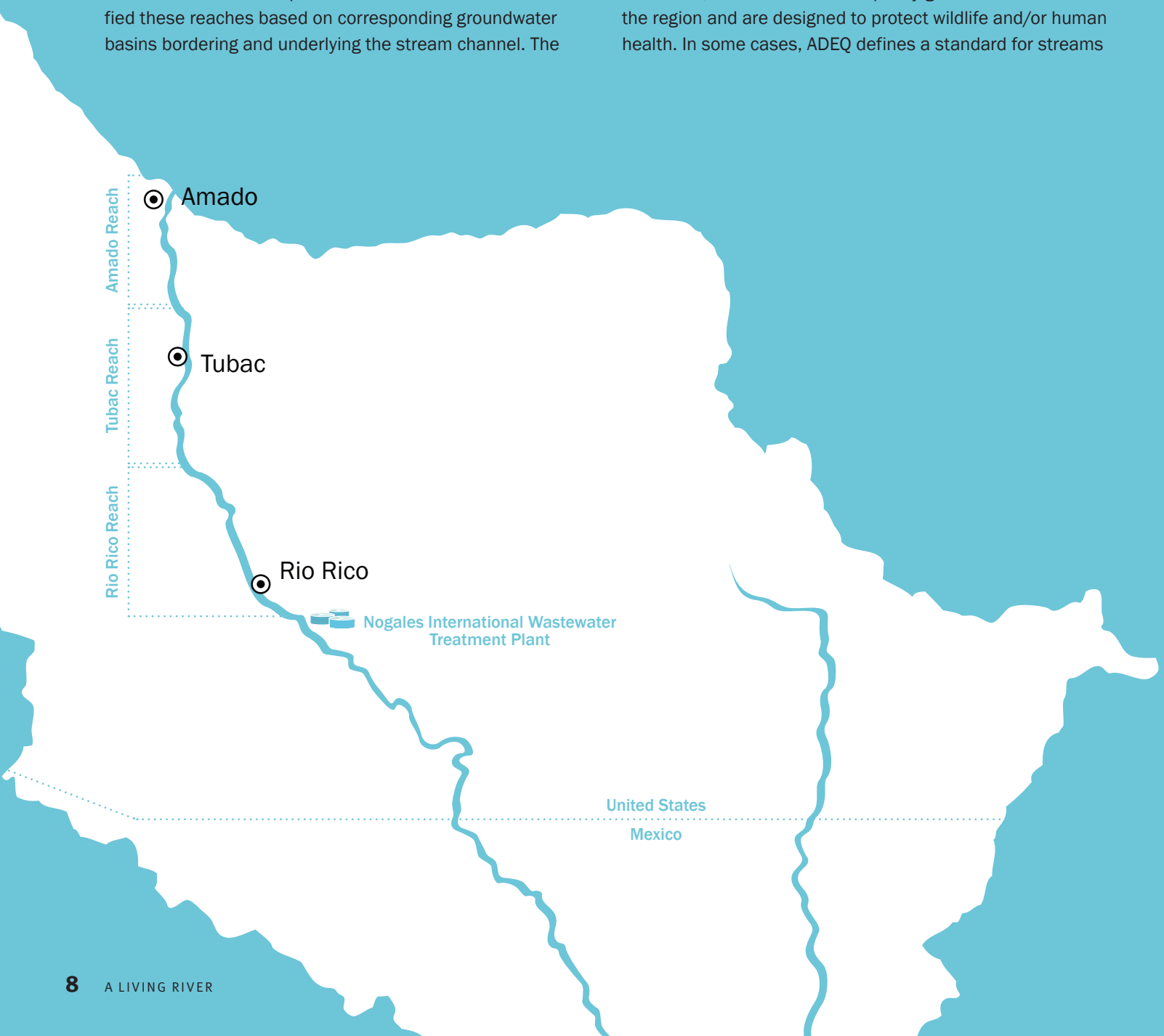
Given the importance of the river to this region and the complexities of an effluent-dominated river, **what can we learn about the health of the Upper Santa Cruz River system by tracking changes in specific indicators on a year-to-year basis?** Answering this question will help us understand what elements of the system are changing from year-to-year, how those changes may be affecting the ability of the system to function, and what stewardship efforts are required to help maintain a healthy river ecosystem.

ASSESSING THE HEALTH OF THE UPPER SANTA CRUZ RIVER

The goal of this assessment is to promote a better understanding of the health of the Upper Santa Cruz River among watershed residents, land managers, and policymakers. The assessment tracks aquatic and riparian health using scientific information and establishes a baseline from which we can compare changes in the health of the Upper Santa Cruz River over time.

This health assessment focuses on the stretch of river from Rio Rico to Amado in Santa Cruz County, Arizona. This stretch of river is divided into three reaches: Rio Rico, Tubac, and Amado. The Arizona Department of Water Resources identified these reaches based on corresponding groundwater basins bordering and underlying the stream channel. The reaches were chosen based on the close connection between surface water and groundwater and the resulting influences on aquatic and riparian ecosystems.

The health of the Upper Santa Cruz River is tracked using 10 indicators that are grouped in two categories: aquatic and riparian (see page 9). Monitoring data from numerous agencies and organizations are evaluated against appropriate standards set by state agencies, federal agencies, or the scientific community. Most water quality indicators are compared to Arizona Department of Environmental Quality (ADEQ) standards, which define water quality goals for streams in the region and are designed to protect wildlife and/or human health. In some cases, ADEQ defines a standard for streams



that are effluent-dominated, such as the Upper Santa Cruz River in the Rio Rico, Tubac, and Amado reaches. For other indicators, the scientific community has determined standards. Some indicators, such as aquatic animals and riparian vegetation, do not have defined standards. For those indicators, this assessment provides baseline data to which they can be compared.

The following pages summarize the data collected by multiple agencies and organizations for the 10 indicators. Information about other aspects of the aquatic and riparian ecosystems is also provided. For each indicator, a chart shows the data collected during the 2008 water year (October 2007-September 2008) and the appropriate standard for each indicator.

Important Note

Changes in water quality and other environmental conditions resulting from the recent upgrade of the Nogales International Wastewater Treatment Plant (NIWTP) are not reflected in this 2008 Water Year Health Assessment. This report analyzes data collected between October 1, 2007 and September 30, 2008. The upgraded system was not officially online until June 2009. Shortly before this assessment was sent to press, casual observation of the river suggests that the NIWTP upgrade will significantly improve water quality in the Upper Santa Cruz River. The 2009 Water Year Health Assessment (to be published in spring 2010) will include data collected following the upgrade of the NIWTP.

Category	Indicators and Standards	Standard Source and Type
aquatic	**Dissolved oxygen:** > 1 mg/L	**ADEQ:** wildlife in effluent[1]
	Ammonia: varies with temperature & pH	**ADEQ:** wildlife in effluent[2]
	Total phosphorus: < 5 mg/L	**Historic (1992-1999 median)**[3]
	E. coli: < 235 CFU/100mL	**ADEQ:** human health[1]
	Metals: varies by specific metal	**ADEQ:** wildlife[2]
	Aquatic invertebrates: 2008 baseline	Baseline information
	Fish: 2008 baseline	Baseline information
riparian	**Depth to groundwater:** < 5.1 m	Scientific standard[4]
	Groundwater variability: < 0.8 m/yr	Scientific standard[4]
	Riparian vegetation: 2006 baseline	Baseline information

1 Arizona Administrative Code. (2003). *Title 18. Environmental Quality, Chapter 11. Department of Environmental Quality, Water Quality Standards.* Arizona Administrative Code Supp. 03-1, pp. 1-85.

2 Arizona Department of Environmental Quality. (2009). *Notice of Final Rule Making Title 18. Environmental Quality, Chapter 11. Department of Environmental Quality, Water Quality Standards. (not a final rule).* Retrieved February 13, 2009 from http://www.azdeq.gov/function/laws/download/NFRM1.pdf.

3 Friends of the Santa Cruz River. Unpublished data.

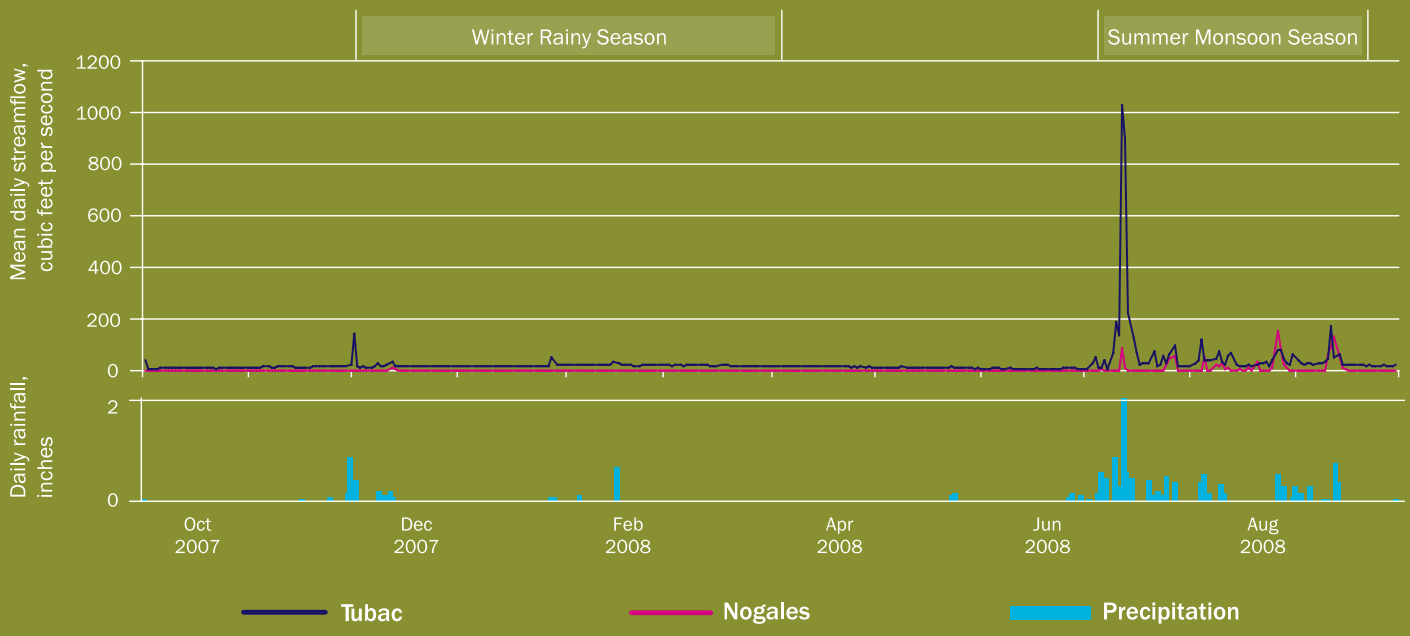
4 Lite, S. J., and J. C. Stromberg. 2005. Surface water and ground-water thresholds for maintaining Populus-Salix forests, San Pedro River, Arizona. *Biological Conservation* 125:153-167.

PRECIPITATION, STREAMFLOW, AND VEGETATION

The water year (October 1, 2007-September 30, 2008) is linked to the growth cycle of riparian trees and 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.

Winter storms often extend over several days and provide valuable moisture and nutrients to tree roots. In February, cottonwood trees begin to leaf out and mesquite trees follow in late March. The trees then rely on shallow water tables and stored reserves from winter rains to endure the hot and dry months from April through the start of the monsoon rains in July.

The summer monsoon season is the main growing season for many of the larger shrubs and trees, and monsoon rains



Data sources: USGS station 09481740 and station 09480500 and National Weather Service station KOLS at Nogales International Airport

frequently induce floods that are critical to a healthy riparian ecosystem. Seasonal floods are important for recharging aquifers, dispersing seeds, inducing seed germination, and clearing natural debris from the riparian forest floor. Monsoon rains generally begin to wane in early fall and riparian trees lose their leaves in late fall as the water year begins anew.

THE STREAMFLOW-PRECIPITATION RELATIONSHIP

Treated effluent from the Nogales International Wastewater Treatment Plant in Rio Rico, AZ provides the majority of the flow for the Upper Santa Cruz River in the Rio Rico, Tubac, and Amado reaches, according to the Arizona Department of Environmental Quality and the Arizona Department of Water Resources. However, the variability of the flow in the river (i.e. flood peaks) is influenced by precipitation events throughout the watershed. In contrast, upstream of the Nogales International Wastewater Treatment Plant and near Nogales, AZ, the amount of precipitation that falls in the watershed is the primary source of streamflow in the river.

2008 Streamflow Results

The U.S. Geological Survey (USGS) measures streamflow, the volume of water flowing past a fixed point for a fixed unit of time (also called discharge), with gages near Nogales, AZ and at Tubac, AZ. The 2008 daily discharge rates are characteristic for the Upper Santa Cruz River at the stream gages.

- Mean daily discharge averaged 3 cubic feet per second (cfs) near Nogales and just under 28 cfs at Tubac.
- Mean daily discharge peaked at 157 cfs on August 26, 2008 near Nogales and at 1,030 cfs on July 12, 2008 at Tubac.

2008 Precipitation Results

The National Weather Service monitors weather at the Nogales International Airport in Nogales, AZ.

- During the 2008 water year, the station recorded 15.96 inches of rain.
- Just over 2 inches of rain fell during the winter rainy season.
- The summer monsoon brought nearly 12 inches of rain.
- On July 11, 2008 over 2 inches of rain fell in Nogales, AZ. This caused the high river flows at Tubac on July 12, 2008.
- Between August 25 and 26, 2008, 0.85 inches of rain fell in Nogales, AZ. This caused the high river flows near Nogales, AZ on August 26, 2008.

CUBIC FEET PER SECOND

1 cubic foot per second = 7.48 gallons per second

aquatic

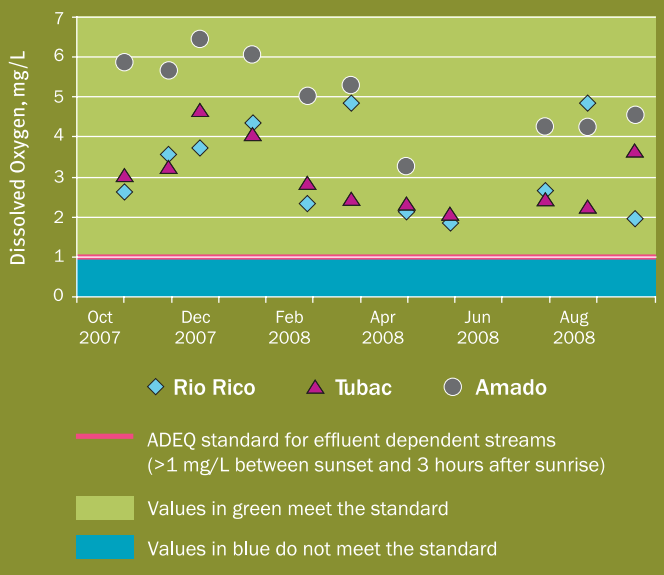
WATER QUALITY

Water quality is a measure of the chemical and biological properties of a stream. Aquatic ecosystems, such as streams, depend on particular water quality conditions to sustain plant and animal communities. Aquatic ecosystems are influenced by inputs of metals, nutrients, toxins, soil erosion, and treated municipal effluent. Water temperature and pH provide important information about river conditions and impact other water quality measures. During the 2008 water year, water temperature ranged from 40˚F in the winter to nearly 80˚F in the summer; and pH was typically between 7.5 and 8.0 with a maximum pH of 8.3.

Rivers require nutrients such as nitrogen and phosphorus to be healthy. However, high levels of nitrogen and phosphorus lead to water quality problems such as low oxygen and declines in wildlife habitat. Nitrogen and phosphorus pollution can come from numerous sources: fertilizer, overflow from septic systems, surface runoff, and discharge of nitrogen and phosphorus from wastewater treatment plants. Elevated nutrient levels in treated effluent can cause riparian plants to grow faster and larger than they would in non-effluent dominated reaches.

O_2 DISSOLVED OXYGEN

Fish and other animals need oxygen to survive. The Upper Santa Cruz River absorbs oxygen from the atmosphere and aquatic plants produce oxygen during photosynthesis. As microorganisms decompose organic materials and aquatic animals respire, they consume oxygen. There are many natural causes of variability in dissolved oxygen levels including nutrient levels, whether the stream is gaining groundwater, and the time of day. Dissolved oxygen concentrations depend on water temperature and vary throughout the day and seasonally. The Arizona Department of Environmental Quality sets the minimum standard for dissolved oxygen at 1 milligram per liter (mg/L) for effluent dependent streams (measured between sunset and 3 hours after sunrise).



2008 Results

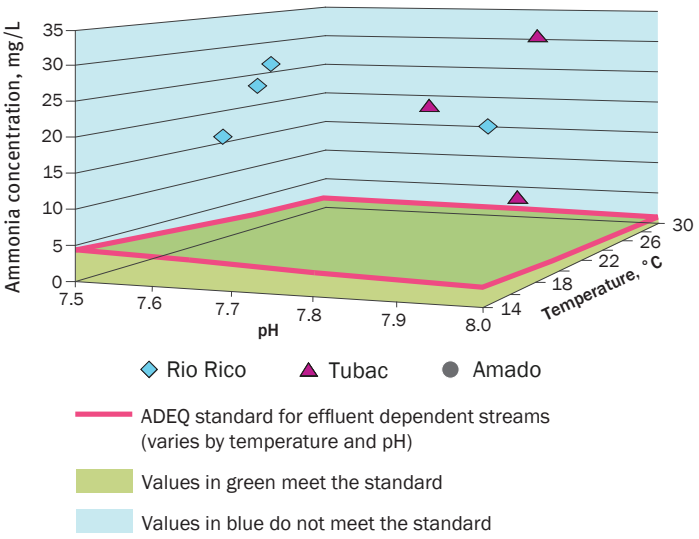
Dissolved oxygen was measured between sunset and 3 hours after sunrise a total of 32 times. All of the 32 samples met the standard (100% attainment).

- Rio Rico: 11 of the 11 samples met the standard (100% attainment).
- Tubac: 11 of the 11 samples met the standard (100% attainment).
- Amado: 10 of the 10 samples met the standard (100% attainment).

Data source: Friends of the Santa Cruz River

AMMONIA

Ammonia (NH_3) has been shown to be toxic to fish, and at low concentrations can cause reduction in hatching success, among other impacts. The toxicity of ammonia varies with several factors such as pH, temperature, and dissolved oxygen concentration. As pH and temperature increase, the toxicity of ammonia increases. In Arizona, the chronic criterion for total ammonia varies by pH and temperature. Based on the range of temperatures and pH in the reaches, ADEQ expects ammonia to average less than 4.5 mg/L.



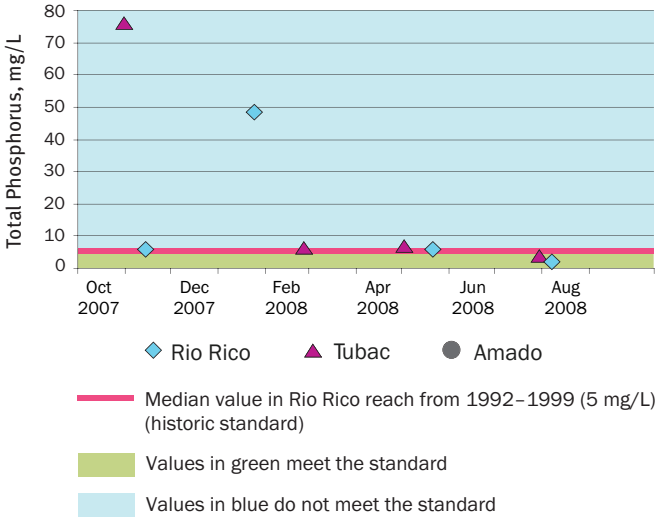
2008 Results

Ammonia was monitored a total of seven times. Overall, the ADEQ standard was met zero out of the seven times (0% standard attainment).

- Rio Rico: Zero of the four samples met the standard (0% attainment).
- Tubac: Zero of the three samples met the standard (0% attainment).
- Amado: No samples were collected.

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, decrease the amount of dissolved oxygen, and kill aquatic animals. 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 historic standard.



2008 Results

Phosphorus was monitored a total of eight times. Overall, the historic standard was met two out of the eight times (25% standard attainment).

- Rio Rico: One of the four samples met the historic standard (25% attainment).
- Tubac: One of the four samples met the historic standard (25% attainment).
- Amado: Phosphorus was not monitored.

Data sources for charts on page 13: Friends of Santa Cruz River and National Park Service (NPS) Sonoran Desert Network

E. COLI

Escherichia coli (*E. coli*) is one of the main species of bacteria living in the lower intestines of mammals, and its presence in water is an indication of fecal contamination. The presence of *E. coli* indicates the potential presence of pathogenic microorganisms such as bacteria and viruses that might be a health risk to people swimming and wading in the river. Arizona's standard for a single sample maximum for full body contact (swimming) is 235 colony forming units per 100 milliliters of water (CFU/100mL).

2008 Results

During the 2008 water year, several groups monitored *E. coli*, including scientists at Tumacácori National Historical Park within the Tubac reach. The National Park Service (NPS) scientists found that the *E. coli* concentrations were highly variable and consistently above full body contact standards during the summer and at the onset of the winter rains. *E. coli* was monitored a total of 100 times across the three reaches, with most of the monitoring in the Tubac reach done by Tumacácori National Historical Park. Overall, the ADEQ standard was met 36 out of the 100 times (36% standard attainment).

- Rio Rico: Two of the three samples met the standard (66% attainment).
- Tubac: 32 of the 94 samples met the standard (34% attainment).
- Amado: One out of three samples met the standard (33% attainment).

METALS

In high concentrations pollutant metals cause major disruption of aquatic ecosystems by lowering reproductive success, interfering with normal growth and development, and, in extreme cases, causing death. The Upper Santa Cruz River is exposed to pollutant metals through numerous sources, including mine drainage, roadways, particles dispersed through industrial processes, and by the release of metals naturally occurring in near-surface rock strata and sediments. Most of these contaminants accumulate in aquatic food webs and may pose long-term threats to all organisms in the aquatic environment.

2008 Results

The Friends of the Santa Cruz River monitors a suite of metals (arsenic, cadmium, copper, lead, selenium, and zinc) on a quarterly basis. During the 2008 water year, all of the samples met the appropriate ADEQ standards. However, levels of cadmium were close to the standard. Cadmium is lethal to aquatic wildlife at relatively low concentrations. Cadmium comes from numerous sources such as fertilizers, pesticides, coal combustion, mine wastes, and electroplating processes.

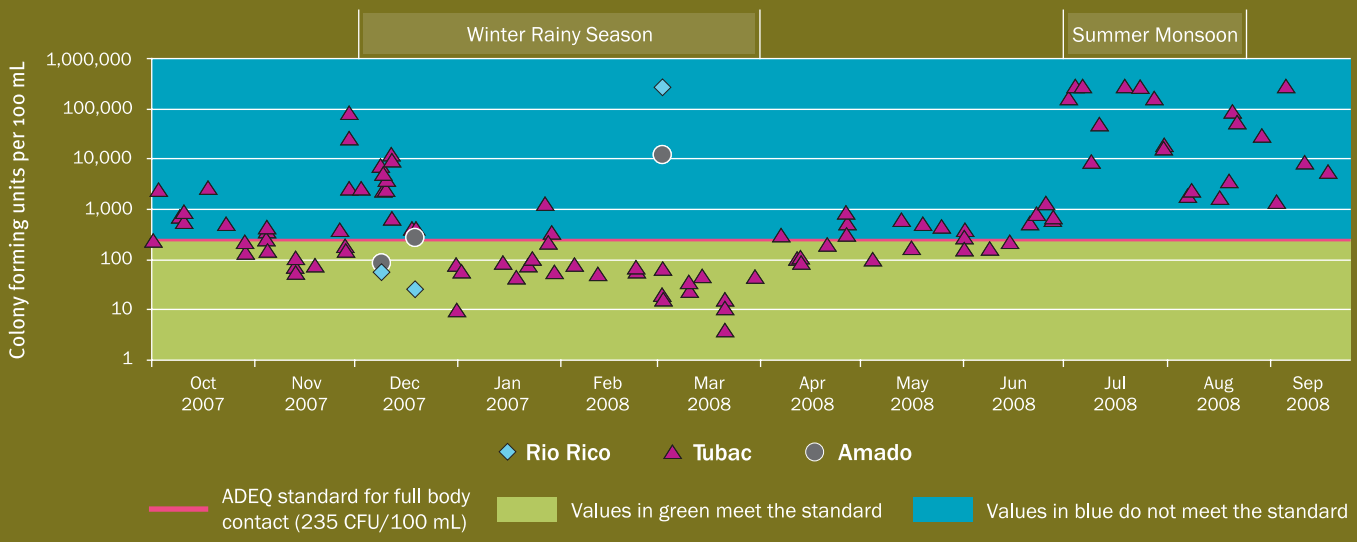
AQUATIC INVERTEBRATES

Aquatic invertebrates are an important biological component in streams. They also are a good indicator of watershed health because they differ in their tolerances to pollution and typically live for more than a year. Aquatic invertebrates with high tolerances to pollution, like those in the Chironomidae family, are found in higher numbers in polluted streams. Aquatic invertebrates in the Chironomidae family tend to be tolerant of low dissolved oxygen levels. In contrast, scientists consider aquatic invertebrates in the Ephemeroptera, Plecoptera, and Trichoptera orders to be sensitive to pollution.

2008 Results

The National Park Service (NPS) Sonoran Desert Network monitors aquatic invertebrates at Tumacácori National Historical Park. This information serves as a baseline to which future assessments will be compared.

- Rio Rico: No samples were collected.
- Tubac: The Chironomidae family dominated the sample and accounted for 81 percent of the aquatic invertebrate assemblage.
- Amado: No samples were collected.



Data sources: Tumacácori National Historical Park, Friends of the Santa Cruz River, and NPS Sonoran Desert Network

FISH

Fish can serve as effective indicators of ecological conditions because they live for several years and differ from one another in their tolerance to pollution. Historically, the Santa Cruz River supported four native fish species: Gila Topminnow, Desert Sucker, Sonora Sucker, and Longfin Dace. Long-term monitoring by Friends of the Santa Cruz River has shown a decline in the number of native fish species present and the number of individual fish in the Upper Santa Cruz River. Three non-native fish (the Western Mosquitofish, Green Sunfish, and Largemouth Bass) were found during an inventory of Tumacácori National Historical Park (2000-2003).

2008 Results

In the fall of 2008, the Arizona Game and Fish Department, Friends of the Santa Cruz River, and the Sonoran Institute conducted a presence/absence fish survey along the Upper Santa Cruz River. This information serves as a baseline to which future assessments will be compared.

- Rio Rico: No fish were caught.
- Tubac: A single juvenile Longfin Dace was caught.
- Amado: A single adult Longfin Dace was caught.

riparian

BIRDS

Birds are an eye-catching component of the Upper Santa Cruz riparian ecosystem. The birds of the Upper Santa Cruz valley attract thousands of visitors a year. Birds are influenced by many factors at various scales that may or may not reflect what is happening at a site specific level, such as a reach on the Upper Santa Cruz River. 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 a part of the Monitoring Avian Productivity and Survivorship (MAPS) program. Working with a variety of partners, the National Park Service has recorded a total of 170 species over the past 11 years.

2008 Results

In 2008, nine new species were encountered during MAPS monitoring at Tumacácori National Historical Park. Bird monitoring at Tumacácori National Historical Park noted several exciting species such as:

- Rufous-winged Sparrow
- Northern Beardless Tyrannulet
- Peregrine Falcon
- Streak-backed Oriole
- Hooded Warbler
- Grey Hawk
- Elf Owl
- Vermillion Flycatcher
- Golden Eagle

In addition to the MAPS program, the National Park Service Sonoran Desert Network monitors birds at Tumacácori National Historical Park using point-transect surveys during the resident bird breeding season. The Tucson Audubon Society uses similar methods to monitor birds at the Esperanza Ranch in the Amado reach.

2008 Results

- Rio Rico: Birds were not monitored.
- Tubac: 84 native and two non-native species were detected at the Tumacácori National Historical Park. The non-native species detected were European Starling and House Sparrow.
- Amado: 63 native and two non-native species were detected at the Esperanza Ranch. The non-native species detected were Eurasian Collared-Dove and Brown-headed Cowbird.

DEPTH TO GROUNDWATER

The interactions between riparian vegetation, surface water, and groundwater in the Upper Santa Cruz River are important factors in overall riparian health. Cottonwoods and willows that depend on surface water and groundwater to meet their annual water requirements dominate native riparian forests in the southwest.

Scientists have estimated the maximum depth to groundwater required to sustain mature native riparian trees. Several scientific studies have estimated that the maximum depth to groundwater required to sustain mature Fremont cottonwoods ranges from 2.5 to 5.1 meters. Since the Upper Santa Cruz River is recognized for its cottonwood-willow riparian forest, locations with maximum groundwater depths less than 5.1 meters meet the standard. It is important to note that areas with depths to groundwater of greater than 5.1 meters may support other types of riparian vegetation.

2008 Results

The Arizona Department of Water Resources and the National Park Service monitored a total of 15 wells within the 100-year floodplain at least once during the 2008 water year. Depth to groundwater measurements are relative to areas that could support cottonwoods and are summarized on the following page.

- Rio Rico: Maximum groundwater levels in seven wells were 2 m, 2.2 m, 2.6 m, 3.1 m, 4 m, 4.3 m, and 6 m (86% attainment).
- Tubac: Maximum groundwater levels in four wells were 1.1 m, 2.4 m, 2.9 m, and 3.9 m (100% attainment).
- Amado: Maximum groundwater levels in four wells were 5.4 m, 6 m, 6.6 m, and 8.8 m (0% attainment). While these depths may not support cottonwood forests, they are within the historic range of variability for the Amado reach.

GROUNDWATER VARIABILITY

Variability in groundwater levels affect the growth and survival of riparian plants. There are several natural and human causes of groundwater variability. Naturally, groundwater levels decline during the hot summer months 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 from January to June.

2008 Results

The Arizona Department of Water Resources and the National Park Service measured depth to groundwater throughout the 2008 water year at four wells within the floodplain. A chart showing the variability in depth to groundwater is shown on the following page. Groundwater declines from January to June 2008 are listed below.

- Rio Rico: Groundwater declined 0.55 m in one well (100% attainment).
- Tubac: Groundwater declined 0.27 m and 0.32 m in two wells (100% attainment).
- Amado: Groundwater declined 0.43 m in one well (100% attainment).

RIPARIAN VEGETATION

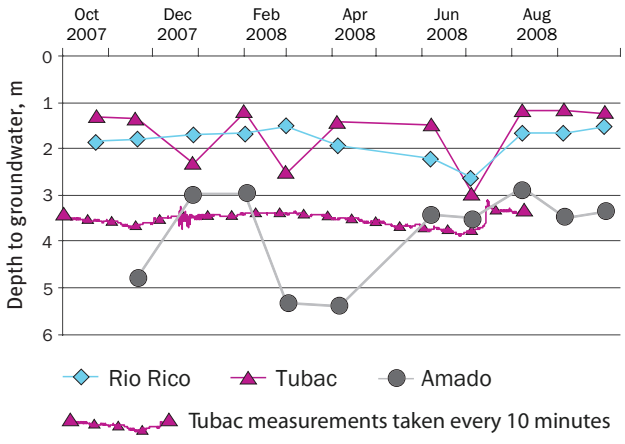
Riparian vegetation represents a small percentage of the land cover in the Upper Santa Cruz watershed, but provides important services, functions, and benefits to the region. Riparian vegetation provides many ecosystem services including filtering contaminants from effluent-dominated water before it infiltrates into groundwater drinking supplies, slowing flood waters, reducing erosion potential along stream banks, increasing groundwater recharge, and providing habitat for resident and migratory wildlife species.

In 2006, Santa Cruz County's Community Development Department, the University of Arizona's Office of Arid Lands Studies, and the Sonoran Institute mapped the riparian vegetation along the Upper Santa Cruz River. The results of the U. S. Environmental Protection Agency funded study can be found at: ***www.co.santa-cruz.az.us/com_development***. Their effort provides information about the distribution, extent, and species composition of the riparian community. A simplified version of the vegetation map establishes a baseline to which future assessments will be compared.

The types of vegetation within the river's 100-year floodplain are divided into five broad categories: cottonwood forests and woodlands; mesquite forests and woodlands; other riparian vegetation; human infrastructure; and agriculture and pasture. Forests and woodlands have greater than 10 percent cottonwood or mesquite tree cover. Other riparian vegetation includes areas not dominated by cottonwood or mesquite trees. Human infrastructure includes roads, railroads, and housing. Agriculture and pasture include crop fields and pasture land. The results of the baseline vegetation map are shown on the opposite page.

Overall, nearly 2,600 acres (38 percent) of the area within the 100-year floodplain were dominated by cottonwoods and mesquites, nearly 500 acres (8 percent) were used for human infrastructure, and 1,600 acres (24 percent) were used for crops or pastures. The Tubac reach has the largest percentage of area dominated by cottonwoods (28 percent) compared to the Rio Rico (13 percent) and Amado (8 percent) reaches.

Groundwater variability



Depth to groundwater

The following legend corresponds to well monitoring, shown right (page 19).

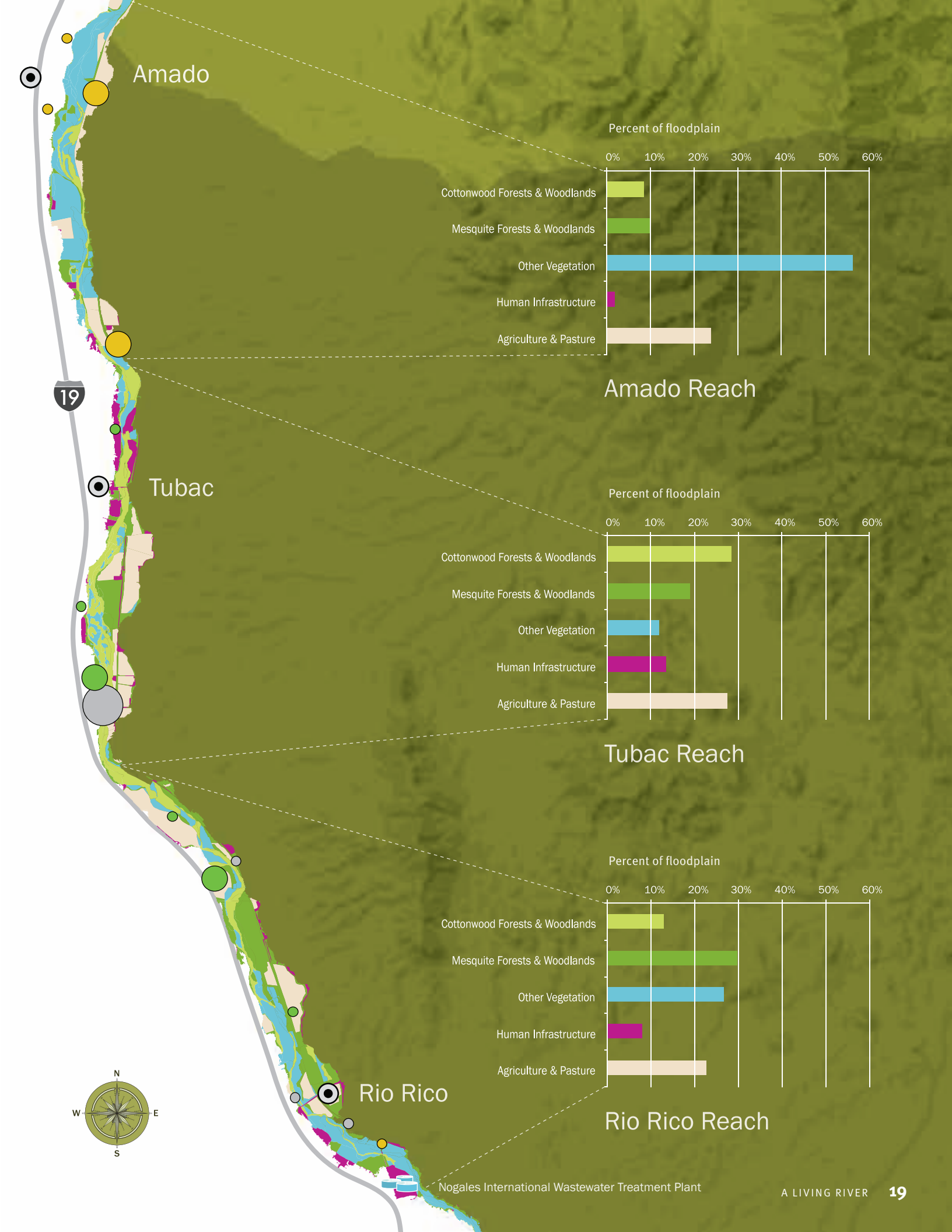
Maximum depth

- < 2.5 m
- 2.5 – 5.1 m
- > 5.1 m

Number of measurements

- 1
- 2 – 12
- Continuous

Data sources: Arizona Department of Water Resources and NPS Sonoran Desert Network


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 Reach
Rio Rico
N
W
E
S
Nogales International Wastewater Treatment Plant

HEALTH ASSESSMENT SUMMARY

The 2008 Upper Santa Cruz Health Assessment is a baseline from which we can see changes in the health of the Upper Santa Cruz River over time. The aquatic ecosystem faced significant challenges due to poor water quality, and most of the Upper Santa Cruz's waters were degraded. Improvements are expected following the upgrade of the Nogales International Wastewater Treatment Plant in Rio Rico, AZ.

During the 2008 water year, high levels of ammonia and low levels of dissolved oxygen threatened aquatic wildlife. *E. coli* levels posed a risk to humans swimming in the Upper Santa Cruz River.

Fish surveys conducted during the fall of 2008 found only two Longfin Dace individuals. While there is limited information on the Upper Santa Cruz River's aquatic invertebrate population, samples collected in the Tubac reach were dominated by the Chironomidae family, which tends to be tolerant to pollution and low dissolved oxygen levels.

Average groundwater levels in the Rio Rico and Tubac reaches were thought to sustain cottonwoods. The depth to groundwater levels in the Amado reach were within the historic range of variability, but may not support cottonwood forests. Nearly 2,600 acres (38 percent) of the area within the 100-year floodplain was dominated by cottonwoods and mesquites. The Tubac reach has the largest percentage of area dominated by cottonwoods (28 percent) compared to the Rio Rico (13 percent) and Amado (8 percent) reaches. Over 2,000 acres are used by humans for infrastructure, crops, and pastures.

Category	Indicators and Standards	% Attainment of Standard		
		Rio Rico	Tubac	Amado
aquatic	**Dissolved oxygen:** > 1 mg/L	100%	100%	100%
	Ammonia: varies with temperature & pH	0%	0%	no data
	Total phosphorus: < 5 mg/L	25%	25%	no data
	E. coli: < 235 CFU/100mL	66%	34%	33%
	Metals: varies by specific metal	100%	100%	100%
	Aquatic invertebrates: 2008 baseline	no data	baseline	no data
	Fish: 2008 baseline	baseline	baseline	baseline
riparian	**Depth to groundwater:** < 5.1 m	86%	100%	0%
	Groundwater variability: < 0.8 m/yr	100%	100%	100%
	Riparian vegetation: 2006 baseline	baseline	baseline	baseline

FUTURE WORK

This report builds on numerous research and monitoring efforts that have been tracking conditions along the river for the past 18 years. While past and current efforts are vital to understanding how the river functions, there is much work to be done in the face of changing climatic and societal conditions. In order to track how the river is changing, more research is needed on the following topics:

- What water quality standards should be applied to effluent dominated rivers like the Upper Santa Cruz River in order to maintain native fish populations?
- To what degree is the riparian vegetation dependent upon the effluent?
- How does this compare to the dependence of riparian vegetation on streamflow and groundwater?
- How sensitive is riparian vegetation to changes in the volume of effluent?
- How variable are groundwater levels in areas dominated by cottonwoods and in areas dominated by other riparian vegetation?
- What are appropriate standards for aquatic invertebrate communities in effluent-dominated rivers?
- What is the appropriate frequency for monitoring metals in the Upper Santa Cruz River?
- What are the sources of *E. coli* in the watershed?
- What is the range of dissolved oxygen concentrations over a 24-hour period?
- How do impervious surfaces in the watershed influence runoff patterns and groundwater recharge?

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:

- Join Friends of the Santa Cruz River and volunteer with RiverWatch to monitor water quality every three months. To sign up visit: ***www.friendsofsantacruzriver.org.***
- Volunteer with the Audubon's Important Bird Areas Program in Arizona and monitor birds in the Upper Santa Cruz River Important Bird Area (Tumacácori to Amado). Contact the Tucson Audubon Society at 520-628-1730, or go to: ***www.aziba.org.***
- Visit Tumacácori National Historical Park and Sonoita Creek State Natural Area to learn more about the plants and animal life in riparian systems.
- Check Sonoran Institute's website for an electronic copy of this report, as well as for updates on additional Upper Santa Cruz River conservation projects. ***www.sonoraninstitute.org***

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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 Upper Santa Cruz Health Assessment and a State of the Upper Santa Cruz River Report (to be published in 2010).

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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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 and Helena, Montana; Glenwood Springs and Denver, Colorado; Cheyenne, Wyoming; and Mexicali, Baja California, Mexico. For more information, visit **www.sonoraninstitute.org**

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