a living river

SANTA CRUZ RIVER 2023 DOWNTOWN TUCSON TO MARANA

LEARN ABOUT TECHNOLOGY AND TOOLS USED TO CARE FOR THE RIVER

Santa Cruz River in Marana

SUPPLEMENTARY REPORT FOR 2013 TO 2022 WATER YEARS

SONORAN INSTITUTE

PIMA COUNTY

CITY OF TUCSON

TUCSON WATER

THE SANTA CRUZ RIVER
A LIVING ECOSYSTEM

Sections of the Santa Cruz River flow all year, providing the principal wetland habitat in the Tucson metro area. River flows in these reaches are sustained by effluent (highly treated wastewater) released from two regional water reclamation facilities. These habitats are managed systems and the distance effluent flows travel is variable, especially in the Heritage Project reach near downtown.

The Tucson area *Living River* reports were developed to annually gauge the health of this valuable ecosystem and track the impacts of our community's investment of over $600 million to upgrade the regional wastewater reclamation facilities in 2013. The series was expanded in 2020 to include available data for the Heritage Project, where Tucson Water started releasing effluent in 2019.

This supplementary report provides more detail on recent accomplishments highlighted in the 2023 report and shares data from the 2013–2022 water years. This enables an easy viewing of trends in the water context and diverse indicators of river conditions. All *Living River* reports can be found on the Sonoran Institute website at **www.sonoraninstitute.org.**

Assessing Conditions

The *Living River* report evaluates conditions of the Santa Cruz River in the Heritage Project reach and from northwest Tucson to Marana using indicators organized into six categories that represent a breadth of biological, chemical, physical, and social properties of the river (see below). The indicators relate to conditions in the river channel and in the riparian areas, the areas next to and affected by the river. This supplementary report expands on information provided in the printed Living River report.

The purpose of the *Living River* series is to monitor and report on wetland and riparian conditions at various intervals downstream of the effluent discharge points. As effluent flows downstream, it impacts and is impacted by the natural conditions of soils, vegetation, and the surrounding ecosystem. For the purposes of this study, the river is divided into a 1.4-mile Heritage Project reach and a 23-mile northwest Tucson to Marana reach. The latter is further divided into three sections delineated by their differing hydrology, geology, and adjacent land use: Three Rivers, Cortaro Narrows, and Marana Flats.

Data are collected and summarized by water year (October 1–September 30) and compared to the baseline conditions observed in the 2013 water year.

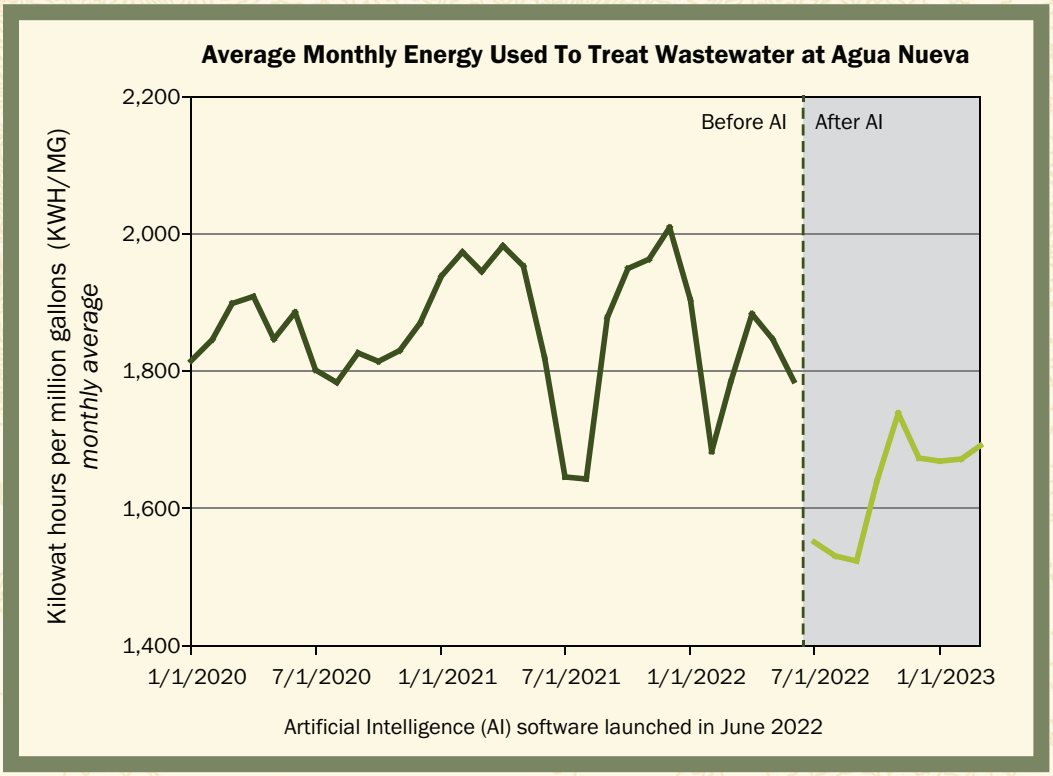
CONTENTS

CATEGORY		PURPOSE	INDICATORS
Flow Extent		Water flowing in and out of the system determines available aquatic habitat.	• Miles of flow in June • Flow at Trico Road and Congress Street
Water Clarity		Solid particles in the water and on the riverbed can impact habitat and conditions for aquatic life.	• Total suspended solids • Turbidity • Percent fines on riverbed
Water Quality		Specific chemical conditions are necessary to sustain the river's animal and plant communities.	• Total dissolved solids • Ammonia • Dissolved oxygen • Biochemical oxygen demand • Metals
Aquatic Wildlife		Wildlife in the river integrate and reflect conditions of many factors of the surrounding environment.	• Fish • Aquatic invertebrates
Riparian Vegetation		Plant communities reflect changes in water quantity and help gauge habitat availability for wildlife.	• Composition and cover in Heritage reach • Cover in northwest Tucson to Marana
Groundwater		Effluent releases recharge aquifers and must be monitored in highly managed ecosystems.	• Aquifer recharge
Social Impacts		Ecosystem recovery provides outdoor areas for people living or recreating along the river.	• Pedestrian and cyclist use of the Loop • Bird-watching

NOTABLE ACHIEVEMENTS

AI TECHNOLOGY REDUCES WASTEWATER RECLAMATION COSTS

Discharging clean water to the river is a vital component of river management, but water treatment is energy intensive. To help address this energy consumption, Pima County Regional Wastewater Reclamation Department deployed Artificial Intelligence (AI) technology in June 2022. To date, the technology has met expectations, reducing energy usage in the treatment process while maintaining the high quality of effluent discharged to the river. The AI software tracks ammonia in the wastewater treatment process and either increases or decreases the use of aeration blowers that provide the dissolved oxygen necessary to oxidize ammonia and reduce its concentration. This technology is a useful tool, but it does not replace staff in the Department. First implemented at the Agua Nueva Water Reclamation Facility, the AI module produced an immediate 20% energy reduction, which equates to an estimated $300,000 savings for the year. Energy usage varies throughout the year, but the AI-mediated trend in energy usage has been sustained through 2023.



U.S. DEPARTMENT OF THE INTERIOR APPROVES MANAGEMENT PLAN FOR SANTA CRUZ VALLEY NATIONAL HERITAGE AREA

Designated by Congress in 2019, the Santa Cruz Valley National Heritage Area encompasses 3,300 square miles within Pima and Santa Cruz counties where natural, cultural, historic, and recreational resources combine to form a cohesive, nationally distinctive landscape shaped by geography and cultural traditions. The recently approved Management Plan provides stewardship approaches through various activities involving conservation, historic preservation, interpretation and education, celebration of cultural traditions, recreation, and more. This approval solidifies federal support through 2034 and provides an avenue for the Santa Cruz Valley Heritage Alliance to achieve their management goals for the Santa Cruz Valley.

SANTA CRUZ VALLEY
NATIONAL HERITAGE AREA

MULTIPLE CLEANUPS REMOVE OVER 10 TONS OF TRASH FROM THE RIVER

Clean up events along the Santa Cruz River can significantly reduce the amount of trash in the river. Pima County Flood Control District hosted 44 events in 2022 alone, encouraging volunteers to come down to the river and help remove trash from the channel. Overall, 864 bags, each with a 55-gallon capacity, were filled by 685 volunteers. These efforts totaled to just over 10 tons of trash pulled out of the Santa Cruz River. The City of Tucson also hosted clean ups in the Heritage Reach in 2022, with more than 50 volunteers helping to fill approximately 65 bags with trash and buffelgrass, as well as pulling 11 tires and 5 grocery carts, plus other large items, out of the river. Work like this is vital for supporting a healthy river ecosystem—trash is aesthetically unpleasant, but also has impacts on the river and the wildlife that uses it.

TUCSON AUDUBON SOCIETY REMOVES INVASIVE TAMARISK FROM THE RIVER

In 2022, with grant funds from the Arizona Department of Forestry and Fire Management, Tucson Audubon Society completed a massive removal project to clear invasive species from the Santa Cruz River. Across 50 acres, invasive grasses were removed and treated with targeted spraying to prevent succession. They felled 27 acres of invasive tamarisk trees, applying a stump treatment to prevent regrowth. Included in this effort was the creation of 13 firebreaks, spaces where invasive species and dead limbs were removed and any trees allowed to remain were pruned to reduce the risk of wildfire spread. Ongoing maintenance will be needed to prevent non-native species from recruiting in cleared and disturbed areas, and Pima County has assumed responsibility for repeating treatments on the 27 acres of tamarisk. This retreatment began in April 2023.

"RAPID RECRUITER REMEDIATION" SEED MIX DEVELOPED TO RECOVER NATIVE VEGETATION AFTER INVASIVE PLANT REMOVAL

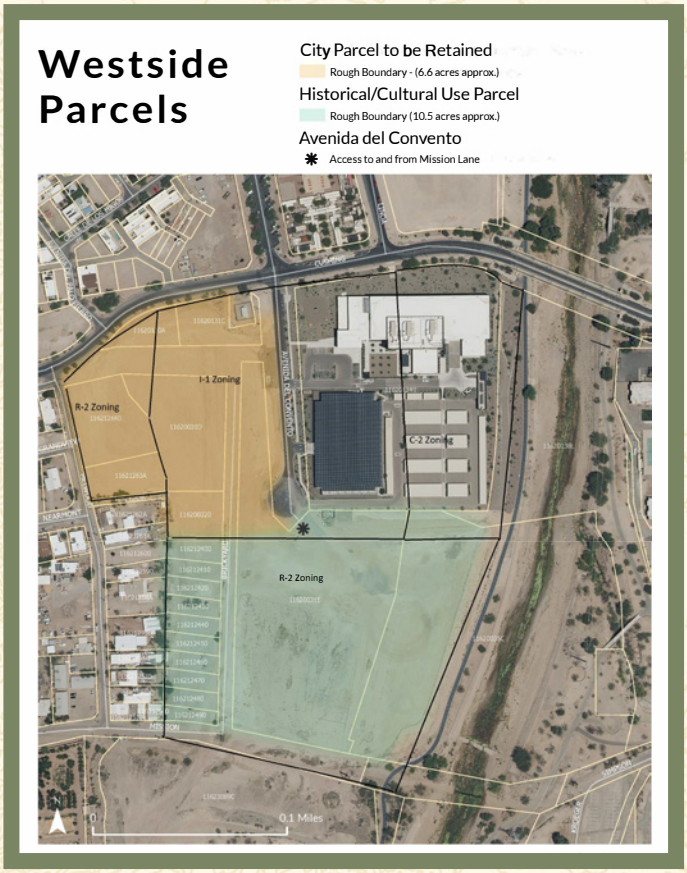
Invasive species management is a growing environmental and public safety issue. In their management of floodplains, Pima County Regional Flood Control District utilizes repeated spot treatments to control prioritized non-native invasive vegetation. However, heavily infested or disturbed soils often lack sufficient native species diversity in the seed bank, so non-native invasives easily re-establish. To address this, District staff have developed seed mixes of "low grow" native species (ie. grasses, herbaceous species, and subshrubs that are short in height) that establish quickly, to create native cover without obstructing ongoing inspections for non-native species. These "Rapid Recruiter Remediation" mixes are comprised of commercially available species that are suited to our arid region's soil, water, and elevation, are adapted to our growing seasons, and are known to perform well in disturbed sites. Species are selected for their likelihood to reach maturity and continue to spread native seed, thereby contributing to soil and ecosystem function restoration. They also promote native plant community succession to out-compete invasive species, which reduces the risk of catastrophic fires. The first mix was applied in July 2022 with promising results at two tributary sites along the Santa Cruz River in Tucson: the District's West Branch Preserve, and the Arroyo Chico Park Avenue Basins. The District is also adapting this mix for use in habitat restoration by adding site-informed native trees, shrubs, grasses, and forbs to restore healthy ecosystem functions that benefit native insects and wildlife.

NATIVE SEEDS DISPERSED IN HERITAGE REACH BY TUCSON WATER

In an effort to establish native vegetation in the Heritage Project, Tucson Water conducts reseeding events with native species obtained from a local nursery. Different species are mixed to create a blend of grasses and herbs that do not need consistently moist soil, and then dispersed. Previously, this took place biannually, in the spring and winter, but data gathered in 2021 showed that most of the spring dispersal was washed downstream during the summer monsoons. Surveys after the 2021 monsoons recorded seeded species as less than 10% of the native species total, down from 33% the year prior; because of this, seeding only occurred in November in 2022. The success of the 120 pounds of seeds dispersed in this event will be reported in the 2024 *Living River* report, after the 2023 vegetation surveys have been completed. Before the 2022 monsoons, however, surveys showed that 15 of the 41 species distributed the winter prior had persisted in the reach. For more information, see the indicator page for Riparian Vegetation: Composition and Cover in Heritage Reach (page 28).

TUCSON APPROVES THE RETURN OF ANCESTRAL LAND NEAR THE RIVER AND A-MOUNTAIN TO TOHONO O'ODHAM NATION

The City of Tucson lies in an area with a long history of inhabitation. The city's name, which was a Spanish assimilation of "S-cuk Son", reflects the name of the Hohokam village that once lay at the base of what is now known as Sentinel Peak (Black Hill or A Mountain). In April 2023, Tucson Mayor Regina Romero and Ward 1 Council Member Lane Santa Cruz led a unanimous approval by the Tucson City Council to return some of this ancestral land. In recognition of the sovereignty of the Tohono O'odham Nation, and as part of the effort to formalize relations between the Nation and the City, approximately 10.5 acres at the base of Sentinel Peak were returned to Tohono O'odham ownership, whose predecessors settled there many thousands of years ago, along the Santa Cruz River.



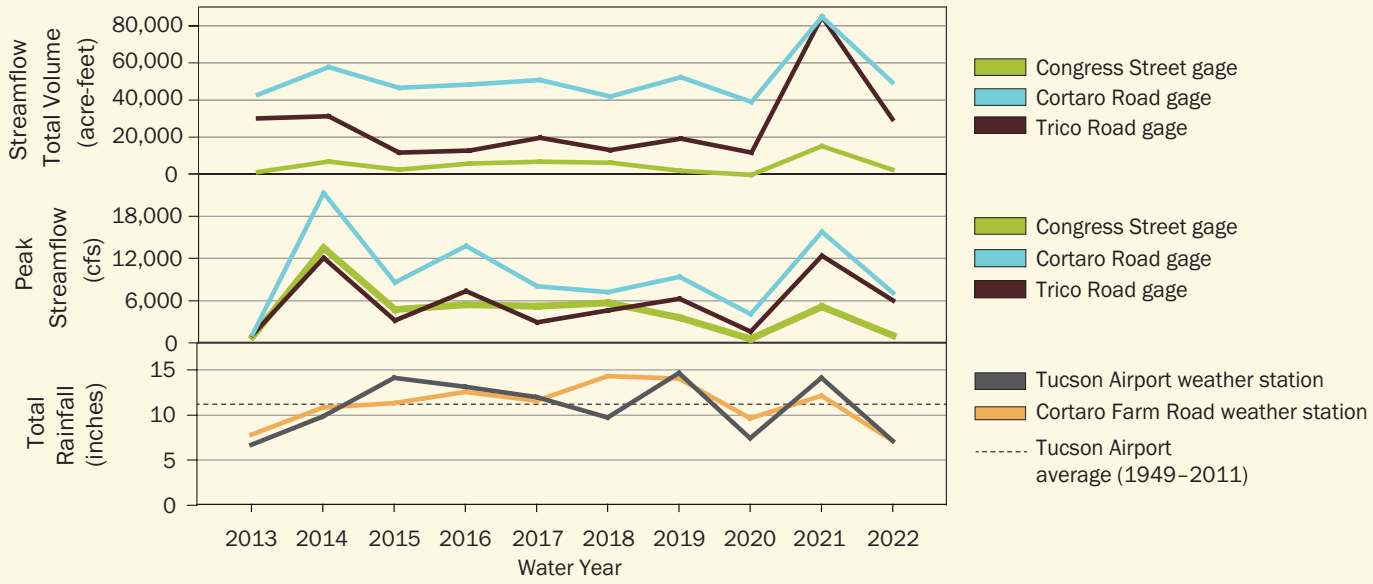
ENDANGERED WETLAND PLANT, ARIZONA ERYNGO, PLANTED AT TWO NEW LOCATIONS

Some plants that were once common in Arizona are now very rare, due to the dewatering and destruction of their wetland ecosystems by widespread development and groundwater pumping. One such species, Arizona eryngo, was listed as endangered in 2022. Since 2018, it has been propagated by the Pima County Native Plant Nursery using seeds from a wild population at La Cebadilla wetlands in eastern Tucson. Plants from the nursery have been placed in multiple locations that have the necessary consistent soil moisture. In March 2022, 80 individuals were planted at a spring on the County's Bar V Ranch southeast of Vail, and in November 2022, 15 were planted at Sweetwater Wetlands (City of Tucson) near the Santa Cruz River. In June 2023, 14 of the plants at Sweetwater (seven months after planting) were alive. At Bar V Ranch, 15 months after planting, 57 of the original plants were alive and at least 59 seedlings were emerging. These planting efforts provide a great opportunity to learn about the influence or impact of environmental factors on the success of such plantings, and to help ensure the survival of a rare species. Establishing populations of this rare species at multiple locations provides redundancy and thereby reduces the chances of it becoming extinct.

RIVER CONTEXT

STREAMFLOW AND RAINFALL

Streamflow, or the amount of water flowing in a river, provides an important context for the results of the indicators monitored in this report. The Santa Cruz River is largely dependent on discharges from water reclamation facilities, but during some parts of the year streamflow also includes stormwater. In addition to the amount of rainfall, runoff after storms depends on the amount of impervious surface (i.e., hard surfaces like paved parking lots) in the watershed. The Santa Cruz River watershed includes all of the land where stormwater flows toward the river. Seasonal floods are important for recharging aquifers, dispersing and germinating seeds, moving sediment, and clearing natural debris.



2013–2022 STREAMFLOW

Streamflow is measured in cubic feet per second (cfs) and represents the volume of water flowing past a fixed point in one second. Streamflow is measured with gages at Congress Street (Heritage Project) and at Cortaro and Trico Roads (northwest Tucson to Marana reach). The Cortaro Road gage also captures flows from two major tributaries that enter just upstream. Total volume sums all of the water passing a gage, allowing comparisons of streamflow between water years. Peak streamflow is the largest volume of water flowing past a gage, allowing the tracking of flood events.

At Congress Street and Cortaro Road, total streamflow has remained steady over the years. Flows at Trico Road decreased after the facility upgrades were completed in December of 2013, with increased days when there is no flow (see Flow Extent). All gages recorded the highest total flows in 2021 when monsoon rainfall was high. Peak streamflows were highest in 2014, with the exception of Trico Road whose largest peak streamflow is in 2021.

2013–2022 RAINFALL

Rainfall totals from the Tucson International Airport (TIA) and near the river at Cortaro Farms Road (CFR) provide a general idea of how stormwater may have increased streamflow.

TIA annual rainfall average is 11 inches. The most rain fell in 2019 with 15 inches (14 inches in 2015 and 2021). From 1949 to 2011 rainfall averaged 11 inches annually.

- Winter rains average 3 inches (range: 1–6)
- Summer monsoon rains average 6 inches (range: 2–12)*

CFR annual rainfall average is 11 inches. The most rain fell in 2018 and 2019 with 14 inches each year. This station was set up in 2012 and has no historical data.

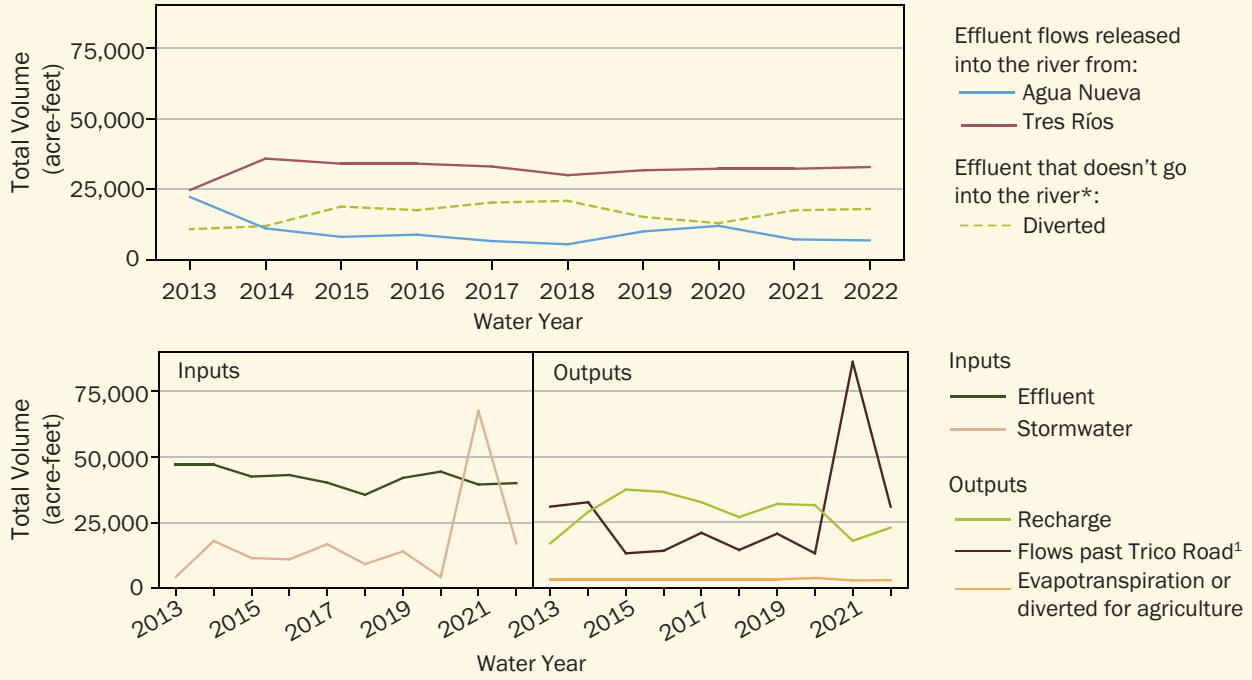
- Winter rains average 3 inches (range: 1–6)
- Summer monsoon rains average 5 inches (range: 2–10)*

*2018 monsoon rainfall was double the average for this season at CFR, and at both stations in 2021.

WATER BUDGET

A water budget quantifies the water inputs and outputs. Inputs to the Santa Cruz River are effluent and stormwater. Effluent flows come from regional wastewater reclamation facilities, Agua Nueva and Tres Rios. In 2022, the Tucson Airport Remediation Project contributed additional effluent flows to the river. Outputs include water that does one of the following: flows past the end of the study area (Trico Road for northwest Tucson to Marana reach and Congress Street for the Heritage Project reach), evaporates or is used by riparian vegetation (evapotranspiration), is diverted for off-channel recharge or agricultural use, or sinks into the riverbed to recharge the local aquifer. Volumes are totaled in acre-feet (AF), the number of acres that would be covered with water one foot deep. For accounting purposes, recharge from stormwater is not quantified. On days when the flow in the river includes stormflow, recharge is assumed to be zero, and managed recharge projects do not receive any credits.

In the northwest Tucson to Marana reach, there are two managed recharge projects. Recharge is calculated as the difference between the volume discharged into the river and the sum of the flow past the Trico Road gage, evapotranspiration, and off-channel diversions. In the Heritage Project reach downtown, Tucson Water calculates recharge by summing the flow past the Congress Street gage and evapotranspiration, and then subtracting this from the total water delivered to the river.



* Includes effluent that is diverted from Agua Nueva either to the reclaimed system for irrigation or to recharge basins located outside the river channel.

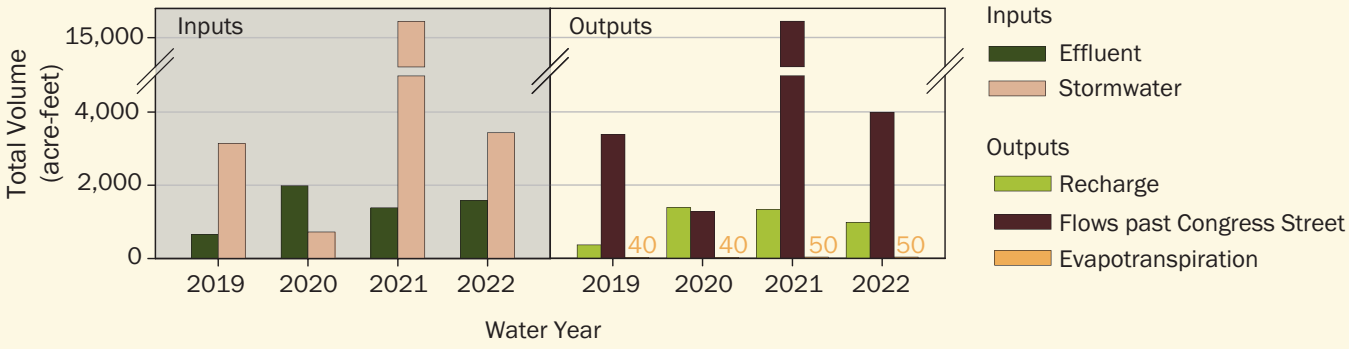
1 Excluding days with stormwater, the volume of effluent flowing past Trico Road is: 2013 = 26,800 AF; 2014 = 13,400 AF; 2015 = 2,100 AF; 2016 = 3,800AF; 2017 = 3,700 AF; 2018 = 6,000 AF; 2019 = 6,000 AF; 2020 = 10,800 AF, 2021 = 16,800 AF, 2022 = 13,200 AF

2013–2022 NORTHWEST TUCSON TO MARANA REACH

Starting in 2015, total effluent inputs have decreased by an average of 13% compared to the 2013 baseline. Total volume released from each facility changed in 2014 when the facility upgrades resulted in some wastewater being redirected to Tres Ríos and released downstream. Water released from Agua Nueva is more variable than at Tres Ríos and influenced by the demand for reclaimed water and the amount of water diverted into adjacent recharge basins. Reduced effluent flows and variable drying of the river in this reach (see flow extent) increased concerns for the endangered Gila topminnow living in the

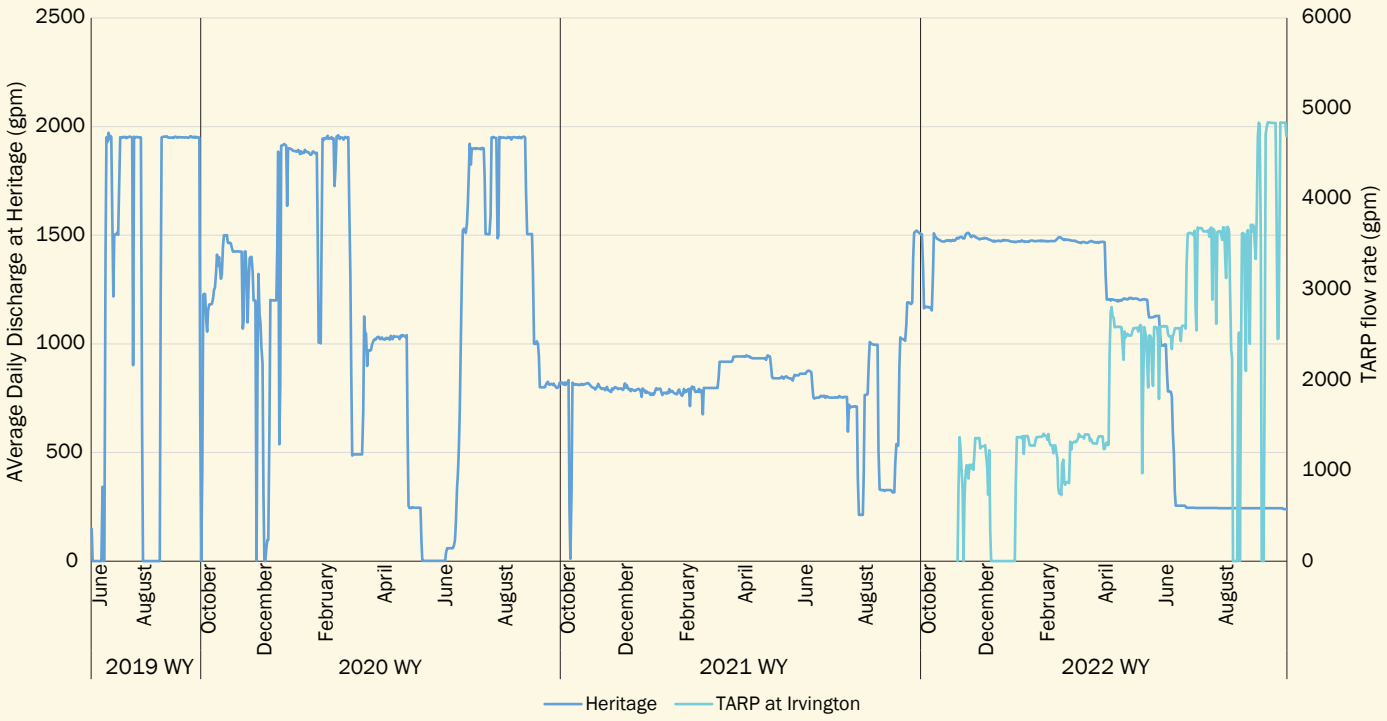
river. In 2021, officialls approved the use of water from the Conservation Effluent Pool to guarantee the release of a weekly average of 5 million gallons a day from Agua Nueva to support the endangered fish.

Stormwater peaked in 2021 with the record monsoon rainfall and contributed to the large amount of water flowing past Trico Road in 2021. Overall, increased recharge has generally reduced the amount of water that flows past Trico Road. However, the amount of recharge has been decreasing in recent years, most notably since 2020 when ash flows following the Bighorn fire covered the river bed. In 2022 recharge increased, likely due to 2021 floods scouring the riverbed and removing the ash, thereby promoting infiltration. Even so, the total flow past Trico Road in 2022 was highest since the 2014 water year, other than 2021. Volumes of water diverted for agriculture or used by wetland vegetation are calculated annually or daily, respectively, for recharge calculations and have remained fairly constant.



2019–2022 HERITAGE PROJECT REACH

Tucson Water started adding effluent to the Heritage Project reach in June 2019. For most of the year, effluent discharge is the only source of water. This was especially true in 2020 when stormwater flows were minimal. However, stormwater contributed significantly to flows in 2021 with the strong monsoon activity. Much of the effluent sinks into the riverbed to recharge the aquifer prior to reaching Congress Street. The volumes of water used by wetland vegetation are estimated for recharge calculations. Starting in 2021, officials approved the use of water from the Conservation Effluent Pool to support the riparian and wetland vegetation in this reach.



THE IRVINGTON OUTFALL AND TARP

TARP—the Tucson Airport Remediation Project—addresses groundwater contamination stemming from Air Force activity near the Tucson International Airport in the 1950s–1970s. Contaminated groundwater is pumped and treated to remove 1,4-dioxane, trichloroethylene, and PFAS. The treated groundwater is then released to the Santa Cruz River at an outfall near Irvington Road, a little more than 2 miles south and upstream of the Heritage Project. Water discharges into the river began in November 2021, and have been a boon to the river and its wildlife. Releases began at an initial average of ~1,000 gallons/minute (gpm) or 400 gpm less than the average release at Heritage, but increased steadily and by September 2022 reached an average high of 4,000 gpm. However, flows from TARP are anticipated to be lower and more variable in the future. In April 2023, the TARP system was connected to Tucson's reclaimed water pipelines, meaning that release volumes at the Irvington outfall are now influenced by the demand from reclaimed water customers. For example, at the time of connection, TARP releases were reduced to ~800 gpm, and then further reduced in May to ~240 gpm due to increasing demands for reclaimed water.

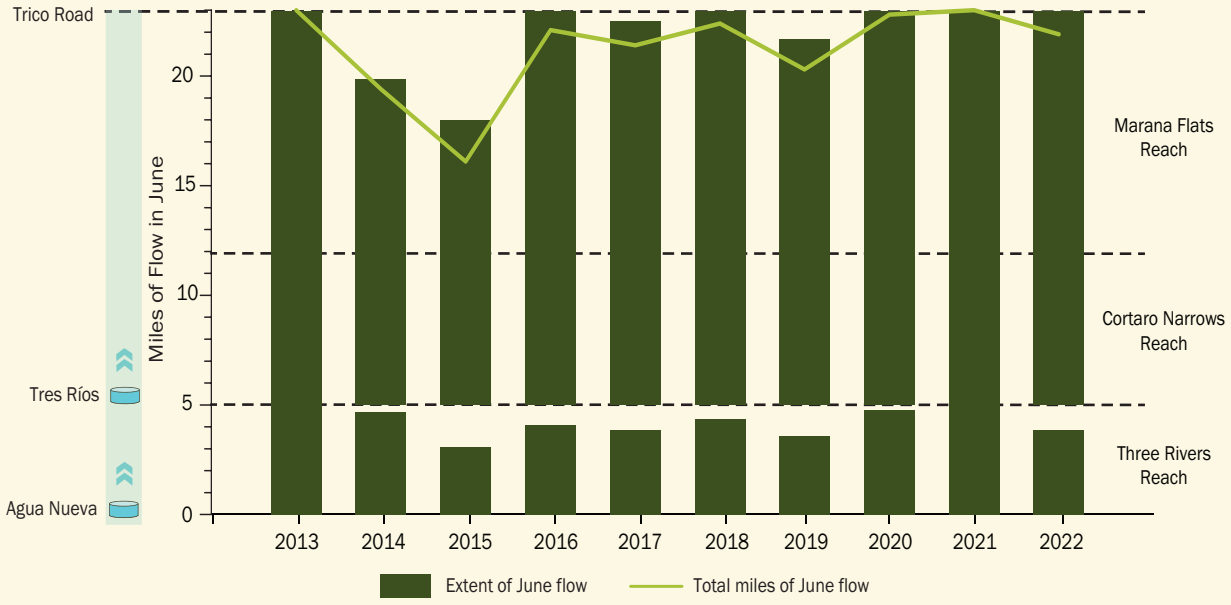
Groundwater levels in the Heritage Project are monitored closely due to the proximity of an historic landfill. TARP discharges upstream have added more complexity to monitoring at Heritage and discharge rates are adjusted for both TARP input upstream and natural stream flows. The additional flow from the Irvington outfall has regularly joined with the Heritage Project, increasing the flow extent of this reach at times by over 1.5 miles. Connection between the TARP flows and releases from the Heritage outfall has combined with natural inputs like stormwater to produce flow that has at times extended past St Marys Road, almost 2.5 miles downstream of the Heritage Project outfall and further than almost all previous flow extent observations for this reach of the river. A reduced but steady discharge at the Heritage Project will be maintained to support a vital wetland refugia near the outfall that harbors endangered Gila topminnow and other aquatic wildlife.

INDICATORS

FLOW EXTENT: Miles of flow in June

Measuring flow extent, or the distance the river is flowing, is a quick visual way to track changes in water inputs and outputs, while providing a rough measure of the quantity of aquatic habitat available. For example, longer flow extent may indicate high inputs and availability of habitat for aquatic life. Shorter flow extent may indicate reduced inputs or greater infiltration of water into the aquifer, which could decrease aquatic habitat.

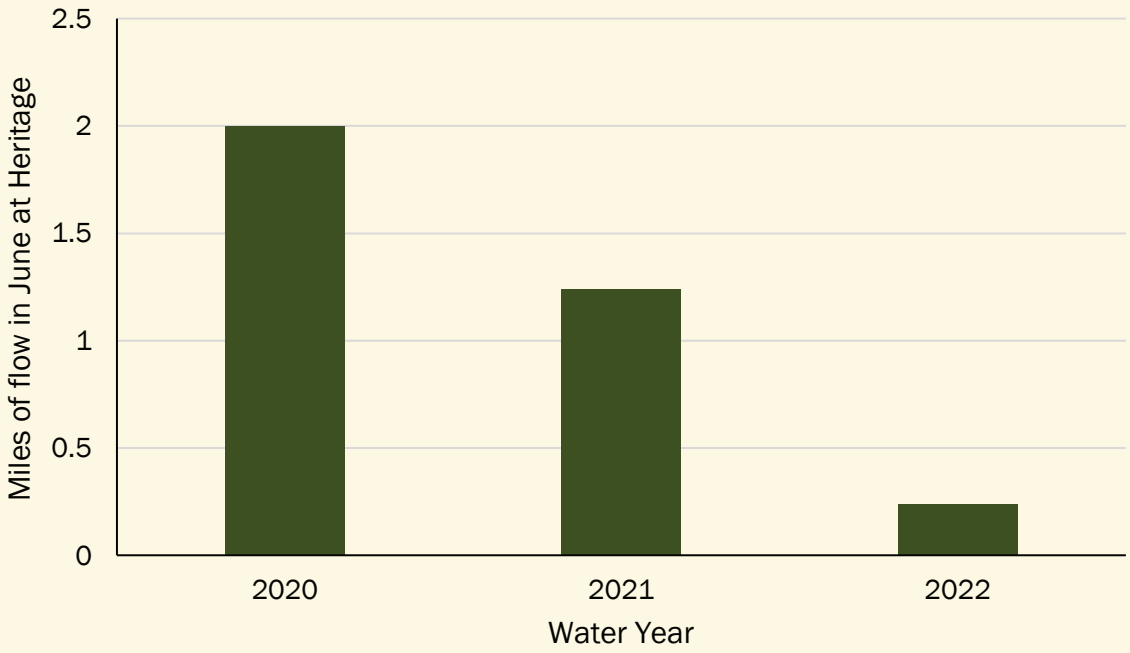
Measuring the **miles of flow in June** from the outfalls to the end of each stretch of river prior to the monsoon season determines the minimum extent of flow in each reach during the driest time of year. This is typically measured on one morning in mid-June.



2013–2022 NORTHWEST TUCSON TO MARANA REACH RESULTS

Flow extent decreased and was more variable after the December 2013 upgrades. In June 2013, the river flowed uninterrupted to the end of the 23-mile study area and continued another 5 miles further into Pinal County. Uninterrupted river flow occurred again in June 2021 for the first time since 2013, with the river reaching past the 23-mile study area. In other years, dry river stretches of varying lengths have formed between Agua Nueva and Tres Ríos reclamation facilities, and upstream of Trico Road.

Many factors influence flow extent. In the northwest reach, discharges of cleaner water beginning in 2013 were strongly correlated with reduced flow extent. We also know that recharge increases after large floods scour the riverbed. The longest dry stretch in the Three Rivers reach was in 2015. This follows the largest flood recorded during this study (see Streamflow)—one that peaked in 2014 at 21,200 cfs near the Tres Ríos facility, which is over twice the average flood peak during this study. Timing of floods may also play a role. Conditions that impact the factors influencing flow extent vary by reach, a helpful detail to keep in mind when comparing these reaches.



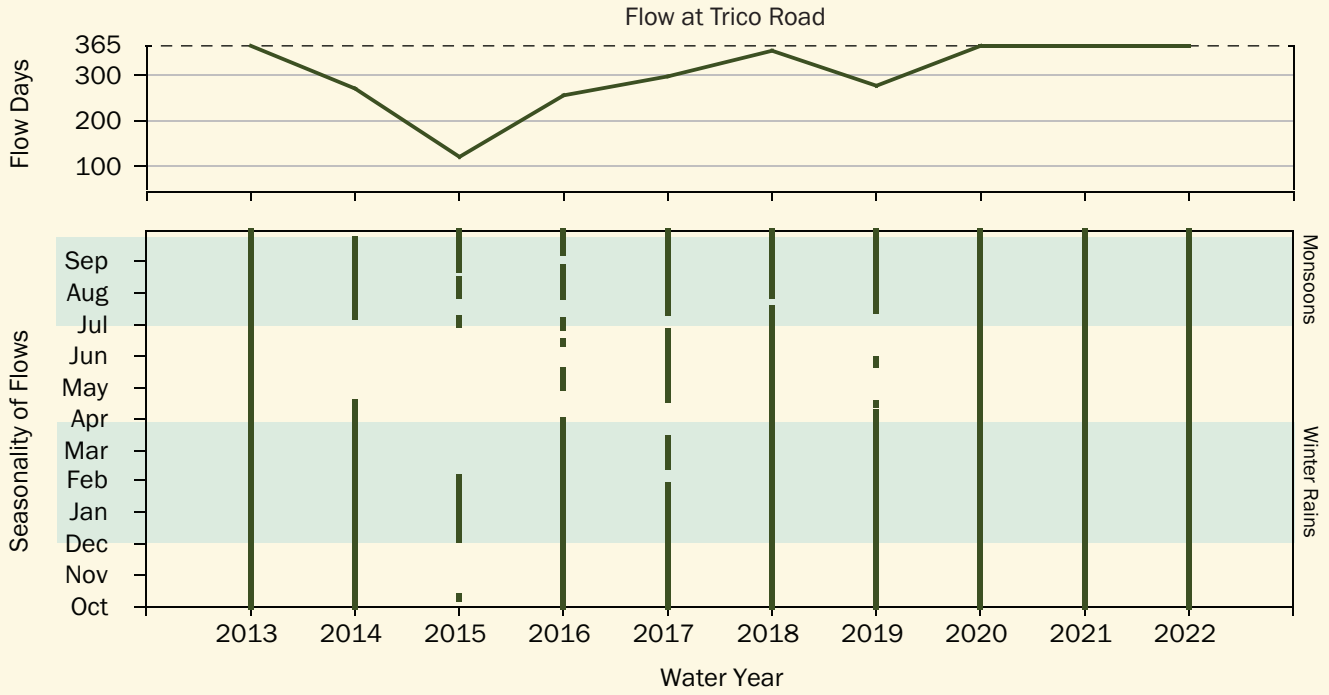
2019–2022 HERITAGE PROJECT REACH RESULTS

In June 2022, the river flowed approximately 0.24 miles from the Heritage Project outfall. This is a much shorter extent than seen in 2020 or 2021—the flow has been steadily decreasing. There are many reasons flow extent varies, as has been discussed previously. Inputs in this highly managed reach are closely monitored and have been lowered in volume as upstream inputs from the new Irvington outfall have increased and, at times, connected. The rate of recharge also plays a role, and the significant monsoon activity of 2021 scoured the river bed, increasing its recharge capability and reducing the flow extent.

FLOW EXTENT: Flow at Trico Road and Congress Street

Tracking the streamflow at the furthest downstream point of each reach estimates daily changes in maximum flow extent. This is done by tracking **flow at Trico Road and Congress Street** and counting the "flow days," or number of days with streamflow at the downstream end of the study area—Trico Road for the northwest Tucson to Marana reach and and Congress Street for the Heritage Project reach.

The Heritage Project is still so new, and flows are highly variable and dependent on the volume of water released. However, a stream gage managed by U.S. Geological Survey has been recording streamflow at Congress Street from long before the Heritage Project started, allowing us to monitor "flow days" at Congress Street since 2013 when this study began.



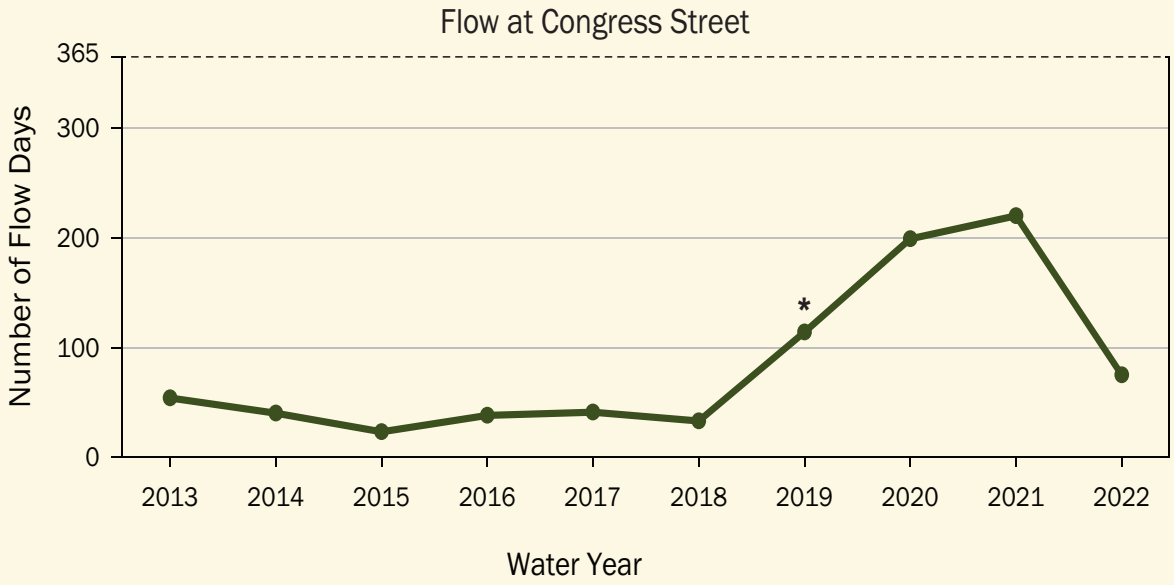
2013–2022 NORTHWEST TUCSON TO MARANA REACH RESULTS

Water management is also an important factor in flow extent. Reduced discharges from Agua Nueva, for example, have likely contributed to the drying of the Three Rivers reach. In Marana Flats, the river is also diverted by an earthen berm into a channel to provide irrigation water for agriculture and water for aquifer recharge at Marana High Plains Effluent Recharge Project, a constructed recharge facility adjacent to the river. Flow extent in this area may temporarily increase on occasion when the berm fails and needs to be rebuilt. For example, the berm failed several times in 2016 and once again in 2020 and may have decreased the number of dry days at Trico Road during those years.

The daily flow at Trico Road has become more variable since the treatment upgrades in 2013. The highest number of dry days occurred in 2015 and 2016 and has been declining since. In addition to increased recharge and human management of river flow, natural flooding has likely influenced conditions at Trico Road. In September 2014, floodwaters moved the location of

the low-flow channel and breached a berm along the El Rio Preserve, a former borrow pit near the start of Marana Flats. This allowed water to flow into the pit and form the wetlands at El Rio Preserve. In addition, the 2014 peak flood was the largest since the 2013 upgrade and may have further increased the infiltration rate. This combined with diversion of flow into the wetlands may have increased the number of dry days recorded in 2015. Floods also bring nutrients and sediments. Ash flows from the Catalina Mountains following the 2020 Bighorn Fire covered parts of the riverbed and likely decreased infiltration, thus allowing the river to flow farther.

Since 2017, flow at Trico Road has increased and in 2020 the number of dry or no flow days was zero for the first time since 2013. During this same time, the average volume of effluent and stormwater flowing in the river decreased (average total water in the river in 2017–2022 was just under 5,000 acre-feet less than the average total in 2014–2016). More flow at Trico Road even with less water in the river may suggest the rate of recharge is stabilizing or even decreasing.



*Santa Cruz River Heritage Project flows began June 24, 2019

2019–2022 HERITAGE PROJECT REACH RESULTS

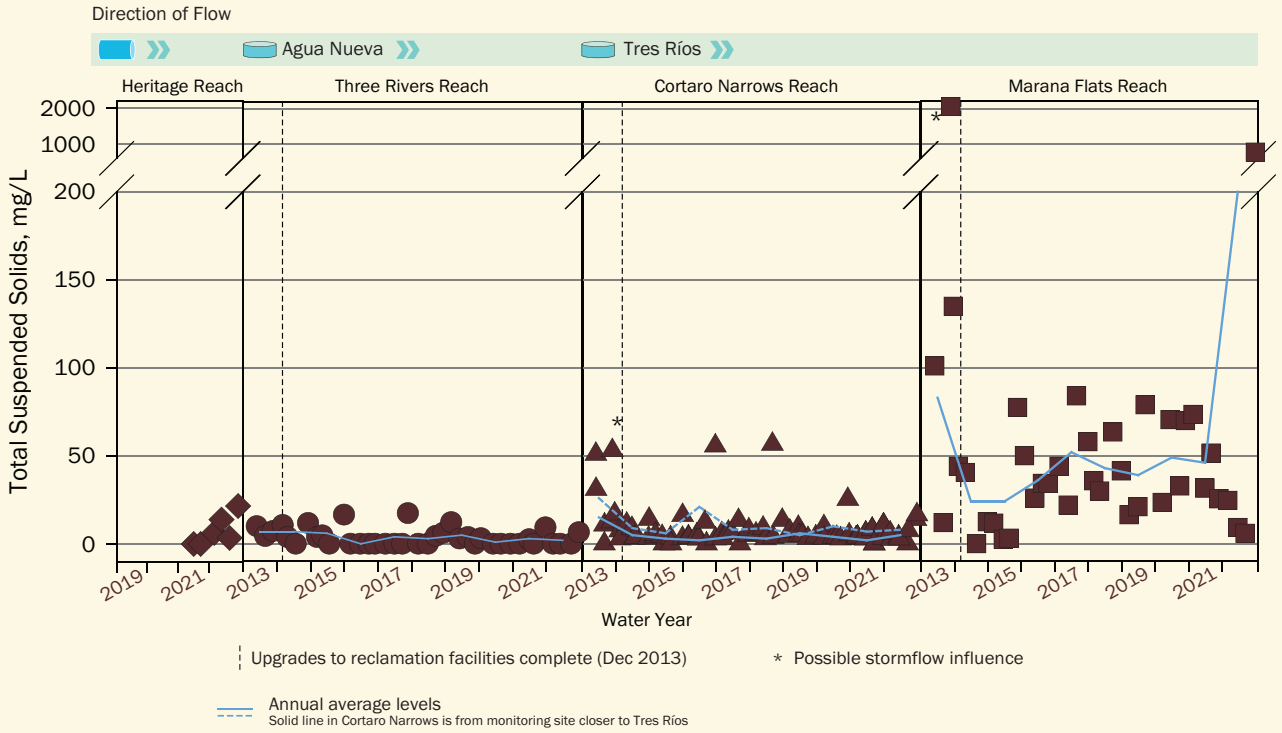
The number of days with flow at Congress Street has significantly increased since the Heritage Project began. Prior to this, flows consisted only of stormwater. Though 2019 had 251 days with no flow at Congress Street, only 14 of these days occurred after June 24 when effluent flows were added to this reach of the river. In 2020, there were only 166 days with no flow at Congress Street. At least 31 of these days occurred during May 2020 when flows had to be reduced or turned off for a project to remove accumulated sediment in the riverbed. There were 145 dry days at Congress Street in 2021, and 290 in 2022. Most dry days in 2022 occurred between late January and late July.

WATER CLARITY: Total Suspended Solids

Rivers naturally move sediments, wildfire ash, and other small particles of algae or detritus downstream. High concentrations of materials in the water can create "dust storm" conditions and can impact conditions for aquatic life.

Total suspended solids is an estimate of the number of particles in the water, or the intensity of the "dust storm."

Levels of total suspended solids naturally increase during flooding conditions with extra stormwater. The Arizona Department of Environmental Quality (ADEQ) does not have a standard for total suspended solids. The concentration of total suspended solids in each reach from the 2013 water year serves as a baseline.



2013–2022 RESULTS

Total suspended solids (TSS) were measured a total of 159 times during normal flow conditions. Levels of TSS are lowest and least variable in the Heritage and Three Rivers reaches. Cortaro Narrows had decreased levels of TSS since 2013, with only occasional high levels observed. Marana Flats had the most variable levels of TSS. From 2014–2015, TSS briefly decreased in Marana Flats after the upgrades were complete. After 2015, TSS levels in Marana Flats increased though remained lower than levels recorded before the upgrade. Levels appeared to be dropping in 2022 until a late September water sample that record the highest level of TSS that didn't have possible stormwater influence. The reasons for this high value are unknown.

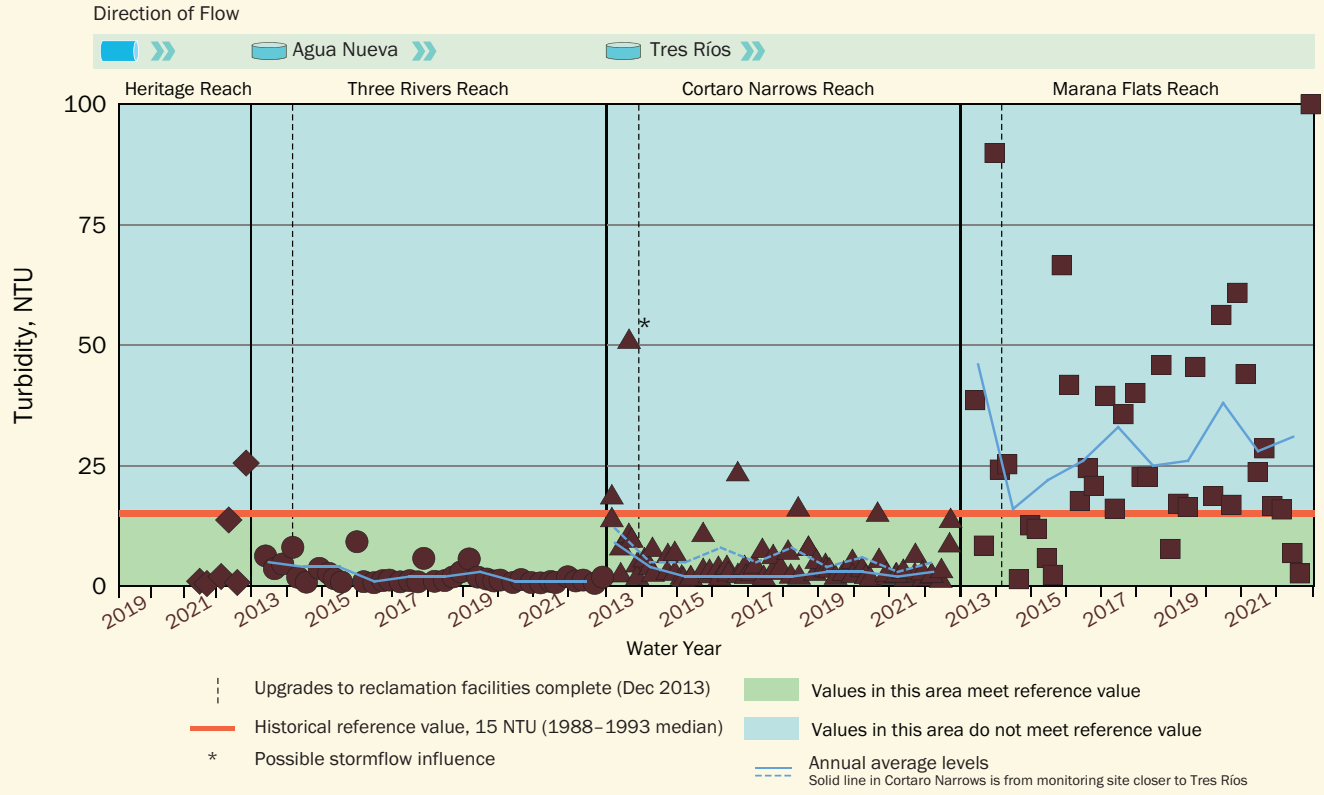
To understand how TSS levels may change with addition of stormwater, samples of stormwater were collected upstream of Agua Nueva. Four samples collected (one each year during the summer monsoon for 2013–2016) had TSS concentrations ranging from 1,050 to 46,300 mg/L and were higher than levels on normal flow conditions. Higher levels of sediment in stormwater is expected because of sediment transport by the stormwater flows.

Measures of TSS in the Heritage Reach began in the 2021 water year and were very low at first but increased in 2022.

WATER CLARITY: Turbidity

Under chronically high "dust storm" conditions when there are high concentrations of suspended sediments in the water, sunlight doesn't travel as deep into the water. Aquatic plants may not receive enough sunlight to photosynthesize and aquatic predators may not be able to see well enough to capture prey.

Turbidity measures water clarity, or how far you can see through the water column and is reported in Nephelometric Turbidity Units (NTU). High NTU indicates the water is cloudy and hard to see through. The 1988–1993 median level of turbidity in the Cortaro Narrows reach was 15 NTU. ADEQ does not have a standard for turbidity, so this assessment uses 15 NTU as a historical reference value. This is slightly higher than a typical value of 10 NTU for a river with normal base flow and no stormwater influence.



2013–2022 RESULTS

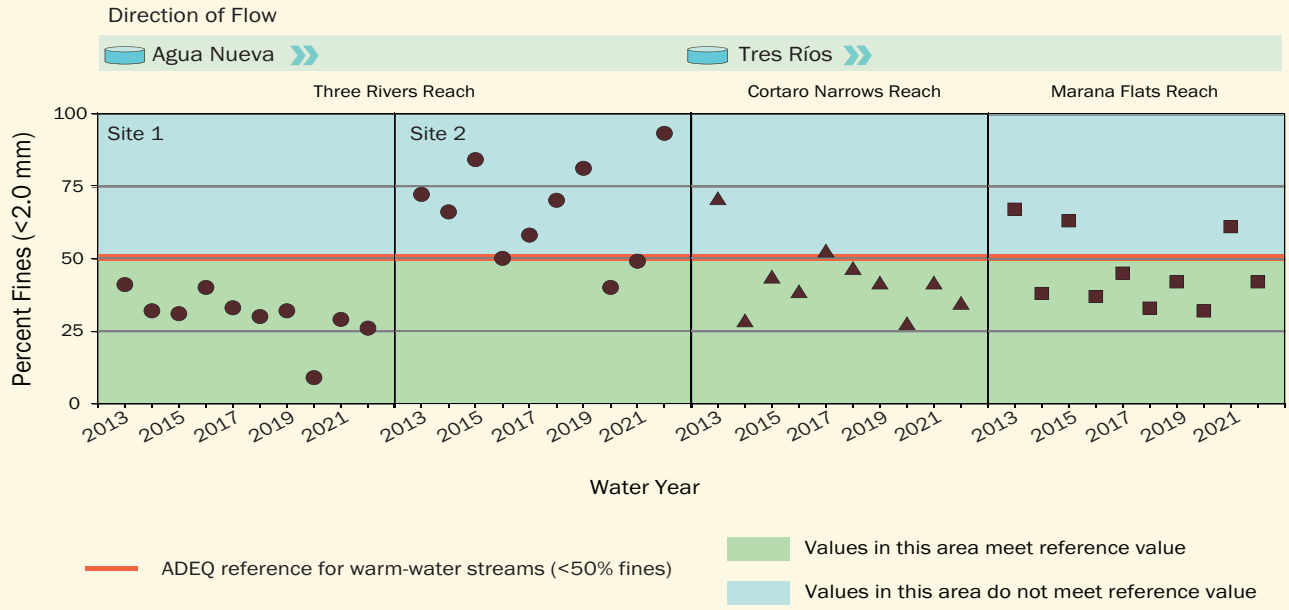
Turbidity was measured throughout the year at several locations for a total of 159 times. Overall, the reference value was met 125 times (79%). Average turbidity within Three Rivers and Cortaro Narrows has decreased since the 2013 upgrades were complete; both have averages below 10 NTU. Although average turbidity decreased in Marana Flats following the upgrades, values have been higher and most variable in this reach since 2016, with the highest reading in 2022.

Measures of turbidity in the Heritage Reach began in the 2021 water year and were far below the two reference values. In 2022 a high value caused an increase in the average of this measure to 11 NTU, higher than it was before but still below the 15 NTU historical reference value used for the river.

WATER CLARITY: Percent Fines

Rivers naturally leave deposits of the sediments, wildfire ash, and other small particles of algae or detritus that are carried downstream. This process provides an important influx of nutrients and materials. However, fine materials that settle out of the water onto the riverbed can become so abundant that they smother aquatic life and habitat, and reduce infiltration of water through the riverbed. Monitoring changes in fine materials can provide important context for changes in direct measures of aquatic life such as diversity of fish and aquatic invertebrates.

Percent fines is an estimate of the portion of the riverbed comprised of small sediments (≤2 mm in diameter). ADEQ does not have a standard for rivers dominated by effluent. This assessment uses the reference value for warm-water streams: percent fines <50%.



2013–2022 RESULTS

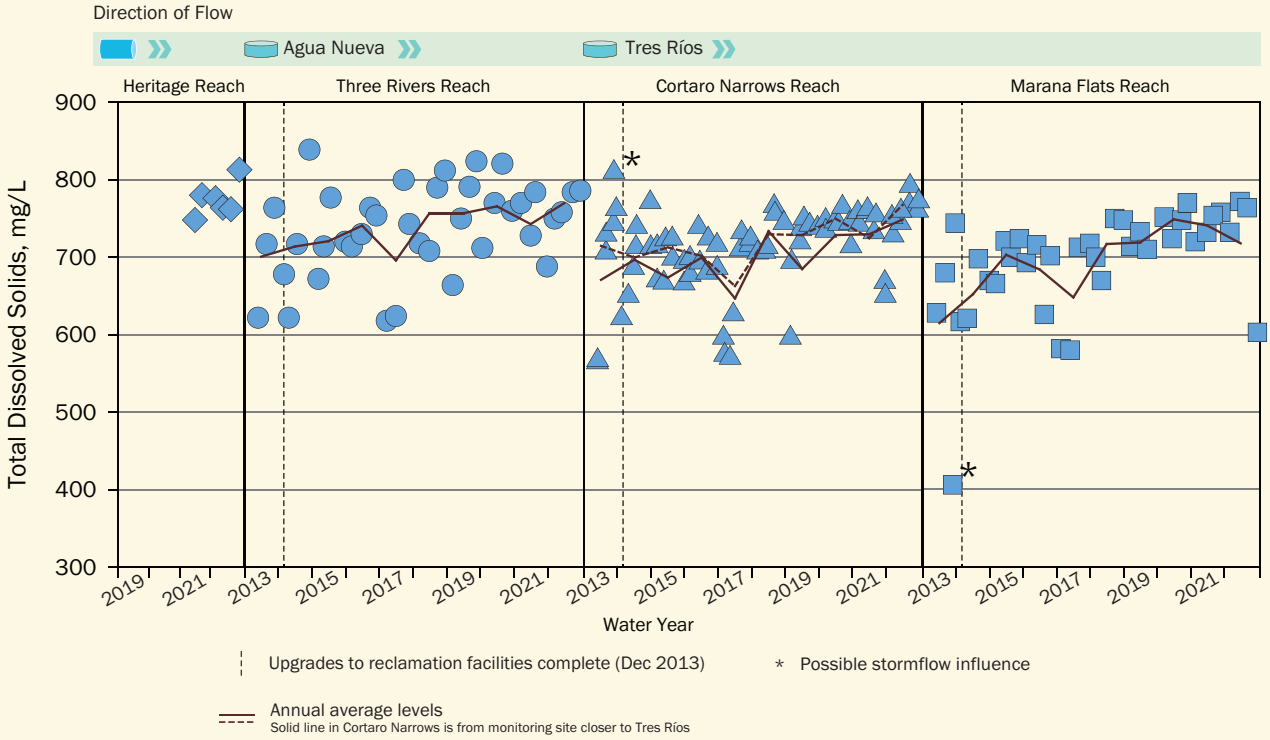
Percent fines were estimated at four sites at the time aquatic invertebrate samples were collected in May of each year. Overall, there was a reduction in the percent fines covering the riverbed at these sites, though there was a lot of variation. In 2020, all sites recorded their lowest percentage of fine materials since monitoring efforts began. For unknown reasons, the second site in Three Rivers had a very linear increase in percent fines between 2016 and 2019 prior to decreasing significantly in 2020. All sites showed an increase again in 2021, although the second site at Three Rivers did not reach the same level as before until 2022, when it exceeded all previous levels recorded at that site. Levels at Marana Flats decreased again after a spike in 2021, returning to a lower level such as that observed in 2017 and 2019.

Due to reductions in flow extent, the second survey site in Three Rivers and the survey site in Marana Flats had to be shifted upstream in 2015 and 2014 respectively.

Measures of percent fines in the Heritage Reach have not been conducted.

WATER QUALITY: Total Dissolved Solids

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 salts in the water. TDS in the effluent has been rising since the 1990s with increased use of Colorado River water in the Tucson area. The Colorado River has greater TDS, mostly in 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. Freshwater generally has TDS <1,000 mg/L and stormwater generally has low levels of TDS.



2013–2022 RESULTS

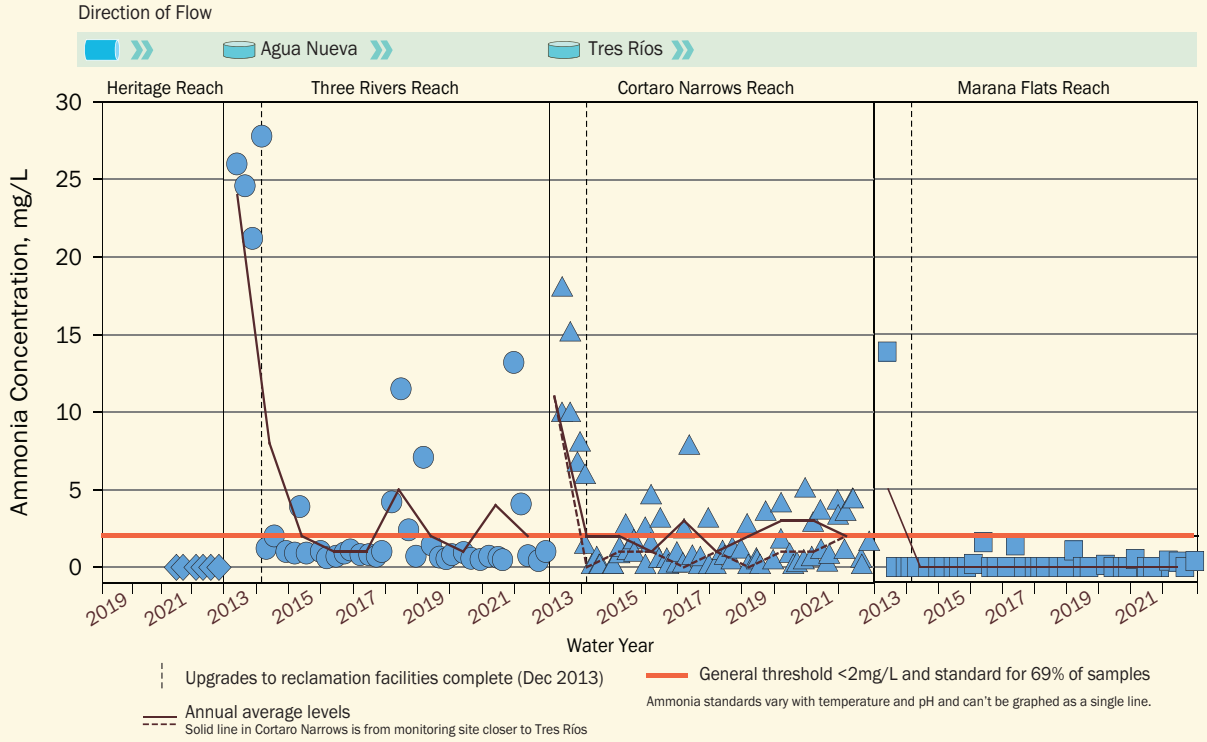
Total dissolved solids (TDS) were measured 158 times. Overall, levels of TDS were similar in all three reaches. Generally, TDS hasn't changed very much, though average levels appear to be increasing in all reaches. The lowest measure of TDS was in Marana Flats. This sample was collected on a day where there was possible stormwater influence—the addition of water with lower TDS levels may have diluted the levels in this reach of the Santa Cruz River. Samples of stormwater are collected upstream of Agua Nueva when possible. Four samples collected (one each year during the summer monsoon in 2013–2016) averaged 280 mg/L.

Measures of TDS in the Heritage Reach began in the 2021 water year and are comparable to levels in the other reaches.

WATER QUALITY: Ammonia

Nitrogen is an essential nutrient for plant and animal life, but too much can contribute to nutrient pollution. Nutrient pollution, such as high levels of nitrogen and phosphorus, enters the river from air pollution, fertilizer, surface runoff, and the release of effluent. While elevated nutrient levels can benefit riparian plants, they can also lead to poor water quality conditions for aquatic wildlife.

Ammonia (NH_3) is one form of nitrogen that is toxic to fish and amphibians. Even at low concentrations, ammonia can reduce hatching success, among other impacts. The ADEQ standard for ammonia 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. A general threshold often used is <2 mg/L to avoid toxic conditions.



2013–2022 RESULTS

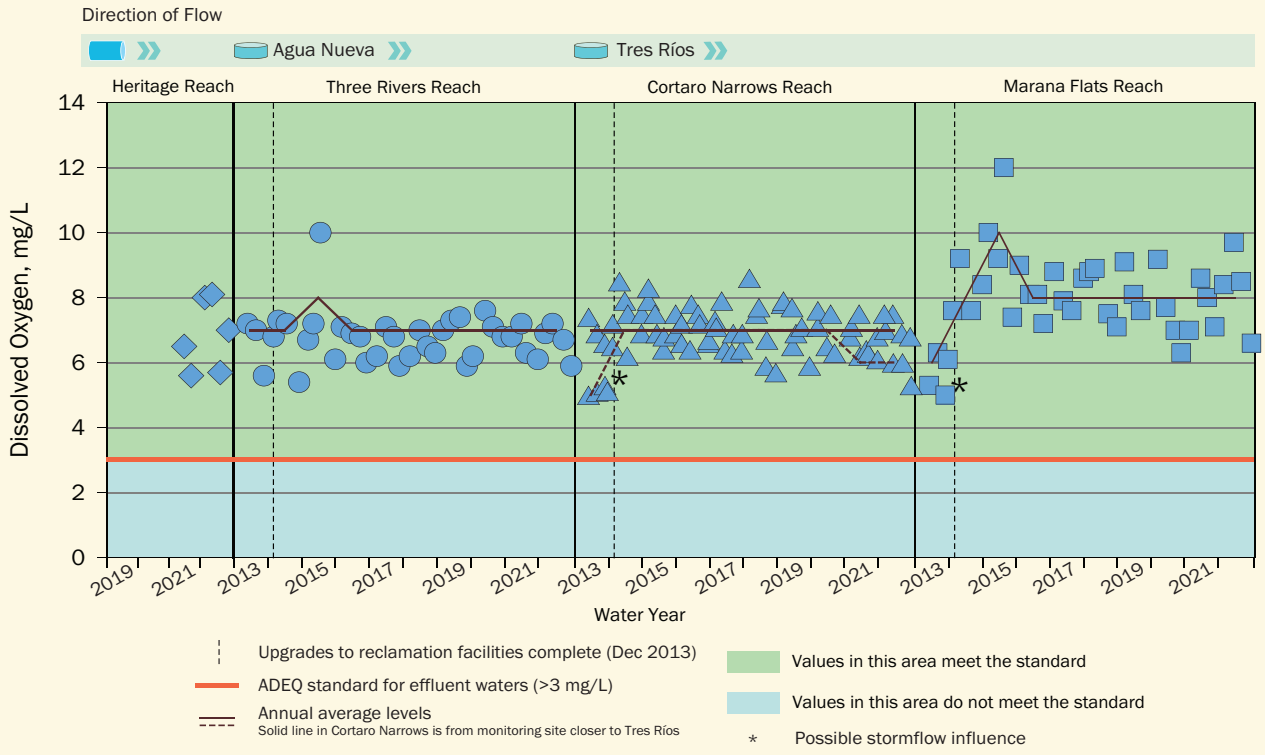
Ammonia was measured 157 times along the river and met the standard 114 times (73%). The standard varies with pH and temperature but was <2 mg/L for 69% of the samples. Levels of ammonia have dropped significantly after the upgrade was complete in 2013. Levels of ammonia also decreased with distance from the reclamation facilities, as it converts into other forms of nitrogen while moving downstream. Measured at four locations (two locations in Cortaro Narrows reach), average ammonia concentrations declined from a toxic 13 mg/L in 2013 to 1 mg/L in 2014–2022.

Occasional elevated levels of ammonia are observed near the Agua Nueva and Tres Ríos Water Reclamation Facilities. Removing ammonia is a complex process. The facilities use a five-stage process that features alternating oxygenated and oxygen-free zones. To prevent any occasional spikes in ammonia, Pima County regularly optimizes processes to better maintain the delicate balance of oxygen needed for maximum ammonia removal. A spring 2021 addition at Tres Ríos is a Nutrient Recovery System, NuReSys, installed to help reduce buildup of magnesium ammonium phosphaste (struvite) in pipes and phosphorus return loading. This system sequesters struvite from the wastewater in a biosolid product and has likely contributed to lower average ammonia levels at the site closest to Tres Ríos (2021 average: 3mg/L; 2022 average: 2 mg/L).

Analyses of ammonia in the Heritage Reach began in the 2021 water year. Ammonia has not been detected in this reach so far.

WATER QUALITY: Dissolved Oxygen

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



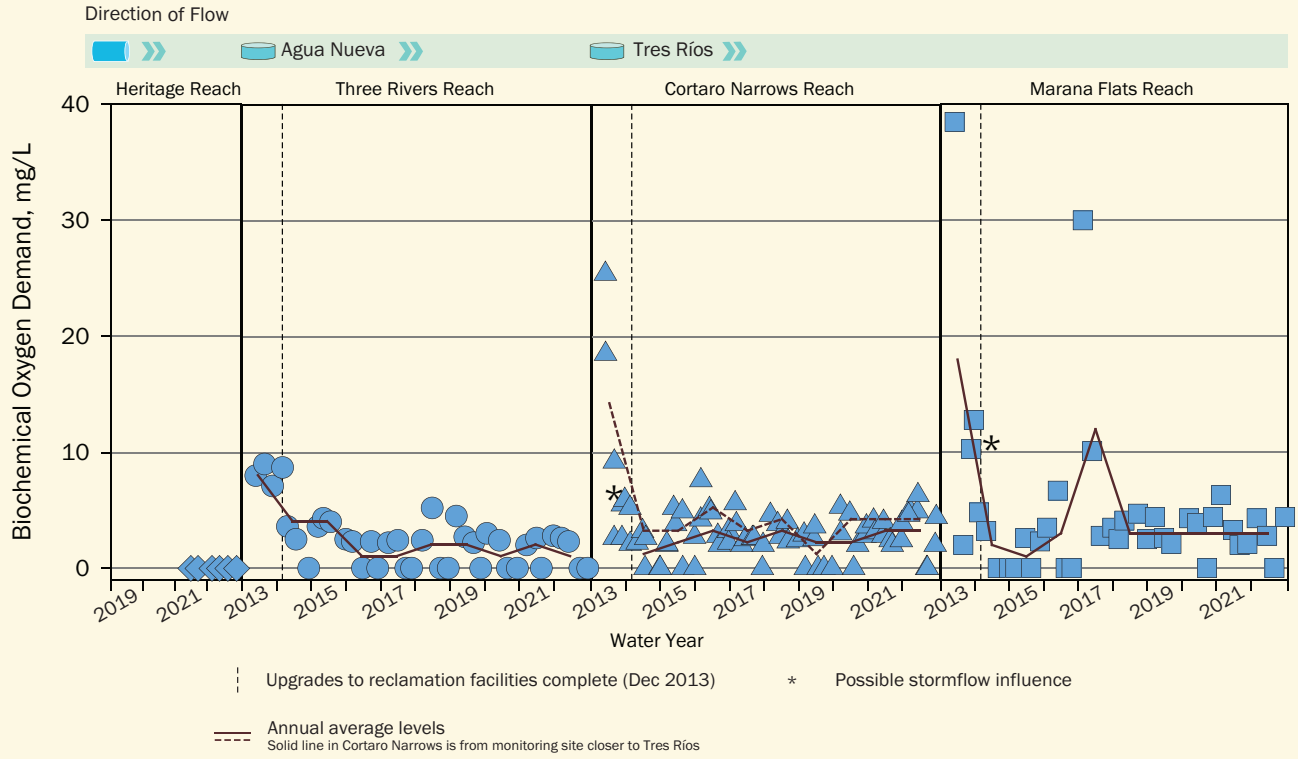
2013–2022 RESULTS

Dissolved oxygen was measured 157 times along the river. All of the samples met the standard for dissolved oxygen (100%). Levels of dissolved oxygen stayed fairly constant in Three Rivers and Cortaro Narrows. However, Marana Flats saw an increase in dissolved oxygen after the facility upgrades were completed.

Measures of dissolved oxygen in the Heritage Reach began in the 2021 water year and have continually met the standard.

WATER QUALITY: Biochemical Oxygen Demand

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 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 much of the 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, which are met in the released effluent, there is no standard for BOD in rivers. The results from the 2013 water year will serve as a baseline.



2013–2022 RESULTS

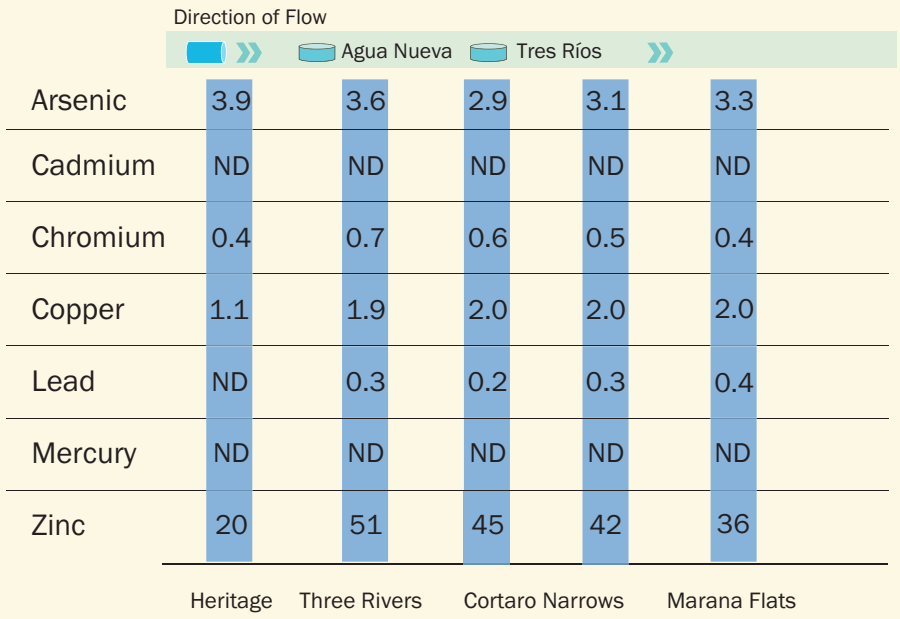
Biochemical oxygen demand was measured 159 times along the river. BOD has decreased since the upgrades to the reclamation facilities were completed. The high levels observed in Cortaro Narrows are absent after the 2013 water year. This pattern is generally the same in Marana Flats except that, for reasons unknown, measures of BOD in the first half of 2017 were similar to the high levels observed during the 2013 baseline.

Measures of BOD in the Heritage Reach began in the 2021 water year. The four measures of BOD have resulted in non-detections.

WATER QUALITY: 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. 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, and zinc.

Average values for dissolved metals tested throughout the year
concentrations in micrograms/liter (ug/L), also known as parts per billion (ppb)



	Average Standard *standards for wildlife vary with water hardness*
Arsenic	150 ug/L*
Cadmium	3.7 ug/L
Chromium	11 ug/L*
Copper	19 ug/L
Lead	7 ug/L
Mercury	0.01 ug/L*
Zinc	249 ug/L

*set value, not an average

ND = Not Detected

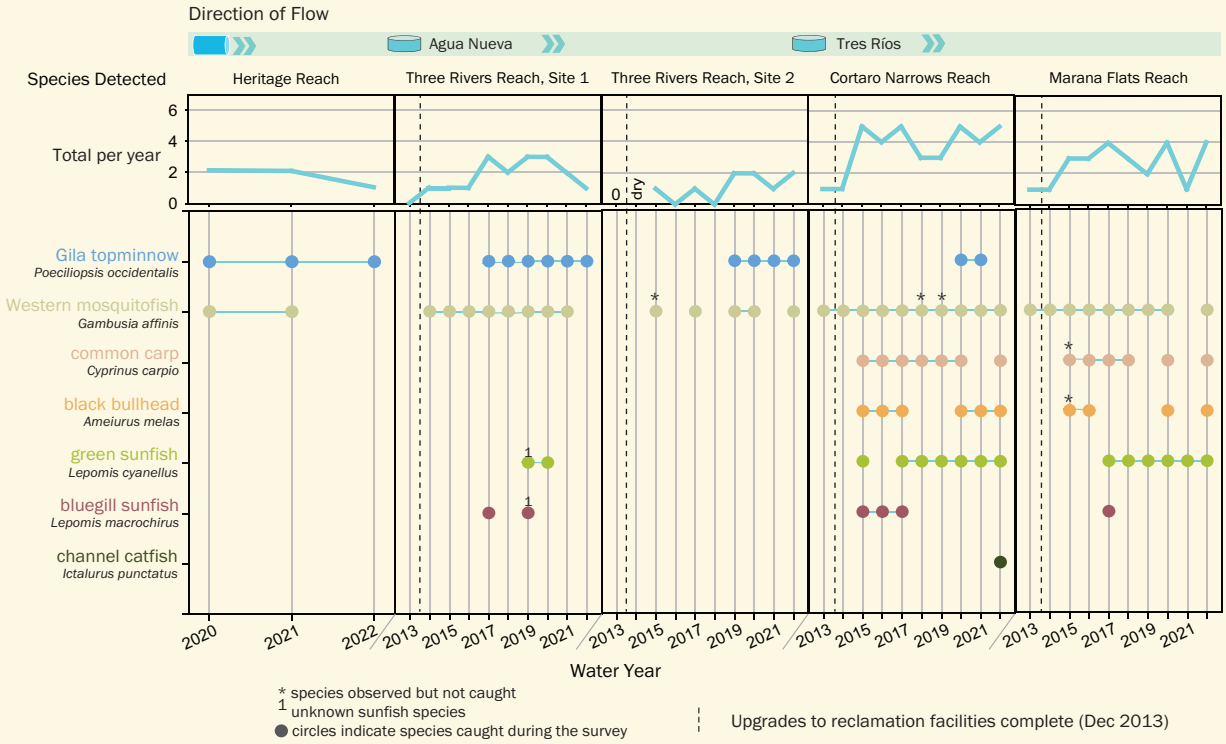
2013–2022 RESULTS

All samples tested at four sites over the years have met the appropriate standard for the following dissolved metals: arsenic, cadmium, chromium, copper, lead, mercury, and zinc. The samples taken within Marana Flats were from three different sites and averaged here. The sample location had to be moved several times due to reduced flow extent and inconsistent flows following increased infiltration rates.

Measures of dissolved metals in the Heritage Reach began in the 2021 water year. Levels have met all standards and remained comparable to or lower than levels in the other reaches.

AQUATIC WILDLIFE: Fish

Fish can serve as effective indicators of river health because they live for several years and vary in their tolerance to pollution. Historically, the greater Santa Cruz River supported several native fish species: Gila topminnow, Gila chub, desert sucker, Sonora sucker, longfin dace, and a pupfish species that went extinct when the river ceased to flow year-round. There is no standard for abundance or diversity of fish. The results from the 2013 water year will serve as a baseline for measuring change in subsequent years.



2013–2022 RESULTS

Fish surveys were conducted annually in the fall at the four locations where aquatic invertebrates were surveyed, with two sites located in the Three Rivers Reach. Surveys aim to detect all fish species present at a location, but do not try to assess population numbers. Improvements in water quality have allowed fish to thrive. Overall, the number of fish species observed increased from one to seven. All are non-native, except for the endangered Gila topminnow, which was found at one site in 2017, three sites in 2020, and three in 2021 and 2022. Exactly how this native fish returned is unknown. Genetic analysis suggests the Gila topminnow in the river near Tucson are most similar to fish found in the Cienega Creek watershed. One possibility is that the fish may have come down with stormwater flows in the Rillito from Sabino Canyon where the closest population lives. Recording the most species, the Cortaro Narrows reach may provide the most diverse habitat for fish. Flows in the Three Rivers reach are often very shallow and may favor smaller fish like the Western mosquitofish and Gila topminnow, although occasional sunfish have been seen.

Fish surveys in the Heritage Reach started in fall 2021. Arizona Game and Fish Department introduced Gila topminnow to this reach in October 2020, with individuals collected from the Tubac reach in Santa Cruz County, and this species has been recorded in the subsequent surveys in this reach.

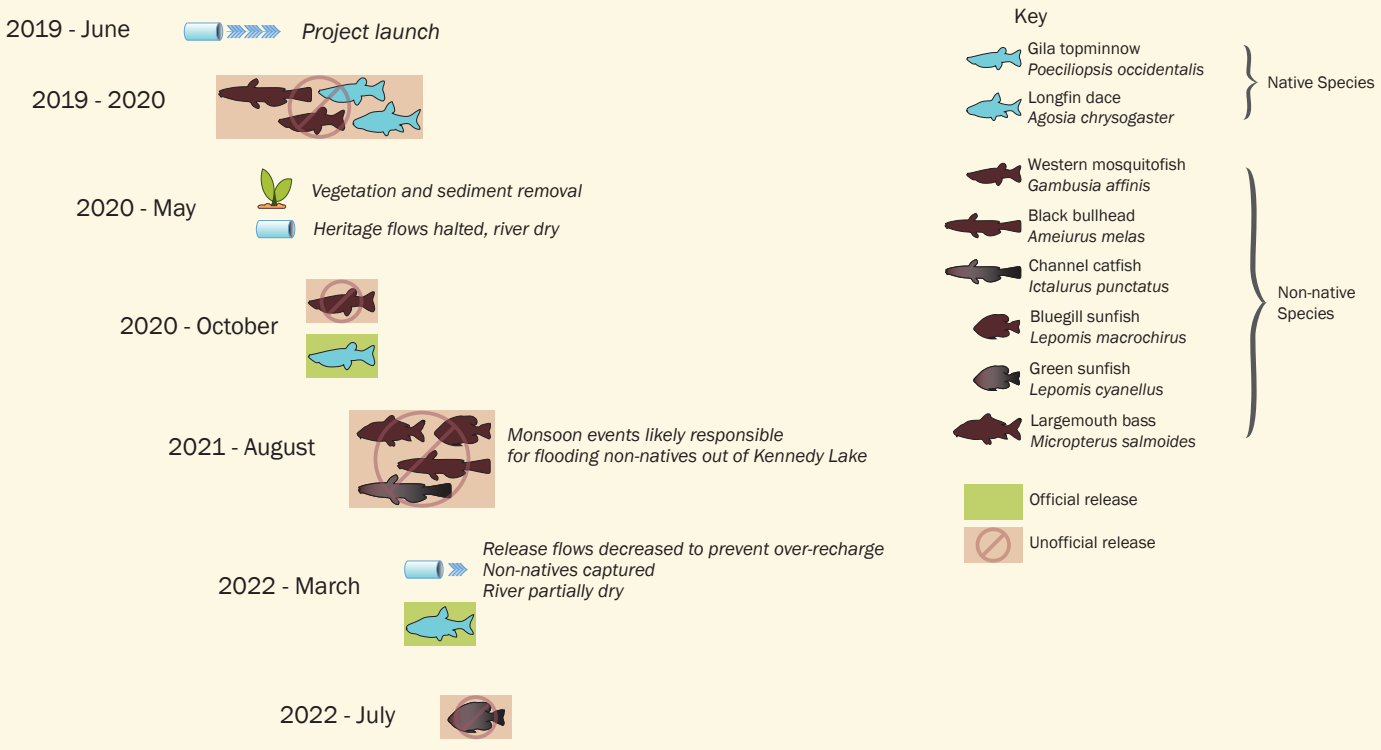
Native longfin dace (*Agosia chrysogaster*) used to be found in Tucson area and were released into the Heritage and Three Rivers reaches in March 2022. Unfortunately, none were observed in surveys later that year.

Introductions like that of the Gila topminnow in 2020 to the Heritage reach reflect the success of conservation work on the Santa Cruz River. However, the unplanned release or translocation of any wildlife or plant can negatively impact efforts to re-establish native species and manage the river ecosystem—any such actions are illegal and subject to heavy fines.

Illegal introductions have been observed in the Heritage Reach from the beginning of the project. After its launch in 2019 multiple species were discovered in pools that subsequently dried, resulting in the death of those populations. Similar fates were met by fish released just before Pima County conducted a sediment removal project. Sometimes weather events can cause flooding that flushes non-native species into the river from nearby sources such as Kennedy Lake, which is stocked with sport species for recreational fishing. However, often these introductions are suspected to have been the result of illegal human action. Western mosquitofish that were discovered in the Heritage Reach in 2020, just prior to the planned release of Gila topminnow, are now an established non-native species that poses an ongoing threat to the native's success, and in July 2022, green sunfish were discovered near the outfall of the Heritage Project without any prior flooding.

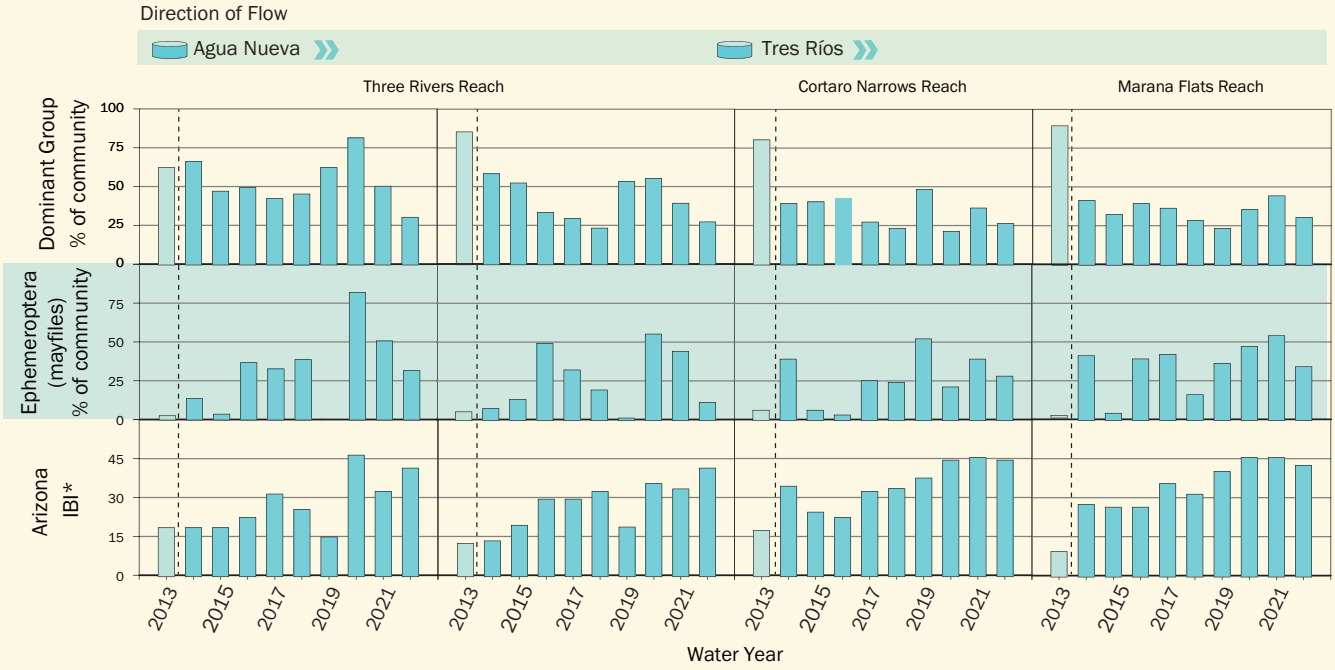
Researchers from the U.S. Fish and Wildlife Service have also identified the presence of *Poeciliopsis monacha-occidentalis*, a hybrid species of the endangered Gila topminnow (*Poeciliopsis occidentalis*) and the Mexico native headwater livebearer (*Poeciliopsis monacha*). This hybrid exploits Gila topminnow for reproduction, discarding the male genome and producing offspring that are clones of the hybrid females. The presence of this hybrid has been confirmed in both the Heritage and Northwest Tucson to Marana reaches, further complicating monitoring efforts: Western mosquitofish and Gila topminnow are difficult to tell apart and must be identified by trained experts, but the hybrid species can only be distinguished from Gila topminnow in the lab by looking at teeth under a microscope or with genetic analysis.

Timeline of Heritage Reach Introductions



AQUATIC WILDLIFE: Aquatic Invertebrates

Aquatic invertebrates break down organic materials and are important prey for fish and other species. They also differ in their tolerances to pollution. Chironomidae (midges) are pollution-tolerant and found in high numbers even with low oxygen levels and high organic matter. Ephemeroptera (mayflies) have exposed gills on the outside of their body, making them very pollution-sensitive. There are several common metrics used to assess aquatic invertebrate communities. The percent of the invertebrate community comprised of Ephemeroptera taxa is commonly used to help track changes in water quality. Regardless of sensitivity to pollution, if a single species or group accounts for more than 50% of the community, this lack of diversity suggests a stream is impaired. The Arizona Department of Environmental Quality has defined an index of biological integrity (IBI) for warm water streams in Arizona that combines many metrics into a single standard. Although there is no index for effluent-dependent streams, the warm-water index can be used as a reference: a value of >50 meets the standard, 42–50 is inconclusive, and <42 is impaired. A final way to look at diversity is simply looking at the total number of unique invertebrate taxa found in the samples collected.



Upgrades to reclamation facilities complete (Dec 2013)

*Arizona Index of Biological Integrity (reference standard for warm-water streams that compiles several metrics into an index score; scores <42 suggests impairment, 43–49 inconclusive, >50 attaining; no index established for effluent-dependent waters)

2013–2022 RESULTS

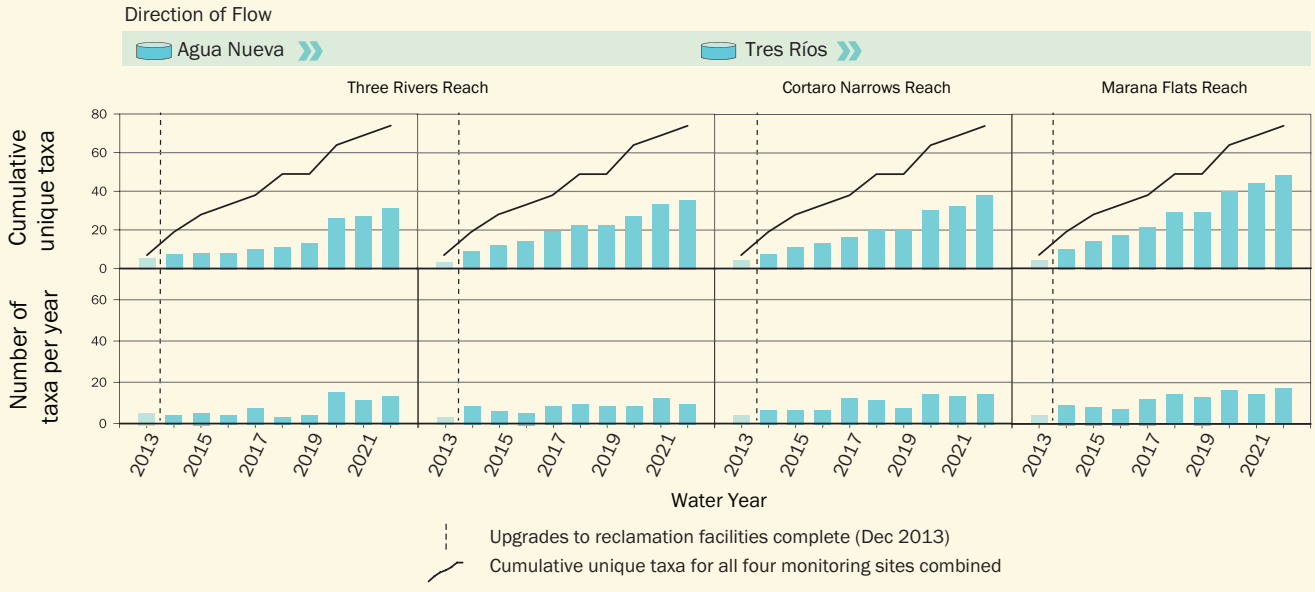
The aquatic invertebrate community was surveyed annually at the four locations that fish were surveyed. Invertebrates were sampled using the standard operating procedure developed by the Arizona Department of Environmental Quality, which involves kick-net samples in riffles or areas where the water surface is broken and agitated by rocks on the riverbed. This does not detect all species present, such as species that may not occur in riffle habitat, but instead gives a quick assessment of the site's biological integrity.

Overall, there were several signs of improvement over the last 10 years. The percentage of the community dominated by a single group or taxa decreased (the standard is met at <50%). The percentage of the community comprised of pollution-sensitive species from the order Ephemeroptera, or mayflies, has increased at all sites, although the percentage of mayflies

has been variable from year to year. The total number of taxa found at a monitoring site has also generally increased each year. This increased diversity is more apparant when you look at the cumulative total number of unique taxa found. This total increased at all sites, although Marana Flats appears to have the greatest diversity.

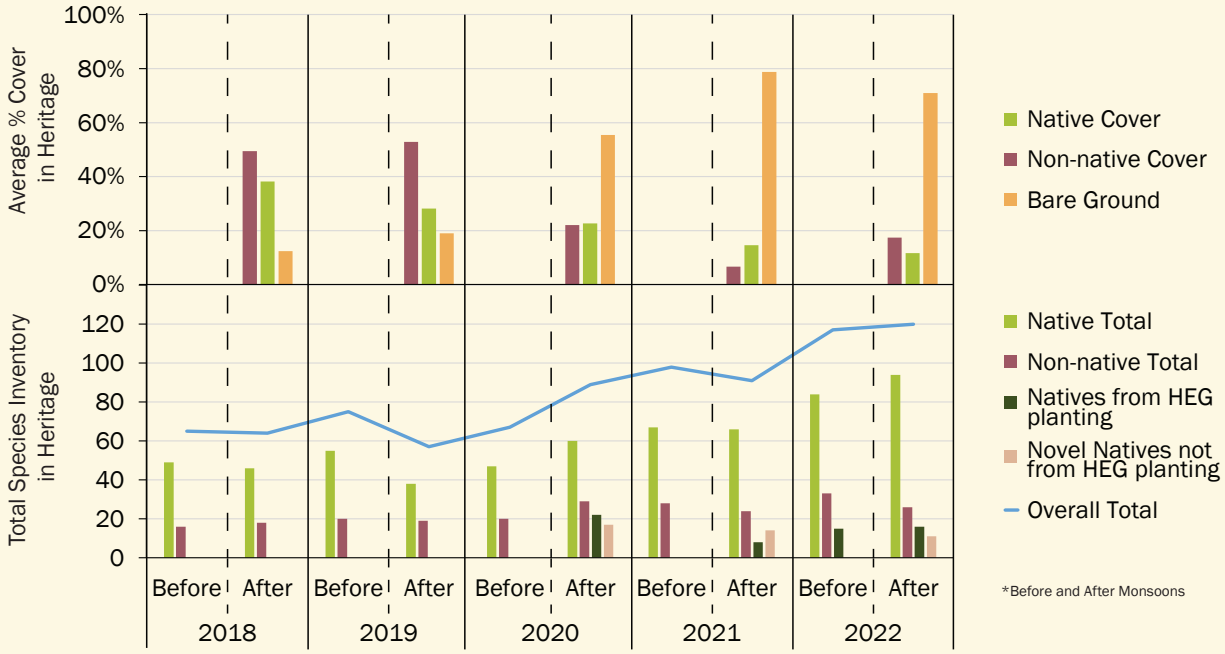
The Arizona Index of Biological Integrity (IBI) has also increased at all sites, with three sites recording scores near or above the level of "inconclusive" over the last three years, suggesting decreased impairment. Invertebrate communities are impacted by many factors; knowing exactly what causes increases or decreases in any metric is difficult. The percent of the riverbed covered by fine sediments decreased and was lowest in 2020, increased again in 2021, and in 2022 decreased again, especially in the silt/clay metric. These changes may have been changing the amount or quality of riffle habitat available and impacting the IBI. There have also been occasional high levels of ammonia in reaches just downstream of the reclamation facilities (see Ammonia) that could have impacted the aquatic invertebrate community and IBI.

University of Arizona has monitored aquatic invertebrates in the Heritage Reach since 2019. In May 2021, a sample was collected under ADEQ methodology that found 16 taxa in this stretch, which is comparable to the northwest Tucson to Marana Reach. Although no sample was taken with ADEQ method in May 2022, UArizona used their survey results to estimate that 17 taxa were present in the Heritage Reach. UArizona's survey methodology attempts to document all species present and detects 2.2 times more species than the ADEQ method.



RIPARIAN VEGETATION: Composition and Cover in Heritage Reach

Riparian vegetation benefits flood management, groundwater recharge, wildlife habitat, and more. The Heritage Project was primarily developed for aquifer recharge but also supports riparian and wetland plants. Tucson Water aims to develop this vegetation by increasing the native shrubs, grass, and other cover, while eliminating trees that increase flood risk in the narrow corridor. Harris Environmental Group (HEG) surveys vegetation **composition and cover in Heritage reach** biannually and disperses native seeds. Surveys began in 2018 and seeding in 2019, prior to a sediment removal project conducted by Pima County Regional Flood Control District in 2020 to improve conveyance of floods through downtown. Surveys before the monsoon monitor changes in vegetation in response to human and natural conditions: water release, flood control, re-seeding and planting, weather and general ecological change. Surveys after the monsoon aim to identify monsoon influence on vegetation and monitor species planted or seeded. Organized seed dispersal intends to help restore the riparian vegetation and re-establish native species. The initial surveys from 2018 and 2019 help establish a baseline for ongoing monitoring, but more data is available from the 2020 survey.



2018–2022 RESULTS

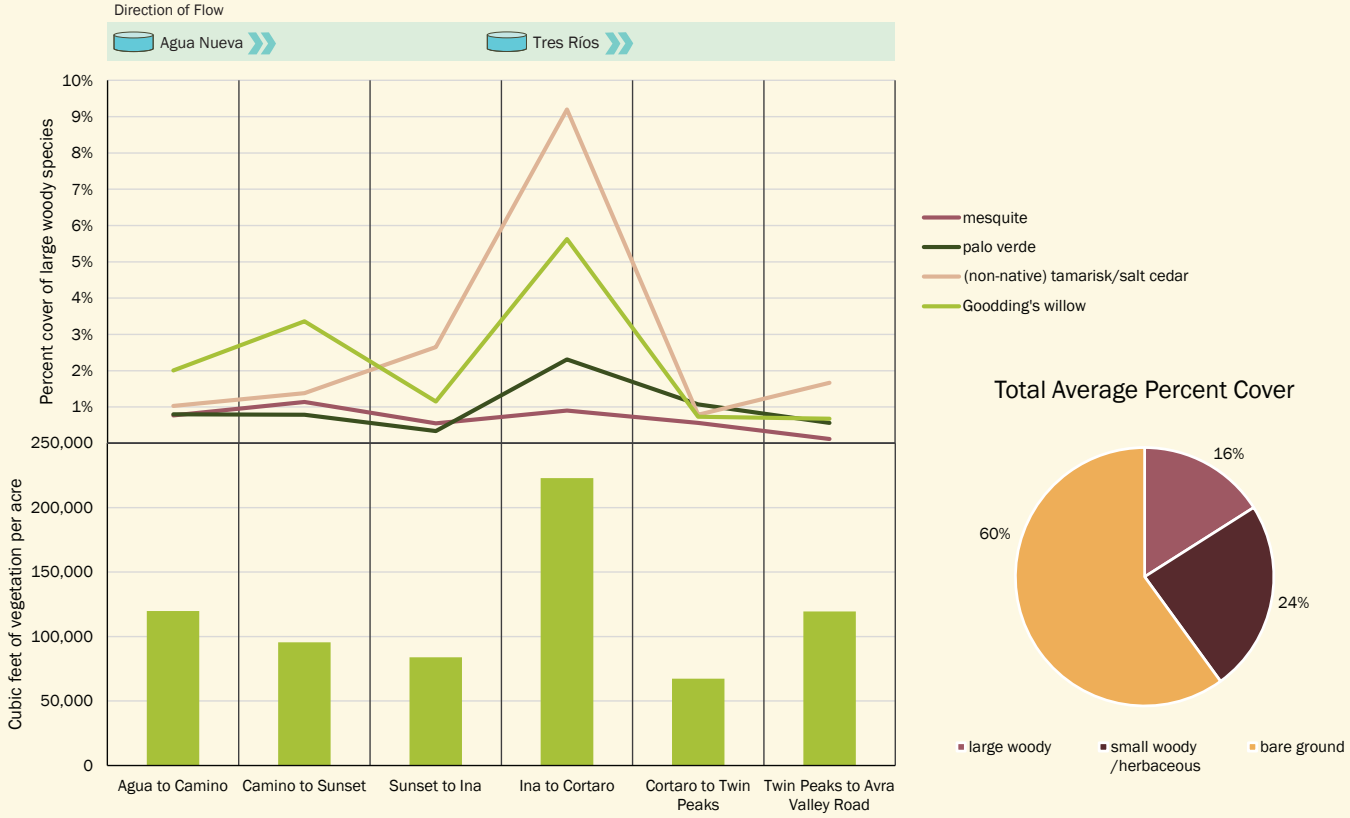
Overall, number of native species is increasing even as percent cover has decreased.

The 2022 pre-monsoon survey recorded 120 total species, 78% of which were native. Land with no cover increased from 2018 to 2021, decreasing again slightly in 2022. Likely factors leading to these changes include the sediment and vegetation removal effort in 2020 by Pima County Flood Control District, monsoon flooding in 2021, and recruitment. The average percent vegetative cover of native species increased and surpassed that of non-native species from 2018 to 2021: from 38% native and 49% non-native, to 15% and 7%. This ratio decreased in 2022, to 11% native and 17% non-native.

Comparisons of the species inventory after the monsoon show native species increasing from 2020 to 2022. Of these, 37% in 2020 were from HEG planting or seeding, and 17% in 2022. This number was less again in 2021, when monsoons likely transported and dispersed seeds downstream and outside of the reach. Novel (not previously recorded) native species not planted by HEG also emerged in 2020 and 2021, less so in 2022. Invasive buffelgrass and Bermuda grass continue to persist.

RIPARIAN VEGETATION: Cover in Northwest Tucson to Marana

Riparian vegetation in the Northwest Tucson to Marana reach has had many more years than the Heritage Project to establish, and routine vegetation surveys were only conducted from 2013 to 2016. However, new data collected in 2021 and 2022 via remote sensing techniques mapped vegetation for land management and restoration, and explored the potential offered by these technologies. The remote sensing techniques utilized included LiDAR (light detection and ranging), and ultra high-resolution imagery captured from both drones and planes. The river was segmented into six reaches for the survey, with the cover and composition of vegetation along the river calculated separately for each one.



2021–2022 RESULTS

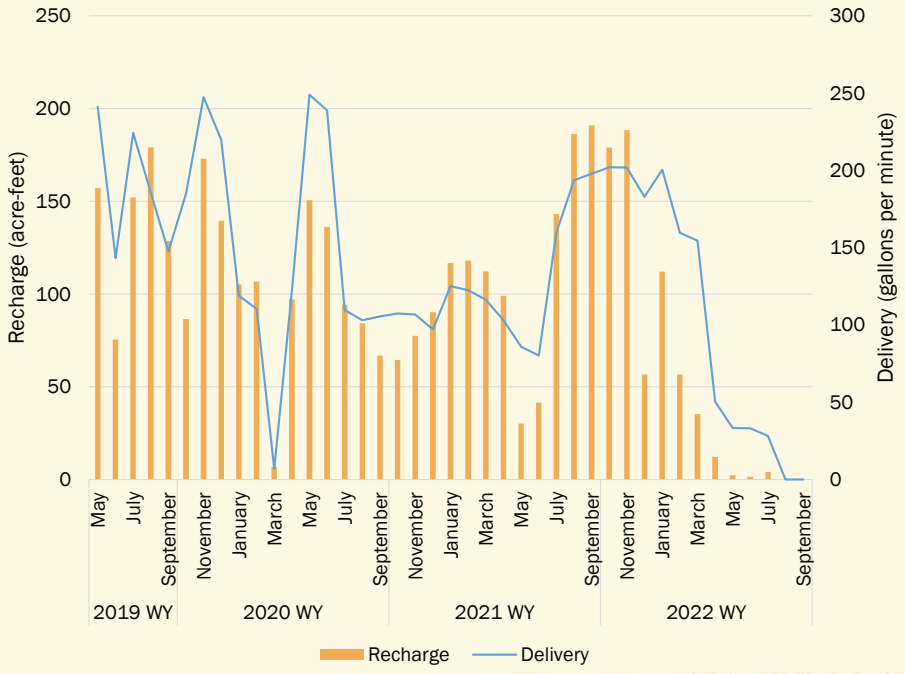
On average, 40% of the river corridor from Agua Nueva to Avra Valley Road was covered with vegetation, with the largest percentage of ground cover being small woody or herbaceous plants. The greatest volume of vegetation and cover by tamarisk trees is between Ina and Cortaro Roads. Native willow cover was highest in the reaches near Agua Nueva.

Bareground, general vegetation cover, and estimations of overall vegetation volume can be determined from airplane or drone imagery. However, identifying the species of small woody or herbaceous plants is harder. Field-based surveys are more appropriate for such detail. Larger woody trees can be identified to species like tamarisk, willow, mesquite, and palo verde, but to do so requires data analysis and interpretation, which take time. Further developments in these technologies may increase this efficacy and efficiency. In the meantime, using remote sensing in conjunction with ground surveys could provide a useful and effective comparison between the large and small scale; ground surveys will remain the best practice for monitoring invasive species like buffelgrass and stinknet, while remote sensing can cover a larger area with less detail.

GROUNDWATER: Aquifer Recharge

Historic groundwater pumping in the Tucson area was a major factor contributing to the drying of the Santa Cruz River and the depletion of local groundwater aquifers. Releasing effluent into the river is a natural and economical way to achieve **aquifer recharge**, but it must be carefully managed in some reaches and is measured to track the effect of effluent releases on the groundwater. Many factors influence recharge. Dense riparian vegetation can slow flow and create pools that increase recharge. Floods can increase recharge by clearing sediment and natural debris, while at other times reduce recharge by depositing sediments like ash from forest wildfires.

The Heritage Project is a good example of a highly managed reach of the Santa Cruz due to its proximity to downtown Tucson and historic landfills. To protect the aquifer from potential contamination from these landfills, groundwater levels are monitored and managed to stay below a particular depth.

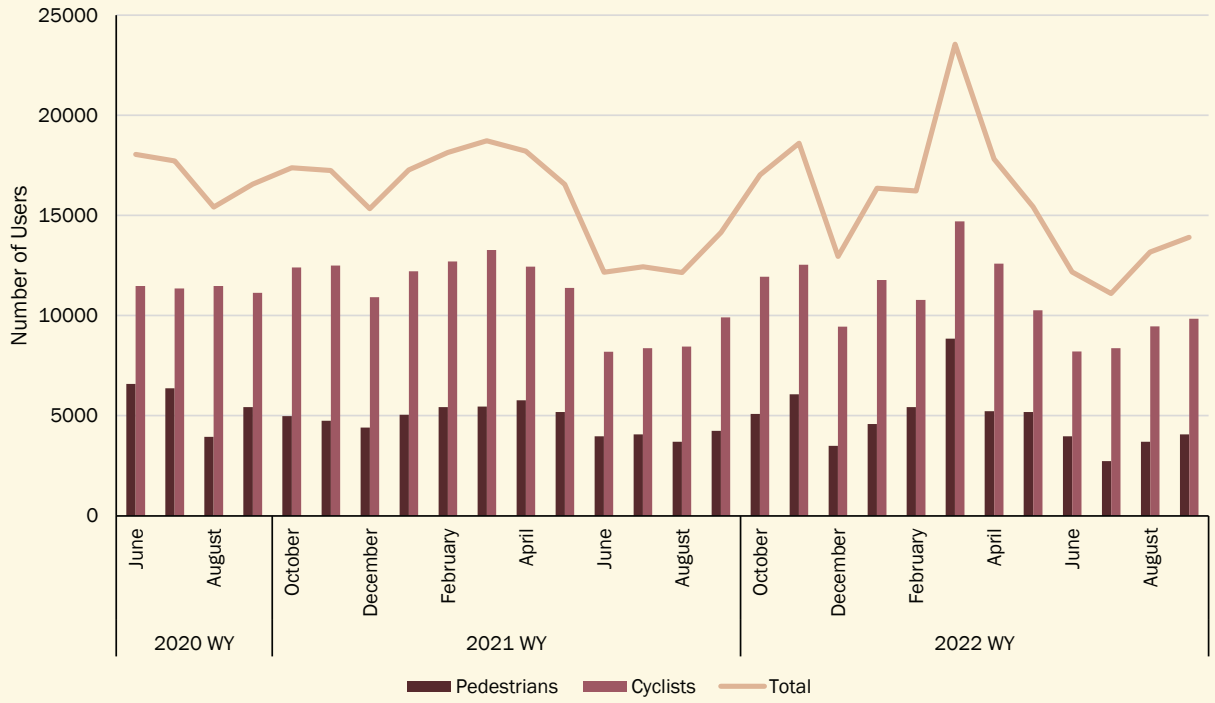


2020–2022 RESULTS

The Heritage Project began releasing water into the Santa Cruz River in June 2019, and within 6 months of the project's start a strong replenishment of the aquifer was observed. Groundwater levels rose approximately 45 feet, achieving a primary goal of the Heritage Project. The rate of water being released is decreased when necessary to manage the water table. In May 2020, water deliveries were also temporarily ceased to allow for the sediment removal project by Pima County. During the summer of 2020, there were very few monsoon floods. Speedwell, a common wetland plant in this reach, became so abundant that water was ponding near one groundwater monitoring well. This led to increased recharge in a localized area and water levels approached the alert level. Tucson Water staff removed some of the vegetation to reduce ponding and encourage flow to continue downstream. Since monsoon floods scoured the riverbed in summer 2021, recharge increased all along the reach and the flow extent reduced. Groundwater levels have been high due to this increase in recharge, although recharge reduced significantly over the course of the 2022 water year, with lower discharge volumes from the Heritage outfall resulting from the increased TARP flow at Irvington and frequent connection of that upstream flow to the Heritage reach.

SOCIAL IMPACTS: Pedestrian and Cyclist Use of The Loop

The Santa Cruz River is not just for wildlife. The Chuck Huckelberry Loop trail and numerous parks along the river corridor provide popular destinations for people to enjoy the river as well. **Pedestrian and cyclist use of the Loop** trail is one way to monitor recreational use along the river. The Loop has more than 136 miles of paths extending throughout the greater Tucson area and in January 2018 the "loop" feature was completed by connecting the Rillito and Pantano River Parks. Users in the Santa Cruz River Park can now connect with the Rillito and Pantano Parks, Harrison Greenway, and Julian Wash on a 53.9-mile circuit. Over the past two years, Pima County has installed counters to monitor activity along the multi-use path, with one counter along the river between the flowing reaches. These counters differentiate between cyclists and pedestrians, allowing trends of use to be studied.



2020–2022 RESULTS

In the Santa Cruz River Park, from Speedway to Saint Mary's Road, counter data shows a steady use year-round, with the lowest numbers in the 2022 water year occurring in December, July, and August. Even the lowest monthly total was 11,103 people, recorded in July 2022. The June-September average for 2022 was 12,899 people, comparable to 12,728 for the same period in 2021, which is perhaps reflective of summer heat and monsoon activity. The highest monthly total was recorded in March 2022, with 23,555 people (8,852 pedestrians and 14,703 cyclists). Generally, a higher proportion of cyclists is a trend seen every month. Apart from seasonal dips and highs, most months in the 2022 water year showed a total ranging from 11,000–18,000 users.

SOCIAL IMPACTS: Bird-watching

The flowing water and rich riparian vegetation of the Santa Cruz River support a diverse array of bird and wildlife species. **Bird-watching** is thus an easy way to understand the importance of wildlife viewing as a type of recreational use of the river and adjacent parks. We can also track the number of different bird species seen along the river. A citizen-science bird-watching program run by Cornell Lab of Ornithology, eBird (www.ebird.org), offers interested passersby an opportunity to take part in data collection by recording bird species they see along the river, thus providing river managers with an ongoing source of information. For this analysis, we include only observations collected during traveling or stationary counts of species making use of the river corridor and adjacent parks. Birds simply flying over, and those that are exotic or domestic, are excluded to focus on the effectiveness of the area as wildlife habitat.

2020–2022 RESULTS

Observed diversity was highest in 2021, with a combined total of 251 species recorded by 2,064 observers. For comparison, 240 species were recorded by 2,157 birders in 2022, and 227 species were recorded along the Santa Cruz River by 1,050 birders in 2020. The majority of bird-watchers recording observations are in the Northwest Tucson to Marana reach: 2,142 participants versus 76 along the Heritage Project, spotting 237 species versus 122. In total, there were 9,138 sampling events by bird-watchers along the river, observing many native species, including some that are rarely seen in the Tucson valley. Efforts like this demonstrate the potential of citizen-science efforts, and the latent willingness of communities to be involved in our natural areas.

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In 2012, the Sonoran Institute convened a Living River Technical 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 Technical Committee provided guidance by selecting and aggregating indicators of river health, identifying reference values or standards for evaluating and tracking changes in river conditions, and reviewing the development of 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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SONORAN INSTITUTE, a non-profit organization, is working to make the Santa Cruz River a living, flowing river and the foundation of community health and prosperity from Mexico to Marana. Since 1990, the Sonoran Institute's mission has been to connect people and communities with the natural resources that nourish and sustain them.

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Desert Sunset by Amayah Reyes-Muro, age 7, White Elementary School — Jessica Ramirez and Dr. Kevan Kiser-Chuc

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