

Santa Cruz River Economic Analysis

Comprehensive Valuation Report

Sonoran Institute

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Acronyms

ADWR	Arizona Department of Water Resource
AF	acre-feet
AMA	active management area
AWS	Assured Water Supply
BEA	Bureau of Economic Analysis
CV	Comprehensive Valuation
EA	Economic Analysis
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
KH	Kimley-Horn
mgd	millions gallons per day
MP	Master Plan
NIWTP	Nogales Internation Wastewater Treatment Plant
NPS	National Park Service
O&M	operations and maintenance
PV	present value
SCR	Santa Cruz River
SCRMP	Santa Cruz River Master Plan
SI	Sonoran Institute

Executive Summary

The Santa Cruz River (SCR) is a critical natural asset in southern Arizona and northern Sonora that supports groundwater recharge, ecological systems, recreation, and community identity. Under current conditions, treated effluent discharged into the river replenishes the aquifer, sustains significant riparian habitat for wildlife, all while providing recreation opportunities throughout.

The Santa Cruz River Master Plan (SCRMP) envisions expanding these benefits through increased effluent flows and targeted restoration actions, including revegetation and channel improvements designed to enhance ecosystem function and expand riparian habitat.

This report presents an economic analysis (EA) to evaluate the economic benefits of the current SCR and the potential benefits from future restoration. The EA quantifies, where feasible, the economic benefits of the river's current and increased supplied effluent conditions. The EA also provides an economic framework for assessing the economic performance of future restoration alternatives, as recommended in the attendant Santa Cruz River Restoration Master Plan produced for Sonoran Institute by Kimley-Horn and Associates.

Study Approach

The EA developed resource-specific economic valuation frameworks to assess both market and non-market benefits of the SCR. This framework integrates established economic valuation techniques, primarily benefit transfer, to translate environmental and social outcomes into economic terms.

The analysis evaluates both existing conditions and a representative high-flow scenario, which assumes an additional 15 million gallons per day (mgd) of treated effluent for the SCR. The framework is designed to be scalable, enabling future incorporation of more detailed restoration scenarios and site-specific data as planning advances.

While the report provides quantitative estimates where possible, there are limitations related to data availability and the inherent challenges of valuing ecological and social benefits. As a result, the EA findings should be recognized as planning-level estimates.

Project Description

The project area is the SCR riparian corridor in Santa Cruz County and southern Pima County, where the physical and most of the ecological impacts from restoration are expected to occur. The corridor encompasses approximately 11,230 acres, including a mix of riparian forest, herbaceous areas, shrubland, and agricultural land, and supports a diverse range of plant and animal species. The SCR's current flows are largely sustained by an average of 14.8 mgd treated effluent discharge from the Nogales International Wastewater Treatment Plant (NIWTP) which results in approximately 11,000 acre-feet per year of groundwater recharge (Niraula 2012).

The SCRMP envisions future restoration alternatives that will combine up to 15 mpd increased effluent flows with in-stream and land-based restoration improvements that may include channel modifications, revegetation, and other interventions to improve riparian conditions. These measures would enhance habitat quality, expand vegetation coverage, strengthen ecological processes (e.g. erosion control and nutrient cycling) while also improving recreational opportunities and overall river function.

At this stage, SCRMP planning has identified restoration approaches as conceptual strategies rather than location-specific project alternatives. As a result, the analysis relies on representative scenarios and generalized assumptions about resource changes. The economic framework is designed to incorporate more detailed, site-specific restoration alternatives as they are developed in future phases.

Economic Benefits Overview

The report evaluates several key SCR-related benefits by which the river contributes to regional economic and community value.

- Groundwater recharge: The SCR is a primary source of aquifer replenishment through infiltration of treated effluent. This supports water supply sustainability for municipal, residential, and agricultural use and reduces reliance on alternative water sources.
- Habitat and wildlife improvement: Future SCRMP restoration will enhance habitat and wildlife biodiversity, and other environmental services (e.g. erosion control, air quality, and pollination).
- Recreation: The SCR provides opportunities for hiking, birdwatching, and other outdoor activities. These uses generate economic value through user benefits (consumer surplus), public health, and contribute to quality of life.
- Property value: Proximity to the SCR increases residential property values, reflecting the premium associated with access to natural amenities and improved environmental conditions.
- Property tax revenue: Increased property values translate into higher local tax revenues, providing fiscal benefits to the counties.

Other resource effects such as water quality, surface water supply, flood risk reduction, and tourism are discussed qualitatively.

Costs

The EA's cost analysis focuses on SCRMP-specific restoration costs, including capital investment and long-term operations and maintenance. Costs associated with wastewater treatment infrastructure are largely excluded, as treated effluent is considered a by-product of required treatment process and are managed at a binational, federal level.

Preliminary unit costs for restoration concepts range widely depending on the level of intervention, with higher costs associated with more intensive land and channel modifications. As specific restoration alternatives have not yet been fully defined, cost estimates remain conceptual and will be refined in future planning phases.

Key Findings

The EA identifies several substantial and diverse SCR-related economic benefits under both its current and future conditions. Table 1 summarizes the benefits quantified by the EA.

Overall EA determined that:

- The SCR currently generates significant ongoing annual economic value, particularly through groundwater recharge and the riparian ecosystem it supports.
- Some benefits, particularly specific ecological and social, are not quantified, suggesting total value of future SCRMP restoration activities is likely higher than reported.
- The high-flow scenario is expected to enhance several resource benefit categories, particularly groundwater recharge. The extent and type future benefits to ecosystem enhancement and recreation use will depend on nature of the SCRMP restoration actions.

Table 1: SCR Benefits Summary

Benefit Category	Description	EA Benefit Valuation
Groundwater	Supplied effluent to SCR naturally infiltrates and recharges the Santa Cruz aquifer and reduces current overdrafts.	Existing: ~\$4.46M/yr SCRMP: ~\$4.52M/yr
Ecosystem	Supplied effluent and SCRMP restoration enhancement of SCR riparian habitat/wildlife resources.	Existing: ~\$49.3M/yr SCRMP: NA
Recreation	SCR provides extensive recreation opportunities (e.g. hiking, wildlife viewing) for users.	Existing: \$6.2M/yr SCRMP: \$0.3 to \$0.9M/yr
Health	Benefits of reduced mortality from project-induced recreation	Existing: ~\$193K/yr SCRMP: ~\$48 to \$145K/yr
Property	Proximity to riparian areas increases home values and residents' quality of life.	Existing: \$5.25M SCRMP: No change
Property Tax	Increase in County tax revenues based on uplift to home values	Existing: ~\$42K/yr SCRMP: No Benefit

Note: SCRMP benefits would be additional to the SCR's benefit estimated for its existing conditions.

The EA's framework and valuation methods can be used for comparative assessments between SCRMP restoration alternatives of their relative economic performance once sufficient description and quantification of their resource outcomes and their implementation costs are determined by future SCRMP planning efforts.

Next Steps

The report outlines a series of next steps to advance the SCRMP and refine the economic analysis:

- Translate conceptual restoration approaches into site-specific, implementable alternatives aligned with hydrologic, ecological, and social conditions.
- Identify measurable changes in habitat, recreation, and other key resource metrics that will allow for quantification of resource outcomes.
- Apply the established valuation framework to alternative-specific outcomes to estimate benefits and compare economic performance.
- Develop more detailed cost estimates and evaluate total lifecycle costs and benefits across alternatives.
- Use the benefit and cost results to identify the most effective and balanced restoration strategies.

Conclusion

The SCR represents a significant economic, environmental, and community asset. More specifically, the EA quantifies substantial economic benefits from the river's current groundwater, ecosystem, and recreation use benefits. The EA also indicates that potential for additional economic benefit gains from SCRMP-related increased river flows and restoration enhancement.

The analysis provides a robust framework for future SCRMP alternatives' evaluation and selection to support continued investment in the river as a catalyst for long-term regional sustainability and economic vitality.

1. Introduction

The purpose of the Economic Analysis (EA) task is to quantify, where possible, the Santa Cruz River's (SCR's) current and potential future economic value under the future Santa Cruz River Master Plan (SCRMP) restoration alternatives. The EA provides guidance on approaches for assessment of future SCRMP capital and operating costs and determining restoration alternatives economic performance and comparative cost-effectiveness.

This Comprehensive Valuation (CV) report includes the following elements:

- **Study Approach:** an overview of the benefit valuation approach used for the EA and key assumptions for the analysis
- **Economic Valuation:** resource-specific methodology for the identified quantifiable benefits and a review of qualitative benefits
- **Cost Analysis:** an overview of applicable issues and approaches for evaluation and lifecycle cost valuation of project-related capital costs and annual operating and maintenance expenses. Includes discussion of issues for comparison SCRMP restoration alternatives' economic performance.

The CV begins with Section 1 which provides an Introduction discussion of the EA's purpose and CV Report organization. The EA's Study Approach is described in Section 2. Brief summary descriptions of the SCR existing conditions and SCRMP alternative scenarios are provided in Section 3. The EA's resource-specific analyses and findings are summarized in Section 4. The EA's Cost Analysis is provided in Section 5. The EA's findings are summarized in Section 6 with a brief discussion of economic performance approach. References for the main report of the CV are provided in Section 7. There are also five technical appendices to the CV which provide more detailed discussion of the resources with monetized economic benefit valuations and the case study analysis review.

AECOM has performed its economic valuation analyses for the CV report based on the currently available data, assumed resource outcomes, and/or unit valuation. This approach is used to select and prioritize the benefit valuation efforts, tailored to later incorporate the resource outcome metrics from future SCRMP restoration alternative scenario development and analysis. The EA's effort has developed and applied a structured framework of resource-specific valuation methodologies supported by relevant existing studies and data. Where possible, the CV report provides quantified valuations of existing and projected future Project-related benefits.

The CV report is structured to facilitate its use as a foundation for evaluating SCRMP alternatives as they are developed. It establishes a benefit valuation framework designed to incorporate future restoration alternative scenario descriptions and outcome metrics when they are determined by future SCRMP planning. This enables the CV report's analysis and findings to be applied to generate scenario-specific benefit valuations and economic performance assessments for SCRMP restoration alternatives.

2. Study Approach

2.1 General Economic Valuation Methods

Existing economic valuation methodologies provide a structured approach to estimating the monetary value of environmental goods and services, particularly those not traded in conventional markets. These methods help decision-makers understand the economic implications of restoration projects by translating ecological benefits, such as improved water quality, habitat enhancement, and recreational opportunities, into quantifiable terms. Common approaches range from market-based techniques to nonmarket valuation methods, including revealed and stated preference models, each offering unique insights into the benefits and trade-offs associated with environmental investments.

Direct Valuation Methods: Market prices and costs can provide estimates for the increase in value of economic activities, based on monetary transactions.

- **Market Price** values services with direct market prices (e.g., timber, fish, or fresh water).
- **Alternative/Replacement Cost** estimates value based on the cost of replacing an environmental good or ecosystem service with a man-made alternative (e.g., valuing wetland flood protection based on the cost of building a levee).
- **Avoided Cost** calculates value based on the costs avoided due to the presence of an ecosystem service (e.g., reduced storm damage due to wetland areas).

Preference-Based Valuation Methods: Many cases of environmental goods and services do not directly involve economic transactions, and therefore market price data are not available to value them. In such cases, methods have been developed to derive consumers' preferences:

- **Revealed Preference** estimates value based on observed behavior, such as how much a person is willing to pay for homes near bodies of water or how much they may be willing to pay to travel to a natural site.
 - **Hedonic pricing** estimates the economic value of an environmental commodity, such as clean air or a visual amenity, by studying the relationship between such attributes and house prices. Hedonic price estimation is commonly applied to environmental and ecosystem values associated with recreation, landscape values, and species diversity (Abdullah 2011).
 - **Travel cost method** estimates the economic value of recreational sites by determining the average travel costs to visit a site. The valuation is derived from a demand curve of the site, using various economic models.
- **Stated Preference** uses survey techniques to directly ask individuals about their willingness to pay for environmental services that may not have a direct market price.
 - **Contingent valuation** is the most used technique for the valuation of environmental goods, with individuals stating their willingness to pay or willingness to accept for a good or service. Contingent valuation can elicit a monetary valuation of non-use values, which typically have no market cost (Abdullah 2011).
 - **Choice experiment** elicits values by asking individuals to choose between alternatives; conjoint ranking, wherein individuals rank alternatives in order of preference and conjoint rating which indicates their strength of preference.

Comparative Valuation: The benefits for a specific project can be estimated based on the valuations determined for other similar projects under comparable circumstances.

- **Benefit Transfer** uses benefit estimates from previous studies or existing sites, applying them to a new context and adjusting for local conditions in similar circumstances. This method is cost-

effective and widely used when direct valuation is not feasible and preference-based methods are impractical.

These methods provide a flexible toolkit for assigning monetary values to a range of benefits accruing from future SCR restoration alternatives. The choice of valuation method depends on the nature of the benefit being valued, data availability, and context of the analysis.

Unless otherwise stated, all monetary valuations of Project benefits are expressed in current (2026) dollar terms using the Bureau of Economic Analysis Gross Domestic Product index to convert prior year values (BEA 2026). Other units of measure, including conversions for land areas (i.e., hectares into acres) and water volumes (million gallons per day [mgd] to acre-feet [AF] per year) are similarly used to ensure consistency and aid comparisons in reported unit benefit valuations.

2.2 Benefit Valuation Methodology Selection

AECOM developed a systematic approach for the economic benefit valuation. Figure 1 outlines the process applied for: (1) the initial screening process of the benefit categories; and (2) determining the specific valuation methodologies for the resource benefits selected for quantification.

2.3 Benefits Screening

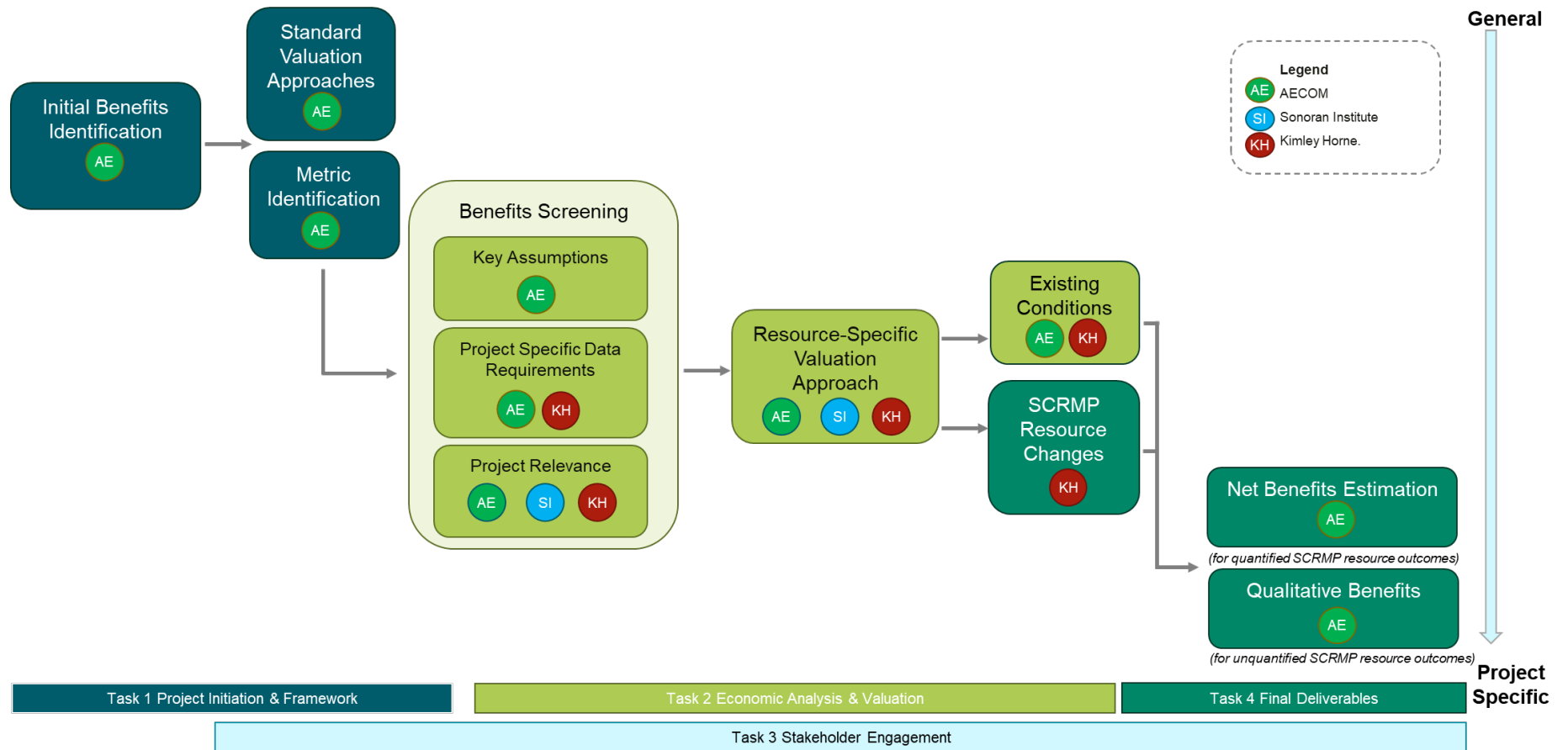
2.3.1 Approach

Although an extensive range of economic benefits can result from river restoration projects, data collection and resource limitations make detailed evaluation of every potential benefit impractical. Furthermore, some resource effects are inherently difficult to quantify or to monetize (e.g., water quality). Incremental changes to resource conditions (such as habitat quality improvement to an existing ecosystem) are also generally more difficult to quantify and monetize than resource quantity changes (e.g., increased habitat area).

Prioritizing benefit categories ensures that evaluation efforts focus on those benefits that are: (1) most relevant to Project objectives; (2) supported by adequate data and sound methodologies; and (3) least dependent on uncertain assumptions. This approach enhances the credibility, efficiency, and decision-making value of the EA finding. AECOM established a prioritization framework to determine which benefits could be evaluated quantitatively and which benefits should be discussed qualitatively. The following prioritization criteria were used:

- **Methodology and Data Availability** is the extent to which established analytical methods and reliable data are available to support benefit quantification/monetization. Resource improvements and benefits with readily accessible data sets and well-documented, peer-reviewed methodologies that are relevant to the study area are preferred.
- **Project Specificity/Metrics** is the degree to which the resource change can be measured and quantified as part of the SCRMP analysis, using site-specific data. Benefits that require fewer assumptions about resource changes and are supported by contextually relevant studies are prioritized.
- **Project Relevance/Significance** is the expected scale or significance of the restoration Project's influence on this benefit category, considering whether the Project is likely to produce substantial, measurable changes in the benefit metric compared to baseline conditions.

Figure 1 Benefit Valuation Process



Each of the benefit categories were reviewed and scored by AECOM using an ordinal/traffic light scale across three areas: (1) Methodology and Data Availability, (2) Project Specificity and Metrics, and (3) Project Relevance and Significance. A positive benefit type scored is reflected by green, a neutral type yellow, and a negative type is red (Table 2). The scores were based on input from the SCRMP team, background research, and literature review findings. Stakeholder and/or public input was also considered in the determination of the approach and level of effort applied between the benefit categories selected for monetized benefit evaluation.

Table 2 Benefit Screening Scores of Benefit Categories

Benefit Type	Methodology and Data Availability	Project Specificity/ Metrics	Project Relevance/ Significance
Groundwater Supply	Yellow	Green	Green
Surface Water Supply	Yellow	Yellow	Red
Water Quality	Red	Red	Yellow
Flood Risk	Red	Red	Red
Ecosystems	Green	Yellow	Green
Recreation Use	Green	Yellow	Green
Property Value	Green	Yellow	Green

Generally, if a benefit type scored positively (green) against two or more criteria, that benefit moved forward for quantified benefit valuation analysis. AECOM then developed specific valuation methodologies for each of the benefit categories selected. These methodologies are the basis for the economic benefit valuation analysis in Section **Error! Reference source not found.**. Selection of the resource-specific methodologies was based on review of relevant economic methodologies, Project-specific conditions, available data, and expected future resource changes identified for the SCRMP scenarios in consultation with KH and Sonoran Institute (SI). The other remaining resource benefit categories were selected for qualitative benefit assessments or were excluded from further analysis.

2.3.2 Findings

The benefit screening process eliminated three resource benefit categories from further analysis for economic benefit valuation. Table 3 identifies the eliminated resources and includes a brief explanation of the rationale for their exclusion.

The benefit screening process also identified four major resource benefit categories for quantitative economic benefit valuation:

1. Groundwater Supply
2. Habitat/Wildlife (Ecosystem) Enhancement
3. Recreation
4. Increased Property Values

The summary benefit findings for each of these resource categories are discussed in Section 4 with detailed support analysis provided in the appendix.

Table 3 **Eliminated Resource Benefits with Rationale**

Benefit Category	Rationale
Surface Water Supply	Current use of SCR surface flow as a water supply is minimal and expected to remain unchanged in the future irrespective of an increase in SCR future flow conditions.
Water Quality / Stormwater	SCR current water quality conditions are predominantly determined by stormwater run-off and land use (e.g., livestock and residential) impacts, except for rare “overflow” releases of untreated wastewater effluent. Increased flows of treated effluent will generally improve SCR water quality. However, in the absence of surface water withdrawals and use, direct benefits to the SCR riparian corridor and/or water users will be limited and difficult to monetize any avoided cost benefits.
Flood Risk	SCRMP related increases in effluent represent a negligible portion of major flood event water quantities. SCRMP restoration actions are generally expected to change retention and infiltration rates to reduce and/or delay the downstream flow of upper SCR flood waters, thereby decreasing flood conditions at those locations. However, the extent of SCRMP flood risk reduction is expected to be relatively limited and unlikely to result in substantial reduction in flood impacts, especially during major flood events. Furthermore, quantification of flood damages requires extensive hydrology, hydraulics, and damage modeling to estimate changes in economic, structural, life-loss consequences of flood events.

2.4 Key Assumptions

It is expected that the resource improvements from the SCRMP restoration alternatives would be relatively linear between existing No Project conditions and the SCRMP flow scenarios of 5, 10, and 15 mgd increases in future wastewater effluent at the Nogales Internation Water Treatment Plant (NIWTP).

Similarly, the economic benefits would be relatively linear between existing No Project conditions and the SCRMP restoration alternatives. As a result, each resource has been evaluated under future high-flow scenario (15 mgd) conditions.

Other resource-specific assumptions are discussed in their corresponding analysis.

2.5 Challenges and Limitations

Evaluating environmental and social impacts can be difficult because it is not always feasible to assign monetary values to these types of benefits. Additional challenges and important considerations for environmental benefit valuation can include the following:

- Data Limitations:** Many environmental and ecological benefits are not traded in markets and therefore do not have readily observable prices. In these instances, nonmarket valuation methods must combine observable biophysical data with other methods to quantify these services in monetary terms. Quantification of Project-related resource changes is generally required for valuation of Project benefits. Under some circumstances, well-defined qualitative metrics of resource changes can also be used as the basis for benefit value determination.
- Spatial Considerations:** The spatial distribution of environmental benefits can vary depending on the type of project, its characteristics, and size. Environmental impacts can also be observed at different spatial scales, with some ecosystem services or other Project benefits potentially extending far beyond the Project’s location. As a result, more comprehensive value assessment

across different spatial scales will require understanding at what scale and for whom benefits result (Chelli et al. 2025).

- **Timing:** Environmental benefits may require time to be fully achieved. For example, revegetation of scrubland or under-used agricultural area can increase recreation opportunities and improve habitat in a specific area. Although the increase in recreational use can be more immediate, the habitat and wildlife benefits may be delayed due to the time required for plants to grow (Chelli et al. 2025).

The EA's value estimates may underestimate the full value of the current and/or future SCR-related benefits because many benefits could not be quantified at this stage of SCRMP planning.

3. Project Description

3.1 Existing Conditions

A major facility and technology upgrade of the NIWTP was completed in August of 2009. This upgrade consisted of adding equipment and apparatus to upgrade the NIWTP's Biological Nutrient Removal system to improve removal of nitrogen from the discharged effluent which, at its pre-2009 levels, had been detrimental to SCR fish and wildlife. Since 2009, NIWTP releases of higher-quality treated effluent have increased SCR surface flows and improved its water quality. The higher-quality effluent has improved the SCR river conditions and recovery of riparian vegetation and growth have increased, promoting the return of wildlife and aquatic species, including several threatened and endangered species, while also renewing the public's interest and advocacy for the SCR's health and restoration.

In 2013, the Los Alisos Wastewater Treatment and Conveyance Project was constructed in Nogales, Sonora to help alleviate the volumes of wastewater entering the NIWTP. This project consisted of a new wastewater treatment plant in the Los Alisos River Basin which is located south of Nogales and outside the SCR watershed. The Los Alisos plant was designed to treat up to 5 mgd. The plant's current inflows are between 3.1 and 3.5 mgd and its treated effluent is released into Los Alisos River Basin, outside of the SCR watershed.

Since 2009, development growth within eastern Nogales, Sonora spurred the need for new wastewater treatment facilities. In 2012 the Lomas de Anza WWTP was constructed, designed to have a maximum capacity of 0.7 mgd. Shortly thereafter, the Puerta de Anza WWTP was constructed near the Lomas de Anza WWTP, with a maximum capacity of 1.5 mgd. Both plants currently discharge their lower-class treated effluent into the Oso Wash which joins the SCR just north of the International Border.

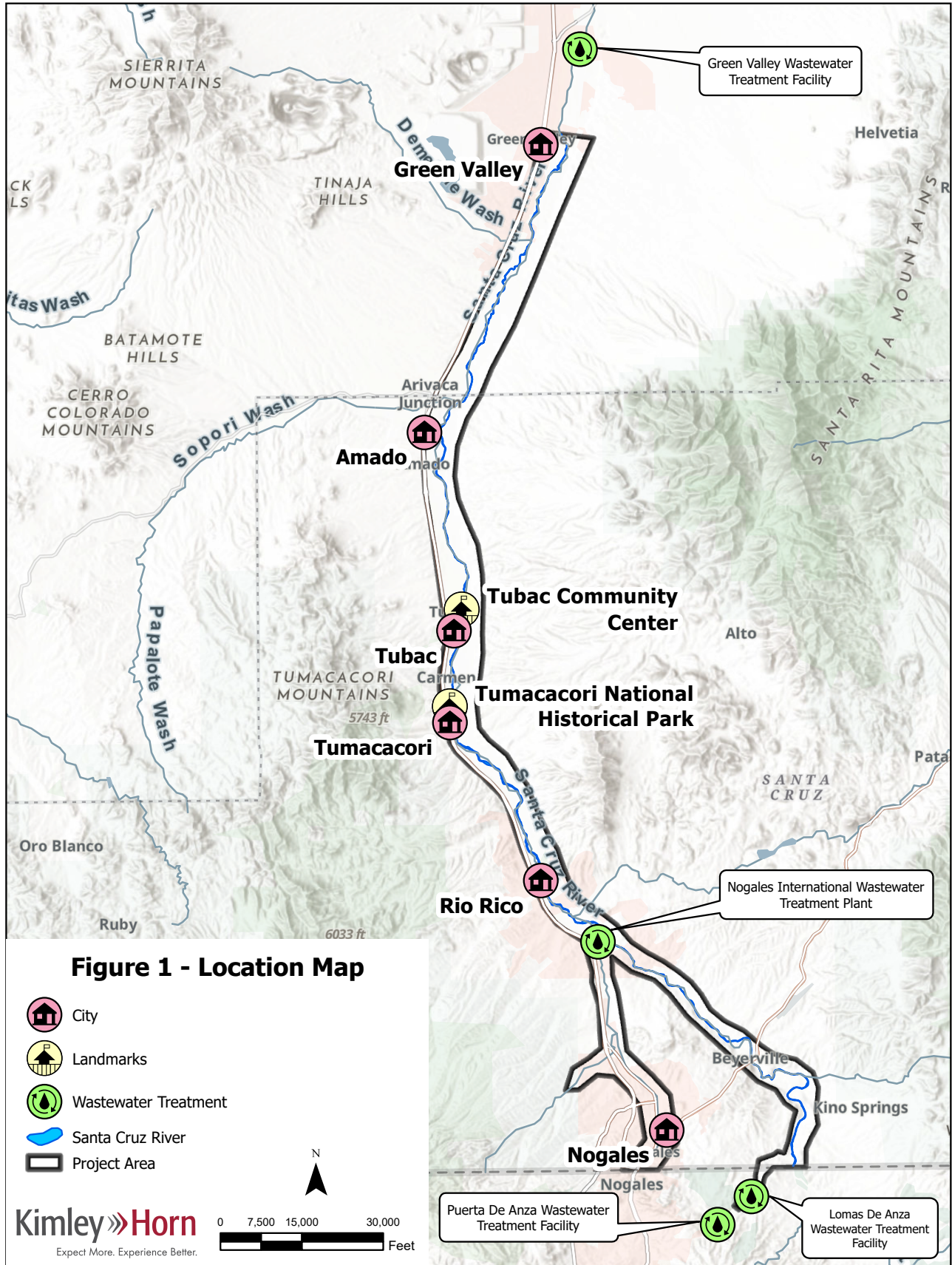
Rehabilitation of the 8.8-mile Nogales International Outfall Interceptor (IOI) wastewater pipeline, which conveys wastewater from the international boundary to the NIWTP for treatment, was completed in 2024.

Figure 2 shows the location of the SCR in Santa Cruz County and the SCRMP Project Area. The Project Area for the EA generally conforms with the SCR riparian corridor, where most of the direct physical resource impacts from the SCRMP restoration alternatives are expected to occur. In a few cases, Project-related benefits will extend more widely in the SCR watershed or Santa Cruz County. The SCR riparian area is estimated to consist of about 11,230 acres of which approximately 2,400 acres consisted of agricultural lands with the other 8,826 acres consisting of three natural land cover types. Riparian forest area account for 5,502 acres (45 percent of all areas) and Herbaceous areas account for another 3,140 acres (28 percent). There is another 634 acres (5.6 percent) of Shrubland within the SCR riparian corridor.

Under the current conditions, 14.8 mgd of treated wastewater is diverted to the SCR from the NIWTP. On an annual basis, this corresponds to 16,590 AF of surface flows added to the SCR. This results in approximately 11,010 AF per year in groundwater aquifer recharge that improves groundwater conditions and availability (Niraula 2012; Norman 2013).

The SCR supports diverse species that live in the region and migrate through the valley. A species count conducted along the river near the international border in spring 2024 documented 90 species, including native fish species Gila Topminnow and Longfin Dace, seven dragonfly species, Cottonwood and Willow trees, and Clark's Spiny Lizard (Sonoran Institute, 2024). The most important variable to quantify changes to habitat and wildlife present is the change in landcover from the SCRMP restoration alternatives. The SCR also includes important recreation destinations and makes an important and central contribution to quality of life and a sense of place for Santa Cruz and Pima County residents.

Figure 2 Project Area Location



3.2 Santa Cruz River Master Plan Restoration Alternatives

The SCRMP team is considering future restoration alternatives that would include both an additional 15 mgd in supplied effluent flows to the SCR (high flow scenario) and in-stream and/or land-side restoration improvements, such as river channel changes and revegetation programs designed to enhance SCR riparian resources.

3.2.1 Increased Supplied Effluent

Research at Sonoran Institute has identified mechanisms throughout Nogales, Sonora and Nogales, Arizona which could increase future effluent volumes to the NIWTP and subsequent effluent into the SCR. In addition, both the Lomas de Anza and Puerta de Anza wastewater treatment plants over the border in Mexico could also be sources for future effluent supplies. These improvements would result in a greater capacity of the treatment plant and collection systems, resulting in fewer breaches of the system, and thus greater overall water quality. The anticipated increase in new effluent discharge of up to 15 mgd is the basis for the SCRMP's high-flow scenario.

Under a future high-flow scenario, 15 mgd of additional treated wastewater effluent could be diverted into the SCR on a relatively constant year-round basis, with a total of approximately 16,800 AF per year of net new surface water flow added to the river. This will represent approximately a 100 percent increase to the amount of effluent currently added to SCR under the No Project conditions (14.8 mgd), adding approximately 11,160 AF per year in new groundwater aquifer recharge, which would further improve future groundwater conditions and availability.

This increased surface water supply is expected to substantially revitalize the existing riparian habitat and may expand the habitat areas elsewhere with the SCR riparian corridor.

Under the future high flow scenario, the increase in SCR's future flows may result in regenerated and expanded riparian vegetation (such as cottonwood and willow stands). This will generate numerous benefits for habitat and wildlife as well as supporting services, including soil erosion control and formation, nutrient cycling, biological control, air quality, and pollination. As vegetation and groundwater conditions improve, the SCR corridor can support species that depend on perennial or near-perennial water sources. Over time, this renewed habitat quality and complexity may increase biodiversity, strengthen ecological resilience, and transform the river into a more functional and vibrant wildlife corridor.

3.2.2 Restoration Improvements

Proposed restoration approaches focus on enhancing riparian ecosystem conditions in the SCR. These approaches range from active, stream-side restoration—such as targeted revegetation, which can rapidly improve habitat quality—to more passive strategies that rely on natural recovery processes and yield slower, more variable outcomes. With additional effluent flows providing hydrologic support, the SCRMP restoration alternatives may incorporate both instream and adjacent land-based actions. Instream measures could include structural or process-based interventions designed to improve channel morphology; stream-side efforts would aim to influence riparian vegetation and associated wildlife communities. Collectively, these actions are expected to improve overall ecosystem function and habitat quality in the existing riparian corridor, with the potential to expand habitat extent where substantial land cover changes are implemented.

The SCRMP planning effort is currently focused on river morphology types, with identification of applicable restoration treatment options for instream and/or land-side improvements expected to enhance the riparian corridor resources. To date, the SCRMP restoration planning effort has:

- performed condition assessments and inventories for the SCR riparian corridor from Oso Wash downstream to Green Valley;

- mapped more than forty vegetation function classes;
- developed draft primary restoration goals describing the desired long-term SCR conditions and outcomes;
- determined draft objectives that define measurable or actionable steps used to advance those goals through specific projects and restoration approaches; and
- identified nine restoration approaches and formulated them into a restoration alternatives Matrix. The restoration approaches are strategies that could be implemented in the Project Area to result in functional improvements to the SCR floodplain.

The identified SCRMP restoration alternatives represent implementation tools/strategies rather than specific objectives or portfolio sets of proposed restoration improvements. At this stage, SCRMP has identified a broad range of restoration approaches/concepts as potential implementation tools/strategies, but it does not yet establish site-specific objectives or program-level portfolios suitable for comparative assessment by the EA. These elements will be developed in later planning phases as the approaches are refined.

Future SCRMP planning is expected to align Project Area sites with applicable restoration approaches, based on valley setting, risk tolerance, hydrologic conditions, and social constraint. The SCRMP would then prioritize these restoration opportunities. When restoration approaches become more advanced in the future, the SCRMP objectives can be applied on a more site-specific basis (Kimley-Horn 2026).

3.3 Resource Changes

For most of the benefit categories, the EA evaluates the net resource changes of the combined increased 15 mgd flow and the restoration activities. However, for groundwater recharge benefits, the resource impacts can be distinguished between the SCRMP's restoration activities and the increase in SCR flow conditions from the additional effluent flow.

For the purposes of the benefit identification and valuation, two general types of resource impacts can be distinguished:

- Quality/conditions of SCR existing resources; and
- Quantity of the resources in the Project area.

The EA's ability to provide economic benefit estimates depends on the availability of quantified information about the SCRMP alternatives. EA data requirements include adequate identification of relevant and measurable resource characteristics for both current (No Project) and future SCRMP conditions. Accordingly, the EA focuses predominantly on SCRMP-related resource *quantity* changes that can be more readily identified and valued. It is difficult to quantify economic benefits for incremental *quality* improvements to existing resources, and to subsequently determine proportional economic valuations.

As discussed above, the current SCRMP restoration alternatives represent implementation tools/strategies rather than specific objectives or portfolio sets of proposed restoration improvements. As a result, at this stage of SCRMP planning only qualitative and high-level information on its restoration approaches and expected resource impacts is available. Due to these informational constraints, the EA benefit valuation of the SCRMP consists of: (1) a qualitative analysis intended as a framework for future quantification; or (2) an evaluation of potential resource outcomes from representative scenarios. In all cases, the EA clearly identifies the assumptions related to its valuation analysis.

4. Economic Benefits

AECOM determined resource-specific economic valuation methodologies for each benefit category which were reviewed by AECOM's principal economists. AECOM also consulted with SI and KH to confirm the reasonableness of the valuation approach, data assumptions, and findings. As discussed in Section 2.5, the EA has evaluated both the existing resource conditions and where possible future effects of the high-flow scenario (15 mgd) conditions. It is expected that economic benefit would be relatively linear between existing No Project conditions and other flow scenarios.

The EA's benefit analysis below also provides a general framework discussion of the issues and approaches that can be used for future valuation of the SCRMP restoration alternatives once they are developed and their resource outcomes are identified.

4.1 Groundwater Benefits

The Santa Cruz River (SCR) serves as an important natural groundwater recharge system for the Upper Santa Cruz watershed. Currently, wastewater originating from Nogales, Sonora and Nogales, Arizona is processed by the Nogales International Wastewater Treatment Plant (NIWTP), which discharges an average of 14.8 million gallons per day (mgd) of treated effluent to the SCR which in turn is estimated to result in 11,010 AF of groundwater recharge (Niraula 2012; Norman 2013). The current groundwater recharge effects from the SCR make an important contribution to the Santa Cruz watershed's groundwater conditions, water availability, and long-term sustainability.

The SCR Economic Analysis (EA) has analyzed the current groundwater conditions and projected SCRMP-related groundwater changes to estimate the economic benefits to the Santa Cruz watershed that might reasonably be attributed to both current SCR and future SCRMP flow conditions. The EA's groundwater benefit valuation approach and findings are discussed in the following sections. Additional details about the groundwater benefit valuation analysis performed by the EA is provided in Appendix A – Groundwater Benefits.

4.1.1 Benefit Valuation Approach

Several valuation approaches and data sources were considered for use in estimating the groundwater supply benefits of SCR and the SCRMP alternatives. The valuation approaches included alternative/avoided cost, contingent valuation, market rate, and benefit transfer. The alternative cost approach was selected due to its Project-specific relevancy and the relative strength of available information.

The EA evaluates several potential options that could substitute for existing supplied effluent in the SCR and otherwise match the additional 15 mgd of supplied effluent under the high-flow scenario for the SCRMP. Each of the alternative supply projects were determined to provide comparable groundwater supply outcomes, by either achieving similar annual groundwater recharge improvements or matching the water supply outcomes for Santa Cruz water users that would be gained from the SCR groundwater replenishment. Three primary alternative water supply options considered to be technically feasible were analyzed:

- Importation of purchased Central Arizona Project (CAP) water;
- Retirement of agricultural land (e.g., pecan orchards); and
- Brackish groundwater desalination.

Although likely difficult to enforce, agricultural retirement is considered the most technically feasible and likely replacement source for SCR's current supplied effluent and/or the additional effluent supplies under SCRMP high-flow scenario conditions. The EA estimated the economic benefit of groundwater recharge based on the cost of obtaining an equivalent level of aquifer replenishment from agricultural retirement. For the purposes of the EA, the groundwater recharge benefit is estimated on a unit value basis of \$405 per acre foot, derived from the alternative cost for agricultural retirement.

4.1.2 Groundwater Benefit Findings

4.1.2.1 Existing Conditions

Water use and supply in the Santa Cruz Basin are currently shaped by a hybrid system of groundwater pumping, surface flows, and imported wastewater, with demand strongly tied to population growth and infrastructure constraints. Groundwater is a critical water source across the Santa Cruz region (USBR 2024). Pumped groundwater is currently the primary source of water supply for homes and businesses in the Upper Santa Cruz watershed. Agriculture currently accounts for the largest share of total withdrawals in Santa Cruz County, followed by municipal and residential demand. As a result, groundwater availability represents a key factor for the Santa Cruz County economy, based both on its agriculture and its support of future residential and commercial development.

The long-term sustainability of the Santa Cruz aquifer will require balancing future pumping with increased groundwater recharge and/or development of new renewable water supplies. Although overall groundwater storage could improve under effective management strategies, localized declines in groundwater supplies are still expected, especially in high-demand areas and under worsening climate conditions.

Between 2020 and 2060, it is estimated that the groundwater will need to be replenished with a total recharge groundwater quantity of between 231,000 and 570,000 AF to offset projected over-pumping (Udall Center 2023). The range in the watershed's groundwater recharge needs varies depending on future growth and climate conditions. At a minimum, the region could face a 6,000 AF annual water supply deficit, and under less favorable future growth and climate conditions, the region could face a 14,000 AF annual water supply deficit (Udall Center 2023).

Under the current (No Project) conditions, 14.8 mgd of treated wastewater is diverted to SCR by the NIWTP. This results in approximately 11,010 AF per year in new groundwater supply and aquifer recharge benefits. This supply of wastewater effluent currently discharged into the SCR plays an important role toward reducing current and future overdraft pumping of the Santa Cruz aquifer and adverse effects on groundwater availability.

Table 4 shows the EA estimated economic valuation of groundwater recharge benefits for the SCR's current conditions as well as those under future high flow scenario conditions and SCRMP restoration alternatives. The groundwater benefit findings are based on a \$405 per AF unit benefit value derived from the alternative cost of agricultural retirement. This is likely a conservative valuation that does not account for related economic costs that would occur from lost agricultural production if such a land retirement program were to be implemented.

Table 4 Groundwater Benefit Valuation Summary

Project Scenario	Supplied Effluent (mgd)	Groundwater Recharge (AFY)	Unit Benefit (\$/AF)	Groundwater Benefit (\$/yr)
SCR Existing	14.8 mgd	11,010 AFY	\$405/AF	\$4,470,000
SCRMP Total	15 mgd	11,260 AFY	\$405/AF	\$4,560,500
High-Flow Scenario	15 mgd	11,160 AFY	\$405/AF	\$4,520,000
SCRMP Restoration Improvements	-	+100 AFY	\$405/AF	\$40,500

4.1.2.2 SCRMP Alternatives

The high-flow scenario's 15 mgd increase in supplied effluent to the SCR will predominantly determine the groundwater recharge benefits that would result from the SCRMP Alternatives. The SCRMP restoration alternatives are expected to result in relatively minor net changes to magnitude or location of

the future groundwater recharge effects compared to those from the high-flow scenario's additional 15 mgd of supplied effluent to the SCR.

As shown in Table 4, the future groundwater benefits from the SCRMP Alternatives are estimated using the same unit benefit value as those used for SCR current conditions benefit valuation. The additional supplied effluent under the high-flow scenario may be expected to have an annual benefit value of approximately \$4.5 million per year.

The future SCRMP restoration improvements may be expected to have only limited and marginal additional economic benefits to groundwater recharge. For representational purposes, an assumed minor restoration-related net groundwater recharge quantity increase of 100 acre-feet is shown in Table 3.

4.2 Ecosystem Benefits

Supported by increased supplied effluent, future SCRMP restoration alternatives will alter the plant and animal species that inhabit the riparian area, resulting in changes to habitat and wildlife quantity and quality, where new habitat area will be created and the existing habitat area will be improved.

This analysis provides a framework to estimate the economic value of increased habitat and wildlife quantity, as well as other habitat-supporting services (i.e., erosion control, biological control, air quality, and pollination) associated with the SCRMP future restoration alternatives.

The benefit valuation for habitat and wildlife improvements is discussed in Appendix B – Ecosystem Benefits. This section provides a summary description of the ecosystem benefit valuation framework.

4.2.1 Benefit Valuation Approach

Methodology

Benefit transfer is a widely used approach for estimating the economic value of habitat and wildlife-related ecosystem services, particularly because these benefits are non-market public goods that are difficult and costly to value directly. This method applies values from existing studies to the project area based on the scale of restoration.

The EA uses benefit transfer to derive unit values (on a per-acre basis) for habitat and wildlife-related ecosystem services provided by the SCR. A variety of secondary valuation methods were also considered for the EA, including benefit transfer of willingness-to-pay (WTP) values, value of specific resources (i.e., vegetation), and alternative costs. Ultimately the unit-value approach was used as: 1) it builds on the FEMA Ecosystem Service Valuation approach which applies a more regionally tailored valuation, using land cover classifications and ecosystem service values that are specific to Arizona, or to regions in the US with similar climates, when possible; and 2) unit values can be more easily applied and scaled to the project area, more than WTP values, which can be difficult to transfer across projects.

While benefit transfer is a commonly used method for ecosystem service valuation, it relies on generalized estimates that may not fully capture local ecological and socioeconomic conditions. As a result, the values derived should be interpreted as approximate, planning-level estimates rather than precise measures of site-specific economic value.

Unit Values

The ecosystem valuation applies the unit values to the net new changes in land cover quantity to determine the SCRMP restoration alternatives' future ecosystem services benefits. Existing land cover acreages by major vegetation type within the SCR riparian area are shown in Table 5.

Extensive literature research and review was conducted to determine the habitat and wildlife-related unit values for the identified landcover types. Table 6 summarizes the ecosystem service values for each of SCR corridor's land cover categories.

Table 5 Existing Land Cover within SCR Riparian Corridor (acres)

Landcover	Existing (acres)
Forest	5,052
Shrubland	634
Herbaceous	3,140
Total	8,826

Source: Sonoran Institute, Upper Santa Cruz River Riparian Vegetation Map, 2008.

Note: SCR Riparian Corridor also includes approximately 2,406 acres of agricultural land.

While this analysis is focused on habitat and wildlife benefits, it also includes ecosystem services that support habitat and wildlife enhancement (erosion control, biological control, air quality, and pollination), rather than strictly using the value for habitat only. Values are provided as dollar per acre per year. Further detail on the methodology for the total service values (aggregated vs unweighted average) is provided in Appendix B.

Table 6 Ecosystem Service Values for the SCR (\$/acre/year, 2025 dollars)

Ecosystem Service	Forest	Shrubland	Herbaceous
Habitat and Wildlife (a)	\$4,190	\$200	\$3,300
Erosion Control (b)	\$1,910	—	\$900
Biological Control (c)	\$20	—	\$230
Air Quality (d)	\$430	\$5	\$75
Pollination (e)	\$390	\$5	—
Total – Aggregated Services	\$6,930	\$210	\$4,500
Total – Unweighted Average	\$4,000	\$205	\$3,900

Notes:

(a) Habitat: providing shelter, promoting growth of species, and maintaining biological diversity

(b) Erosion control: retaining arable land, slope stability, and coastal integrity

(c) Biological control: providing pest, weed, and disease control

(d) Air quality: providing clean, breathable air

(e) Pollination: pollinating wild and domestic plant species via wind, insects, birds, or other animals

4.2.2 Ecosystem Benefit Findings

4.2.2.1 Existing Conditions

Table 7 presents the value of habitat and wildlife in the project area under existing resource conditions based on the estimated economic service value unit values determined above for forest, herbaceous, and shrubland land cover.

Table 7 Annual Benefit of Wildlife/Habitat – Existing Conditions

	Forest	Shrubland	Herbaceous	Total
Acreage – Existing	5,052	634	3,140	8,826
Benefit Value (\$/ac)	\$6,930	\$210	\$4,500	\$5,580
Total Benefits (\$M/yr)	\$35.0	\$0.1	\$14.1	\$49.3

The annual habitat and wildlife ecosystem services within the project area are currently valued at \$49.3 million.

4.2.2.2 SCRMP Alternatives

At this stage, the SCRMP has not determined specific restoration alternatives or improvements suitable for comparative assessment by the EA. During future SCRMP planning phases, the EA's approach and the unit benefit values in Table 7 can be applied to site-specific restoration scenarios that include changes to landcover. Annual net wildlife and habitat benefits would represent the incremental gains relative to current conditions from converting existing land cover into new habitat because of increased effluent flows in the project area.

When evaluating future SCRMP benefits, it should be recognized that benefits from restoration are expected to increase gradually over time rather than occurring immediately, as riparian vegetation and habitat conditions need time to establish and mature. Early years may show limited gains while plant communities become established, but ecological functions such as habitat quality, shading, and bank stabilization typically improve as vegetation grows. As a result, the full suite of wildlife and habitat benefits is likely realized only over the longer term.

Given data limitations and the inherent challenges of valuing ecosystem services, the benefit estimate should be interpreted as an informed approximation rather than a precise measure. The results provide a useful indication of the scale and relative importance of benefits associated with restoring flows and habitat along the SCR. Specifically, these results can be compared with project costs to estimate the cost effectiveness of proposed future SCRMP interventions.

4.3 Recreation Use

The Santa Cruz River (SCR) is a well-established and popular site for outdoor recreation in Arizona and is one of the top five water bodies most visited by state residents.

The recreation benefit valuation analysis performed by the EA is discussed in detail in Appendix C – Recreation Benefits. This section provides a summary description of the recreation benefit valuation analysis approach and findings.

4.3.1 Benefit Valuation Approach

There are various approaches for quantifying user benefits from recreation. Direct market valuation of recreation user transactions is a commonly used and direct approach, reflecting the economic value of engaging in recreational activities.

Market values provide a useful and conservative valuation that does not fully account for the benefits that recreation generates. Nonmarket approaches, such as revealed and stated preferences methods, can be used to estimate the additional consumer surplus benefits obtained by recreational users. Consumer surplus is the net economic benefit that individuals enjoy: the difference between their willingness to pay and the price paid for recreation. Because this value cannot be directly observed in market transactions, these approaches allow for the estimation of an important dimension of economic value to more fully represent the welfare benefits of recreational experiences.

Benefit transfer is a commonly used approach for quantifying recreation benefits. because other primary valuations are often data-intensive and costly. Use and adaptation of findings and estimates from comparable analysis and published literature is an established method frequently used for project benefit valuation. Benefit transfer relies on carefully and correctly identifying source study information from relevant and comparable projects and modifying them (when necessary) for the subject study's circumstances.

The EA used a benefit transfer approach to determine the recreational benefits from the SCR under its existing current and those that might be expected under the future high-flow scenario and SCRMP restoration alternatives.

4.3.2 Recreation Benefit Findings

4.3.2.1 Existing Conditions

Although SCR is largely surrounded by private lands, the river can be publicly accessed from multiple locations and several trails allow visitors to traverse and recreate within the SCR riparian area. As noted in Section 3.1 the EA's project area generally conforms with the SCR riparian corridor where most of the SCRMP restoration alternatives direct physical resource impacts are expected to occur. The width of the riparian corridor within Santa Cruz County varies with the geography but generally extends as a 0.25-mile buffer area to the river.

SCR currently supports several outdoor recreational activities including walking/hiking, bicycling, camping, picnicking and nature viewing. In addition, numerous areas along the SCR are popular wildlife and birdwatching sites due to considerable biodiversity in its riparian areas.

There are very limited SCR recreation use data available. The most recent estimate of the SCR visitation is for 2018, when an approximately 45,800 adult residents spent 199,000 recreation days along this water body, resulting in an average of 4.34 recreation days annual per adult recreationist (Audubon 2019).

The EA assumes that SCR recreation use since has increased pro rata with the County's population increases and that user recreation participation rates would remain unchanged. Based on this assumption, it is estimated that approximately 50,465 state resident adults spent 219,268 recreation days along the river in 2025. This does not account for out-of-state visitors and should therefore be considered a conservative estimate of total visitation for recreation purposes.

Consumer surplus is the primary unit of measurement for estimating the economic value of SCRMP related recreation. Total recreation benefits represent the consumer surplus value that current SCR visitors gain from their recreational activities within the SCR project area. Table 8 presents the annual recreational value of the SCR under the current (No Project) conditions.

Table 8 Recreation Benefit Valuation – Existing Use

Annual Use (Recreation Days)	Benefit Value
219,268	\$6,237,000

Note: Benefit value is rounded to the nearest thousand.

4.3.2.2 SCRMP Alternatives

Enhancement of SCR current recreational areas can be expected to improve recreational experience quality for their existing users. The future value of the SCR corridor's recreation resources to its existing users could be enhanced if: (1) perennial reaches are sustained over a longer portion of the year (i.e., reduced dry season); (2) increased species diversity (especially birds and endangered species such as the Gila Topminnow); and (3) quality will enhance/encourage future recreation use, including through larger or improved facilities.

As the expected new visitation following river restoration is unknown, it is important to emphasize that changes in recreation demand because of river restoration may greatly vary, depending on the specific characteristics of the SCRMP restoration improvements, accessibility, carrying capacity, and availability of recreational facilities and activities. In the context of the SCR, an uplift in recreation participation may be driven by changes in trail length and quality for supporting recreational activities (i.e., shaded infrastructure for picnicking).

AECOM assessed three induced recreation scenarios within the SCR corridor. These scenarios include a 5 percent, 10 percent, and 15 percent rise in recreation from estimated 2025 levels. Such changes in recreational patterns will largely depend on the SCRMP restoration alternative outcomes on recreation user experiences from its effects on the SCR habitat and/or recreational opportunities. Changes to the SCR perennial surface flow extent and duration may also be expected to have a positive effect on future recreation use.

Table 9 shows the estimate net increase future benefits under each future recreation use growth scenario. Using the EA's selected unit benefit valuation of \$28.44 per person per day, the future increase in recreation benefits are estimated to range between \$312,000 (+5 percent increase in recreation days) and \$936,000 (+15 percent) per year.

Table 9 Recreational Benefits – Future Recreation Use Growth Scenarios

Scenario	Recreational Use Growth Scenario (Recreation Days)		
	5% Increase	10% Increase	15% Increase
<i>Annual Change in SCR Recreation Use</i>	10,960	21,930	32,890
Unit Benefit Value = \$28.44	\$312,000	\$624,000	\$936,000

Note: Benefit values are rounded to the nearest thousand.

4.4 Property

The value that homeowners place on living close to riverways is commonly demonstrated in the housing market by the price premium during house purchases. The uplift effect on home prices from river proximity is typically recognized as a one-time price increase based on the river's presence.

The property benefit valuation analysis performed by the EA is discussed in detailed in Appendix D – Property Benefits. This section provides a summary description of the property benefit valuation analysis approach and findings.

4.4.1 Benefit Valuation Approach

AECOM conducted an extensive literature search to identify river-related property impact analysis studies for review as possible reference studies. Reference studies were selected that included quantified economic valuation findings determined to be applicable to the SCRMP. A primary focus was to identify analysis of SCR and other Arizona river areas. Other recent out-of-state studies were also selected as reference studies. Notably, a recent 2019 study specifically analyzed the property impacts from 209 stream restoration projects in Oregon across their before, during, and post-project conditions for a variety of land use and condition factors. The study observed property impact variability across the project phases with generally positive property effects when mature post project conditions are achieved (Netusil 2019).

Table 10 provides summary information on the reference studies used to determine the methodology for the EA's valuation of the SCRMP-related property benefit.

The EA used a benefit transfer approach to estimate the property benefits from the current SCR corridor conditions and its future enhanced conditions based on: (1) an additional 15 mgd of supplied effluent under the future SCRMP high increased flow scenario; and (2) effects of SCRMP restoration improvements.

After assessment of the studies in Table 10, Bourne 2007 was selected as the basis for the EA valuation of the SCR property benefits. A primary consideration for selection was its specific assessment of SCR conditions to homes prices in the Rio Rico and Tubac communities. In addition, the analysis provides graduated price impacts at 0.1-mile intervals, and its findings are generally comparable and consistent with other studies.

Table 10 Property Benefit Reference Studies

Study / Tool	Description of Approach	Findings	Notes
SCR Watershed			
Bourne 2007	Hedonic analysis of home prices within Rio Rico and Tubac.	0.2% to 5.8% home price premiums within 1.1 miles of SCR riparian corridor.	Project area home price effects determined at 0.1-mile intervals.
Arora 2012	Hedonic analysis of home prices within upper SCR watershed with GIS analysis of habitat, biodiversity, land cover/ownership and other amenities.	Observed increased house prices values for homes near: (1) species-rich habitat; and (2) public land access or undeveloped private lands.	No quantification of property impact but biodiversity found to be a significant factor.
Colby 2002	Hedonic analysis of 7,659 homes located in Tucson, Arizona within 2.5 miles of riparian areas.	Up to 6% price increase for homes within 1.5 miles of river.	Results comparable to Bourne 2007.
Norman 2013	Evaluated land prices based using SCWEPM–MLP model.	3.1% price increase for parcels within 1.1 miles of SCR	SCWEPM – MLP model no longer available.
Bark-Hodgins 2005	Hedonic analysis of Tucson, Arizona home sales within 0.2 miles of 51 riparian sites.	20% price premiums for homes within 0.2 miles of well-vegetated riparian areas.	Uplift effects higher than most other studies.
Bark 2008	Hedonic analysis of Tucson, Arizona homes at 51 locations	Est. 4.1% increase for homes within 0.2 miles	Results comparable to Bourne 2007.
Out of State			
Netusil 2019	Hedonic analysis of 209 stream restoration projects in Oregon of numerous attributes to homes within 0.5 km (0.32 miles) for pre-project, project, post-project and mature phases.	Mature restoration effect of ~3.8% for instream but decrease for stream side between 0.25 and 0.5 km. Increased recreation access results in 6.3% to 7% increase.	Results specifically for river restoration projects show impact variability over time; mature phase results comparable to Bourne. Analysis limited to 0.32 miles from the river.
Towe 2021	Hedonic analysis of home sales in Baltimore County, Maryland.	15% in property appreciation (<1,000 feet) and 11% (<2,000 feet).	Greater property uplift findings may be related to local housing conditions

Note: SCWEPM–MLP = Santa Cruz Watershed Market Land-Price Submodel

4.4.2 Property Benefit Findings

4.4.2.1 Existing Conditions

AECOM conducted preliminary geospatial analysis and identified 380 single-family homes located within 1.1 miles from the SCR. Table 11 reports the number of homes within each 0.1-mile interval from the SCR, along with their aggregated assessed value. The property benefit factor for each interval is also shown with the estimated total property value increased attributed to the SCR.

GIS analysis identified 364 homes located within a mile of SCR. This number includes homes in northern Santa Cruz County where currently SCR may not reliably flow year-round. The properties evaluated represent approximately 2.5 percent of the total single-family homes in the county. Nearly half of the homes are in Tubac, while about 31 percent of the homes are in Rio Rico.

Table 11 Property Data of Single-Family Homes near Santa Cruz River

Distance to SCR (miles)	Number of Properties	Average Parcel Size (acres)	Average Assessed Value	Riparian Premium (%)	Property Value Increase per Home	Total Increase in Property Value
0.1	32	10.6	\$331,432	5.8%	\$19,200	\$614,400
0.2	62	1.9	\$446,206	5.2%	\$23,300	\$1,444,600
0.3	52	2.4	\$368,089	4.7%	\$17,100	\$889,200
0.4	61	3.9	\$420,160	4.1%	\$17,200	\$1,049,200
0.5	28	4.8	\$344,177	3.5%	\$12,100	\$338,800
0.6	37	4.5	\$332,818	3.0%	\$9,800	\$362,600
0.7	21	4.0	\$316,523	3.0%	\$9,300	\$195,300
0.8	31	5.0	\$349,566	1.8%	\$6,400	\$198,400
0.9	26	2.9	\$365,038	1.3%	\$4,700	\$122,200
1	14	4.4	\$344,752	0.7%	\$2,500	\$35,000
Total	364	4.1	\$375,800	3.8%	\$14,400	\$5,249,700

Notes: Riparian price premiums are based on (Bourne 2007). Property value increases are rounded to the nearest hundred.
Source: (Bourne 2007), (UrbanFootprint. 2026)

4.4.2.2 SCRMP Alternatives

Under the SCRMP future high-flow scenario, effluent flows into the SCR would increase by 15 mgd resulting in total effluent inflows of nearly 30 mgd. In addition, restoration improvements would also be made to improve SCR hydrology and/or enhance the ecosystem conditions in sections of the SCR corridor. Together, these SCRMP improvements may result in substantial quality enhancement to the existing resource conditions in the SCR riparian corridor.

In addition, the increased total effluent flows to the SCR may be expected to have a noticeable change in SCR conditions because perennial flows might be expected to extend further downstream from Tubac where it is usually dry during the late summer months.

However, as discussed in Section A.1.2.2 of Appendix A, the EA does not attribute any additional property benefits from SCRMP restoration improvements even though the enhanced environmental amenities (e.g. improved water quality, scenic views, restored habitat and increased recreational opportunities) might be expected to increase the market desirability and price premiums that future home buyers would be willing to pay.

4.5 Surface Water

Surface water supplies consist of water flowing within natural channels (e.g. rivers, streams and canyons) or definite underground channels (e.g. man-made conveyance facilities or hydrological underground channels). Surface water diversions commonly include conveyance for reservoir storage and water supply use such as stock ponds, and other agricultural diversion uses. However, within the Santa Cruz active management area (AMA) surface diversions are relatively limited and are reported to have remained unchanged since 1990 at 1,236 AFY (ADWR 2024). As discussed in Appendix A, pumped groundwater is the primary source of water supply for users within the Santa Cruz AMA.

Under the SCRMP high-flow scenario, an additional 15 mgd in supplied effluent would be discharged into the SCR, which will increase the future surface water flows in the river by an estimated 16,800 AFY. However, given the currently limited and unchanged level of surface water use, no change in future surface water diversions may be expected irrespective of any increase in SCR surface flow quantities. As a result, no surface water supply benefits to Santa Cruz County water users are expected.

4.6 Water Quality

SCR water quality has been a long-standing concern for Santa Cruz County residents. Effluent accounts for most of the SCR streamflow from Rio Rico to Amado. Streamflow also includes stormwater from the Santa Cruz River watershed.

Since the 2009 upgrades to the NIWTP, phosphorus, ammonia, and metal concentrations have declined and generally conformed with ADEQ standards. Over that period, the SCR's dissolved oxygen levels also improved and exceed State standards as a result of the 2009 NIWTP upgrades (Sonoran Institute 2025).

The primary water quality issue of concern within the SCR is high E. Coli and sediment levels that occur after flood events in the monsoon season (June through September) or the winter rainy season (December to February). E. Coli is observed to originate from cattle, ruminants, and canine and human feces run-off into the SCR. There are also occasional incidents of untreated wastewater discharges into the SCR because of operational and capacity problems at the upstream treatment facilities.

Future increased supplied effluent under the high flow scenario is not expected to result in any adverse water quality impacts to SCR and may result in some future improvements as higher quality treated water will reduce SCR concentration levels of dissolved salts, nutrient and minerals originating from stormwater run-off. This effect is consistent with past SCR water quality effects following the NIWTP upgrades.

Furthermore, future restoration improvements are generally expected to improve SCR water quality conditions. In-stream changes to SCR should improve dissolved oxygen levels and in conjunction with on-land revegetation efforts water temperatures and reduced soil bank erosion may improve. On-land restoration may also improve the SCR riparian areas' stormwater management capabilities.

While future SCRMP restoration improvement effects can be expected to be positive, the magnitude of their effects may be relatively limited and/or difficult to measure. Furthermore, valuation of water quality benefits is generally difficult as it typically relies on avoided cost effects to water users (e.g. reduced water treatment costs for utility providers or decreased hard water damages from scale build-up to household appliances). As a result, the EA has not estimated any water quality benefits for the SCRMP.

4.7 Flood Risk

Flooding is one of the most serious natural hazard risks across Arizona and is a concern for many Santa Cruz residents (Norman 2022). Since 1995, 82 major flood events have occurred in Santa Cruz County, of which nearly all (79 cases) were "flash floods" caused by excessive rainfall in a short period of time (i.e. six or less hours of rainfall) (NOAA 2026). These events generally occur during the region's late summer monsoon season in July and August. Arid regions such as Santa Cruz County are prone to flash flooding as dry soils have less ability to absorb storm waters. Drought-stricken soils can also be hardened which also reduces its water absorption and retention rate. Flash flooding results from the rainfall within the watershed which rapidly travels and collects in the area's streams and rivers.

The majority (55 percent) of Santa Cruz County's past major flood events did not result in any reported damages. However, from 38 flood events since 1995, there have been four flood-related fatalities, ten injuries and an estimated \$12.5 million in property damages (mostly to buildings and infrastructure) in Santa Cruz County. Most of the flood damage (\$10 million) occurred during the August 24, 2007 storm. Nearly all flood-related fatalities and injuries occurred during July flood events in 2004, 2008, and 2021.

The flow rates from 15 mgd are equivalent to 23 cubic feet per second (cfs) while serious flash flood events in Santa Cruz County typically have peak flows of 5,000 cfs or more (NOAA n.d.) (Norman 2016). As a result, both the current (No Project) and future increase in supplied effluent under the high flow scenario will have a negligible contribution to future flash flood events.

SCRMP restoration improvements are generally expected to improve retention and infiltration rates within the SCR riparian corridor which would reduce and/or delay the downstream flow of upper SCR flood waters, thereby decreasing flood conditions at those locations. However, the extent of SCRMP flood risk reduction is expected to be relatively limited and unlikely to result in substantial reduction in flood impacts,

especially during major flood events. Furthermore, quantification of flood damages requires extensive hydrology, hydraulics, and damage modeling to estimate changes in economic, structural, and life-loss consequences of flood events. As a result, the EA has not estimated any flood risk reduction benefits for the SCRMP.

4.8 Health Benefits

The user (consumer surplus) benefits that individuals gain from recreational activity is analyzed in Appendix C. However, recreation participation has important and valuable additional health benefits to both its participants and public health more broadly. Engaging in physical activity, especially in outdoor areas, generally lowers the participant's stress and blood pressure levels while also improving their ability to focus and their sense of well-being (EPA 2025). Recreational use can also contribute to a reduction in health risks in the long term (Barton et al. 2019). These benefits are not specific to riparian ecosystems, but riparian corridors can facilitate such outcomes by providing access to outdoor green space and opportunities for walking/hiking and nature enjoyment. The SCR is no exception: where surface water flows are sustained and willow-cottonwood forests emerge, the recreational quality of trails may improve. In Santa Cruz County, state residents spent 120,000 recreation days cycling or doing trail sports in or along waterbodies in 2024 and 2025 (Audubon 2026). This could translate into costs avoided from lower mortality risks that restoration of the SCR could enhance.

Benefit-cost analysis guidance from the United States Department of Transportation provides a standard approach for monetizing the mortality reduction benefits of new induced pedestrian and bicycling use (USDOT 2025). USDOT recommends use of \$8.80 per induced trip (in 2026 dollars) to estimate the health benefits to walkers and a \$7.80 per induced cyclist trip (in 2026 dollars). These values are based on the U.S. average distance and speed for each mode and are provided for users aged 20 through 74 (walking) or 20 through 64 (cycling). A key consideration for using this approach relates to the notion of *induced* trips, which refer to trips diverted from non-active transportation modes (e.g., motorized). In focusing on this subset of trips, it is possible to recover the benefit of switching transportation modes enabled by a given intervention.

Although typically used for transportation infrastructure projects, this approach can be helpful for estimating potential high-level benefits associated with the restoration of the SCR. Walking and cycling likely represent a significant portion of the recreational activities taking place along the trail, especially considering that there are constraints for water-based recreation such as swimming and boating. The Anza Trail already supports walking and hiking, notably in the segment between the Tumacácori National Historical Park and the Tubac Presidio State Historic Park (NPS 2025). Facilities in Pima County also show the potential that recreational enhancements could bring for walking and bicycling along the SCR. The Chuck Huckelberry Loop is a prime example, adding as many as 138 miles of paved pathways and bicycle lanes through Pima County, Marana, Oro Valley, Tucson, and South Tucson (Pima County 2026), with multiple access points to the SCR. Furthermore, nearby areas like the Sonoita Creek State Natural Area offer at least 20 miles of scenic trails for hiking along a perennial water body in Santa Cruz County.

The proportion of this recreation use that might be considered induced by the SCR's current conditions (i.e. as supported by the 14.8 mgd of supplied effluent) is unknown. Nonetheless, it may be expected that SCR recreation use levels would decrease if the current supplied effluent flows were curtailed, and its riparian habitat and wildlife were degraded as a result. The portion of SCR recreation use that would otherwise not occur at SCR (or elsewhere) under those conditions can reasonably be considered existing induced use. And as such, project-related health benefits for that induced recreation use can be reasonably estimated using USDOT per trip unit health benefit values.

Given the limited site-specific user data on walking and cycling along the SCR, the proportion of induced trips is conservatively assumed to be at most 10 percent of the existing visitation which presumes that most (90 percent) of the current cycling and walking use would nonetheless occur (either along SCR or at other locations elsewhere) under drier SCR riparian conditions without current supplied effluent flows. This 10 percent assumption of existing SCR induced recreation use may be considered likely to be conservative given that there few comparable recreation experiences in the region and proximity may be expected to be an important factor in user participation rates. Furthermore, visitor experience is likely

another motivating factor and consequently visitation may be expected to decrease if the SCR's habitat and wildlife conditions were majorly degraded.

As discussed in Appendix C, current SCR recreation by Santa Cruz and Pima County residents is estimated to total approximately 219,300 recreation use days annually. If 10 percent (21,930 trips) of current SCR visitation consists of induced walking trips by adults, then the SCR existing health benefits would be \$193,000 per year.

It might be expected that a higher proportion of any future user growth related to the SCRMP's high-flow scenario and restoration activities might consist of induced recreation that would otherwise not occur. Table 12 shows the annual health benefits that would result under each of the three recreation growth scenarios with an assumption that 50 percent of SCRMP-related recreation growth is induced use.

Table 12 Health Benefits – Future Recreation Use Growth Scenarios

Scenario	Change in Recreational Use (Recreation Days)		
	5% Increase	10% Increase	15% Increase
<i>Annual Change in SCR Recreation Use</i>	10,960	21,930	32,890
<i>Induced Use (at 50% Rate)</i>	5,480	10,960	16,440
Health Benefit (@\$8.80 per walking trip)	\$48,000	\$96,000	\$145,000

Note: Benefit values are rounded to the nearest thousand.

4.9 Tourism

Arizona is a popular destination for recreation in the United States. It is home to numerous natural sites especially suited for recreational activities. There are 3 national parks located in Arizona including most notably the Grand Canyon, and over 20 National Park Service sites. Arizona State Parks and Trails also operate 33 state parks. Recreation has an important role in the state's economy. In 2024, recreation-related spending is estimated to have contributed approximately \$15.4 billion (2.7 percent of GDP) and supported nearly 119,000 jobs, not only within the hospitality sector (entertainment, recreation, lodging, food and beverage industries) but also related retail trade and manufacturing businesses (BEA 2026).

Water-related recreation accounts for a major share of visitor use within Arizona's diverse natural landscape. Between September 2024 and August 2025, more than 2.2 million Arizona residents (around 39 percent of its adult population) are estimated to have participated in water-based recreation. The most popular visitor activities were outdoor relaxation/picnicking (21.4 percent), water sports (14.1 percent) and fishing (12.2 percent). A large portion of this recreation use typically occurred within a 50-mile distance from residents' homes—indicating that proximity to water bodies a key factor determining recreational participation (Audubon 2026),

More specifically, SCR is a well-established and popular site for outdoor recreation in Arizona. SCR is ranked among the state's top five most visited waterbodies by state residents. In 2018, approximately 199,000 recreation days along the SCR within the project area. The majority share of the SCR visitation was Santa Cruz and Pima Counties residents who accounted for approximately 147,500 visits (Audubon 2019).

These water-based recreational activities have contributed to Santa Cruz County's tourism sector, with SCR visitors estimated to have generated \$3.2 million in visitor spending in 2019 (Duval 2021) which is equivalent to approximately \$16 per visit. This relatively low amount of visitor spending is likely since a major portion of SCR recreation use is by local or Pima County residents. These users generate very limited new related spending since they do not need overnight lodging and are less likely to spend money on other hospitality businesses.

As discussed in Appendix C, the recreation growth induced by the SCRMP cannot be projected at this stage of planning. Furthermore, future SCR flow increases and SCRMP restoration improvements are expected to predominantly result in enhancement to the SCR's existing recreation resources which may

improve future visitor experiences. However, at this point, the quantity of the SCR recreation resources is expected to remain largely unchanged. Generally, future growth in SCR recreation use would be expected to be limited unless: (1) there are major changes in the recreation facilities; and (2) there is sufficient visitor demand to use the expanded recreation opportunities.

In any case, given the relatively low spending by local and Pima County visitors, the economic benefit to the Santa Cruz County tourism economy from increased SCR recreation is expected to be very minor. SCR is however recognized as a popular bird-watching destination and as such, its out-of-region visitors could potentially represent a more significant source of increased visitor spending and benefit to the County's tourism economy with improved ecosystem restoration conditions.

5. Cost Analysis

The EA's cost analysis importantly differentiates between effluent supply facilities/operations-related costs and those specifically for the SCRMP restoration improvements. The EA's cost analysis is focused on the SCRMP-specific capital and operating costs of its restoration improvements. This incremental cost approach is applied for several reasons:

- The primary purpose of the NIWTP is to treat the wastewater from its service customers which is a regulatory requirement independent of the SCRMP. Current and future NIWTP wastewater collection, treatment, and effluent disposal will be necessary under future (No Project) conditions, so NIWTP treatment costs are a federal facility and responsibility independent of its effluent use. As a result, full capital costs for the NIWTP and conveyance facilities upgrades that provide the water flow scenarios are not included in the EA.
- Comparative analysis between river restoration options and river flow scenarios is most appropriate and useful in preliminary restoration conceptual design.
- The level of effort, complexity, and uncertainty in wastewater planning and cost estimation for Project and No Project conditions is substantial and beyond the scope and resources of the EA.

Note that the primary justification and rationale for the NIWTP current and future operations are thereby based on its service needs and regulatory requirements, while its economic feasibility/cost-effectiveness will be determined by its next best treatment options. As such, the treated effluent is considered a by-product of the NIWTP operations. For the purposes of the EA, it is assumed that the supplied effluent is delivered to the Project at no cost. More specifically, it is only the marginal additional capital (and operating costs) that should be attributed if more comprehensive cost-benefit analysis is performed to evaluate the SCRMP restoration alternatives economic feasibility.

5.1 Restoration Improvement Costs

Future SCRMP planning will provide estimates for each SCRMP restoration scenario's costs for: (1) capital improvements (e.g., river rechanneling, vegetation removal/replanting, and recreation facilities); and (2) average annual operations and maintenance (O&M) requirements. At which point, standard life cycle cost analysis approaches discussed below can be used to estimate the present value of the SCRMP restoration scenarios' total expected cost over the period of operations to be analyzed.

5.1.1 Capital Costs

The capital costs for the SCRMP will correspond to the construction or implementation costs for future restoration improvements whether in-stream or for land-side changes. The SCRMP's preliminary unit cost estimates for its two active channel and adjacent overbank restoration concepts range from \$74,100 per acre (Concept A1/A2) to \$152,100 per acre (Concept D). For restoration concepts with more extensive land and revegetation work, the unit cost estimates for restoration range from \$231,400 per acre (Concept C) to \$382,400 per acre (Concept B) (Kimley Horn 2026). These estimates assume phased implementation and there could be economies of scale if a large-scale restoration project was implemented.

It should be noted that there may be significant risk of future damages and losses to SCRMP restoration improvements in the event of major storm events during Project establishment period (likely 5 to 10 years). The cost analysis does not account for this risk. However, flood-risk analysis using US Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) or other hydrologic and hydraulic modelling methods could be used to factor in the potential flood risk cost based on the probability of flood risk and potential flows. The potential damages per flood recurrence interval will change over time as the restoration matures.

5.1.2 Operations and Maintenance Costs

Future SCRMP planning will determine the expected annual O&M expenses for the proposed restoration improvements. For the purposes of future cost analysis, these expenses should be estimated in the same dollar terms used to estimate project construction costs.

However, in general it can be expected that the O&M costs may be limited for passive or natural-based restoration approaches where the subsequent riparian and/or ecosystem rehabilitation would occur with little, if any, subsequent interventions. For those restoration approaches that would involve gradual implementation, it will be necessary to determine the magnitude and schedule that those expenses be incurred.

The O&M cost assessment for the SCRMP restoration scenarios could also recognize any expected indirect or interim land-use impacts (compared to the No Project conditions) for affected landowner. For example, reduced fire risk from native species replacement might allow decreased vegetation management. Alternatively, non-native tree replacement might result in interim costs to adjoining farmers due to the short-term reduction in wind protection. Note that impacts might alternatively be recognized as resource benefits (or disbenefits) in the resource benefit valuation analysis.

Similarly, if nature-based solutions are proposed that might result in identifiable wastewater supply facility capital and/or operating cost savings they could be recognized as resulting economic benefits attributable to the Project.

5.2 Water Treatment and Conveyance

As discussed above, only the incremental costs to supply the treated effluent for SCRMP restoration alternatives should be attributed to the Project. It is assumed that the net infrastructure necessary for future SCRMP use would be minimal, so capital costs for the NIWTP and conveyance facilities upgrades to support the water flow scenarios have not been analyzed. It is recommended that they might reasonably be excluded from future comparative evaluation of SCRMP restoration alternatives as well.

5.2.1 Capital Cost

5.2.1.1 Existing Conditions

The NIWTP upgrade in 2009 cost approximately \$64 million dollars (roughly equivalent to \$94 million in 2025 dollars) and was funded largely by a grant from the Environmental Protection Agency through the Border Environment Infrastructure Fund (IBWC 2026). The construction cost for the Nogales Trunkline and IOI project was \$35.3 million in 2024 (IBWC 2024).

5.2.1.2 High-Flow Scenario

The construction cost for the proposed NIWTP upgrade is approximately \$40 million (KJZZ 2025). However, as discussed above, only the incremental costs to supply the treated effluent for SCRMP restoration alternatives should be attributed to the Project.

5.2.2 Operations and Maintenance Costs

5.2.2.1 Existing Conditions

The United States Section of the International Boundary and Water Commission (IBWC) currently operates and maintains the NIWTP. The Project is staffed by seventeen people, including administrative support. The total annual O&M cost in fiscal year 2024 was \$7.9 million (in 2024 dollars) (IBWC 2025). Mexico, the City of Nogales, Arizona, and the United States Congress fund the Project based on flow contributions to the facility from each country.

In April 2024, the IBWC received \$12.5 million in congressional funding for future O&M of the rehabilitated IOI pipeline that conveys Nogales Sonora wastewater to the NIWTP for treatment and subsequent discharge to the SCR.

5.2.2.2 Future Operations

Future O&M cost information for the planned upgraded NIWTP facility are unknown can be expected to have a unit cost rate comparable or lower than its current unit O&M expenses. Generally, the upgraded facilities should operate more efficiently with a lower unit O&M cost, especially during the early portion of its useful life, unless future changes in water quality standards and/or requirements (such as PFAS) add new or higher treatment requirements with additional costs that offset its efficiency savings.

6. Summary of Findings

6.1 Benefits

The EA has evaluated both the existing resource conditions and where possible, future effects of the high-flow scenario (15 mgd) conditions. Table 13 provides a summary of the benefits findings for each resource benefit quantified by the EA. The benefit findings for each quantified resource are discussed briefly below:

Groundwater Recharge: The current and potential future increased supplied effluent are the most readily quantifiable project-related resource effects. The groundwater recharge benefits depend on both; (1) the magnitude of aquifer replenishment from discharged effluent to the SCR surface water flows; and (2) the value of those increased groundwater quantities.

The groundwater recharge from the current 14.8 mgd of supplied effluent discharges to the SCR are estimated to result in 11,010 AF per year of aquifer replenishment. Under the future high-flow scenario, an additional 15 mgd of supplied effluent would occur and result in another 11,160 AF per year of aquifer replenishment. The EA estimates that the unit value of an acre-foot of increase in groundwater supplies would be approximately \$405 based on the alternative cost of agricultural retirement to otherwise obtain that same groundwater recharge outcome. Based on which, the SCR current groundwater recharge benefit is estimated to be nearly \$4.5 million per year and future implementation of the high-flow scenario would be expected to add another \$4.5 million in groundwater recharge benefits.

Future SCRMP restoration actions are expected to have relatively limited, if any, net impact on groundwater conditions. However, if measurable groundwater recharge impacts can be discerned then their economic benefit value can be similarly estimated.

Ecosystem Services: The SCR riparian area currently consists of an estimated 8,826 acres of natural land areas most of which are either forest or herbaceous areas. The SCR natural areas support diverse wildlife species that live in the region and migrate through the valley. The EA's ecosystem benefit valuation is based on a benefit transfer approach applied to the SCR riparian area land cover conditions. Annual unit benefit valuations from several existing valuation tools and studies were derived for each of SCR's three land use types: forest areas (\$6,930/acre); herbaceous areas (\$4,500/acre); and scrubland (\$210/acre). These valuations include the site's support for habitat and wildlife as well as its soil, carbon and other environmental effects. Based on these unit values, the SCR riparian areas are estimated to have a benefit value of \$49.3 million per year.

Future implementation of the high-flow scenario and SCRMP restoration actions can be expected to enhance the future quality of the SCR's existing ecosystem resource. As discussed in Appendix B, it is difficult to attribute incremental benefit value increases from resource quality enhancements especially if they are difficult to measure. However, if future SCRMP restoration alternatives result in quantity changes in land covers areas, then the ecosystem unit benefit values can be readily applied to estimate the ecosystem benefit increase. Future SCRMP restoration alternatives could increase the ecosystem areas through expansion of the SCR riparian area and/or conversion of current shrubland or agricultural locations to forest or herbaceous natural areas.

Recreation: SCR is a well-established and popular outdoor recreation location with an estimated annual visitation of approximately 220,000 by Arizona residents who use its trails for hiking, bird watching and enjoying nature. Based on comparison with other river use studies, the average recreation use value for SCR visitors is conservatively estimated by the EA to be approximately \$28 per visit. Based on which the total economic benefits for recreation users of the SCR project area is estimated to be approximately \$6.2 million per year.

Table 13 Summary of EA Quantified Benefits

Benefit Category	Description	Resource Change	Selected Valuation Method	EA Benefit Valuation	Notes
Groundwater	Supplied effluent to SCR naturally infiltrates and recharges the Santa Cruz aquifer and reduces current overdrafts.	Existing: +11,010 AFY SCRMP: +11,160 AFY	Unit water benefit based on a \$405/AF alternative cost of agricultural retirement for equivalent GW recharge	Existing: ~\$4.46M/yr SCRMP: ~\$4.52M/yr	Conservative benefit value that does not include indirect economic losses of land fallowing.
Ecosystem	Supplied effluent and SCRMP restoration enhancement of SCR riparian habitat/wildlife resources.	Existing: 8,826 acres SCRMP: Unquantified	Benefit transfer of unit values by land cover type from ecosystem valuation tools and FEMA's Forest value.	Existing: ~\$49.3M/yr SCRMP: NA	Focus on quantified resource changes; benefits from enhanced quality of existing habitat areas not estimated
Recreation	SCR provides extensive recreation opportunities (e.g. hiking, wildlife viewing) for users.	Existing: 219,300 recreation days/yr SCRMP: User Growth Scenarios (5%, 10% and 15%)	Benefit transfer analysis of recreation user's consumer surplus of \$28.80/recreation day	Existing: \$6.2M/yr SCRMP: \$0.3 to \$0.9M/yr	Need to differentiate new induced recreation from relocated use (which results in little net benefit).
Health	Benefits of reduced mortality from project-induced recreation	Existing: 21,930 induced trips/yr SCRMP: User Growth Scenarios (5%, 10% and 15%)	USDOT unit value of \$8.80 per adult induced walking trip	Existing: ~\$193K/yr SCRMP: ~\$48 to \$145K/yr	Need to identify new induced user recreation
Property	Proximity to riparian areas increases home values and residents' quality of life.	Existing: Homes located within 1.1 miles of SCR SCRMP: No change	Price premium to homes based on distance to SCR and % impact on assessed values from hedonic pricing studies	Existing: \$5.25M SCRMP: No change	One-time uplift effect; benefits from enhanced quality of habitat, scenic views of existing areas not estimated
Property Tax	Increase in County tax revenues based on uplift to home values	Increase in assessed property values and annual tax payments from property uplift effects	County property tax rate of 0.8% applied to SCR property increase	Existing: ~\$42K/yr SCRMP: No Benefit	None

Future implementation of the high-flow scenario and SCRMP restoration actions could induce new visitor use as a result of their improvement to the future recreational experience and/or user access. The economic benefit value of a 15 percent increase in SCR recreation use is estimated to be approximately \$900,000 per year.

Health Benefits: Recreation participation has important and valuable additional health benefits to both its participants and public health more broadly which can be economically valued. SCR-related health benefits can be attributed for the induced recreation activity that would otherwise not occur if its recreation opportunities were not available. Conservatively assuming that 10 percent of SCR's current recreation is induced by SCR current flow conditions, the annual value of the health benefits for those users are estimated to total approximately \$193,000 per year.

The health benefit value of a 15 percent increase in SCR recreation use of which 50 percent consists of new induced use is estimated to be approximately \$145,000 per year.

Property Values: Homes located near riverways typically include a price premium in the property value based on their proximity to the river and local real estate conditions. They can be estimated by statistical analysis of housing sales data. The total price premium for the 364 homes located within 1.1 miles of the SCR is estimated to be approximately \$5.25 million based on a prior study of Santa Cruz home sales. This is a one-time "bump" in home values which can be attributed to the SCR existing conditions.

Future SCR flow increases and SCRMP restoration improvements could result in substantial quality enhancement to the existing resource conditions in the SCR riparian corridor. However, the EA does not attribute any additional property value benefits from those resource quality changes.

Property Tax: The current annual tax benefit to Santa Cruz County from SCR-related property uplift effects is estimated to be approximately \$42,000 per year. No future property tax benefits are expected.

6.2 Costs

The EA's cost analysis importantly differentiates between effluent supply facilities/operations-related costs and those specifically for the SCRMP restoration improvements. As discussed in Section 5, the EA's cost analysis is focused on the SCRMP-specific capital and operating costs of its restoration improvements. NIWTP and conveyance facilities upgrade costs that provide the water flow scenarios are not included in the SCRMP EA since the treated effluent is considered a by-product of the NIWTP operations.

At this stage of SCRMP planning restoration program alternatives have not been developed and consequently their implementation costs are not determined. Future SCRMP planning will provide estimates for each SCRMP restoration scenario's costs for: (1) capital improvements (e.g., river rechanneling, vegetation removal/replanting, and recreation facilities); and (2) average annual operations and maintenance (O&M) requirements. At which point, standard life cycle cost analysis approaches discussed below can be used to estimate the present value of the SCRMP restoration scenarios' total expected cost over the period of operations to be analyzed.

The SCRMP has developed preliminary unit cost estimates for its two active channel and adjacent overbank restoration concepts which range from \$74,100 per acre (Concept A1/A2) to \$152,100 per acre (Concept D). For its more intrusive restoration concepts with more extensive land and revegetation work, the unit cost estimates for restoration range from \$231,400 per acre (Concept C) to \$382,400 per acre (Concept B). These estimates assume phased implementation and there could be economies of scale if a large-scale restoration project was implemented.

It should be noted that there may be significant risk of future damages and losses to SCRMP restoration improvements in the event of major storm events during Project establishment period (likely 5 to 10 years).

Future SCRMP planning will determine the expected annual O&M expenses for the proposed restoration improvements. In general, it can be expected that future O&M may be limited for passive or natural-based restoration approaches where the subsequent riparian and/or ecosystem rehabilitation would occur with little, if any, subsequent interventions. For those restoration approaches that would involve restoration activities over the period of analysis, it will be necessary to determine the magnitude and schedule that those expenses may be expected to be incurred.

6.3 Economic Performance

Net economic benefits are a key metric for evaluating and comparing the outcomes of future SCRMP restoration alternatives. Future comparative assessments should focus on determining which restoration alternative offers the greatest overall economic benefit. For example, restoration measures that are less cost-effective but can be implemented more widely and/or at a greater scale may result in greater overall economic benefits than highly cost-effective improvements that can only be deployed narrowly.

All EA costs, benefits and findings should be presented in constant dollars (i.e. nominal values) over the Project lifetime. The total project costs should also be aggregated on an undiscounted basis (i.e. without factoring in any time value of money). This approach can facilitate comparative assessment and decision-making for how benefits are expected to accrue over time in the most straightforward and value-free terms.

EA findings may also be determined on a present value (PV) basis. PV in economic analysis represents the current worth of a future stream of benefits or costs, calculated by discounting expected future cash flows to the present day using a specific discount rate. PV enables the comparison of monetized Project benefits by accounting for the “time value of money” concept that a sum of money in hand today is likely worth more than the same sum in the future.

Although PVs can generally be readily calculated and are commonly used, it is important to recognize that discounting can often result in substantially lower representation of the Project’s future total benefits, as long-term benefits (e.g., occurring 20 or more years in the future) will diminish over time. As a result, a PV analysis may understate the societal value of projects with long-term benefit horizons, as is common for ecosystem restoration, climate resilience, and other long-horizon initiatives. Some environmental and social benefits result immediately upon installation (e.g. recreation improvements) but others will require years before the resource effects occur. For example, building a new park can both increase local recreation opportunities and improve air quality. Although the increased recreational use may be more immediate, its air quality benefits will occur more gradually as the tree plantings mature.

Consequently, use of even the relatively modest 3.25 percent discount rate used by the Bureau of Reclamation in water resources planning (Federal Register 2026), a Project benefit realized 40 years from now is worth only a small fraction of its nominal value in present-day terms. This effect can create the impression that long-term benefits are minimal, even when their actual (undiscounted) value to communities and ecosystems will be significant and permanent.

6.3.1 Life Cycle Analysis

As discussed above, all cost expenditures and attributed benefits should be converted into a single common constant dollar-year term (e.g. 2025 dollars) to remove any inflation-effects (i.e. nominal value).

Life cycle analysis is commonly used to determine the total value of future streams of costs (or benefits) that occur at different points in time during the period of analysis. Generally, a project’s lifecycle costs and lifecycle benefits are calculated separately.

The period of analysis used for economic analysis can vary based on the type of project and its expected useful life. Generally, a 20–30-year timeframe is used, although longer analysis periods are often used for major infrastructure developments with longer useful life (e.g. reservoirs or pipelines).

6.3.1.1 Undiscounted Total Value

The undiscounted total cost of each SCRMP restoration alternative is calculated as the summation of its expected capital and O&M expenses project costs over the period of analysis. This summation does not include any other adjustment to individual cost items but instead is simply the accumulated total of the items undiscounted and constant monetary values. As such, the value of a specific expense would be unchanged irrespective of whether it is incurred today or 10 years later.

The same procedure should be applied to various benefits attributed to the Project over the period of analysis to determine its undiscounted total benefits.

6.3.1.2 Discounted Present Value

As discussed above, the time of value money can be recognized by discounting a specific future expense to convert it into its present value terms. A higher discount rate decreases the present value of a future monetary values, while a 0 percent discount rate will correspond to the undiscounted total value discussed in 6.1.1.

While the Bureau of Reclamation currently uses a 3.25 percent discount rate (FY2026) for its water resource planning, some federal agencies use a 7 percent rate for their feasibility and benefit-cost analyses.

6.3.2 Comparative Assessment

The EA's framework and valuation methods can be used for comparative assessments between SCRMP restoration alternatives once sufficient description and quantification of their resource outcomes for benefit valuation is available and their implementation costs can be determined.

Net economic benefits are a key metric for evaluating and comparing the outcomes of future SCRMP restoration alternatives. Future comparative assessments should focus on determining which restoration alternative offers the greatest overall economic benefit and/or the desirable set of benefit outcomes. Given the inherent challenges in measuring resource changes – especially quality improvements – comparative approaches can provide more useful and practical means for decision-making. Potential application of the economic performance assessment can include:

- (1) assist in understanding and differentiating future benefits between alternatives;
- (2) determine the resource improvement benefits linearity and possible scale issues; and
- (3) identify the potential trade-offs between resources.

Accordingly, comparative assessment can guide future SCR planning efforts toward more optimal and/or well-balanced (equitable) restoration outcomes. It can also be applied to help secure and maintain the long-term economic viability and support for SCR restoration. However, the usefulness of any such comparative assessment of future SCRMP restoration alternatives will depend on clear characterizations that describe and differentiate both their implementation and that quantify their respective resource outcomes.

6.4 Next Steps

As discussed in Section 3 – Project Description, at this stage, the SCRMP effort has identified numerous restoration approach concepts to represent implementation tools/strategies options for potential implementation. The identified SCRMP restoration concepts represent implementation tools/strategies rather than specific objectives or portfolio sets of proposed restoration improvements.

The following section provides a brief overview of the expected next steps for future SCRMP planning with suggested opportunities where additional economic analysis might assist.

6.4.1 SCRMP Restoration Alternatives Development

Once the current SCRMP restoration concept approaches are accepted and approved for advancement, the SCRMP team will apply the objectives on a more site-specific basis to develop restoration alternatives. This process can be expected to consist of several steps of planning analysis.

Future SCRMP planning is expected to first align Project Area sites with applicable restoration concepts, based on valley setting, risk tolerance, hydrologic conditions, and social constraint. Using that screening process to match restoration concepts with project locations, the SCRMP Team would thereby identify, locate and characterize potential restoration opportunities. At which point, it is expected that SCRMP efforts would then prioritize between these restoration opportunities to develop potential program/portfolio sets of proposed restoration improvements (Kimley-Horn 2026).

These identified program/portfolio sets of proposed restoration improvements would then be further developed and described as implementable alternatives suitable for comparative assessment by the EA and decision-makers.

6.4.2 SCRMP Restoration Alternatives Evaluation and Selection

Once restoration alternatives have been developed, the SCRMP team would then begin its evaluation and selection process. Key elements of that process would include resource impact analyses to evaluate and quantify the resource changes that might reasonably be expected as outcomes under each restoration alternatives' implementation. Economic benefit valuations would then be performed for resources changes that can be adequately quantified. Qualitative analysis could also be performed to compare and contrast resource outcome differences between the SCRMP restoration alternatives so that those factors can also be recognized in the alternative selection process. However, the usefulness of any comparative assessment will depend on clear characterizations that describe and differentiate both their implementation and that quantify their respective resource outcomes.

Future SCRMP planning will then provide estimates for each SCRMP restoration scenario's costs for: (1) capital improvements (e.g., river rechanneling, vegetation removal/replanting, and recreation facilities); and (2) average annual operations and maintenance (O&M) requirements. At which point, standard life cycle cost analysis approaches discussed above can be used to estimate the present value of the SCRMP restoration scenarios' total expected cost over the period of operations to be analyzed.

Comparative economic analysis and selection between SCRMP restoration alternatives can then be performed provided adequate information differentiating between future SCRMP restoration alternatives is available. At which point, comparative assessment can guide future SCR planning efforts toward more optimal and/or well-balanced (equitable) restoration outcomes. The EA findings can also be subsequently used to help secure and maintain the long-term economic viability and support for SCR restoration.

6.4.3 Binational Infrastructural Analysis

The purpose of the binational infrastructure analysis (BIA) is understood to be primarily to describe the benefits derived from the binational infrastructure to provide justification for their development. As such, a major component of future BIA for the SCRMP would include presentation of the EA's economic benefit valuation findings.

In addition, the BIA could also provide: (1) an overview of the IBWC jurisdiction and regulatory/approval process relevant to future SCRMP implementation; (2) specify any key IBWC/CILA requirements and regulations necessary for future project development; and (3) identify key planning analyses, components, issues and potential obstacles to the future Master Plan implementation.

At this current stage of SCRMP's conceptual restoration planning evaluation, binational infrastructure analysis is considered premature and has not been performed. However, once SCRMP restoration alternatives are determined with their resource effects, then binational infrastructural analysis may be warranted.

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Appendix A Groundwater Benefits

Valuation of groundwater supply benefits related to the Santa Cruz River Management Plan (SCRMP) requires considering both the Project and “without project” conditions. The Santa Cruz Active Management Area (SCAMA) assessment projects a steady increase in the region’s future water demand, largely due to growth, but available supplies will remain variable and constrained (AZWR 2012).

The Santa Cruz River (SCR) serves as an important natural groundwater recharge system for the Upper Santa Cruz watershed. Currently, wastewater originating from Nogales, Sonora is processed by the Nogales International Wastewater Treatment Plant (NIWTP), which discharges an average of 14.8 million gallons per day (mgd) of treated effluent to the SCR. Annually, this effluent stream results in approximately 16,590 acre feet (AF) per year in surface water supplied to SCR, which in turn is estimated to result in 11,010 AF of groundwater recharge (Niraula 2012; Norman 2013). The current groundwater recharge effects from the SCR make an important contribution to the Santa Cruz watershed’s groundwater conditions, water availability, and long-term sustainability.

Under the SCRMP’s high-flow scenario, an additional 15 mgd or 16,802 AF of treated effluent would be discharged to the Santa Cruz River. This will represent an approximately 100 percent increase to the amount of effluent currently added to SCR. This would provide approximately 11,160 AF per year in new groundwater aquifer recharge, which will improve groundwater conditions and availability.

The SCR Economic Analysis (EA) has analyzed the current groundwater conditions and projected SCRMP-related groundwater changes to estimate the economic benefits to the Santa Cruz watershed that might reasonably be attributed to both current SCR and future SCRMP flow conditions. The EA’s groundwater benefit valuation approach, key assumptions, analysis, and findings are discussed in the following sections.

A.1 Benefit Valuation Approach

A.1.1 Standard Methodologies

A range of methods can be used to estimate the economic value of groundwater. Table shows various such methods that can generally be used.

Table A-1 Standard Groundwater Benefit Valuation Methods

Method	Description of Approach
Market Prices	Purchase cost to obtain comparable groundwater benefit
Hedonic Pricing	Estimates water value by analyzing its impact on the market price of land (e.g., comparing sales prices of properties with access to irrigation water to similar properties without such access)
Alternative Cost	Calculates the cost to achieve the same groundwater resource conditions with the next best alternative (e.g., imported water or desalination)
Avoided Cost	Similar to Alternative Cost Method; estimates water value based on expenses avoided (e.g., cost saving from higher groundwater levels and/or improved water quality conditions)
Production Function	Evaluates the contribution of groundwater as an input in production (e.g., use of water for irrigation based on increased crop yields)
Contingent Valuation	Surveys individuals to determine their willingness to pay for improved water quality or increased availability, often used for assessing non-use or preservation values
Benefit Transfer	Uses published analysis, data, and findings from comparable projects, adjusted as necessary to represent the Project’s circumstances and expected performance outcomes

The selection and use of these groundwater benefit valuation methods are generally determined by the specific circumstances of the Project being analyzed. Common consideration factors will include data availability; resources (budget, schedule, and technical expertise) available for study effort performance; and Project characteristics and context/circumstances—especially to the extent that comparable projects can be identified.

A.1.2 Key Evaluation Factors and Considerations

A.1.2.1 Data Requirements

Key information requirements for the EA's groundwater benefit valuation are listed below:

- Incremental groundwater recharge quantities and supply yield (acre-feet/year) for regional water users is required under both:
 1. Current No Project conditions; and
 2. SCRMP restoration alternatives under the high-flow scenario conditions.

If applicable, locational factors affecting the recover and supply yield for regional water users should be recognized in the groundwater benefit valuation.

- Current water uses in the region and beneficiaries of SCR current effluent supplies should be identified.
- Expected future water availability conditions, use changes, and beneficiaries from SCRMP restoration alternatives under the high-flow scenario conditions are needed.
- It will be necessary to identify potential supply options (with costs) that could provide equivalent groundwater recharge effects resulting from:
 1. Current (No Project) 14.8 mgd of NIWTP effluent supplied into the SCR; and
 2. SCRMP restoration alternatives under the high-flow scenario conditions.

A.1.2.2 Assumptions and Limitations

The EA's selected groundwater benefit valuation methodology estimates the economic benefits of both existing (No Project) supplied effluent flows to the SCR and potential groundwater-related benefits from the SCRMP restoration alternatives under the future high-flow scenario (i.e., with an additional 15 mgd in treated wastewater effluent to the SCR). The EA considered the following assumptions and factors in its development and application of the selected groundwater valuation methodology:

- Increased groundwater supply from future additional supplied effluent can be used for its intended purposes (municipal, industrial, households, agriculture etc.). As discussed briefly in Section 4.8 of the EA, no adverse water quality impacts to the Santa Cruz aquifer are expected from either the existing supplied effluent or the additional supplied effluent under the SCRMP's future high-flow scenario conditions.
- Demand exists for additional supply in other forms (purchasing from the Central Arizona Project [CAP], retiring agriculture land, etc.) if the Project was not in place. Agriculture remains the largest water use in the region; municipal demand in urban areas such as Tucson rank second, followed by industry and environmental flows sustained by wastewater discharge. Over time, agricultural land has declined as urban demand has grown, increasing reliance on groundwater, imports from the CAP, and water reuse systems.
- Groundwater depletion is an ongoing issue. Groundwater levels are highly dependent on recharge from surface flows, with declines driven by pumping and evapotranspiration (Arizona Department of Water Resources 2020).
- There are few alternative sources of net new water. Most supply strategies rely on reallocating or reusing existing resources rather than expanding total availability. Potential options of sourcing

this water explored in the EA include purchasing water from CAP, retiring irrigated agricultural land of pecan trees, and establishing a brackish desalination plant.

A.1.3 EA Methodology Review

Several valuation approaches and data sources were considered for use in estimating the groundwater supply benefits of SCR and the SCRMP alternatives. The valuation approaches included alternative/avoided cost, contingent valuation, market rate, and benefit transfer. The alternative cost approach was selected due to its Project-specific relevancy and the relative strength of available information.

The EA's benefit valuation for SCR-related groundwater supply benefit is based on regional water-use data, groundwater supply assessments, and valuation methods that link water availability to current regional water demands as well as projected future development needs and water availability conditions.

Without the current (or increased future) wastewater effluent discharges to SCR, satisfying this increased demand would necessitate long-term water purchases from other sources, including the CAP, which presents long-term sustainability concerns because the CAP sources its supplies from the already overallocated Colorado River. Such continued reliance would contribute to the depletion of CAP resources and exacerbate existing system-wide stresses, with costs expected to remain elevated or increase over time. As a result, the value of additional water provided by the Project can be reasonably approximated by the cost that users would have to pay to secure the reliable supply under constrained conditions (avoided cost). This establishes a lower-bound estimate of water's economic worth, reflecting its scarcity and the essential role it plays in sustaining regional growth and stability.

A.1.3.1 Market Prices

The market price for water purchases is a valuation method commonly used by water supply analysts to approximate the economic values of Project-supplied water.

In their analysis of the SCR's resource benefits, Norman used CAP potable water prices to represent the value of Nogales International Wastewater Treatment Plant (NIWTP) effluent. Using the biophysical models embedded in the Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM), the study generated estimates of groundwater supply in the Santa Cruz Active Management Area (SCAMA) for five scenarios of effluent discharge from the NIWTP. The value of each effluent flow scenario was estimated based on Tucson Water rate costs for CAP water in FY 2013 (Norman 2013).

Consistent with Norman's market valuation, the EA estimates a current (2025) market price for CAP-supplied water of \$389 per acre-foot. The unit water purchase price for CAP participants is \$309 per acre-foot. Water buyers must also pay net capital charges of \$56 per acre-foot and \$24 per acre-foot water storage capital and operations and maintenance (O&M) charges.

However, Norman's analysis did not recognize the facility and conveyance costs that would be necessary for delivery of the CAP supplies. The EA's alternative cost approach for CAP imported water supplies discussed below applies a market price similar to that used in Norman et al. 2013 but updated its underlying assumptions to better reflect current conditions and recognize the additional related delivery costs in its estimate of the Project's water supply benefits.

A.1.3.2 Alternative/Avoided Cost

As discussed in Section 2.1 of the EA, alternative and avoided cost valuation approaches measure the value of a good, service, or intervention based on the costs that are prevented or no longer incurred due to its implementation.

There are few sources of new net water supplies in the Santa Cruz River Basin. As a result, most of the region's water supply options reallocate existing water resources rather than improving overall water availability in the SCR watershed.

The EA evaluates several potential options that could substitute for existing supplied effluent in the SCR and otherwise match the additional 15 mgd of supplied effluent under the high-flow scenario for the SCRMP.

The EA first determined alternative supply projects that can be expected to provide comparable groundwater supply outcomes, by either achieving similar annual groundwater recharge improvements or matching the water supply outcomes for Santa Cruz water users that would be gained from the SCR groundwater replenishment.

The EA identified and evaluated these three primary alternative water supply options considered to be technically feasible:

- Importation of purchased CAP
- Retirement of agricultural land (e.g., pecan orchards)
- Brackish groundwater desalination

Imported CAP Supply

As shown in Figure A-1, Santa Cruz County is outside the CAP's direct service area. As a result, imported CAP water would have to be delivered through engineered infrastructure from its closest existing connection at Pima Mine Road in Sahuarita, in southern Pima County. Supplying specific areas in Santa Cruz County or adjacent southern Pima County areas would require additional pumping and pipeline infrastructure to convey the CAP water.

Figure A-1 Central Arizona Project Facilities



Source: CAP 2026

Furthermore, unlike the treated effluent that naturally flows and infiltrates downstream through the Santa Cruz River system, imported CAP water could also require development of groundwater recharge facilities.

Comparable large-scale water conveyance infrastructure in Arizona, including the CAP, were used to provide unit cost benchmarks to estimate the construction for the conveyance facilities that would be necessary to import purchased CAP supplies for groundwater recharge or direct use purposes (e.g., Agricultural or M&I use). The CAP system, which spans 336 miles and includes extensive pumping infrastructure, cost approximately \$4 billion to construct; this is equivalent to roughly \$11.9 million per mile (CAP n.d.). Based on that unit construction cost, development of the 42.5-mile extension to NIWTP would be approximately \$506 million. This estimated \$506 million capital expense for the imported water facilities would add \$3,047 per AF, based on a 20-year period of analysis and 3 percent real discount rate.

Alternatively, a simplified conceptual design for the conveyance system consistent with operating parameters is used to develop a more project-specific and realistic estimate of the imported water cost. For the purposes of the alternative cost estimation for imported supplies the EA assumes the following:

- A 36-inch welded steel pipeline would have sufficient capacity to account for peak conveyance so that CAP delivery schedules would be able to deliver 16,580 acre feet per year (AFY) (14.8 mgd x 365 days), consistent with SCR's current supplied effluent quantities.
- Two pump station facilities with 565 brake horsepower, providing 450 feet of head pressure for 15 mgd of the CAP, would supply the 42.5 miles and 765-foot elevation to the NIWTP.
- The CAP system's existing 36-inch pipeline terminus/connection at Sahuarita would have sufficient capacity to provide the 14.8 mgd. This is considered a reasonable assumption, based on past planning by the Community for its proposed \$25 to \$30 million extension of CAP supplies to a groundwater recharge facility west of Old Nogales Highway. The CAP supply pipeline is designed to be oversized for a 28,000 AFY delivery capacity, of which Community Water Company (CWC) needs only 7,000 AFY for its operations (CWC 2026).
- Required water quantities could be purchased from the CAP at its current water prices and rate costs.

The unit construction cost for the pipeline component may be expected to be in the range of \$4 million per mile (equivalent to \$750 per linear foot); as a result, development of the 42.5-mile extension to NIWTP would be approximately \$170 million. In addition, it is expected that the pump station facilities would likely cost at least \$15 million each to build, in which case construction cost for the imported water facilities would total \$200 million. The annualized cost of the Project would be \$1,200 per AF, based on a 20-year period of analysis and 3 percent real discount rate.

The estimated O&M cost for the pipeline was derived from the 2026 Water Rates Analysis Report prepared for the Town of Oro Valley Water Utility in Arizona. The total projected annual O&M expenditures for 2026 were divided by the total AF of water delivered to calculate an average unit O&M cost of \$360/AF, of which the annual energy cost would be approximate \$155 per AF. Based on this, the total estimated cost per AF (CAP purchase and pipeline construction costs) is \$1,560 per AF. Combined with the previously estimated CAP purchase cost of approximately \$390 per AF, the total unit cost to supply imported CAP supplies to NIWTP would be approximately \$1,950 per acre foot.

It should be noted that this alternative cost scenario would discharge an equivalent 14.8 mgd of imported CAP water to the SCR to achieve both SCR current groundwater recharge benefits as well as its ecosystem benefit. Currently, the Green Valley Recharge Facility in southern Pima County is permitted for 30,000 AF operations. If only the 11,010 AF in annual groundwater recharge benefit needs to be achieved, there may less expensive options based on new groundwater recharge facilities downstream of the NIWTP.

Based on this, SCR's current annual 11,010 AF of groundwater recharge would have a total estimated value of \$41.8 million per year. Similarly, the 11,160 AF of additional groundwater recharge under the SCRMP high-flow scenario would have a total estimated value of \$42.3 million per year. However, it is important to note that this analysis is based on the groundwater-equivalent recharge derived from the 15 mgd (16,802 AF) of treated wastewater flows.

However, although importation of CAP water would be technically feasible as an alternative supply, CAP participation and purchase of new substitute supplies may be considered impractical and/or economically infeasible. CAP is supplied by the Colorado River, whose flows have declined by more than 20 percent over the last century. Most climate model projections of 2050 Colorado River stream show flows declining by 5 to 30 percent from its 1971 to 2000 levels (Bolinger 2024). In the face of major and permanent long-term declines in Colorado River water conditions and current deadlock in the multi-state renegotiation of state allocations, it may be considered highly unlikely that comparably reliable imported supplies could be purchased.

Agricultural Retirement

Pecans are considered a high water-use crop, due in large part to an extended growing season that begins in late March and continues through mid-November in most locations. Because pecan orchards are both prevalent in the area and water-intensive, they were selected to estimate the lost revenue associated with retiring an equivalent volume of water from mature pecan production.

A mature pecan tree in Arizona typically requires approximately 34,000 gallons or 0.104 AFY (Call 2006). Using the Project benchmark of an additional 11,160 AFY in groundwater supplies, this volume would support approximately 106,956 mature pecan trees. Average annual production per tree in Arizona ranges from 40 to 50 pounds of pecans. This corresponds to roughly 4.8 million pounds of annual production, based on an average midpoint yield of 45 pounds per tree (Call 2006).

The average sale price for pecans in Arizona was \$1.96 per pound in 2024 (USDA 2026). Adjusting to 2025 dollars using the Consumer Price Indexes (CPI) calculator increases this value to \$2.01 per pound. The estimated production costs for pecan orchards are approximately \$2,310 per acre (2025 dollars), including labor, fuel, machinery, pruning, weed control, irrigation, fertilizer, insecticide, and harvest-related expenses. The total area in production would be approximately 2,228 acres, assuming 48 mature trees per acre (Vitale 2024).

Based on these assumptions, the total value of pecan production that would need to be retired to meet the equivalent water supplied by the Project under its highest-flow scenario is approximately \$4.5 million per year. This reflects estimated net operating profit derived from gross annual revenues of \$9.7 million, minus \$5.1 million in operating costs. This value therefore represents the direct economic surplus foregone per year.

This estimate is based on the replacement cost of pecan trees that would need to be retired to offset an equivalent quantity of water use. This approach provides a tangible, market-based proxy for the value of groundwater, but it is important to note that it represents only a partial measure of the total economic value associated with groundwater availability. Specifically, the estimate does not account for the additional costs that would be required to make alternative water supplies usable, including the infrastructure for water sourcing, treatment, conveyance, and delivery to end users.

Agricultural retirement is not a full or straightforward replacement for the Project's groundwater recharge effects. In terms of its water supply performance, the groundwater recharge derived from agricultural retirement is less reliable and drought-vulnerable than the SCR's supplied effluent. Furthermore, groundwater impacts may occur in different locations which depending on the aquifer hydrology could in turn could affect its economic value. Unlike other supply alternatives, agricultural retirement does not create transferable municipal supply and will also result in significant secondary adverse economic and social impacts. Water savings from agriculture may not align geographically with urban demand, limiting its practical usefulness.

Additionally, this valuation does not capture broader social and economic impacts associated with reduced groundwater availability. For example, it does not reflect potential income losses to farmers, changes in agricultural employment, or secondary effects on local economies that depend on pecan production. Nor does it incorporate nonmarket impacts such as community disruption, land-use changes, or long-term effects on regional agricultural viability.

Brackish Desalination

In contrast to reallocating existing agricultural water use, developing new supply through brackish groundwater desalination represents a more capital-intensive alternative. Brackish desalination is a potential source of net new water; however, it involves significant costs and implementation challenges. Arizona has identified brackish groundwater as a potential supplemental supply in its updated statewide study of viable regions for future development (Montgomery & Associates 2024). However, these efforts emphasize that large-scale implementation remains complex and uncertain, requiring further evaluation of treatment costs, infrastructure needs, and overall feasibility before it can be considered a practical solution.

Brackish water desalination is emerging as a viable supplemental water supply strategy in California, Texas, and other Southwest locations where more traditional water sources are inadequate and/or unreliable and which can access high-salinity groundwater supplies. Brackish desalination can provide a reliable, drought-resilient supply from otherwise unusable groundwater. Larger facilities benefit from lower per-unit costs, but the process is inherently energy intensive and produces concentrated brine waste, which must be carefully managed to avoid environmental harm. Coastal facilities can often discharge their brine waste into the ocean at a relatively low cost. Inland plants face higher costs and more complex regulatory hurdles for brine disposal. Deep well injection and evaporation ponds are costly and tightly regulated; consequently, brine management is a major barrier that can make such projects prohibitively expensive to build and operate. As a result, brackish desalination may be viable in select locations with favorable hydrogeology and disposal options. However, without major advances in brine management technology or regulatory support, it is unlikely to serve as a cost-effective and more widely use alternative water supply source.

The cost to supply Santa Cruz County water users with 11,010 AF of desalinated water to replace SCR current annual groundwater recharge is used to determine its alternative cost value. The unit cost for water from smaller brackish desalination facilities (i.e., grouped by Cooley as facilities that can produce up to 16.2 TAF per year production capacity) is estimated to range from \$1,450 to \$2,600 per AF (2025 dollars) (Cooley 2019). Larger facilities (i.e., grouped by Cooley as facilities with annual production greater than 9.7 TAF) will benefit from economies of scale that can reduce their unit costs to between \$1,350 and \$1,900 per AF (Cooley 2019). Development of a 50 TAFY to 200 TAFY desalination facility at the Sea of Cortez has also been analyzed as a potential new water supply to offset expected future declines in Colorado River water availability. The estimated unit cost for this facility's supplied water is \$2,600 to \$2,825 per AF (2025 dollars) (Black & Veatch 2020).

Conservatively applying a median cost of \$2,300 per AF per acre-foot from Cooley's smaller and larger high-end unit cost estimates, the equivalent economic value of the SCR's 11,010 AF of groundwater recharge supplies would be approximately \$25.3 million.

Arizona generally has extensive brackish groundwater resources and has numerous brackish wells. Nearly all of the identified potential desalination sites that could supply treated groundwater to Arizona water users are inland and have brine water management challenges (ADWR 2024). More specifically, the challenges and costs for brine disposal are likely to be substantial in Santa Cruz or southern Pima Counties.

Alternative Supply Options Comparison

Table A-2 provides a summary comparison of the Project and alternative supply options considered by the EA in its alternative cost valuation of the SCR and SCRMP restoration alternatives' groundwater benefits.

Table A-2 Summary of Alternative Supply Options

Approach	Sourcing	Facilities	O&M	Indirect Impacts	Reliability/ Local Control	Est. Cost per AF
SCR/SCRMP	Net New Supply	Minimal – natural infiltration	Negligible	Benefit to SCR habitat/wildlife	High/Yes	—
Alternative Supply Options						
CAP Imports	Transferred with Purchase	Conveyance Groundwater Recharge	Medium	Reduced state jobs/activity	Low/No	\$1,950
Agricultural Retirement	Transferred with Buyout	Limited	Low	Reduced local agricultural jobs/activity	Low/Yes	\$405
Brackish Groundwater Desalination	Net New Supply	Groundwater Pumping Desal w/ Brine Disposal Groundwater Recharge	High	Benefit to SCR habitat/wildlife	High/Yes	\$2,300

A.1.3.3 Production Function Valuation

Agricultural Production

The alternative cost valuation of agricultural retirement of pecan farming is similar to a production function valuation of use of Project-related water supplies for agricultural purposes. Both approaches incorporate the agricultural product water use in their valuation methods, but the production function value is focused on estimating the economic activity and net income that is attributable to its water use.

Since production function valuation is based on the consumed water use, it needs to account for the expense of pumping groundwater for irrigation. However, the production function approach can include consideration of indirect and induced economic effects generated by farming (e.g., multiplier effects on jobs and income for agricultural support business) that are not recognized in the alternative cost methods.

Residential Use

Agriculture is an important industry for Santa Cruz County, but residential and municipal and industrial (M&I) users will represent the most economic beneficial use of groundwater. As a result, these water uses will result in the highest production function valuation. Accordingly, the EA assessed economic benefits that can reasonably be attributed to the hypothetical residential development and could be supported by the Project-related improvements in the Santa Cruz aquifer's groundwater conditions as an upper bound estimate of the SCR current and future groundwater supply benefits for the region's water users.

The dependency of the economic development on the water supply is a central and key factor in the attribution of the production benefits. Water availability can often be a limiting factor for residential development in arid regions across the Southwest. More specifically, Arizona has well-established regulatory requirements that limit residential development based on local water availability. The Santa Cruz Active Management Area (AMA) is one of Arizona's designated groundwater management areas established under the 1980 Groundwater Management Act in response to long-term groundwater depletion concerns. Figure A-2 shows the location of the Santa Cruz Active Management Area. In AMAs, new subdivisions are required to demonstrate a 100-year assured water supply under the Arizona Department of Water Resources (ADWR) Assured Water Supply program prior to approval and lot sales. Outside AMAs, water supply adequacy is evaluated under the Adequate Water Supply program, which is generally less restrictive and may require disclosure of water availability, depending on local jurisdictional requirements.

Both programs are designed to ensure long-term water availability for new development over a 100-year planning horizon (UA Cooperative Extension 2024). As a result, future development in these areas is limited to projects that can secure sufficient long-term supplies of water. To the extent that water availability can be recognized as the critical limiting factor, the economic benefits from resulting development (such as residential or agriculture production) may be attributed to related economic benefits of the increased supply. However, any such benefit attribution needs to account for its net effect,

recognizing when the resulting development is new for the regional economy and not simply a relocation of the development that would otherwise occur elsewhere in the region.

In any case, the economic value that might be attributable to residential use of increased groundwater supplies in the region under the high-flow scenario could be very high. It may be conservatively assumed an acre-foot of groundwater could provide dependable long-term water supply sufficient to support three new homes in Santa Cruz County. Based on a current median county-wide home price of \$295,000, the value of residential development that would be supported by an acre foot of groundwater would be nearly \$900,000. As discussed above, the construction employment and spending to develop the three new homes would benefit Santa Cruz workers, businesses, and the regional economy. It is important to note that the EA is not suggesting that any such SCRMP-related housing growth would occur or be necessary—the valuation is provided as a possible representation of the groundwater supply's potential economic development-related value.

However, the magnitude of the beneficial impact of new housing development on the Santa Cruz County will depend on the extent to which it would simply relocate homes from elsewhere in the County or would be a net increase as the increased groundwater supply makes otherwise undevelopable land usable for housing. A more conservative estimate of the economic benefit of the residential development can be derived focused on the net income (or profit) that might be expected to result. Assuming a 5 percent profit margin, the net income benefits for the housing developer would be \$44,750 per acre-foot. Unlike most of the other benefit valuations, this is a one-time benefit effect.

The EA does not suggest that all this income generation should be attributed to groundwater availability; numerous other factors are necessary requirements (e.g., developer expertise, access to funding) or contribute for successful residential development. Nor does the EA in any way assume that any such increase in new residential development is feasible or recommended. The purpose of the housing-related production function assessment is to show the high upper bound of economic valuation from potential use of increased effluent supplies under the SCRMP's high-flow scenarios.

A.1.4 EA Selected Methodology

The EA estimates the economic benefit of groundwater recharge based on the cost of obtaining an equivalent level of aquifer replenishment from agricultural retirement. Although likely difficult to enforce, agricultural retirement is considered the most technically feasible and likely replacement source for SCR's current supplied effluent and/or the additional effluent supplies under SCRMP high-flow scenario conditions.

As discussed above, there is a wide range between the groundwater supply benefits that can potentially be applied to estimate the value of the SCR's existing groundwater benefits and those that might be expected under future high-flow scenario conditions and implementation of SCRMP restoration alternatives. For the purposes of the EA, the groundwater recharge benefit is estimated on a unit value basis of \$405 per acre foot, derived from the alternative cost for agricultural retirement. This valuation is very comparable to the current price of CAP water of \$389 per acre foot, as estimated in Section A.1.3.1.

Figure A-2 Santa Cruz Active Management Area Location



- Groundwater Basin
- Mexico Boundary
- River
- National Forest

- Major Population Center
- Major Highway
- Lake

Source: ADWR 2024

Large-scale crop retirement would likely be highly controversial, politically unpopular, and administratively challenging to implement. However, although its implementation feasibility may be highly questionable, it is the easiest option to deploy, with no expected technical feasibility issues. Agricultural retirement would also require only limited new infrastructure and once established could be operated and maintained at very low cost compared with the imported water and desalination supply options.

A.2 Resource Conditions

A.2.1 Existing Groundwater Resources

A.2.1.1 Groundwater Aquifer Conditions

Water use and supply in the Santa Cruz Basin are currently shaped by a hybrid system of groundwater pumping, surface flows, and imported wastewater, with demand strongly tied to population growth and infrastructure constraints. Groundwater is a critical water source across the Santa Cruz region (USBR 2024). Pumped groundwater is currently the primary source of water supply for homes and businesses in the Upper Santa Cruz watershed. Agriculture currently accounts for the largest share of total withdrawals in Santa Cruz County, followed by municipal and residential demand. As a result, groundwater availability represents a key factor for the Santa Cruz County economy, based both on its agriculture and its support of future residential and commercial development.

The long-term sustainability of the Santa Cruz aquifer will require balancing future pumping with increased groundwater recharge and/or development of new renewable water supplies. Although overall groundwater storage could improve under effective management strategies, localized declines in groundwater supplies are still expected, especially in high-demand areas and under worsening climate conditions.

Between 2020 and 2060, it is estimated that the groundwater will need to be replenished with a total recharge groundwater quantity of between 231,000 and 570,000 AF to offset projected over-pumping (Udall Center 2023). The range in the watershed's groundwater recharge needs varies depending on future growth and climate conditions. At a minimum the region could face a 6,000 AF annual water supply deficit, and under less favorable future growth and climate conditions, the region could face a 14,000 AF annual water supply deficit (Udall Center 2023).

A.2.1.2 Groundwater Recharge

Groundwater recharge in the Santa Cruz watershed is highly dependent on surface water flows from monsoon storms and effluent discharges to SCR. Without the recharge from the current effluent flows, groundwater levels would decline more rapidly and extensively. Between 2020 and 2060, it is estimated that the groundwater will need to be replenished with between 231,000 and 570,000 AF to offset projected over-pumping. The range in the watershed's groundwater recharge needs varies depending on future growth and climate conditions but at a minimum would require a 6,000 AF decrease in water use. Under less favorable future growth and climate conditions, the region could face a 14,000 AF annual water supply deficit. As a result, it might be expected that an addition of 11,160 AF under the future high-flow scenario could exceed or majorly offset (i.e., 80 percent reduction in overdraft under less favorable future climate change conditions) the watershed's future Project overdraft conditions.

There are currently several active groundwater recharge and managed aquifer recharge initiatives operating in the Upper Santa Cruz River watershed in southern Arizona. These projects are designed to address groundwater depletion, enhance riparian ecosystems, and improve long-term water resilience. Major efforts include Tucson Water's Santa Cruz River Heritage Project, which has released highly treated reclaimed water into the river channel since 2019 to promote aquifer recharge and restore perennial flow conditions; multiple recharge and replenishment facilities operated by the Pima County Regional Flood Control District that use CAP water, stormwater, and reclaimed effluent for groundwater storage; and Project Renews in the Sahuarita–Green Valley area, which conveys CAP water to recharge basins adjacent to the Santa Cruz River to offset regional groundwater declines. In the Nogales and upper basin region, university and agency studies have focused on streamflow recharge processes, aquifer response, and climate-related groundwater vulnerability. Across the watershed, reclaimed wastewater and engineered recharge basins are increasingly being used to sustain river flows, support riparian habitat restoration, and enhance aquifer storage in this water-scarce region.

The Upper SCR watershed faces current groundwater overdraft conditions and long-term water availability challenges because of the current imbalance between its demand and renewable water supply. Under the current (No Project) conditions, 14.8 mgd of treated wastewater is diverted to SCR at the NIWTP. This results in approximately 11,010 AF per year of groundwater aquifer recharge that

currently play an important role toward reducing current and future overdraft pumping of the Santa Cruz aquifer and adverse effects on groundwater availability (Nirula 2012).

A.2.1.3 Water Supply Benefits of Project-Related Groundwater Replenishment

Although total recharge represents an increase in water entering the aquifer system, it is possible that not all of that water may be recoverable for future supply use without adverse hydrologic or regulatory impacts. The proportion of recharge that is recoverable will vary depending on aquifer conditions, with studies indicating recoverability of applied surface supplies commonly range from 50 percent to more than 70 percent in managed recharge systems. High-level and general groundwater resource assessments often assume roughly half of applied surface water is practically recoverable. It may be possible that not all of the Project-related recharge is recoverable, due to losses to evapotranspiration, baseflow, and subsurface storage outside of economically or physically accessible zones (ADWR 2010, USGS 2003). In this case, the estimated groundwater benefits should be adjusted based on the quantity needed for the region's water users.

A.2.2 SCRMP Impacts

A.2.2.1 Increased Supplied Effluent

The high-flow scenario's 15 mgd increase in supplied effluent to the SCR will predominantly determine the groundwater recharge benefits that would result from the SCRMP alternatives because it can be expected to add approximately 16,800 AF per year in surface flows to SCR at the NIWTP. This will represent an approximately 100 percent increase to the amount of effluent currently added to SCR.

More detailed hydrologic study of surface and subsurface conditions is necessary to fully understand the connectivity between surface water and groundwater. Such model could aid in predicting the impacts that stream restoration would have on the overall surface water / groundwater system as well as the impacts of increases in supplied effluent to the SCR. The Lacher hydrological study initially planned to model and understand the complex nature and properties of surface and groundwater connectivity and interaction within and along the SCR. An overview of the model was provided to the SCRMP team and preliminary findings appeared promising for use in SCRMP and other SCR planning projects (Lacher 2026). Although, the study and its findings are still forthcoming, it is expected that the once available they will be informative for future SCRMP efforts and benefit valuation.

Based on the hydrologic analysis for the current SCR condition referenced by Norman 2013, for the purposes of the EA, the SCRMP high-flow scenario conditions are assumed to add approximately 11,160 AF per year in new groundwater aquifer recharge, which would further improve groundwater conditions and supply availability (Niraula 2012). As a result, the SCRMP-related additional effluent supply would be expected to help reduce current overdraft conditions to stabilize the basin's water supply and increase groundwater levels over the long term.

A.2.2.2 Restoration Alternatives

In-stream restoration improvements could result in higher infiltration rates (and consequently greater groundwater recharge impacts). If SCRMP instream restoration-related changes to the SCR's hydrology are quantifiable, then differences between SCRMP restoration alternatives' economic benefits may be attributable.

Stream-side land and habitat restoration alternatives could potentially result in greater water retention due to increased vegetation and/or species changes in SCR riparian areas. Replacement of nonnatives with less thirsty native species might allow greater infiltration unless this effect is offset by increased vegetation density. The extent and timing of each species' net groundwater effects may be difficult to quantify due to locational/site factors and uncertainties in revegetation rates (under both active and passive restoration approaches). However, it may be possible that differences between SCRMP restoration alternatives economic benefits can be identified if net incremental changes in Santa Cruz aquifer conditions can be quantified for SCRMP stream-side restoration improvements.

It is currently expected that groundwater effects from the SCRMP restoration alternatives would be relatively minor and mostly result in greater upstream recharge that would otherwise occur lower

downstream. In this case, the net change in total groundwater recharge quantities and benefits might be minimal unless there are any location-related groundwater recharge benefit factors.

In any case, the net effects on groundwater recharge quantities of the restoration improvements in SCR riparian will be relatively limited/marginal in magnitude compared to those from the additional supplied effluent flows. As a result, the overall future groundwater recharge increases from the SCRMP alternatives under the high-flow scenario are estimated to be roughly double those resulting under SCR current supplied effluent conditions.

A.3 Groundwater Benefit Findings

A.3.1 Existing Conditions

As discussed in Section A.2.1, under the current (No Project) conditions, 14.8 mgd of treated wastewater is diverted to SCR by the NIWTP. This results in approximately 11,010 AF per year in new groundwater supply and aquifer recharge benefits.

Table A-3 shows the EA estimated economic valuation of groundwater recharge benefits for the SCR's current conditions as well as those under future high flow scenario conditions and SCRMP restoration alternatives. The groundwater benefit findings are based on a \$405 per AF unit benefit value derived from the alternative cost of agricultural retirement.

Table A-3 Groundwater Benefit Findings

Project Scenario	Supplied Effluent (mgd)	Groundwater Recharge (AFY)	Unit Benefit (\$/AF)	Groundwater Benefit (\$/yr)
SCR Existing	14.8 mgd	11,010 AFY	\$405/AF	\$4,460,000
SCRMP Total	15 mgd	11,260 AFY	\$405/AF	\$4,560,500
High-Flow Scenario	15 mgd	11,160 AFY	\$405/AF	\$4,520,000
SCRMP Restoration Improvements	—	+100 AFY	\$405/AF	\$40,500

As discussed above, this likely a conservative valuation that does not account for related economic costs that would occur from lost agricultural production if such a land retirement program were to be implemented.

A.3.2 SCRMP Alternatives

As discussed in Section A.2.2, the high-flow scenario's 15 mgd increase in supplied effluent to the SCR will predominantly determine the groundwater recharge benefits that would result from the SCRMP alternatives. The SCRMP restoration alternatives are expected to result in relatively minor net changes to magnitude or location of the future groundwater recharges effects compared to those from the high-flow scenario's additional 15 mgd of supplied effluent to the SCR.

The groundwater benefits attributed to the 15 mgd increase under future SCRMP high-flow conditions are estimated on the same unit basis applied to the groundwater benefits estimated for the existing SCR's 14.8 mgd supplied effluent discussed in Section A.4.1.

As shown in Table A-3, the future groundwater benefits from the additional supplied effluent under the high-flow scenario may be expected to have an annual benefit value of approximately \$4.5 million.

The future SCRMP restoration improvements may be expected to have only limited and marginal additional economic benefits. For representational purposes, an assumed minor restoration-related net groundwater recharge quantity increase of 100 acre-feet is shown in Table A-3.

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Appendix B Ecosystem Benefits

Ecosystem services (ES) can represent both direct and indirect benefits that humans derive from natural ecosystems (FEMA 2022). These benefits are related to both physical resource conditions and human well-being, so ecosystem benefits may range from clean air and water to recreation opportunities and cultural significance. Ecosystem services are commonly classified into four broad service categories (FEMA 2022):

- *Provisioning Services* are the material or energy outputs from an ecosystem, including food, forage, fiber, fresh water, and other resources. For example, a forest can provide timber, and grasslands can provide livestock forage.
- *Regulating Services* are benefits from moderation/control and/or enhancement of ecosystem processes/resources. Regulation service benefits can include impacts on local climate, air, or soil quality; carbon sequestration; flood, erosion, or disease control; and pollination. For example, wetlands provide flood regulation, where they absorb and store excess rainfall, reducing flood peaks and protecting downstream communities.
- *Supporting Services* are services that maintain fundamental ecosystem processes, such as habitat for plants and wildlife and/or the maintenance of genetic and biological diversity. For instance, trees and shrubs provide habitat for avian species, and soil microorganisms support plant growth through nutrient cycling.
- *Cultural Services* are the nonmaterial benefits that ecosystems provide to human societies and culture, including opportunities for recreation, tourism, aesthetic or artistic appreciation, and spirituality. Examples include the recreation value of a public park, the scenic beauty of natural open space landscape, and the cultural significance of sacred forests.

The Economic Assessment's (EA's) ecosystem benefit valuation framework is predominantly focused on future Santa Cruz River Master Plan (SCRMP)-related habitat and wildlife improvements in the Santa Cruz River (SCR) riparian corridor—as well as other habitat-supporting services, including soil erosion control and formation, biological control, air quality, and pollination. Riparian vegetation (vegetation along the river) plays a fundamental role in maintaining the physical and ecological health of river systems, and intercepts precipitation, enhances infiltration, uptakes nutrients, and dissipates stream flows. Healthy vegetation in a high functioning river floodplain improves resiliency, water quality, and habitat diversity.

Other ecosystem services, including benefits for recreation, property values, water quality, and flood reduction, are discussed in Section 4, Economic Benefit Valuation, of the EA. Carbon sequestration/climate benefits are recognized and discussed as an additional ecosystem benefit but not included in final unit values estimated for habitat and wildlife benefits.

Benefits are only monetized in the SCRMP project area, but there are also additional habitat and wildlife benefits that might be expected to accrue beyond it. River restoration can enhance habitat connectivity and wildlife populations in ways that extend beyond the project area, as improved flow, water quality, and migration pathways support species movement and ecological functions both upstream and downstream across the broader watershed.

B.1 Benefit Evaluation Approach

B.1.1 Standard Methodologies

Benefit transfer is commonly used to estimate the economic value of habitat and wildlife-related ecosystem services. These services—including air quality improvements, improved soil control, and pollination—are public goods that lack market prices, making primary valuation challenging and resource-

intensive. As a result, benefit transfer is a standard approach in applied analyses when original nonmarket valuation studies are not feasible.

Benefit transfer involves identifying existing, peer-reviewed studies that estimate values for changes in habitat quality, habitat extent, or wildlife populations, using accepted nonmarket valuation techniques such as contingent valuation, choice experiments, travel cost models, or hedonic pricing. Reported values, often expressed on a per-acre-of-habitat, per-household, or per-species outcome basis, are then transferred to the project area and scaled based on the magnitude of habitat restoration or enhancement. For habitat and wildlife services valuation specifically, benefit transfer commonly relies on:

- per-acre values for restored or new habitats; and
- species-based willingness-to-pay estimates, particularly for charismatic, threatened, or culturally important species.

Table B-1 identifies numerous ecosystem valuation tools and resources that were evaluated for their applicability for estimating both the SCR project area's current ecosystem resources and future SCRMP Restoration Alternatives' expected benefits.

Table B-1 Ecosystem Service Valuation Tools

Tool	Best Use	Notes
ARIES (ARTificial Intelligence for Environment and Sustainability)	Integrated, open-source modeling platform for environmental sustainability, on which researchers can add their own data and models to web-based repositories	Ecosystem service valuation focuses on crop provision value and climate regulation value.
InVEST	Exploring GSI investment options to improve equity outcomes and/or maximize benefits	Requires detailed site-specific information and advanced GIS analysis.
FEMA BCA Toolkit	Conducting BCA for hazard mitigation investments	Can be used to determine wildlife/habitat values for EA. Uses global values in ecosystem service unit valuation.
Land Trust Alliance/Earth Economics Ecosystem Services Valuation Tool	Generating high-level estimates of the value of co-benefits generated by ecosystems	Can be used to determine wildlife/habitat values for EA. Note that tool inputs/sources are not provided and cannot be reviewed.
Ecosystem Service Valuation Database	Database of ecosystem service values that standardizes monetary values of ecosystems	Landcovers reviewed are not applicable to EA.
Blue Value	A searchable database of ecosystem service valuation for coastal habitats	Only provides valuations for coastal habitats (e.g., beaches, dunes, wetlands, mangroves), not applicable to EA.
iTree (MyTree)	Quantifying individual tree benefits	Is specific to individual tree values, and benefits are largely driven by carbon sequestration.
Social Values for Ecosystem Services, USGS	GIS tool to quantify the perceived social values of ecosystem services using a 10-point "value index" based on surveys	Does not monetize ecosystem services.
WRF GSI TBL Tool	Excel-based tool that allows users to assess the TBL benefits and costs of alternative GSI stormwater management options	Focused on GSI interventions.

Notes:

BCA = Benefit Cost Analysis
 EA = Economic Assessment
 FEMA = Federal Emergency Management Agency
 Geographic Information System (GIS)

GSI = Green Stormwater Infrastructure
 TBL = Triple Bottom Line
 USGS = United States Geological Survey
 WRF = Water Resource Foundation

Many benefit transfer approaches used in ecosystem service valuation studies rely on per-acre values compiled by the Federal Emergency Management Agency (FEMA), which uses average estimates from the United States and overseas for nine landcover types (FEMA 2022). The FEMA values are a useful and widely accepted framework of generalized values that support consistency and comparability. However, FEMA unit values may not fully capture regional ecological conditions because habitat and wildlife values are highly context-dependent. Economic estimates vary based on habitat type, species characteristics, baseline ecological conditions, regional scarcity, human population characteristics, and valuation method. As a result, transferred values should be interpreted as approximate, planning-level estimates rather than precise measures of site-specific economic value.

B.1.2 Key Evaluation Factors and Considerations

B.1.2.1 Data Requirements

Estimation of habitat and wildlife restoration benefits requires quantification of the incremental changes in area and/or quality of land cover and/or land use. Changes in area (quantity) are estimated based on the amount of new vegetated land created through planned planting activities, as well as the anticipated natural expansion of vegetation or habitat areas resulting from increased effluent flows. Habitat quality can be determined by vegetation/habitat density, as well as species composition and/or productivity. Data required to more accurately quantify the change in habitat/wildlife values include the following:

- Existing land cover/land use (acreage) to provide a baseline information on land cover and habitat/wildlife conditions.
- Expected land cover/land use (acreage) following implementation of SCRMP restoration alternatives are needed to determine resulting ecosystem resource quantity changes. The benefits of future increased effluent flow discharges to SCR may be most readily observed and valued by any net landcover changes in the SCR riparian area resulting and/or supported in conjunction with SCRMP restoration activities.
- Expected changes in habitat density or species composition within the SCR riparian area are required to understand the ecosystem resource quality improvements. Although such incremental and unquantifiable resource enhancement likely cannot be readily or directly valued. However, if the relative productivity changes from prior and post restoration conditions can be determined, it might provide a reasonable basis for valuation by a proxy derived from ecosystem resource expansion.

B.1.2.2 Assumptions and Limitations

The following assumptions and limitations define the key methodological boundaries, conditions, and data constraints that underpin the analysis and should be considered when reviewing the outcomes of the EA.

- SCRMP alternatives are expected to result in a change in both quality and quantity of resources in the project area. This study evaluates the net new benefits of restoration—i.e., only the improvements from new habitat (quantity).
- This valuation quantifies the benefits of the highest flow scenario (15 million gallons per day [mgd]). The river flow scenarios are expected to be relatively linear and proportional. Consequently, reduced daily effluent flows would result in a proportional reduction in ecosystem service benefits.
- Estimating ecosystem service values using benefit transfer requires caution because many services are highly context-specific.
- A key limitation in valuing ecosystem services is the use of single-point estimates that mask substantial variability across locations and methods. Since values differ widely based on geography, ecology, and valuation approach, relying on an average can over- or underestimate benefits in specific contexts.

B.1.3 EA Methodology Review

The EA considered a wide variety of secondary valuation methods in the benefit transfer approach. This section presents alternative valuation approaches that were not used as the primary method but provide useful points of comparison. Given the challenges of valuing ecosystem services, particularly when relying on benefit transfer, these methods offer additional context by referencing observable costs or market-based proxies, albeit with limitations.

B.1.3.1 Willingness-to-Pay

Willingness-to-pay (WTP) studies are widely used to estimate nonmarket benefits of river restoration, capturing values linked to a range of ecosystem services. However, WTP estimates are often highly variable because they depend heavily on study design; how restoration outcomes are framed; and differences in respondents' income, preferences, and connections to the river. A further challenge is that these studies rarely isolate the value of a single ecosystem service component (e.g., habitat and wildlife), whereas "river restoration" packages typically bundle multiple changes (habitat, aesthetics, flood risk etc.). Table B-2 presents a range of WTP studies relevant to the project (all values in 2025 dollars).

Table B-2 WTP Reference Studies

Author, Year	WTP	Frequency	Study Inclusions	Valuation Approach
Wang 2021	\$77	Annual, per household	Preserving ecosystem services (conservation of habitat for wildlife, provision of freshwater supplies, recreational use and cultural heritage) provided by the Rio Grande Basin	
Wang 2021	\$32	Annual, per household	For habitat and wildlife only	
Norman et al., 2013	\$116	One-time, per visitor	To maintain the Upper Santa Cruz riparian corridor	Contingent valuation
Weber et al., 2009	\$241	Annual, per household	River restoration of the Middle Rio Grande (restoring fish and wildlife, vegetation density, tree type, natural river processes)	Choice experiment
Weber et al., 2009	\$72	Annual, per household	River restoration of the Middle Rio Grande (restoring fish and wildlife, vegetation density, tree type, natural river processes)	Contingent valuation
Mueller et al., 2019	\$54	One-time	Restoration projects that protect critical habitats for endangered and threatened species in the Phoenix area	
Richardson 2009	\$678	Annual, per household	Habitat and biodiversity in Platte River, Colorado	
Loomis et al., 2000	\$477	Annual, per household (on river only)	To increase five ecosystem services (dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation) along 45 miles of the South Platte River	

In the benchmark studies listed in Table B-2, values relate to different levels of improvement, involve different habitat and species types, and are conducted in different locations, making WTP estimates difficult to transfer across projects. An average of these studies may double-count other ecosystem services (e.g., recreation and groundwater supply) or entirely exclude relevant benefit components for the

SCRMP. For information purposes only, a selection of the WTP studies in Arizona were used to calculate a rough order-of-magnitude benefit for the SCRMP, as presented in Table B-3.

Table B-3 SCRMP Benefits Using WTP Studies

Author/study	WTP (\$2025)	Units	Total
Wang 2021	\$32 (annual, habitat and wildlife only)	Per household – 17,000 households in Santa Cruz County (United States Census Bureau)	\$544,000 (annual)
Norman 2013	\$116 (one-time) value for “maintenance of riparian corridor” not specific to habitat/wildlife; may overstate	Per visitor (Estimated 2025 visitation of 210,000)	\$24.8 million (one-time)
Mueller 2019	\$54 (annual)	Per household – 17,000 households in Santa Cruz County (United States Census Bureau)	\$918,000 (annual)

Source: United States Census Bureau, Santa Cruz County Quick Stats – Households (2020-2024).

Notes: Some of the project area falls within Pima County, and it is expected that the households in this county would also benefit.

WTP = willingness to pay

Using WTP in the benefit transfer approach, the annual WTP for habitat and wildlife improvement in the Santa Cruz River may range from approximately \$545,000 to \$920,000 annually. The Norman (2013) value is a one-time payment of approximately \$25 million.

B.1.3.2 Value of Specific Resources

Another alternative approach for valuing river restoration activities is to quantify the value of specific habitat and species in the project area. The preliminary species mix for the SCRMP alternatives identified by KH has been used to estimate the value of specific vegetative cover features using the valuation tool *iTree*. Table B-4 shows the per tree ecological benefit estimates obtained from the *iTree* model.

Table B-4 Vegetation Unit Benefit by Species

Tree	Carbon Dioxide Uptake per Tree	Stormwater Mitigation per Tree	Annual Value
Forest			
Fremont Cottonwood	\$48.74	\$0.33	\$49.07
Goodding's Willow	\$21.01	\$0.21	\$21.22
Western Hackberry	\$0.84	\$0.06	\$0.84
Arizona Ash	\$8.74	\$0.06	\$8.74
Velvet Mesquite	\$0.92	\$0.21	\$1.13
Shrub			
Desert Broom	\$1.62	\$0.01	\$1.62

Source: *iTree*.

Note: Herbaceous plants have not been valued in *iTree* and so cannot be quantified.

The benefits monetized by *iTree* are largely driven by carbon sequestration rather than habitat and wildlife benefits. Carbon sequestration is not captured in the unit value benefit transfer methodology used in the EA, so it could be considered as an addition to the final estimated benefit value. *iTree* also monetizes minor stormwater mitigation benefits, which range from \$0.01 to \$0.33 for the identified trees. For comparison, FEMA's ecosystem service value for climate regulation from forested land is \$227 (2025 dollars) per acre per year.

The \$/tree value is a coarse proxy for economic benefits and should be interpreted with caution because it relies solely on an estimated acreage rather than site-specific conditions or tree characteristics. This

approach simplifies spatial and ecological complexity and does not account for variation in species, age, health, or ecosystem services provided by individual trees. Accordingly, this was not the primary valuation method used for the EA.

B.1.3.3 Alternative Cost

Alternative cost methods for valuing river restoration focus on estimating the economic value of restoration by examining the costs of avoided damage or the expenses of replacing lost ecosystem services, rather than relying on direct market prices. For habitat/wildlife, this may include cost to restore or create equivalent habitat if the existing habitat were lost. For instance, the economic value of a forested wetland that supports bird and amphibian species could be approximated by the cost to restore an equivalent wetland elsewhere, including land acquisition, site preparation, planting native vegetation, and post-restoration monitoring.

The cost of conservation easements may also serve as an alternative cost by using the price paid to permanently protect riparian land along the Santa Cruz River as a proxy for restoration value. These costs reflect real market transactions aimed at preventing development and preserving benefits like flood control, habitat, and water quality. However, easement prices may undervalue restoration by capturing land market conditions rather than the river's full ecological and social benefits. The cost of conservation easements used to protect riparian land shows notable variability, with prices typically ranging from less than \$900 to approximately \$2,600 per acre (United States Department of the Interior 2014). Easement prices also reflect the value of the *existing* habitat, whereas restoration is anticipated to create *new* habitat, which may be undervalued at current prices.

Desktop research into restoration costs in the Southwest reveals a wide range of financial investment for riparian restoration projects. Total project costs span from approximately \$68,000 (Santa Fe Ranch Riparian Restoration 2005) for smaller restoration efforts to nearly \$28 million (Laguna Division Conservation Area 2022) for large-scale initiatives. When considered on a per-acre basis, costs can vary significantly, from approximately \$2,000 per acre for less intensive projects to over \$70,000 per acre for highly engineered or urban-focused restoration. These figures highlight the diversity of restoration strategies and the broad spectrum of costs associated with achieving meaningful ecological and social outcomes. The cost of river restoration projects is difficult to use as a direct proxy for the economic value of habitat and wildlife enhancement in the SCR because restoration design, scale, ecological conditions, and implementation costs vary widely by location, making expenditures highly context-specific and not directly comparable.

B.1.4 Selected Methodology

The EA uses benefit transfer to derive unit values for individual ecosystem services provided by the SCRMP. This builds on the FEMA approach by applying a more regionally tailored valuation, using land cover classifications and ecosystem service values that are specific to Arizona, or to regions in the United States with similar climates, when possible. A similar approach was undertaken for the Ecosystem Service Values for Texas project, by Texas A&M AgriLife Extension Service (2025), which sought to identify ecosystem services for habitats specific to Texas.

Consistent with best practices, this study applies benefit transfer conservatively by:

- selecting valuation studies relevant to similar habitat types and wildlife outcomes where possible;
- using average values to reduce the influence of extreme estimates;
- clearly documenting assumptions, sources, and limitations; and
- framing results as order-of-magnitude indicators of economic benefit, intended to support decision-making rather than replace ecological metrics.

Literature Review

Using the benefit transfer methodology, extensive literature research and review was conducted to determine the habitat- and wildlife-related ecosystem services for the identified landcover types. The research entailed reviewing existing literature for relevant ecosystem services generated by the identified

land covers, focusing on studies that were specific to Santa Cruz or Arizona. Where values for the Santa Cruz watershed or Arizona were not available, values from other regions were used, prioritizing similar climates, projects, or landcovers when possible. Global ecosystem service value databases (Blue Value, Ecosystem Service Valuation Database) were also reviewed.

Extensive literature research and review was conducted to source unit values for the relevant ecosystem services related to the identified land covers in Table B-6. Very limited information was available for Santa Cruz and Arizona, so a variety of unit values were transferred from other studies, including the following:

- Earth Economics, *Nature's Value in the Colorado River Basin*, 2014: This study presents the value of ecosystem services in the Colorado River Basin, using a combination of primary benefit valuation and benefit transfer methods. This study was used due to its geographic relevance because the SCR is in the Lower Colorado River Basin. It provides an extensive range of landcovers and associated ecosystem services.
- FEMA *Ecosystem Service Values*, 2022: FEMA uses a benefit transfer approach to derive unit values for nine landcover types, from ecosystem service value studies around the world. The reference values are global, but FEMA's values are widely used and accepted in BCA assessments for environment and restoration projects across the United States. The FEMA value for 'forest' has been used by the EA, however, FEMA also reports ecosystem values for riparian, and rural green open space landcover categories which may also be applicable to some of the SCR's non-scrubland areas. The ecosystem unit valuations for these three FEMA land cover types vary in magnitude and attributions. FEMA's unit valuation for riparian areas is attributed to very high water filtration, erosion control and flood hazard benefits. For its rural green open space areas, FEMA recognizes major aesthetic value benefits that exceed those for riparian and forest areas by a factor of 10 and 5 respectively. FEMA also uniquely includes an existence value for forest areas. The habitat and other biological benefits for both the open space and riparian areas are comparable at \$2,800 and \$3,240 per acre respectively.

A landcover classification crosswalk of the SCRMP's detailed land inventory was not available. As such, forest was selected to be the most consistent with the landcover classification from Sonoran Institute. In the future, when more detailed restoration alternatives and landcover information is available, ecological experts may be able to provide more information to confirm which FEMA landcover type and value are most appropriate for the SCR riparian areas. It is also worth noting that FEMA's total economic valuation for forest landcover recognizes an additional \$8,585/acre (in 2025 dollars) of existence value and \$1,680/acre in aesthetic value which the EA has excluded from its benefit valuation (FEMA 2022).

- Land Trust Alliance, *Ecosystem Services Valuation (ESV) Tool*, 2024: The Land Trust Alliance tool values 11 ecosystem services across nine landcover types. The ESV tool uses a benefit transfer approach that draws from 1,467 values across 181 studies sourced from Earth Economics' database of peer-reviewed studies, reports, and gray literature on the value of ecosystem services. Since the ESV tool was published more recently than their 2014 Colorado Basin study, it was used under the assumption that it may include additional data points that are applicable for the EA. It is noted that the ESV tool reported significantly higher unit values than other data sources. The basis and/or differences for its higher valuations cannot be determined since its calculations and source inputs are not observable. As a result, the EA derived valuations could be correspondingly over-estimated if the ESV tool values are overstated.

Although numerous valuation studies exist, many were not directly applicable to the SCR because they evaluate different land cover types, ecological conditions, species compositions, or hydrologic systems. For example, some studies focus primarily on forested wetlands or humid river systems, while others assess grasslands, coastal habitats, or urban green space, making direct comparisons difficult in an arid riparian environment such as the SCR. In addition, many ecosystem valuation studies only monetize a subset of ecosystem services (e.g. carbon sequestration, recreation or flood control) rather than the full range of wildlife, habitat, and supporting ecological functions relevant to the SCRMP. For example, the 2013 Norman et al. study, while specific to SCR restoration, does not provide habitat/wildlife-specific values that can be used in the EA. Methodologies can also vary substantially between studies, including

differences in assumptions, geographic scale, valuation techniques, and baseline environmental conditions, which can produce a wide range of estimated values.

Unit Value Calculation

When estimating ecosystem service values for a given ecosystem, two distinct approaches can be used:

1. Averaging values for each individual ecosystem service across all identified studies, then summing up these average values to produce a total ecosystem value, or
2. Summing all ecosystem service values reported within each study to calculate a total value for that study, then averaging these totals across all observed studies.

The first approach—averaging values for each ecosystem service across studies—ensures that each service is consistently represented in the final value. For example, if multiple studies provide values for habitat and wildlife, pollination, and air quality, the average value for each service is calculated separately. These average values are then summed up to generate a single, comprehensive value representing the total ecosystem service value of the ecosystem type. This method provides a balanced view that avoids giving undue weight to any single study that may have unusually high or low values for one service.

The second approach—summing up all ecosystem service values within each study and then averaging these totals—captures the full value as assessed by each individual study. This method reflects how each study has chosen to measure the value of the ecosystem, accounting for a unique combination of services included in each analysis. However, it is important to recognize that not all studies are designed to capture the total value of an ecosystem. In many cases, researchers intentionally focus on one or a subset of ecosystem services based on their research objectives, available data, or methodological preferences. For example, one study may exclusively evaluate flood regulation and water quality because these services align with their focus on water management, while another may emphasize recreation value, carbon storage, and habitat support. As a result, the final average value may be influenced by the range of services considered in each study, potentially leading to an over- or underestimate of total value if certain services are inconsistently included or omitted.

The EA's habitat/wildlife benefit valuations rely on the first method (average values for each ecosystem service across studies, then summing), which is in line with FEMA's methodology. Table B-5 shows the ecosystem component and total values derived using the aggregated individual ecosystem service averaged values. The estimated unit total ecosystem values by the EA's selected approach are estimated to be approximately \$6,930 per forest acre, \$4,500 per herbaceous acre, and \$210 per acre of shrubland.

In addition, the unweighted average method is also reported in Table B-5. The second methods results in lower total values for each landcover – approximately \$4,000 for forest, \$3,900 for herbaceous, and \$205 for shrubland. The valuation for forested areas from the unweight total average method is \$2,930 per acre or nearly 43 percent lower.

The unit values applied by the EA are derived from a combination of sources, including both single studies and multi-study averages. This approach reflects the inherent variability in ecosystem service valuation literature, where reported values often differ based on methodology, geographic context, and the specific services being measured. In selecting values for the EA's ecosystem valuation, emphasis was placed on those judged to be most relevant and representative of the SCR project area and its ecological conditions. While this results in a mix of individual and averaged values, this approach does not represent selective bias but instead is a practical response to the diversity of available data and decision to apply the best available estimates for each service category. For example, erosion control values for forest land cover were sourced from a single, well-aligned dataset (FEMA), while habitat and wildlife-related services draw from multiple studies and are represented as aggregated or averaged values across sources.

Table B-5 Ecosystem Service Values for the SCR (\$/acre/year, 2025 dollars)

Ecosystem Service	Forest	Shrubland	Herbaceous
Habitat and Nursery (a)	\$4,190	\$200	\$3,300
Erosion Control (b)	\$1,900	—	\$900
Biological Control (c)	\$20	—	\$230
Air Quality (d)	\$430	\$5	\$75
Pollination (e)	\$390	\$5	—
Total – Aggregated Services	\$6,930	\$210	\$4,500
Total – Unweighted Average	\$4,000	\$205	\$3,900

Notes:

- (a) Habitat: providing shelter, promoting growth of species, and maintaining biological diversity
- (b) Erosion control: retaining arable land, slope stability, and coastal integrity
- (c) Biological control: providing pest, weed, and disease control
- (d) Air quality: providing clean, breathable air
- (e) Pollination: pollinating wild and domestic plant species via wind, insects, birds, or other animals

Final Unit Values

Table B-5 summarizes the ecosystem service values for each of SCR corridor's land cover categories. Although this analysis is focused on habitat and wildlife benefits, it also includes ecosystem services that support habitat and wildlife enhancement (erosion control, soil formation, biological control, air quality, and pollination), rather than strictly using the value for habitat only. These other ecosystem services have not been valued elsewhere in the EA. Values are provided as dollar per acre per year.

These derived unit valuations attribute a substantial economic benefit to forest and herbaceous land areas. There are several factors to consider in determining reasonable valuations of the SCR current and potential future ecosystem benefits.

- A central factor may be comparative resources between the SCR's conditions and those of the reference studies' land cover categories. Although the SCR forested area density and productivity may be lower than other semi-arid forested areas within Arizona or the Colorado River watershed, its high biodiversity, especially for birdlife, suggests that the habitat and wildlife values are appropriate. However, other environmental regulating (e.g. air quality and erosion control) and/or supporting service functions (soil formation and pollination) may be less than the reference or unit average land cover conditions.
- The unit values are based on an underlying assumption that individual ecosystem services represent separate and distinct benefit attributes, rather than correlated or duplicative resource outcome factors. As a result, the valuation treats each service as independently derived contributions to overall ecosystem value. This assumption speaks to the wide variation in unit values across both source studies and service categories, as each estimate reflects distinct ecological functions, methodological approaches, and study contexts. Consequently, these values should be interpreted as approximate and additive indicators of value rather than precise or directly comparable measures.
- Unit values may vary significantly depending on underlying site-specific habitat productivity and ecological quality. The per-acre values applied by the EA are generally derived from studies that assume average or representative ecological conditions. However, actual conditions within the SCR corridor may differ due to factors such as vegetation maturity, hydrologic variability, soil condition, and habitat connectivity. Lower-quality or less productive habitats generally provide fewer ecosystem services per acre, while well-established, high-functioning systems may generate higher values. As a result, it may be appropriate to adjust or scale unit values to reflect site-specific conditions and functional performance as more detailed restoration designs and monitoring data become available.

As stated earlier, when restoration alternatives are determined, ecological experts may be able to provide more informed assumptions regarding landcover types and their associated values applicable to the SCR.

B.2 Resource Conditions

B.2.1 Existing Conditions

The SCR riparian area supports a variety of land types and vegetation. The Sonoran Institute's *Upper Santa Cruz River Riparian Vegetation Map* (Sonoran Institute 2008) determined that the total area of the SCR Riparian area was approximately 11,230 acres, of which almost 2,400 acres is agricultural land and 8,826 acres is either forest or herbaceous areas. For the EA's ecosystem benefit valuation framework, land cover types in the Vegetation Map have been combined into a single general land cover classification. For example, "forest," "woodland," and "developed woodland" are evaluated using values for "forest." This consolidation is based on the definitions of land cover provided in Sonoran Institute's Vegetation Map. Land cover (types and acreage) in the project area under existing conditions are provided in Table B-6.

Table B-6 Existing Land Cover within SCR Riparian Corridor (acres)

Landcover	Existing (acres)
Forest	5,052
Shrubland	634
Herbaceous	3,140
Total	8,826

Source: Sonoran Institute, Upper Santa Cruz River Riparian Vegetation Map, 2008.

Note: SCR Riparian Corridor also includes approximately 2,406 acres of agricultural land.

The SCR supports diverse wildlife species that live in the region and migrate through the valley. A species count conducted along the river near the international border in spring 2024 documented 90 species, including native fish species Gila Topminnow and Longfin Dace; seven dragonfly species; cottonwood and willow trees; and Clark's Spiny Lizard (Sonoran Institute 2024). The most important variable to quantify changes to habitat and wildlife present is the change in landcover from the SCRMP restoration alternatives.

B.2.2 SCRMP Resource Impacts

Under the SCRMP's high-flow scenario, 15 mgd of additional treated wastewater effluent will be diverted into the SCR on a relatively constant year-round basis, with a total of approximately 16,800 acre-feet per year of net new surface water flow added to the river. This increased surface water supply is expected to substantially revitalize the existing riparian habitat and may expand the habitat areas elsewhere in the SCR riparian corridor.

In addition, future restoration and revegetation efforts could be implemented to further enhance SCR's existing riparian area ecosystem conditions and/or change landcover conditions in the SCR riparian area. Stream-side restoration activities would have the most direct and rapid result in landcover changes because active revegetation of riparian areas would more quickly and assuredly result in ecosystem enhancement. More passive restoration approaches to riparian area resources would likely occur more gradually, with more variability in the future resource condition outcomes.

Due to the expected dependency of the future SCRMP Restoration Alternatives ecosystem outcomes on the increased supplied effluent flows, the EA provides a framework to evaluate the net resource changes of the combined flow *and* restoration activities. This differs from other benefit categories such as groundwater recharge benefits, where the resource impacts can be readily distinguished between the SCRMP's restoration activities and the increase in SCR flow conditions.

Under the future high-flow scenario, the increase in SCR's future flows will result in regenerated and expanded riparian vegetation (such as cottonwood and willow stands), which will generate numerous benefits for habitat and wildlife, as well as supporting services such as soil erosion control and formation,

nutrient cycling, biological control, air quality, and pollination. As vegetation and groundwater conditions improve, the SCR corridor can support species that depend on perennial or near-perennial water sources. Over time, this renewed habitat quality and complexity may increase biodiversity, strengthen ecological resilience, and transform the river into a more functional and vibrant wildlife corridor.

However, without specific restoration alternatives that detail proposed improvements or changes in landcover, future SCRMP-related habitat benefits cannot be quantified. As a result, this benefit valuation provides a framework that offers a method for evaluating net new quantity changes in land cover to determine the future SCRMP Restoration Alternatives' ecosystem services benefits.

B.3 Ecosystem Benefit Findings

B.3.1.1 Existing Conditions

Table B-7 presents the estimated economic benefit value of habitat and wildlife in the project area under existing resource conditions based on the estimated unit values determined above for forest, herbaceous and shrubland land cover.

Table B-7 Annual Benefit of Wildlife/Habitat – Existing Conditions

	Forest	Shrubland	Herbaceous	Total
Acreage – Existing	5,052	634	3,140	8,826
Benefit Value (\$/ac)	\$6,930	\$210	\$4,500	\$5,580
Total Benefits (\$M/yr)	\$35.0	\$0.1	\$14.1	\$49.3

Based on the EA's derived unit benefit values, the total economic value of the SCR riparian area's habitat and wildlife ecosystem services are estimated to be up to \$49.3 million per year.

B.3.1.2 SCRMP Alternatives

Annual net wildlife/habitat benefits represent gains from converting existing land cover into new habitat because of increased effluent flows in the project area. These annual net benefits are the incremental economic benefit generated by the restoration scenario relative to current conditions.

At this stage, the SCRMP does not identify specific restoration alternatives or improvements suitable for comparative assessment by the EA. During future SCRMP planning phases, the SCRMP team can apply the per acre benefit values to site-specific restoration scenarios that include changes to landcover.

When evaluating future benefits, the SCRMP team should note that benefits from restoration are expected to increase gradually over time rather than occurring immediately because riparian vegetation and habitat conditions need time to establish and mature. Early years may show limited gains while plant communities become established, but ecological functions such as habitat quality, shading, and bank stabilization typically improve as vegetation grows. As a result, the full suite of wildlife and habitat benefits is likely realized only over the longer term.

Given data limitations and the inherent challenges of valuing ecosystem services, the benefit estimate should be interpreted as an informed approximation rather than a precise measure. The results provide a useful indication of the scale and relative importance of benefits associated with restoring flows and habitat along the SCR. Specifically, these results can be compared with project costs to estimate the cost effectiveness of SCRMP interventions.

As discussed, ecosystem service values in this analysis are estimated using benefit transfer from studies conducted in regions with different climatic and environmental conditions. Since the Santa Cruz River is relatively arid in parts, these transferred values may overstate benefits if ecosystem functions differ from wetter systems. For example, the Land Trust Alliance tool valuations are significantly higher than other

source studies, and the backend inputs are not available to validate its unit values. This results in higher overall unit values, specifically for habitat and wildlife ecosystem services.

However, riparian ecosystems in arid landscapes are relatively scarce, suggesting that transferred benefit estimates may still be reasonable or even conservative. Additionally, the analysis does not include other ecosystem services such as aesthetic/amenity value, existence value, and research/education benefits. Considering stakeholder feedback that amenity improvements are highly valued for restoration alternatives in the SCRMP, this suggests that the estimated benefits may be reasonable given the other limitations.

B.3.1.3 Qualitative Benefits

Restoration of the SCR is intended to reestablish natural processes that support both ecological health and community well-being. Although these ecosystem services have not been quantified as part of this project, several are discussed in further detail in Section 4.

- *Improved Water Quality:* Restoration of natural channel form and riparian vegetation helps filter sediments, nutrients, and pollutants, resulting in cleaner surface and groundwater that benefits downstream users and aquatic life.
- *Cultural and Community Value:* River restoration can strengthen connections to place, supporting the cultural heritage of local and Indigenous communities and creating gathering spaces that foster community well-being.
- *Climate Resilience:* Vegetated riparian areas moderate extreme temperatures, provide shade, and buffer the river system against droughts and intense rainfall linked to climate change.
- *Enhanced Flood Protection:* Reconnected floodplains and natural riverbanks slow and spread floodwaters, reducing erosion and lowering flood risks to nearby communities and infrastructure during monsoon storms.

B.3.1.4 Summary of Findings

The estimated value of existing habitat and wildlife resources provides an important benchmark for understanding the scale of ecosystem services currently supported by the SCR corridor. Although the benefits of future restoration alternatives cannot yet be quantified, valuation of the SCR's existing conditions demonstrates that the SCR already generates substantial economic value - estimated at approximately \$49.3 million annually - through habitat provision, soil stabilization, air quality improvements, pollination, and other supporting ecological functions.

This baseline valuation illustrates the economic importance of maintaining reliable treated effluent flows to the river, as the existing riparian ecosystem is heavily dependent on effluent-supported surface water conditions in many reaches. Continued treated effluent discharges sustain vegetation communities and habitat functions that underpin these ecosystem services, while future increases in effluent flows could further expand and revitalize riparian conditions. The findings demonstrate both the value of the river's current ecological resources and the potential importance of protecting and enhancing treated effluent supplies as the critical basis of the SCR's ecosystem health, resilience, and associated economic benefits.

As future SCRMP alternatives are refined and landcover changes are quantified, this existing condition analysis can serve as the foundation for evaluating the incremental benefits and cost effectiveness of proposed restoration activities.

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Appendix C Recreation Use

Recreation is one of the most common ways for people to experience the natural world. These social interactions with ecosystems can derive from their multiple natural functions (i.e., habitat, food) and typically involve a wide array of activities, including trail walking, picnicking, and nature appreciation; or more specialized hobbies such as bird watching. FEMA classifies recreation and tourism as an information ecosystem service, grouped with other social factors including aesthetic value, existence value, cultural value, research, and education (FEMA 2022).

The Santa Cruz River (SCR) is a well-established and popular site for outdoor recreation in Arizona and is one of the top five water bodies most visited by state residents. In 2018, approximately 45,800 adult residents spent 199,000 recreation days along this water body, resulting in an average of 4.34 recreation Arizona adult resident recreation days (Audubon 2019).

C.1 Benefit Valuation Approach

C.1.1 Standard Methodologies

There are various approaches for quantifying user benefits from recreation. Direct market valuation of recreation user transactions is a commonly used and direct approach, reflecting the economic value of engaging in recreational activities. Examining spending patterns on entry fees, accommodation, and equipment purchases is a typical feature of market valuations. Many of these studies also consider the indirect and induced economic activity, jobs, and wages from spending related to recreational spaces, which are often presented in economic impact analyses.

Market values provide a useful and conservative valuation that does not fully account for the benefits that recreation generates. Nonmarket approaches, such as revealed and stated preferences methods, can be used to estimate the additional consumer surplus benefits obtained by recreational users. Consumer surplus is the net economic benefit that individuals enjoy: the difference between their willingness to pay and the price paid for recreation. Because this value cannot be directly observed in market transactions, these approaches allow for the estimation of an important dimension of economic value to more fully represent the welfare benefits of recreational experiences.

Table C-1 Recreation Use Primary Valuation Approaches

Method	Potential Application to SCR
Direct Market Valuation	
Market Price	Sales or purchases of goods and services with the purpose of recreating such as camping rental fees; hunting permits; and entry fees to parks, facilities, or private land
Production Approach	Net new economic contribution of recreation to overall economic activity, jobs, wages, and tax revenues in jurisdictions in the Santa Cruz Watershed
Revealed Preference	
Travel Cost	Costs incurred to be able to access, participate, or enjoy recreational activities especially travel expenses (e.g., fuel) and opportunity cost of time (e.g., foregone earnings)
Hedonic Pricing	Recreation-related premium or price uplift in nearby properties
Stated Preference	
Contingent Valuation	Explicit willingness to pay for the protection, restoration, or enhancement of natural areas for recreational use

Benefit transfer is a commonly used approach for quantifying recreation benefits, considering that primary valuation methods (identified in Table C-1) are often data-intensive and costly. Use and adaptation of findings and estimates from comparable analysis and published literature is an established method frequently used for project benefit valuation. Benefit transfer relies on carefully and correctly identifying source study information from relevant and comparable projects and modifying them (when necessary) for the subject study's circumstances. Benefit transfer can rely on a single value or a weighted average of multiple estimates of value or alternatively may use statistical modelling—including meta-analysis—to derive its recreation valuation (Rosenberger et al. 2017).

The Recreation Use Values Database (RUVd) is a prominent source for valuations using benefit transfer (Rosenberger 2025). The RUVd systematically reports more than 4,000 estimates of recreation use in North America on a per-person, per-activity-day basis, collected from more than 500 recreational studies. The database was initially created in 1984 and has since been updated eight times, allowing for comparability across four decades of knowledge.

For instance, the RUVd has been extensively by the United States National Forest Service (USFS) valuation of outdoor recreation. Estimates of economic benefits for 14 individual recreational activities at a national level by USFS region were derived from a meta-analysis of relevant RUVd data (Rosenberger et al. 2017). Table C-2 provides user benefit estimates for the Southwestern Region (Region 3), which includes the states of Arizona and New Mexico, focused on SCR-relevant recreational activities.

Table C-2 User Benefit Estimates, by Recreation Activity, Forest Service Region 3 (2025 dollars)

Primary Activity	Average Consumer Surplus (Per Person Per Primary Activity Per Day)
Backpacking	\$54.79
Biking	\$126.60
Developed Camping	\$58.10
Hiking	\$123.55
Nature-related	\$90.95
Picnicking	\$76.27

Source: Rosenberger et al. 2017

Note: Values converted to 2025 dollars, using the BLS CPI Inflation Calculator.

As noted in Appendix B, riparian forest is one of the dominant land cover types in the study area, especially along the SCR trails. However, it is important to consider the potentially significant differences between the SCR and national forests before using estimates from Table C-2 for a benefit transfer function. For instance, Forest Service Region 3 includes 11 forests with more than 1 million acres each, which is much larger than the forest area adjacent to the SCR. In addition, their federal designation as national forests denote their public importance as well as their potential access to a higher pool of resources for their protection. National forests typically serve recreational purposes that could increase their economic value, making comparisons with the SCR more difficult. Given the risk of overstating its value and the uncertainty about the specific conditions of the Santa Cruz River Master Plan (SCRMP)'s intervention areas and expected changes in recreation participation by activity, these estimates are not used for the EA.

C.1.2 Key Evaluation Factors and Considerations

C.1.2.1 Data Requirements

Comprehensive recreation analysis to understand current visitation and/or project expected future recreation use requires an understanding of the wider range of contributing factors that influence the recreation decisions of individual users that collectively determine visitation patterns. Characterizing and understanding the user demand motivations, experiences, and causality that determine visitation patterns is inherently difficult and incomplete. Nonetheless, past use trends and information from other

destinations can be applied to identify user responses and visitation changes that can be reasonably expected from recreation opportunities and experience changes.

Benefit valuation of existing recreation is fundamentally dependent on visitation data that describes the magnitude, type, and nature of users' onsite activity. Information on average user profiles and recreation behavior (observed or judgement based) can then be applied to those use levels to approximate their aggregated effects and better identify user groups. In addition, user demographic and origin/destination data can provide helpful descriptive and explanatory information on the current and potential future recreation visitor use patterns.

Projecting future visitor response and use levels from facility or resource changes is difficult and imprecise. It will require an understanding of several key aspects of the user population, recreation facility/resources, and their context in relation to other recreation destinations. More specifically, estimation of potential project-related recreation substitution effects that relocate existing (i.e., No Project) user visits will require assessment of user demand (including currently unmet latent demand), competing recreation destinations, and facility carrying capacities.

C.1.2.2 Assumptions and Limitations

The EA's recreation analysis relies on several underlying assumptions and limitations:

- Benefit valuation of the future high-flow scenario and SCRMP Restoration Alternatives conditions is predominantly focused on estimation of benefits from quantified changes in recreation use levels.
- Potential substitution impacts from SCRMP improvements on existing recreational locations in Santa Cruz County are qualitatively assessed.
- Future visitor responses to SCRMP-related improvements in recreation quality are not attributed. Ecosystem improvements to existing recreation areas can be expected to increase the quality of visitor experiences, which may be observed through changes in visitor satisfaction, activities, and/or length of stay. However, recreation valuations are generally unable to recognize any resulting increase in existing users' consumer surplus benefits. As a result, the economic benefits from any future project-related recreation resource quality enhancement will be limited to *new* visitor trips.
- The recreational use preferences and demand of SCR's current recreational users will remain generally unchanged in the future.
- The types of available SCR recreational opportunities will remain unchanged under future conditions. More specifically, current prohibitions on water-contact recreation in the SCR will remain in place.
- Existing and/or proposed recreation facilities can accommodate increased visitor use.

C.1.3 EA Methodology Review

The EA performed an extensive background and literature review to identify relevant studies for the recreation benefit analysis. The EA research of information databases and published studies focused on analyses covering national and state parks in Arizona (including Santa Cruz County) but also considered analysis of river-related recreation elsewhere in the western United States.

The valuation methods and key information sources selected and analyzed for potential use in the EA's methodology and benefit estimates are discussed in the following sections.

C.1.3.1 Market Prices

Market transactions can provide relevant information about consumers' willingness to pay to recreate. This approach was considered, but ultimately not applied, for estimating a baseline value of SCR recreation use. Fee-paying visitors of the Tumacácori National Historic Park (NHP) and Tubac Presidio State Historic Park (SHP) are granted access to SCR adjacent SCR riparian areas of cottonwood-willow forest. However, public access is also widely available along most the SCR riparian corridor, including its well-vegetated area.

Use of park fee revenues should also distinguish between those user benefits most attributable to historical/cultural visitation and those related to SCR recreation. Nonetheless, market prices can provide a conservative indication of visitor use benefits.

C.1.3.2 Production Approach

SCR is an important outdoor recreation destination and visitor attraction for Santa Cruz County. Duval et al. (2021) conducted an economic impact study of Santa Cruz County's nature-based tourism, nature-based industries, and conservation, restoration, and preservation—which, collectively, represent the County's nature-based restorative economy. Recreation was analyzed as a component of Santa Cruz County's nature-based tourism industry and was quantified using public data and IMPLAN input-output modeling to estimate direct, indirect, and induced economic effects (e.g., employment and income).

Using survey data on water-based recreation, Duval et al. (2021) estimated that SCR visitors from Arizona in 2019 spent \$3.2 million, of which fuel (\$1.4 million) and groceries (\$0.6 million) were the largest components (Duval et al, 2021). Furthermore, through semi-structured interviews with key stakeholders, this report assessed the value of conservation, restoration, and preservation by computing the operational and project-level expenses incurred by entities involved in these activities. Notably, the SCR has concentrated restoration activities in the County, especially watershed and habitat restoration (Duval et al, 2021).

These estimates provide a measure of the relative importance of recreation as an industry. However, similar to market price valuation, the production approach provides only a partial accounting of user's recreation benefits. As acknowledged by the authors, these calculations do not capture nonconsumptive use and non-use values of recreation (Duval et al, 2021). As a result, using this approach, the benefit valuation will generally understate user benefits from recreation. This effect will likely be more pronounced in cases such as SCR, where nonconsumptive recreational activities like birdwatching are an important and growing component of existing and future recreation.

C.1.3.3 Travel Cost

Outdoor recreation along the SCR requires investments beyond any potential admission fees. Visitors incur travel-related costs to be able to participate in activities such as hiking, cycling, picnicking, or wildlife watching. In choosing the SCR, visitors implicitly indicate that they value this recreational experience at least as much as the associated participation costs. These costs not only include transportation and fuel expenses, but also the opportunity cost of time (e.g., income foregone while engaging in recreation). Therefore, this approach can capture a dimension of value that is overlooked from conventional market valuation methods.

In Arizona, travel cost studies have been conducted to estimate the value of important recreational areas: Weber and Berrens (2006) investigated visitor patterns in the Aravaipa Canyon Wilderness in the Sonoran Desert, while Duval et al. (2020) measured the economic benefits of the main trails across the state. These studies are summarized in subsequent sections, along with a discussion about their relevance for the SCR.

C.1.3.4 Benefit Transfer Approach

The EA uses a benefit transfer approach to determine the SCR recreational benefits. A comprehensive literature review was conducted to identify relevant recreation benefit studies in semi-arid riparian ecosystems, including available resources from the Santa Cruz Watershed Ecosystem Portfolio Model (SCWEPM) and the RUVD (Rosenberger 2025). Norman et al. (2013) underlined the importance of maintaining 15 mgd of effluent releases to SCR, to avoid potential negative impacts on SCR's recreational areas such as Audubon's Important Bird Area, Tubac Presidio SHP, and Tumacácori NHP.

Weber et al. (2015) also analyzed the role that recreation may have in the willingness of Tucson and Phoenix residents to pay and support SCR management. Respondents were for the most part supportive of increased water flows and forest cover but appeared to place a lesser importance on recreation. Improving water quality to allow for full body contact was not a significant predictor of WFP, likely due to respondents' distrust of treated wastewater. A similar safety concern was the most important theme in separate interviews and focus groups with nearby residents, who also positively valued SCR's recreational amenities (Weber and Ringold 2015).

Although informative, these studies do not provide monetary estimates of SCR recreation benefits. Except for the analyses discussed above, no other Santa Cruz County specific recreation benefit studies were found in the EA's background and literature research efforts. As a result, the EA uses a set of reference studies selected based on their geographical relevance, recreation focus, or more generalized and common use for recreation valuation.

The EA selected reference studies used by the recreation benefit valuation are shown in Table C-3. The studies are arranged in order of importance, with the least applicable source shown last. The EA relies on these consumer surplus estimates to derive a more comprehensive representation of the benefits that individuals gain from current SCR recreation (Rosenberger et al. 2017).

Table C-3 Recreation Benefit Valuation Studies and Estimates (2025 dollars)

Source	Study Area	Average (Low/High)	Notes
Weber and Berrens (2006)	Aravaipa Canyon Wilderness, Arizona	\$41.72 per person day (\$28.44/\$61.35)	This study is geographically relevant due to its focus on a riparian area with instream flow in the Sonoran Desert and presence of cottonwood-willow trees. It uses a zonal travel cost model to estimate recreation trip demand, based on census data and available Bureau of Land Management permit records. Recreational uses include hiking, backpacking, wildlife watching, and hunting. Included in the RUVD.
Duval et al. (2020)	Arizona	\$73.42 per person day (\$63.49/\$90)	This is a travel cost method study of state residents' use of 25 trail sites in Arizona, including Green Valley in Santa Cruz County. Estimates are shown for nonmotorized trail use. Although results are not disaggregated by site or activity, this study is relevant due to its focus on trails, which are among the main forms of recreational use along the SCR. Included in the RUVD.
Loomis and Bair (2023)	Intermountain Region	\$63.24 per visitor day	This study provides the average economic value for general freshwater-based recreation in the Intermountain region (Rocky Mountains/Cascade and Sierra Nevada mountain ranges), based on 21 estimates and using multiple valuation methods. The study includes a combination of water-related (i.e., swimming, fishing, and boating) and near-water shore-based (i.e., picnicking) recreation. This study serves an illustrative purpose, although its relevance may be medium for SCR due to potential differences in water quality standards and recreational uses.
United States Army Corps of Engineers (2026)	United States	\$10.66 per recreation visitor day (\$5.33/\$15.99)	This study provides estimates for general recreation. It is the standard source for measuring potential recreational benefits of projects in the United States. Based on expert or informed opinion, values vary depending on a project's total score in recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental quality. Although this source allows for comparability, its importance may be lower in the context of the SCR, given its generalized approach across ecosystem types.

Note: All values are shown in 2025 dollars using the BLS CPI Inflation Calculator, when appropriate.

These values were considered to estimate the benefit value of SCR existing recreational use. It was generally assumed that the estimates represented the per-visit, per-person value of recreation.

C.1.4 Selected Methodology

As discussed in Section C.3.4, the EA uses a benefit transfer approach to determine the recreational benefits from the SCR. Overall, studies shown in Table C-2 represent relevant source studies for a benefit transfer function. However, it is important to understand how these can be applied to the current and expected conditions of the SCR in detail.

Weber and Berrens (2006) stands out as a relevant source due to its geographical focus; it is one of the very few recreation valuations conducted in a water body in the Sonoran Desert. Its use of travel cost

methods allows for the quantification of consumer surplus, which could represent a more comprehensive value estimate. Having said that, its focus on the Aravaipa Canyon Wilderness could pose certain challenges. Unlike the SCR, this site enjoys a perennial stream and potentially better scenery. These characteristics could positively influence the length and quality of the recreational activities it can support. Given the recreational use of the SCR in Santa Cruz County, applying the average economic benefit from the Aravaipa Canyon Wilderness could overstate the value of the SCR.

With most recreational activities in the SCR happening in its adjacent trail, Duval et al. (2020) is a relevant source for quantifying the value of nonmotorized trail activities. Green Valley in Santa Cruz County is considered, but this study provides aggregated average values for a sample of 25 trail use areas in Arizona, ranging from a 21.4-mile trail in Quartzite to notable natural areas like the Grand Canyon Area or large urban centers such as Phoenix. This poses important challenges to fully gauge whether the use of these estimates may be a good representation of recreation along the SCR. However, upon comparison with the three other relevant source studies, Duval et al. (2020) is at the higher end, suggesting a potential overstatement if applied to the EA.

Loomis and Bair (2023) pose a similar difficulty. Although geographically relevant, its applicability to the SCR may be limited due to the potential differences in water quality standards and recreational uses of the study areas considered for the larger and more diverse Intermountain Region, as well as the focus on freshwater-based recreation (which could have a higher value than [treated] wastewater-based recreation).

Lastly, United States Army Corps of Engineers (USACE) Unit Day Value (2026) estimates for general recreation are more widely accepted for the assessing recreation benefits. This generalized approach provides a relatively quick way of comparing and evaluating multipurpose initiatives. However, the USACE method is inherently subjective because it relies heavily on point assignments that reflect the evaluator's judgment rather than purely quantitative measures. As a result, outcomes can vary significantly depending on how the user interprets project features and allocates points to different impact factors. The SCR has a special importance in Santa Cruz County as its only major river and a primary recreation location. Securing continuous perennial water flows, which is the main component of the SCRMP, suggests the significance of water scarcity as a challenge in this semi-arid area. Therefore, using the midpoint value estimate of \$10.66 per recreation visitor day should be interpreted as conservative. As the SCRMP progresses, the appropriateness of this value could be revised in the future based on the SCR's score on recreation experience, availability of opportunity, carrying capacity, accessibility, and environmental quality.

C.2 Resource Conditions

C.2.1 Existing Conditions

Although SCR is largely surrounded by private lands, the river can be publicly accessed at multiple locations and several trails allow visitors to traverse and recreate within the SCR riparian areas. As noted in Section 3.1, the EA's project area generally conforms with the SCR riparian corridor where most of the SCRMP Restoration Alternatives direct physical resource impacts are expected to occur. The width of the riparian corridor in Santa Cruz County varies with geography but generally extends as a 0.25-mile buffer area to the river.

SCR currently supports several outdoor recreational activities, including walking/hiking, bicycling, camping, picnicking, and nature viewing. In addition, numerous areas along the SCR are popular wildlife and bird-watching sites due to considerable biodiversity in its riparian areas.

There are very limited available visitor data on recreation use in the SCR. The most recent estimate of the SCR visitation is for 2018, when approximately 45,800 adult residents spent 199,000 recreation days along this water body (Audubon 2019). As a result, the EA's recreation analysis uses the 2018 Arizona resident water-based outdoor recreation participation along the Santa Cruz River in Santa Cruz County to establish baseline recreation use, resulting in an average of 4.34 annual recreation days per adult recreationist.

It is assumed that SCR recreation use has since increased pro rata with the County's population and that user recreation participation rates have remain unchanged. Based on this assumption, it is estimated that approximately 50,465 state residents spent 219,268 recreation days along the river in 2025, for an average of 601 recreation visits per day. This does not account for out-of-state visitors and should therefore be considered a conservative estimate of total visitation for recreation purposes.

The Juan Bautista de Anza National Historic Trail (Anza Trail) is the primary recreation destination in the SCR project area. The Anza Trail extends more than 1,200 miles from Sonora, Mexico, through Arizona and on to California (National Park Service 2025). In addition to its historical and cultural importance, the Anza Trail has approximately 300 miles of certified recreation trails across its full extent in the United States (National Park Service 2024), which are maintained and operated independently of the National Park Service (NPS).

Figure 1. Project Area Recreational Sites



Note: 'Trails' and 'Project Area' were provided by Kimley-Horn.

In Santa Cruz County, the trail section beginning near the Nogales International Wastewater Treatment Plant (NIWTP) in Rio Rico runs along or close to SCR for most of its northerly route through to Pima County. The Anza Trail Coalition of Arizona manages approximately 15 miles of the Anza Trail in multiple segments, which provide public access to the riparian areas for hiking, cycling, camping, and birdwatching.

The Anza Trail includes a popular 4-mile trail, with cottonwood-willow riparian forest and mesquite bosque, that connects the Tumacácori NHP and Tubac Presidio SHP (National Park Service 2024), with both parks having fee-based admission to their attractions and facilities. This segment extends northward for another 2 miles through Tucson Audubon's Esperanza Ranch conservation easement. Together, these sections provide visitor access to a 6-mile section of the SCR riparian corridor designated as the Important Bird Area (IBA) of Upper Santa Cruz River (Arizona Game and Fish Department 2026). It is assumed that most of the recreation along the SCR occurs in or close to the Anza Trail.

User access to the De Anza trail is uneven and varies along its route. Northern sections of the trail are generally more accessible and open to the public while it is currently more limited to its southern portions. Interpretive signage, guideposts and fingerposts are currently located within most of the trail network. The SCRMP determined that trailheads are generally in fair to good conditions while wayfinding posts were observed as poor to fair conditions (Kimley Horn 2026).

The SCRMP recognizes birding as a major driver for outdoor recreational activities within the SCR riparian corridor particularly in the Tubac and Tumacácori-Carmen area at locations such as Santa Gertrudis Lane. This area provides the space and habitat for many migratory and resident bird species throughout the seasons, drawing a large community of birders to these recreational areas. These areas are also frequently used by hikers and equestrians (Kimley Horn 2026).

Other recreation and visitor destinations in the project area include the following:

- *Tumacácori NHP*: The park consists of 360 acres and includes the ruins of three Spanish mission communities, two of which are National Historic Landmark sites. The Tumacácori Museum (also a National Historic Landmark) also provides interpretive services to park visitors. Over the last years, park visitation has averaged 36,810 per year (NPS 2026).
- *Tubac Presidio SHP*: The park consists of an 11-acre park with eight gardens. There are several historic buildings and the Griffin museum. In 2024, there were 7,256 park visits.
- *Tubac Golf Resort and Spa*: The resort includes a historic hotel and 27-hole golf resort located on 500 acres along the west of the SCR in Tubac. The resort is listed by the Historic Trust for Historic Preservation. Access to the property is limited to resort guests.

C.2.2 SCRMP Resource Impacts

Enhancement of SCR's current recreational areas can be expected to improve recreational experience quality for their existing users. The future value of the SCR corridor's recreation resources to its existing users could be enhanced if: (1) perennial reaches are sustained over a longer portion of the year (i.e., reduced dry season); (2) species diversity (especially birds and endangered species such as the Gila Topminnow) is increased; and (3) quality is enhanced/encourages future recreation use, including through larger or improved facilities.

Because the extent of new visitation following river restoration remains unknown. It is important to emphasize that changes in recreation used resulting from river restoration may vary greatly, depending on the specific characteristics of the restoration project, accessibility, carrying capacity, and availability of recreational facilities and activities. In the context of the SCR, an uplift in recreation participation could result from quantity changes to its recreation resources (e.g., trail expansion or possibly the quality of its recreation resources and visitor experiences, such as more visually appealing or more shaded trails).

C.2.2.1 Increased Supplied Effluent

The extent to which increases in SCR future flows and hydrogeologic improvements would result in enhanced recreational user experiences and related changes in SCR recreational use is uncertain.

Between 2018 and 2023, annual minimum river flows have ranged between 14 and 17 miles at different times each year, with river extent consistently reaching Tubac (Sonoran Institute 2025). Estimated baseline visitation data for 2025 assumes that the river extent remains constant. Therefore, the resulting valuation analysis does not account for future changes in effluent releases from the NIWTP, nor shifts in biophysical, economic, or behavioral drivers of recreational demand along the Santa Cruz River.

C.2.2.2 Restoration Alternatives

Although additional water quantity may in and of itself have minor effects, recreational use could benefit from additional measures that could enhance the overall user experience. Future implementation of SCRMP restoration concepts is expected to improve river conditions and expand recreational and educational opportunities. Targeted improvements—such as enhanced signage, wayfinding, and amenities (e.g. restrooms at Guy Tobin and/or Palo Parado trailheads) would improve usability and overall visitor experience. Improvements to the conditions of the trailheads and specific section of the De Anza trail in need of minor improvements can be expected to increase future visitor use. While the Guy Tobin and Palo Parado trailheads are in good condition, but updates to informative signing and wayfinding as well as installing bathrooms could greatly increase these areas' attractiveness to visitors. The SCRMP's stakeholder advisory group also identified multiple informal access points, such as Santa Gertrudis Lane, that could benefit from formal trailheads (Kimley Horn 2026). Santa Cruz County is currently studying pedestrian and recreation connectivity along the SCR corridor.

Improved waste management practices, especially trash in several segments of the SCR, could translate into more scenic and pleasant trips. If combined with better odor control methods for wastewater, these actions could ameliorate the naturalistic experience, attract a greater number of visitors, and increase future visitor use level even greater than the use growth scenarios identified above. Additional gains could be expected if river restoration includes changes in infrastructure, such as increasing the number of camping facilities, trailheads, or surrounding parking areas, as well as improving the connectivity of the Anza Trail.

C.3 Recreation Benefit Findings

C.3.1 Existing SCR Recreation

Consumer surplus is the primary unit of measurement for estimating the economic value of SCRMP-related recreation. Table C-4 presents the estimated annual recreational benefit value of the SCR current recreational use based on the EA's selected unit benefit valuation of \$28.44 per recreation day. Total recreation benefits represent the benefit that users currently gain from recreational activity in the SCR riparian area.

Table C-4 Recreation Benefit Valuation – Existing Use

Annual Use (Recreation Days)	Recreation Benefit Value
219,268	\$6,237,000

Note: The recreational benefit value is rounded to the nearest thousand.

C.3.2 SCRMP Alternatives

Since the expected new visitation following river restoration remains unknown, the EA presents results for hypothetical scenarios in which recreational visits increase by 5 percent, 10 percent, and 15 percent. It is important to emphasize that changes in recreation demand because of river restoration may greatly vary, depending on the specific characteristics of the SCRMP restoration improvements, accessibility, carrying capacity, and availability of recreational facilities and activities. In the context of the SCR, an uplift in

recreation participation may be driven by changes in trail length and quality for supporting recreational activities (i.e., shaded infrastructure for picnicking). It must therefore be noted that any significant improvements in the recreational experience could result in larger increases in net new recreation than the conservative range used in this EA.

This recreation valuation is based on the lower-bound estimate (\$28.44) from Weber and Berrens (2006). Using this conservative value provides a reasonable basis for the quantification of the economic benefits of the SCR. Despite its physical differences with the Aravaipa Canyon Wilderness, this study may capture a significant part of the intrinsic value of a river in a water-scarce area such as the Sonoran Desert. Unfortunately, no other river recreation analyses more comparable to the SCR were identified.

As human and climatic pressures on waterbodies across the Sonoran Desert and Arizona have intensified since the publication of the study, Weber and Berrens (2006) may understate *current* recreational value. While not strictly focused on river-related recreation, the estimate used by the EA is only 55 to 60 percent lower than average value found by Duval et al (2020) and Loomis and Bair (2023), suggesting that Weber's valuation may be a conservative measure of river-related recreational benefits.

Using the EA's selected unit benefit valuation of \$28.44 per person per day, future net benefits are estimated to increase between \$312,000 (+5 percent increase in recreation days) and \$936,000 (+15 percent) for Arizona state residents. These estimates are presented in Table C-5.

Table C-5. Recreational Benefits – Future Recreation Use Growth Scenarios

Scenario	Recreational Use Growth Scenario		
	5% Increase	10% Increase	15% Increase
<i>Annual Change in SCR Recreation Use</i>	10,963	21,927	32,890
Unit Benefit Value = \$28.44	\$312,000	\$624,000	\$936,000

Note: Benefit values are rounded to the nearest thousand.

It is important to note that these benefits might not occur immediately and could instead materialize gradually over time, depending on the visitor responses to future SCRMP restoration improvements.

C.4 References

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Appendix D Property Benefits

Riparian corridors can provide a variety of benefits to nearby landowners. Well-vegetated areas can support diverse birds and wildlife. Homeowners enjoy scenic views, open space, and bird and wildlife viewing. Riparian trees can provide shade and provide a buffer from urban or roadway noise. Rivers and the adjacent riparian areas they support are commonly recognized as desirable amenities that positively contribute to residents' quality of life and sense of place.

The value that homeowners place on living close to riverways is commonly demonstrated in the housing market by the price premium during house purchases. The uplift effect on home prices from river proximity is typically recognized as a one-time price increase based on the river's presence. However, it might reasonably be expected that substantial improvements to the riparian corridor's quality would increase the market desirability of adjacent properties and would similarly increase the price premium future home buyers would be willing to pay.

As discussed in the following sections, increased property values will also result in higher San Cruz County property tax revenues.

D.1 Benefit Valuation Approach

D.1.1 Standard Methodologies

The value that homeowners place on living close to riverways is commonly demonstrated in the housing market by the price premium paid during house purchases. The most direct method for estimating resource-related effects on property values is the use of hedonic price analysis. Hedonic price analysis is a regression-based economic valuation method to separate the implicit price of a consumer good's key attributes; it is a revealed preference method that measures the economic value to customers based on their observed sales transactions.

Project- and/or location-specific hedonic analysis requires extensive econometric analysis of large datasets of real estate sales and property information. Consequently, most hedonic pricing analyses of resource-related property impacts are academic studies.

As a result, a benefit transfer approach is commonly used by non-academics when estimating project-related property benefits. As discussed in Section 2.1 of the Environmental Assessment (EA), the benefit transfer approach applies values obtained from other applicable studies and/or comparable projects to determine the benefit values for the subject project, with adjustment when necessary to better correspond with specific circumstances.

D.1.2 Key Evaluation Factors and Considerations

D.1.2.1 Data Requirements

The EA primarily relies on Santa Cruz County assessor data to identify the number of homes and property values within 1.1 miles from Santa Cruz River (SCR) riparian areas. Benefit transfer studies frequently use a county median home value for a representative single-family home as the basis for their estimate of property uplift benefits. However, the EA uses individual assessed home values by location to more precisely estimate the property effects within each distance interval and across different communities.

D.1.2.2 Assumptions and Limitations

The assessed value is based on the property's prior purchase price—with subsequent adjustments to account for interim market changes determined by the County Assessor, frequently based on the rate of inflation. As a result, unless the specific property has been recently purchased, a home's assessed value may not accurately represent its actual market values and interim changes in the local housing market conditions. For homes that have been off market for extended periods, their assessed value may differ from the market sale price. Depending on the applicable interim housing market conditions, assessed home values may be expected to undervalue or overstate SCR's property increase benefits to local homeowners.

The EA's evaluation of potential property-related impact from the Santa Cruz River Master Plan (SCRMP) Restoration Alternatives primarily focuses on determining the SCR's current value, with its current year-round flows largely supported by the 14.8 million gallons per day (mgd) of treatment effluent supplies from the Nogales International Wastewater Treatment Plant (NIWTP). In absence of those supplies, it is assumed that the SCR presence and its supported riparian vegetation and other current amenity benefits (e.g., visual and sense of nature) would otherwise be severely reduced and would greatly diminish the property benefits to surrounding landowners. Note that the uplift benefit is based on effects on homeowners and does not include any such effects on commercial businesses (e.g., Tubac Golf Resort).

Relatedly, the EA does not attribute any additional property value uplift impacts from SCRMP-related future improvements to SCR's flow conditions, riparian ecosystem enhancement, or quality improvements to its other amenities. This may be considered a conservative assumption if future SCRMP restoration results in substantial and long-lasting improvements to the SCR riparian corridor that increase the desirability and market demand for housing in Santa Cruz County.

Finally, it should be noted that there is potential for some double counting of benefits to the extent that home buyers may also be recognizing in part the value of SCR's recreation and/or its habitat/wildlife amenities that are valued separately in Sections A.2 and A.3 of Appendix A. However, the extent of any such double-counting will be reduced to the degree that the price premium reflects SCR-related other effects (e.g., visual/scenic and sense of place) rather than any expected recreation or habitat use benefits to home buyers.

D.1.3 Selected Methodology

AECOM conducted an extensive literature search to identify river-related property impact analysis studies for review as possible reference studies. Reference studies were selected that included quantified economic valuation findings determined to be applicable to the SCRMP. A primary focus was to identify analysis of SCR and other Arizona river areas. Other recent out-of-state studies were also selected as reference studies. Notably, a recent 2019 study specifically analyzed the property impacts from 209 stream restoration projects in Oregon across their before, during, and post-project conditions for a variety of land use and condition factors. The study observed property impact variability across the project phases, with generally positive property effects when mature post-project conditions are achieved (Netusil 2019).

Table D-1 provides summary information on the reference studies used to determine the methodology for the EA's valuation of the SCRMP-related property benefit.

The EA uses a benefit transfer approach to estimate the potential property benefits from the current SCR corridor conditions and its future enhanced conditions, based on: (1) additional 15 mpg of supplied effluent under the future SCRMP high increased flow scenario; and (2) effects of SCRMP restoration improvements.

Table D-1 Property Benefit Reference Studies

Study/Tool	Description of Approach	Findings	Notes
SCR Watershed			
Bourne 2007	Hedonic analysis of home prices in Rio Rico and Tubac	0.2% to 5.8% home price premiums within 1.1 miles of SCR riparian corridor	Findings for project area homes; price effects determined at 0.1-mile intervals
Arora 2012	Hedonic analysis of home prices in upper SCR watershed, with GIS analysis of habitat, biodiversity, land cover/ownership, and other amenities	Observed increased house prices values for homes near (1) species-rich habitat; and (2) public land access or undeveloped private lands	No quantification of property impact, but biodiversity found to be a significant factor
Colby 2002	Hedonic analysis of 7,659 homes in Tucson, Arizona, within 2.5 miles of riparian areas	Up to 6% price increase for homes within 1.5 miles of river	Results comparable to Bourne 2007
Norman 2013	Evaluated land prices based on SCWEPM – MLP model	3.1% price increase for parcels within 1.1 miles of SCR	SCWEPM – MLP model no longer available
Bark-Hodgins 2005	Hedonic analysis of Tucson, Arizona, home sales within 0.2 mile of 51 riparian sites	20% price premiums for homes within 0.2 mile of well-vegetated riparian areas	Uplift effects higher than most other studies
Bark 2008	Hedonic analysis of Tucson, Arizona, homes at 51 locations	Est. 4.1% increase for homes within 0.2 mile	Results comparable to Bourne 2007
Out of State			
Netusil 2019	Hedonic analysis of 209 stream restoration projects in Oregon of numerous attributes to homes within 0.5 km (0.32 miles) for pre-project, project, post-project, and mature phases	Mature restoration effect of ~3.8% for instream but decrease for stream side between 0.25 and 0.5 km; increased recreation access results in 6.3% to 7% increase	Results specifically for river restoration projects show impact variability over time; mature phase results comparable to Bourne; analysis limited to 0.32 mile from the river
Towe 2021	Hedonic analysis of home sales in Baltimore County, Maryland	15% in property appreciation (<1,000 feet) and 11% (<2,000 feet).	Greater property uplift findings may be related to local housing conditions

Notes:

GIS = Geographic Information System

km = kilometers

SCR = Santa Cruz River

SCWEPM – MLP = Santa Cruz Watershed Market Land-Price Submodel

After assessment of the studies in Table D-1, Bourne 2007 was selected as the basis for the EA valuation of the SCR property benefits. A primary consideration for selection was its specific assessment of SCR conditions to home prices in the Rio Rico and Tubac communities. In addition, the analysis provides graduated price impacts at 0.1-mile intervals, and its findings are generally comparable and consistent with other studies.

D.2 Resource Conditions

D.2.1 Existing

AECOM conducted preliminary geospatial analysis and identified 380 single-family homes within 1.1 miles of the SCR. Table D-2 shows the number of identified properties at 0.1-mile intervals from the SCR. Table D-2 reports the number of homes within each distance interval, along with their aggregated assessed value. The property benefit factor for each interval is also shown, with the estimated total property value increased attributed to the SCR.

GIS analysis identified 364 homes within a mile of SCR. This number includes homes in northern Santa Cruz County, where SCR may not currently flow year-round. The properties evaluated represent approximately 2.5 percent of the total single-family homes in the county. Nearly half of the homes are in Tubac, and about 31 percent of the homes are in Rio Rico. It is also notable that most (65 percent) homes are within 0.5 mile of the river.

Table D-2 Property Data of Single-Family Homes near Santa Cruz River

Distance to SCR (miles)	Number of Properties	Average Parcel Size (acres)	Average Assessed Value	Riparian Premium (%)	Property Value Increase per Home	Total Increase in Property Value
0.1	32	10.6	\$331,432	5.8%	\$19,200	\$614,400
0.2	62	1.9	\$446,206	5.2%	\$23,300	\$1,444,600
0.3	52	2.4	\$368,089	4.7%	\$17,100	\$889,200
0.4	61	3.9	\$420,160	4.1%	\$17,200	\$1,049,200
0.5	28	4.8	\$344,177	3.5%	\$12,100	\$338,800
0.6	37	4.5	\$332,818	3.0%	\$9,800	\$362,600
0.7	21	4.0	\$316,523	3.0%	\$9,300	\$195,300
0.8	31	5.0	\$349,566	1.8%	\$6,400	\$198,400
0.9	26	2.9	\$365,038	1.3%	\$4,700	\$122,200
1	14	4.4	\$344,752	0.7%	\$2,500	\$35,000
Total	364	4.1	\$375,800	3.8%	\$14,400	\$5,249,700

Sources: Bourne 2007, UrbanFootprint 2026

Note: Riparian price premiums are based on Bourne (2007). Property value increases are rounded to the nearest hundred.

D.2.2 SCRMP Impacts

Under the SCRMP future high-flow scenario, effluent flows into the SCR would increase by 15 mgd, resulting in total effluent inflows of nearly 30 mgd. In addition, restoration improvements would be made to improve SCR hydrology and/or enhance the ecosystem conditions in sections of the SCR corridor. Together, these SCRMP improvements may result in substantial quality enhancement to the existing resource conditions in the SCR corridor.

In addition, the increased total effluent flows to the SCR may be expected to have a noticeable change in SCR conditions because perennial flows might be expected to extend farther downstream from Tubac, where it is usually dry during the late summer months.

D.3 Property Benefit Findings

D.3.1 Existing Conditions

As discussed above, the EA used Santa Cruz County parcel data to identify homes and property values within a 1.1-mile distance from SCR riparian areas. As shown in Table D-2, the EA estimated that a \$5.3 million one-time property value increase can be attributed to the SCR. Furthermore, as discussed in Section A.1 of Appendix A, this benefit can reasonably be fully attributed to the effluent supply.

This property uplift also results in secondary benefits on Santa Cruz County through property tax collections. Based on the current property tax rate of 0.8 percent of assessed home values, the current SCR-related property taxes benefits for Santa Cruz County are estimated to total \$42,400 per year.

D.3.2 SCRMP Alternatives

However, as discussed in Section A.1.2.2 of Appendix A, the EA does not attribute any additional property benefits from SCRMP restoration improvements, even though the enhanced environmental amenities (e.g., improved water quality, scenic views, restored habitat, and increased recreational opportunities) might be expected to increase the market desirability and price premiums that future home buyers would be willing to pay.

D.4 References

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Appendix E Case Studies

E.1 Approach

The purpose of the case study analysis is to identify and review comparable published economic analyses for river restoration projects to understand their valuation approaches with the aim of determining their applicability and findings and inform the Santa Cruz River Master Plan (SCRMP) Economic Analysis (EA).

The projects examined by the EA the case study analysis were selected as potentially representative and informative methodological and contextual analogs to this stretch of river, with each contributing specific lessons about how ecosystem service values can be estimated, used for economic benefit valuation and applied to managed or restored riparian systems under varying flow conditions.

E.1.1 Selected Case Studies

The Santa Cruz River (SCR) between Nogales and Green Valley is distinctive within the Southwest as an effluent-sustained riparian corridor of cottonwood (*Populus fremontii*)-willow (*Salix* spp.) forest passing through a binational watershed, Tumacácori National Historical Park, and a variety of rural and Indigenous communities. AECOM reviewed publicly available literature as well as SCR-specific documents and studies provided by the Sonoran Institute. Although, no single study fully addresses the SCR context and conditions, the following reports we reviewed as cases study examples for the EA:

SCR-specific Studies

- Weber & Ringold, Priority River Metrics for Residents of an Urbanized Arid Watershed, 2015.
- Norman et al., Santa Cruz Watershed Portfolio Model (SCWEPM), 2013.
- Tucson Water, Santa Cruz Heritage Project, 2019–present

Other Southwest Studies

- Bagstad et al., Ecosystem Services Valuation to Support Decision Making on Public Lands - A Case Study of the San Pedro River Watershed, 2012.
- Bagstad et al., A Comparative Assessment of Decision-Support Tools for Ecosystem Services Quantification and Valuation, 2013.
- Batker et al., Earth Economics, Nature's Value: Colorado River Basin, 2014.
- Wang et al., Perceived Economic Value of Ecosystem Services in the US Rio Grande Basin, 2021.

E.2 Case Studies Summary

Evaluation methods vary widely between the studies, and include quantitative modeling, specialized spatial tool analysis, benefit transfer, willingness-to-pay surveys, and qualitative approaches. Only a few studies included binational perspective and/or recognized cross-border issues between US and Mexico communities. Effluent supplied and managed flows were components of the valuation scenarios for only the SCR-related analyses.

For each case study, a summary profile identifying key similarities and differences from the Santa Cruz River corridor is provided in Table E-1 and E-2, followed by the specific lessons incorporated into this case study's approach.

Table E-1 Case Studies Analyses Overview

Attribute	SCR-Specific Studies			Other Southwest Studies			
	Weber & Ringold 2015	Norman et al. 2013	Tucson Water 2019–present	Bagstad et al. 2012	Bagstad et al. 2013	Batker et al. 2014	Wang et al. 2021
Geographic Focus	Two effluent-sustained reaches: Tumacácori (south) and Marana (north)	Full Santa Cruz Watershed; binational U.S.–Mexico	Heritage Reach in Tucson, AZ.	San Pedro watershed, SE AZ & N. Sonora	Upper San Pedro River, U.S. portion	Colorado River Basin	U.S. Rio Grande Basin (CO, NM, TX)
Primary Method	Willingness to pay (WTP) survey; econometric modeling	SCWEPM; GIS multicriteria; three linked sub-models (ecological, well-being, real estate); SWAT; hedonic pricing	No formal Ecosystem Services Valuation (ESV) method applied	Multi-tool: value transfer, ARIES, InVest, and Wildlife Habitat Toolkit	Comparison of ARIES and INVEST models	Benefit transfer	WTP mail survey
Resource Benefit Valued							
Water / Groundwater	✓	✓	✓	✓	×	✓	✓
Habitat / Biodiversity	✓	✓	×	✓	×	✓	✓
Recreation	✓	×	×	×	×	✓	✓
Carbon / Climate	×	×	×	✓	✓	✓	×

Note: SWAT = Soil and Water Assessment Tool InVEST = Integrated Valuation of Ecosystem Services and Tradeoffs Tool ARIES = Artificial Intelligence for Ecosystem Services Tool,

Table E-2 Applicability and Key Limitations

Attribute	SCR-Specific Studies			Other Southwest Studies			
	Weber & Ringold 2015	Norman et al. 2013	Tucson Water 2019–present	Bagstad et al. 2012	Bagstad et al. 2013	Earth Economics 2014	Wang et al. 2021
Project-level. Economic Valuation Applicability	- WTP results not fully published - Format not compatible with benefit transfer - Finding that low public awareness of effluent flows has implications for EA use of recreation and aesthetic values	- Index-based outputs not convertible to \$/acre/year values - Effluent reduction scenario findings provide qualitative directional support for EA scenario framing - Used selectively as an EA source study	- No formal ESV or BCA published. - Ecological monitoring data represents the richest available baseline for SCR corridor and provides strongest foundation for future valuation work	- Outputs not in \$/acre/year format compatible with benefit transfer methodology - Findings inform tool selection rationale and regional habitat context only	- Change-based scenario outputs not convertible to standing per-acre values - Carbon reliability finding informed service selection in EA	- Per-acre values from supplemental tables used where Arizona or SW-specific data was unavailable - Geographic relevance as SCR is within the Lower Colorado Basin - Used selectively as an EA source study	- WTP format not compatible with benefit transfer \$/acre/year output - Highlights gap in cultural and existence values not addressed in EA
Key Limitations	- Results not fully published - WTP not BCA-ready - Low public awareness of effluent-fed flows suggests recreation and aesthetic values derived via benefit transfer by EA may be conservative.	- Index-based outputs - Monetization layer not completed - Tool development stalled post-USGS funding - Effluent reduction scenario findings are directionally useful but cannot be translated into dollar values for EA	- No formal ESV published - Richest ecological dataset for the corridor has not yet been translated into per-acre economic values that could have strengthened EA's source literature base	- Outputs not in \$/acre/year format - Values not disaggregated by land cover type in a way compatible with benefit transfer - Site-specific to San Pedro; values not directly transferable to effluent-sustained SCR conditions	- Tool agreement context-dependent - Outputs are change values not standing ESV - Carbon most reliable service, water and scenic values less so - Relevant caution for EA's water-related benefit estimates	- Broad non-Southwest literature base means values reflect national and international conditions rather than Arizona-specific ones - Used in EA only where more regionally specific data unavailable	- WTP format incompatible with \$/acre/year benefit transfer - Cultural heritage WTP highlights a dimension of SCR value not captured anywhere in this study's analysis
Relationship to Current Study	- Only existing stated preference study specific to the SCR - Demand-side values complement EA's supply-side benefit transfer approach - Low effluent awareness supports conservative EA interpretation of recreation and aesthetic values	- Only existing spatial model designed for the SCR watershed - Effluent reduction scenario findings provide directional support for EA's scenario framing - M-SEVI equity findings relevant to binational beneficiary context not captured in EA	- Provides the most relevant on-the-ground ecological baseline for the corridor - Rapid recolonization findings support assumption that restoration benefits are achievable within a reasonable timeframe	- Most ecologically comparable watershed - Strongest regional methodological reference - Validated benefit transfer as the most feasible practical approach - Informs context and tool selection rationale	- Confirmed carbon as most reliable service in desert riparian ESV - Scenario divergence findings inform uncertainty framing for EA's results - Change-based outputs not applicable to standing value benefit transfer	- Provides regionally relevant per-acre values for land cover types present in the SCR corridor - Values applied selectively as a regional anchor where Arizona-specific data unavailable - Primary source for ecosystem valuation	Highlights the gap between WTP-derived values and benefit transfer values for cultural, heritage, and existence services

E.3 Case Study Key Observations

The case study review highlights several consistent findings across economic analyses of river restoration projects.

- Benefit transfer is the most widely used and most practically feasible method for estimating ecosystem service values, reflecting both its practicality and its acceptance in literature. However, the review also shows that applying regionally calibrated values can produce materially different results from national averages, supporting this study's prioritization of Arizona and Southwest literature when possible.
- Water supply and groundwater recharge consistently emerge as the largest and most defensible value components of total value across all Southwest studies. These services are both highly relevant in arid environments and relatively straightforward to quantify in economic terms, making them central to most valuation frameworks.
- Among individual ecosystem services, carbon sequestration and climate regulation is the most methodologically reliable service to quantify desert riparian systems due to clear measurement techniques and established valuation approaches.
- No existing study produces BCA-ready per-acre values, specifically for effluent-sustained arid riparian land cover types. Economic valuation of the SCR is relatively limited.
- The SCR is one of the most studies and data-rich desert riparian restoration site in the Southwest and its ecological foundations exist for significantly more rigorous future analyses.

E.4 Applicability to the EA

Despite its ecological and economic importance, formal monetary valuation of services provided by the SCR remains very limited. Existing ecosystem service studies relevant to arid and semi-arid riparian systems in the Southwest typically: (1) value intact natural systems rather than managed or effluent-sustained ones; (2) produce outputs formatted for landscape-level policy advocacy rather than project-level benefit-cost analysis; and/or (3) apply national average values derived from wetter, higher-productivity ecosystems that may not adequately reflect the unique conditions of desert riparian corridors.

As a result, there is a gap between the ecological knowledge base that has been built for this corridor and the economic valuation tools needed to justify continued and expanded investment in its restoration. The case studies highlighted the following EA-relevant limitations:

- No existing study addresses the full combination of attributes characterizing the SCR corridor: effluent-sustained flows, binational watershed, desert riparian land cover types, and BCA-ready output format.
- Benefit transfer introduces uncertainty when source studies are from different climates, ecosystems, or socioeconomic contexts; values in this study should be interpreted as order-of-magnitude estimates.
- Cultural, heritage, and Indigenous significance values are absent from all seven studies and are not analyzed by the EA. a documented gap that future work should address.
- Equity and environmental justice dimensions, particularly relevant in a binational border community context, are not captured in per-acre average values.
- Birdwatching and nature-appreciation are important components of SCR recreation use but these activities are not separately valued in any of the studies reviewed.
- Standing value vs. restoration trajectory: benefit transfer approaches assume full ecosystem service delivery from the current state; they do not model recovery trajectories over time, which may

understate long-term benefits of restoration investment. Relatedly benefit transfer approaches are not well-suited to quantify incremental changes in resource quality.

- Spatial precision is low across all benefit transfer studies including this one; uniform per-acre averages do not reflect variability in ecosystem condition, proximity to population centers, or local ecological context.

Despite these limitations, some of the case studies were utilized in the benefit valuation. Using a benefit transfer approach, the ecosystem service values in the Earth Economics report were used to estimate unit values for habitat and wildlife benefits of the SCR existing conditions and future SCRMP Restoration Alternatives. The WTP values from the Wang, Weber and Norman studies were used as an 'alternative methodology' in estimating the value of habitat and wildlife; however, this was not the primary method of evaluation given limitations of the WTP survey methods and applicability to this project in all studies.

E.5 Conclusion

The reviewed studies reviewed are not comparators but are building blocks and represent the best available methodological and contextual foundation for ecosystem service valuation in the SCR corridor. While none individually could serve as a direct template for the EA, they provide valuable context for the project area as well as the variety of valuation methods for EA consideration.

Although some of the case studies were used in the EA's benefit valuation, the case study review indicates that existing gaps between ecological knowledge and economic valuation remains a defining challenge for desert riparian conservation evaluation and funding in the Southwest. Reducing this informational and analytic gap even partially can potentially have meaningful practical consequences for federal and state grant applications. For future work, site-specific WTP survey for the Nogales–Green Valley corridor; birdwatching recreation valuation using United States Fish and Wildlife Service (USFWS) National Survey data; cultural heritage valuation in collaboration with Tohono O'odham Nation and Tumacácori National Historic Park; and spatially explicit modeling using InVEST or other tools, could all be useful for greater understanding of the economic value of the SCR and future restoration efforts.

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