National Park Service
U.S. Department of the Interior

Grand Canyon National Park
Grand Canyon, Arizona

Statement of Findings for Director's Order #77-1: Wetland Protection

Transcanyon Water Distribution Pipeline Project
Coconino County, Arizona

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Wetland Statement of Findings

Transcanyon Water Distribution Pipeline Project
Grand Canyon, Arizona

Coconino County, Arizona
Environmental Assessment
and Finding of No Significant
Impact
May 2019

National Park Service
Grand Canyon National Park

Recommended:

Superintendent, Grand Canyon National Park	Date

Certification of Technical Adequacy and Servicewide Consistency:

Chief, Water Resources Division, Washington Office	Date

Approved:

Director, Intermountain Region	Date

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1.0 Introduction

Executive Order (EO) 11990, Protection of Wetlands, require the National Park Service (NPS) and other federal agencies to evaluate the likely impacts of action in wetlands. NPS Director's Order #77-1: Wetland Protection provides NPS policies and procedures for complying with EO 11990. The NPS adheres to a "no net loss" of wetlands policy, as well as other federal and agency policies. This Statement of Findings (SOF) has been prepared to comply with Director's Order #77-1: Wetland Protection and Procedural Manual #77-1.

The NPS prepared an Environmental Assessment (EA; DOI NPS 2019) for the proposed relocation of the water intake for the existing Transcanyon Water Distribution Pipeline (TCWL; Proposed Action) from Roaring Springs to a new area near Bright Angel Creek (BAC) at Phantom Ranch and replacement of portions of the TCWL between Phantom Ranch and the South Rim in Grand Canyon National Park (Park). The Finding of No Significant Impact (FONSI) was approved on May 6, 2021. The Proposed Action area is located within Grand Canyon National Park, approximately 6.5 miles north of the Town of Tusayan in Coconino County, Arizona, and approximately 60 miles north of the City of Williams, Arizona. The 12.5-mile TCWL was constructed in the 1960s, is beyond its useful life, experiences frequent failures, and requires continual maintenance to repair leaks. The line transects several riverine and palustrine wetland systems. Except for impacts resulting from relocation of a water intake, all the wetlands that would be impacted by the Proposed Action were previously impacted during initial installation of the TCWL in 1966 and would be subject to temporary impacts only. Relocating the water intake also results in impacts to wetland functions; however, 'no net loss' of wetland area results after implementation of avoidance, minimization, and compensation.

The purpose of this SOF is to document the anticipated effects on wetlands and demonstrate that the Proposed Action does not result in a net loss of wetlands. For the purpose of this report all aquatic features are treated as wetland pursuant to the U.S. Fish and Wildlife Cowardin Classification (Cowardin et al. 1979; Federal Geographic Data Committee 2013). This statement of findings has been prepared in accordance, and documents compliance with Executive Order 11990 (Protection of Wetlands), NPS Director's Order #77-1, and Procedural Manual #77-1.

1.1 Background

The Proposed Action area is located within Grand Canyon National Park, approximately 6.5 miles north of the Town of Tusayan in Coconino County, Arizona, and approximately 60 miles north of the City of Williams, Arizona. The National Park Service is proposing to relocate the water intake for the TCWL from Roaring Springs to a new area near BAC at Phantom Ranch and replace portions of the TCWL and associated infrastructure between Phantom Ranch and the South Rim in Grand Canyon National Park (2019 EA/FONSI).

The TCWL was constructed in the 1960s and plays a critically important role supporting Park operations. It supplies all potable water to the Park's South Rim as well as the Park's Cross Canyon Corridor. Water transported by the TCWL supports more than 6 million annual visitors and approximately 2,500 year-round residents. Water from the TCWL also provides fire suppression protection capabilities for all South Rim and Cross Canyon Corridor facilities.
The current pipeline begins at an intake at Roaring Springs (elevation 5,270 feet) within the

canyon, approximately 3,000 feet below the North Rim at the confluence of Roaring Springs Canyon and Bright Angel Canyon (**Figure 1 – TCWL and Existing Water Infrastructure**). Water is conveyed by gravity through the 12.5-mile TCWL from Roaring Springs along BAC and the North Kaibab Trail through Phantom Ranch (elevation 2,500 feet), over the Colorado River suspended from a bridge, and up to the Havasupai Garden[1] Pump Station (elevation 3,800 feet). The Havasupai Garden Pump Station pumps water to the South Rim storage tanks, which are at an elevation of approximately 7,040 feet.

The 6-inch-diameter, aluminum TCWL has exceeded its expected useful life and now experiences frequent failures requiring continual maintenance in a remote and rugged environment. Since 1978, the TCWL has experienced 5 to 30 pipeline failures per year caused by pipe failures such as pipe weld failures at joints, internal pipe corrosion, freezing, flooding, and falling rocks. The TCWL is also susceptible to damage during major flood events that occur periodically in Bright Angel Canyon. Interruptions of the water supply at Phantom Ranch occur periodically due to breaks and leaks in the TCWL. A typical pipeline failure stops the flow of water in the TCWL for about 4 days. A failure of longer than 2 to 4 weeks could interrupt the water supply at the South Rim. In 1995, a flood damaged the TCWL and the pipeline remained offline for 28 days while it was repaired, requiring the Park to implement emergency measures to truck in water from outside sources to the South Rim. The South Rim has 14 million gallons of water storage, which is a 2- to 3-week supply. In the event of a complete failure of the TCWL, the South Rim could run out of water for visitor use and fire suppression. Pipeline failures are increasing in both frequency and severity each year.

1.2 Proposed Action

The Proposed Action would relocate the water intake for the TCWL from Roaring Springs to a new area within BAC at Phantom Ranch and replace portions of the TCWL and associated infrastructure between Phantom Ranch and the South Rim of Grand Canyon National Park (**Figure 2: Proposed Action**). This alternative would relocate the water intake for the TCWL from Roaring Springs Cave to an area along BAC near Phantom Ranch, replace the section of TCWL between Phantom Ranch and Havasupai Garden, abandon or remove over time 7.5 miles of TCWL from Phantom Ranch to Cottonwood Campground, and reuse 1.5 miles of TCWL for slip-lining a smaller waterline from Cottonwood Campground to Roaring Springs.

Additional elements of this alternative include:

- Phantom Ranch: raw water storage tank, booster pump station, pump station, local water treatment plant (WTP), potable water storage tank, and overnight accommodations for employees
- South Rim: local WTP, expanded helibase and contractor staging and operations area, and a new access road
- Upgrade existing electrical line from the South Rim to Phantom Ranch

The components of the Proposed Action that impact wetlands include 1) Havasupai Garden

[1] On November 10, 2022, Indian Garden was officially renamed to Havasupai Gardens. Some project and historical documents herein, including attachments, may still reference the location as Indian Garden.

Campground Distribution Pipeline Improvements, 2) Havasupai Garden to Phantom Ranch Pipeline Replacement, 3) BAC Intake Relocation and Phantom Ranch Distribution Improvements and 4) Roaring Springs to Cottonwood Campground Waterline Rehabilitation. These components of the Proposed Action are described below.

Upon completion, base flows within the upper reach of BAC (above the new intake structure) will be increased by approximately 5%. Reduction in water overflow from the TCWL at the Havasupai Garden Pump Station into Garden Creek would reduce the extent of the Garden Creek riparian area at and downstream of the pump station. The outflow makes up approximately 50% of Garden Creek flow. The reduction of overflow would restore this corridor to its natural condition. The riparian area just downstream of the Havasupai Garden pumphouse is approximately seven acres and with the reduced flow, it is expected that this riparian area would be reduced to some extent. Monitoring would occur to track the change in the riparian area and NPS could decide to augment the flows by releasing water again from the Havasupai Garden pumphouse or develop another strategy to minimize the reduction in the riparian area.

Access to work sites is expected to be through a combination of helicopter flights, hiking, and small all-terrain vehicle (ATV) use. ATVs would be used in developed areas, such as Phantom Ranch and on trails wide enough to accommodate ATV use. No trail modifications would occur to further accommodate ATVs. It is expected ATVs would be used daily during daylight hours.

Staging areas for pipeline construction would be located within the disturbance footprint for water line replacement and surface water intake construction or in previously disturbed areas approved for use by Park resource staff. Materials would be transported to the staging areas throughout the project duration. Material delivery from staging areas to the work sites is expected to be accomplished primarily using standard mini equipment, operating within the construction zone, described above. Recontouring soils, trail restoration and revegetation using native plant species would occur after construction is complete.

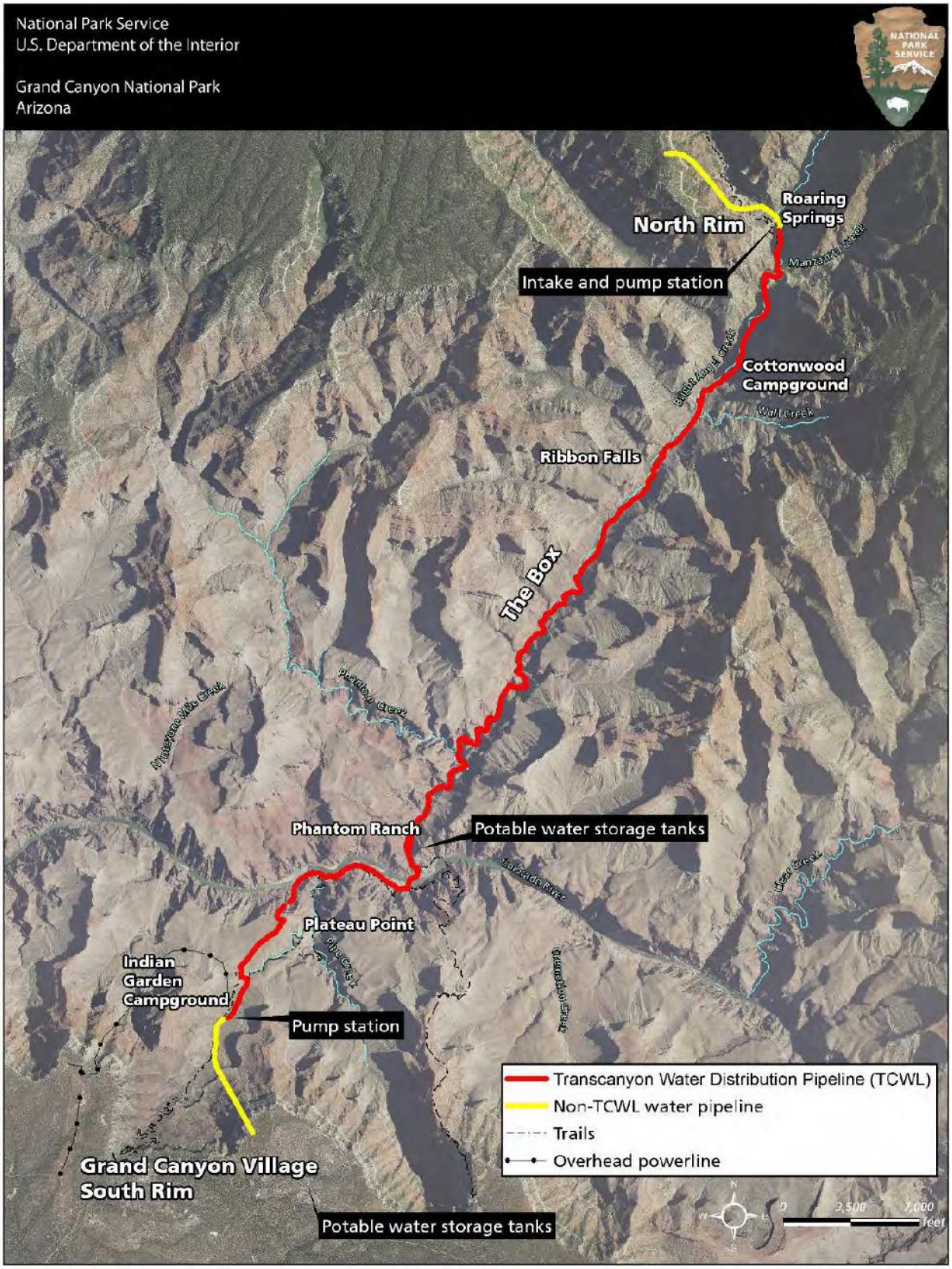


FIGURE 1: TRANSCANYON WATER DISTRIBUTION PIPELINE AND EXISTING WATER INFRASTRUCTURE

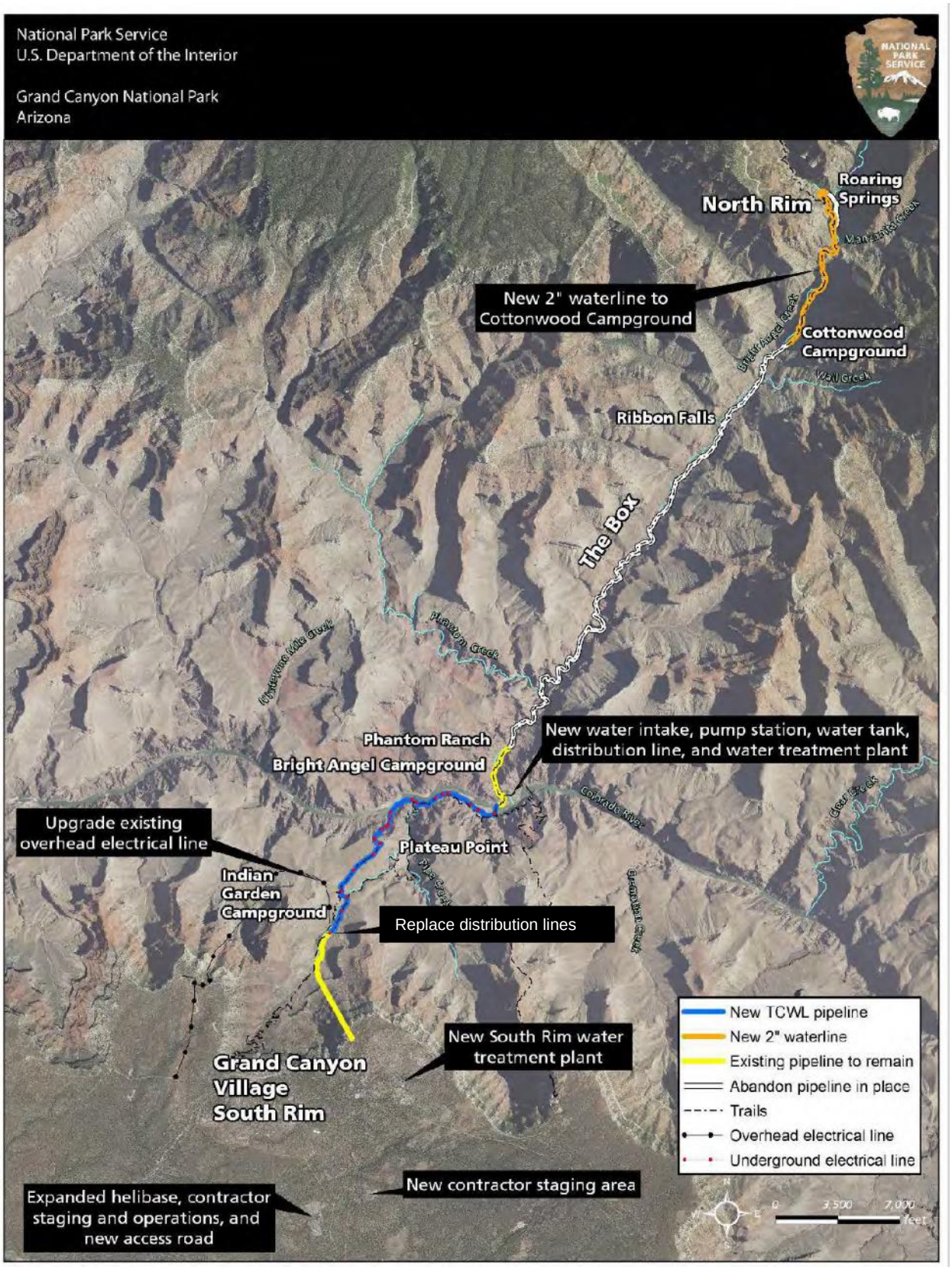


FIGURE 2: PROPOSED ACTION

1.2.1 Havasupai Garden Campground Distribution Improvements and Havasupai Garden to Phantom Ranch Pipeline Replacement

The section of the TCWL and distribution pipelines at Havasupai Garden Campground and between Havasupai Garden and Phantom Ranch will be replaced using open trench methods. Waterline would be replaced in the same location, adjacent to, or below the existing pipeline and the existing pipeline would be removed. Bedding from the existing pipe would be salvaged where practicable and reused for the new pipeline installation. Additional bedding material, if needed, would be obtained from trenching operations, or produced with a rock crusher and screened on-site or off-site materials may be brought in.

The section of the TCWL and distribution pipelines at Havasupai Garden Campground and between Havasupai Garden and the proposed intake at Phantom Ranch cross Pipe Creek, Garden Creek, several ephemeral side drainages that flow into Garden Creek, and Bright Angel Creek. The TCWL would be designed to maintain the drainage profile and would allow for unimpeded flows. The existing TCWL is suspended from the pedestrian bridge over the Colorado River. The new pipeline would be suspended in a similar manner as the existing TCWL. In total, approximately 3 miles of existing TCWL from Havasupai Garden to Phantom Ranch would be replaced.

1.2.2 BAC Intake Relocation and Phantom Ranch Distribution Improvements

Relocating the water surface intake to the south end of BAC increases the resiliency of the water source, which would be fed by multiple tributaries in addition to Roaring Springs. As depicted in **Figure 3 – Proposed Surface Water Intake Structure at BAC and Appendix B Sheet 04-WL03,** the new surface water intake will be constructed at the south end of Phantom Ranch in BAC and would consist of a precast concrete slab and stainless-steel screen box (8’-8” x 12’-10”) anchored along the shoreline and connected to the existing bridge abutment with 2-foot to 4-foot rounded to sub-angular native stones (habitat boulders). The screen is 1.7 millimeters (mm) profile bar and measures approximately 11.7 square feet (sf) in area with an intake flow rate of 700 gallons per minute ([gpm], 1.56 cubic feet per second [cfs]), a design maximum approach velocity (Va = 0.2 ft/s), and safety factor of 50 percent to reduce approach velocity and provide better self-cleaning.

Sediment will collect in the intake box itself and the pump wetwell. The intake box will be equipped with a plug valve on a sediment drain with a discharge pipe back to the creek. It is anticipated that NPS Facility Management and Engineering Division (FMD) staff will operate the sediment drain as needed (estimated at 2 times per year and after high water flow events), and that they will coordinate operation of the drain with the Park’s fisheries team. This discharge is anticipated to be permitted under an Arizona Pollution Discharge Elimination System De Minimis Permit, which has been coordinated with Arizona Department of Environmental Quality (ADEQ) and the Park.

The pump wetwell will also be a collection point for sediment, but this sediment will be manually removed and stockpiled in the adjacent sediment drying bed constructed in upland. The bed is

designed to dewater the sediment while retaining the solids. The bed will be approximately 10' x 10' and will be comprised of gravel and sand layers with cedar posts to form the perimeter. Park staff have indicated a desire to use the sediment from the bed around the Phantom Ranch area for trail reconstruction and similar activities.

The flow in BAC is extremely variable, and some modification of the BAC channel would be required to maintain a minimum depth of 1.5 feet at the intake box to keep the intake screen immersed. Specifically, the low flow channel of the creek would be reconfigured by the placement of fill for a length of approximately 100 feet. The channel would gradually narrow as it approaches the intake box (see **Figure 3**). At the intake box, the low flow channel would be reduced from approximately 24 feet wide to approximately 20 feet wide (see **Figure 3**). Approximately 50 feet upstream of the intake box, grading will tie the low flow channel back into the natural contours where the ordinary high water mark (OHWM) is approximately 18 feet in width. Approximately 50 feet downstream of the intake box, grading will tie the low flow channel back into the natural contours where the OHWM is approximately 27 feet in width. In total, grading would permanently raise approximately 200 sf of the channel bottom. However, because the south bank of the low flow channel is not confined and normal water levels would rise and widen slightly due to the change in channel cross section, no loss of wetland or Waters of the U.S. is anticipated.[2] No further modification of the channel is anticipated after construction is completed.

Cross vanes will be constructed of native rock embedded in the channel bottom to divert low flows to a narrow channel on the north side of the creek. One rock vane will be constructed upstream of the intake and one rock vane will be constructed at the intake. Under higher flow conditions, the rock cross vanes will be submerged and will blend in with the natural creek bed.

Riprap consisting of native material with a well-graded matrix of rounded to subangular rock ranging from 8-inches to 24-inches in diameter, will be placed on the north (left) bank of the creek at the location of the intake box.

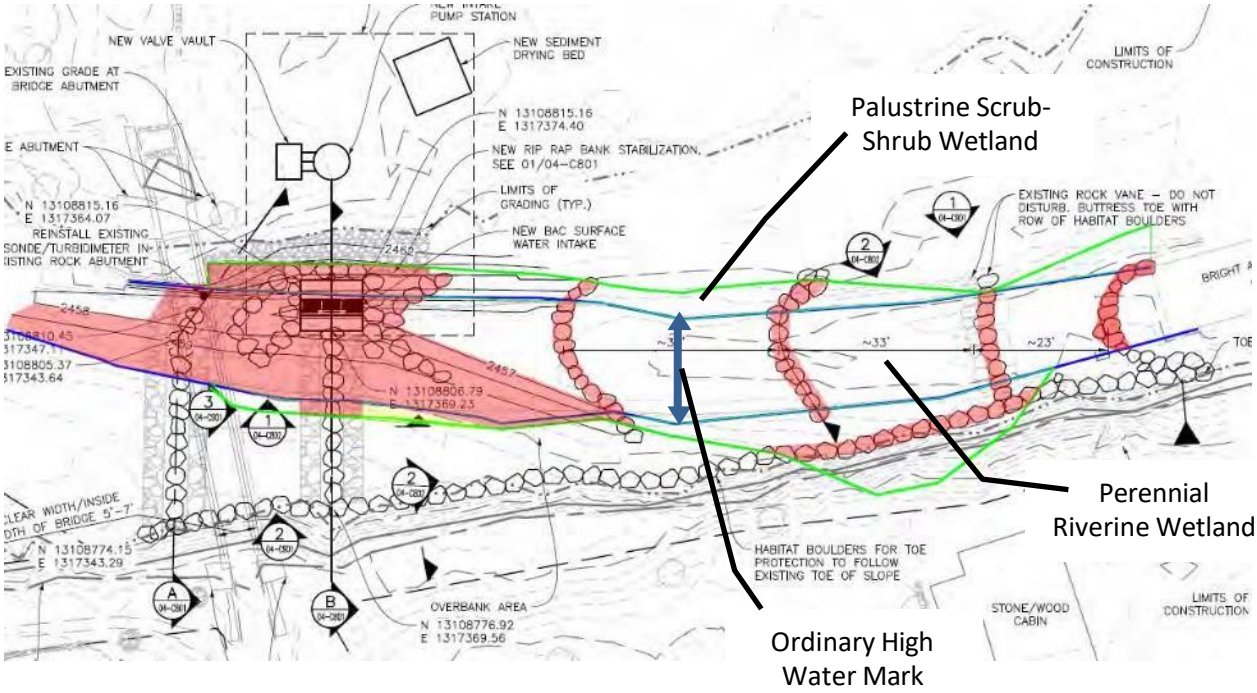
Five rock weirs are proposed downstream of the intake box to reinforce the existing rock weir with preventing scour during large storm events in the future that could lower water levels and leave the Park with an insufficient water supply. These weirs are constructed by embedding habitat boulders in the creek bed and banks. The resulting channel bed would mimic natural conditions (**Figure 4: Rock Vane, Rock Weir and Toe Protection Details**).

All the rock structures (i.e., vanes, weirs, and riprap) associated with the proposed intake structure, as described above, would be constructed using materials already present in the creek.

[2] Appendix C Exhibits 1 and 2 depict normal depth calculations for the creek at the proposed inlet location prior to the project and following project implementation. Normal flow used to establish the limits of Waters of the U.S. was inferred based on the observed OHWM elevations. The observed elevations were determined by overlaying the limits of Waters of the U.S. over the exiting topographic contours.

1.2.3 Roaring Springs to Cottonwood Campground Waterline Rehabilitation

Waterline rehabilitation between the Roaring Springs and Cottonwood Campground will be completed by slipping new 2-inch waterline through the existing larger diameter waterline. Surface disturbance for this segment is limited to temporary pull pits, staging areas and access.



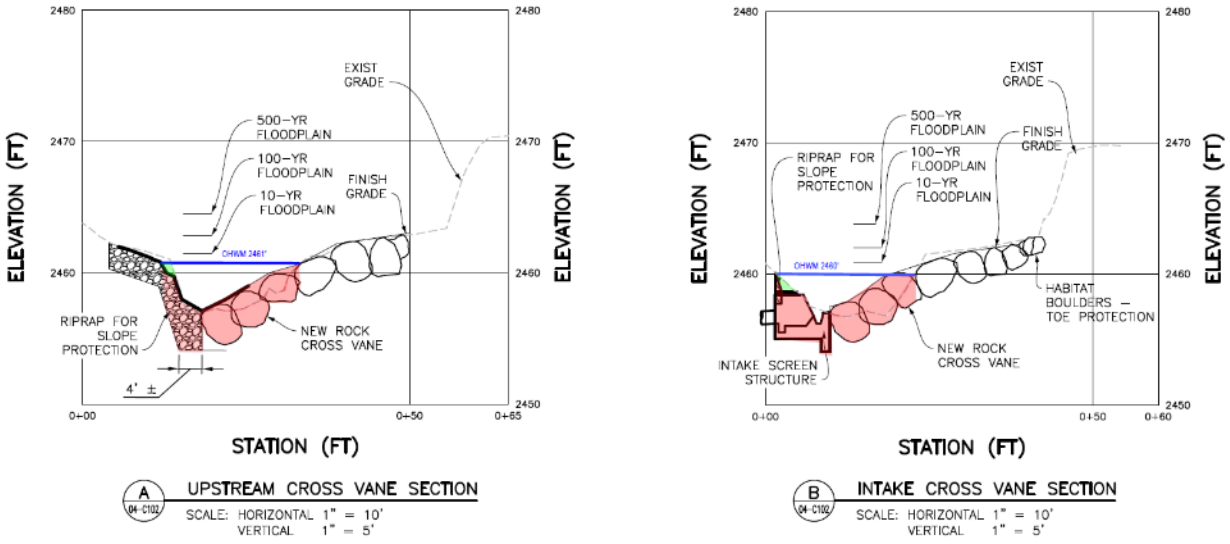
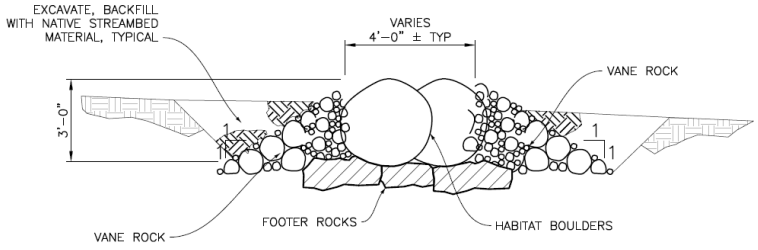
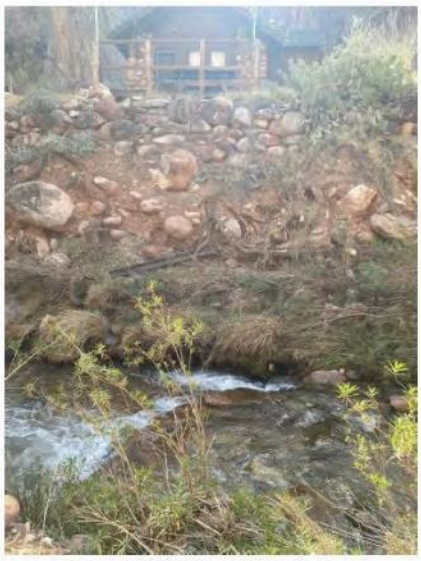


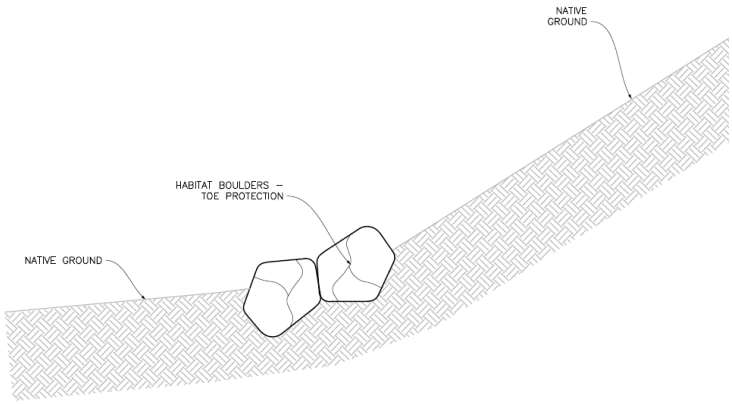
FIGURE 3: PROPOSED SURFACE WATER INTAKE STRUCTURE AT BAC – PLAN VIEW (TOP) AND CROSS-SECTIONS (BOTTOM). LIGHT RED INDICATES FILL PLACED BELOW THE ORDINARY HIGH WATER MARK



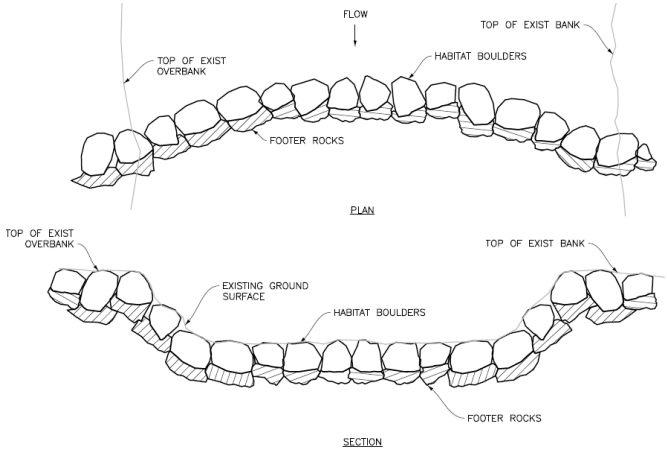
1 04-C102 ROCK VANE – TYPICAL SECTION
NTS



1 04-C103 EXISTING ROCK VANE
NO SCALE



2 04-C102 SLOPE TOE PROTECTION TYPICAL SECTION
NTS



3 04-C102 ROCK WEIR – TYPICAL PLAN AND SECTION
NTS

FIGURE 4: ROCK VANE, WEIR AND TOE PROTECTION DETAILS

1.3 Other Alternatives Considered

The Environmental Assessment (EA) carried forward three alternatives for evaluation, including the Proposed Action. Alternative B – Relocate Water Intake was the preferred alternative identified in the EA, see Section 1.2 for project details. A description of the other two alternatives carried forward for evaluation in the EA, the four alternatives considered but dismissed from further analysis in the EA, and other alternatives considered throughout project development are provided below.

1.3.1 No Action Alternative

The No Action Alternative proposes no relocation of the water intake for the TCWL from Roaring Springs to a new area near BAC at Phantom Ranch, no replacement of portions of the TCWL between Phantom Ranch and the South Rim of the Grand Canyon National Park, and no restoring base flows within the upper reach of BAC or Garden Creek to natural conditions.

No new facilities, such as water treatment facilities at Phantom Ranch, Havasupai Garden, and South Rim, would be constructed. Water would continue to be gravity fed from Roaring Springs to Havasupai Garden and pumped from Havasupai Garden to the South Rim. Water in the Cross Canyon Corridor would continue to be supplied by the TCWL. Currently, about 1 million gallons per day of water is gravity fed to Havasupai Garden and the amount pumped to the South Rim varies depending on visitation and water usage.

Existing infrastructure related to the TCWL includes the 6-inch diameter, aluminum pipeline itself, water intake at Roaring Springs, four water storage tanks at Phantom Ranch (approximately 20,000 gallons total), one water storage tank at Havasupai Garden (10,000 gallons), and five water storage tanks at the South Rim (14 million gallons total).

Repairs of the TCWL would occur periodically due to breaks in the pipeline. Between 5 and 30 breaks occur each year and this number is expected to increase as the TCWL ages. Water restrictions in the Cross Canyon Corridor and on the South Rim would continue to be required during and following pipeline breaks and repairs.

Helicopter flights to support the repairs would continue to be needed and are highly variable based on the extent and location of the break. Generally, a break would require between 2 and 10 flights per day.

1.3.2 Replace TCWL in Same Location Alternative

The Replace TCWL in Same Location Alternative proposes to replace the TCWL within the existing pipeline corridor. The current water intake at Roaring Springs would be retained and no improvements would be made at Roaring Springs. This alternative would result in a TCWL system that is essentially the same as the current system, with the exception that the existing aluminum pipe would be replaced with 8-inch-diameter steel or another durable pipe material, and a pressure-reducing valve would be added between Ribbon Falls and the north entrance to the Box. The pipeline would continue to have a capacity of 1 million gallons/day.

Primary elements of this alternative include (1) Replacement of 12 miles of pipeline; and (2) Development of expanded helibase and contractor staging and operations area and a new access road. The sections of the TCWL from Roaring Springs to Phantom Ranch and from Phantom Ranch to Havasupai Garden would be entirely removed and replaced on the same alignment. Construction methods and equipment would be the same as described above for the TCWL replacement portion of the Proposed Action.

1.3.3 Surface Water Intake Alternatives

The intake alternatives presented below were considered throughout development of the project, some of which were not included in the EA because they were determined to be not feasible.

1.3.3.1 Alluvial Wells

Alluvial wells are shallow wells (<50 ft) that are typically classified as groundwater under the influence of surface water. Each well consists of a borehole, casing with well screen, and a well pump that can discharge above or below grade. Hydraulic conductivity of the alluvial sediments at BAC was lower than anticipated, increasing the number of wells that would be required. Additionally, should the diameter of the wells also need to be increased to meet necessary intake rates, the size of the drilling equipment becomes prohibitive. For example, testing utilized a K-max helicopter and the NPS helicopter to airlift a 3,000-pound modular tracked air rotary drill rig in pieces. The drill rig was then assembled at Phantom Ranch and dissembled at the end of the work. This type of rig is limited to a 12 inch bore hole size. If subsurface conditions will support a larger bore hole size (as proved by the second test well program), then a larger air rotary drill rig will be required. The weight of this drill rig will require a Chinook helicopter capable of a 20,000-pound payload for airlifting. Finally, subsurface conditions near BAC are more variable and exhibit a higher concentration of cobbles/boulders and fine sediments than initially anticipated.

1.3.3.2 Surface Water Intake

A surface water intake is a structure located on the bank of the river or stream channel that diverts water directly from the channel. A screen is installed to protect the intake from debris and to protect fish. This option is included in the Proposed Action in Section 1.2.

1.3.3.3 Infiltration Gallery

This intake type consists of perforated pipes encased in an engineered graded fill material installed in the river channel bed or channel banks. This option was not carried forward due to concerns over plugging from the silty material present in BAC.

1.3.3.4 Radial Collector

Radial collectors consist of a central shaft with radial collector pipes projecting horizontally from the bottom of the central shaft. Water is collected in the radial pipes and flows to the central shaft where it is pumped. Radial collectors generally only become feasible at a minimum flow rate of 2 million gallons per day (MGD) and were consequently eliminated for further analysis.

1.3.4 Alternatives Considered and Dismissed

1.3.4.1 Horizontal Directional Drill Alternatives

Alternatives were considered using horizontal directional drilling (HDD) for pipeline construction in conjunction with relocating the water intake for the TCWL or replacing the TCWL in the same location. HDD would require several staging areas up to 200 by 300 feet in area along the pipeline corridor to contain a drill rig and other related equipment (HDR 2014). Concerns with the HDD alternatives included impacts of the staging areas, disposal of drilling slurry, potential instability and reliability issues because of the Bright Angel Fault, and much higher costs. In addition, the HDD alternatives would result in greater impacts on natural and cultural resources than alternatives that use traditional construction methods. Alternatives using HDD were dismissed due to concerns that they would result in too great of an environmental impact on natural and cultural resources.

1.3.4.2 Wells on South Rim

Under this alternative, water supply wells would be drilled along the South Rim of the Grand Canyon. The water source for these wells would be groundwater. The primary concern with this alternative is the risk that pumping water from the aquifer south of the Grand Canyon would reduce the amount of water that supports springs and seeps on the South Rim and adjacent tribal lands (Montgomery and Associates 1999). Therefore, this alternative was dismissed because it would have potentially too great of an environmental impact on natural resources.

1.3.4.3 Regional Water Solutions

Under this alternative, water would be pumped from the Colorado River or another regional source through a pipeline to the South Rim. This alternative would require partnership(s) with other public or private entities to purchase water, significant regional infrastructure, and a multiyear planning effort. This alternative was dismissed because the current TCWL is failing and an immediate solution is needed and no regional water solutions are feasible within the immediate project timeframe.

1.3.4.4 Transport Water via Truck or Train

Under this alternative, water would be supplied to the South Rim via truck or train. Following a flood in 1995, the TCWL remained offline for 28 days while it was repaired, requiring the Park to implement emergency water hauling measures to transport water from outside sources at a total cost of approximately $5 million. This alternative was dismissed because of issues with feasibility, reliability, and cost due to the large number of required trucks and the anticipated need to upgrade train tracks and roads.

2.0 Existing Environment

The Proposed Action area is comprised of eight separate segments: three within the inner-canyon (Havasupai Garden, Phantom Ranch, and Cottonwood), three in uplands along Bright Angel Trail, and two in upland forested areas within the South Rim region of the Park. The three segments in the inner-canyon span portions of the Corridor Trails between the North and South Rims. Havasupai Garden supports a campground, NPS staff housing, and a potable water pump station, and is developed along Bright Angel Trail and Garden Creek approximately 4.8 miles below the South Rim; Phantom Ranch is approximately 0.5 mile north of the Colorado River along BAC at the bottom of the canyon, approximately 10 miles from the South Rim and 14 miles from the North Rim; and Cottonwood is located approximately 6.8 miles below the North Rim on the North Kaibab Trail. The inner-canyon areas are only accessible by foot, mule, or helicopter.

Vegetation in the Proposed Action area includes species within five primary vegetation communities: ponderosa pine forest, pinyon-juniper woodland, riparian, desert scrub, and palustrine wetlands. Wetlands in the study area are primarily riverine and others are associated with perennial streams as fringe wetlands, springs, and effluent discharge, and headwater streams draining through canyons within the Park. These wetlands are associated with Garden, Pipe, and Bright Angel Creeks and the Colorado River.

3.0 Wetland Distribution and Characteristics

3.1 Wetland Mapping Methodology

Biologists with HDR Engineering, Inc. conducted an on-site routine wetland determination of the wetlands and surface waters from March 22 – 29, 2021.[3] Soil conditions, hydrology, and plant communities were evaluated using methods described in the USACE Wetlands Delineation Manual (Environmental Laboratory 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region Version 2.0 (USACE 2008a). Data plots were selected by initial observation of topographic depressions, wetland vegetation, visual evidence of hydrology, and examination of soil samples. At locations exhibiting positive indicators of wetland characteristics, soil pits were excavated in conjunction with identification of vegetative and hydrologic indicators to aid in the determination of wetland boundaries. Once a plot site was selected, a soil pit was excavated; soils, hydrology, and vegetation were investigated; and results were recorded on wetland determination data forms. Methods used to determine the presence of hydric soil, hydrology, and hydrophytic vegetation are discussed below. Variations to the standard methodology, if necessary, are indicated on the data forms, which are included in Appendix A.

Wetland habitats in the Study Area, which was larger than but encompassed the Proposed Action area, were also classified according to the system outlined by USFWS in Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979; Federal Geographic Data Committee 2013). The Cowardin system classifies wetlands based on their dominant vegetation structure and water regime. See Appendix A for the Wetland Study Area.

During the field investigation, data plot locations and wetland boundaries were recorded in ESRI ArcCollector using Trimble R1 Global Navigation Satellite System (GNSS) and EOS Arrow 100 submeter GNSS receivers paired to Apple iPads. Mapping accuracies of the units are submeter using Trimble Real Time eXtended (RTX) and/or SBAS (Satellite-Based Augmentation Systems) and SBAS differential data correction for the Trimble R1 and EOS Arrow 100, respectively.

To delineate the riverine wetlands, the ordinary high water mark (OHWM) of the stream channels in the Study Area was determined in the field using the methodology outlined in A Field Guide to the Identification of the Ordinary High Water Mark in the Arid West Region of the Western United States (USACE 2008b). The physical characteristics most commonly used to indicate the OHWM include changes in sediment texture, shelving or recent bank erosion, and changes in vegetation communities between adjacent areas. These indicators were observed in the field and used to determine the location of the OHWM. Mapped waterbodies were assigned National Wetland Inventory (NWI) mapping codes based on Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979). Distinctions between the low flow channels, terraces within the active floodplain, and low terraces were determined in the field. Low flow channels were identified by the complete absence of shrub vegetation, presence of sand or coarse sand substrates, and clear shelving. Low terraces within the active floodplain were identified based on the reduction of shrub vegetation, presence of very coarse sand or pebble substrates, and faint

[3] The lead delineator Ryan Hammons is a certified Professional Wetland Scientist

shelving. The boundary between the active floodplain and adjacent upland was determined based on presence of cobble or boulder substrates, dense shrub layer, and a break in channel slope.

3.2 Wetland Delineation Results

Table 1: Summary of Wetlands Mapped within the Study Area provides the classification and quantity of wetlands mapped in the Proposed Action area. As previously described, wetlands in the Proposed Action area are primarily associated with perennial streams as fringe wetlands, springs, and effluent discharge, and headwater streams draining through canyons within the Park. These wetlands are associated with Garden, Pipe, and Bright Angel creeks and the Colorado River. The wetlands mapped within the Study Area are shown on the figures in Appendix A.

A total of 1.672 acres/2,831 linear feet of perennial stream, 1.783 acres of palustrine wetlands and 0.365 acre/1,330 linear feet of ephemeral stream were delineated in the Proposed Action area.

Baseline information characterizing the wetlands occurring within the Proposed Action area including contiguity, vegetative structural diversity, edge relationships, wildlife habitat value, hydrologic functions, public use, and integrity is found in **Table 2: Baseline Wetland Functions and Values**. The wetland polygons were individually characterized based on their Cowardin Classification and are depicted on the Aquatic Resource Overview Maps provided in **Appendix A: Aquatic Resource Delineation Report - Figure 8 Sheets 1 through 20**. Photographs of each feature are also provided in **Appendix A**.

Table 1. Summary of Wetlands Mapped within the Proposed Action Area

Feature ID[1]	NWI Code[2]	Extent within Study Area (acres)	Linear Feet
BAC			
Palustrine Wetlands			
W-2	P-SS-1B	0.015	N/A
W-3	P-SS-1B	0.085	N/A
W-4	P-SS-1B	0.031	N/A
W-5	P-SS-1B	0.033	N/A
W-8	P-SS-1B	0.179	N/A
W-9	P-FO-1B	0.102	N/A
W-13	P-SS-1B	0.092	N/A
W-14	P-SS-1K	0.120	N/A
W-16	P-SS-1B	0.015	N/A
W-17	P-SS-1B	0.035	N/A
Palustrine Wetlands Sub-total		*0.707*	--

Feature ID[1]	NWI Code[2]	Extent within Study Area (acres)	Linear Feet
Perennial Stream			
S-1b	R3-UB-1H	0.155	553
S-1h	R3-UB-1H	0.091	100
S-1j	R3-UB-1H	0.041	130
S-1t	R3-UB-1H	0.264	617
Perennial Stream Sub-total		*0.551*	*1,340*
Unnamed Ephemeral Tributaries			
S-2	R6	0.026	139
S-3	R6	0.030	110
S-4	R6	0.034	128
S-5a	R6	0.152	241
Ephemeral Tributary Sub-total		*0.242*	*618*
BAC Sub-total		***1.500***	***1,958***
Colorado River (TNW)			
Palustrine Wetlands			
W-20	P-SS-1E	0.022	N/A
Palustrine Wetlands Sub-total		*0.022*	--
Perennial Stream			
R-1b	R3-UB-1H	0.826	294
R-1e	R3-UB-1H	0.066	196
Perennial Stream Sub-total		*0.892*	*490*
Colorado River Sub-total		***0.914***	***490***
Pipe Creek (Perennial Stream)			
Perennial Stream			
S-8	R5-UB-1H	0.105	285
Pipe Creek Sub-total		***0.105***	***285***
Garden Creek (Perennial Stream)			
Palustrine Wetlands			
W-22	P-FO-1B	0.408	N/A
W-23	P-EM-1E	0.581	N/A
W-24	P-EM-1B	0.065	N/A
Palustrine Wetlands Sub-total		*1.054*	--
Perennial Stream			
S-14a	R5-UB-1H	0.014	154
S-14b	R5-UB-1H	0.023	99
S-14c	R5-UB-1H	0.028	80
S-14d	R5-UB-1H	0.006	34
S-14e	R5-UB-1H	0.039	170
S-16a	R5-UB-1H	0.007	54
S-16b	R5-UB-1H	0.002	16

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Feature ID[1]	NWI Code[2]	Extent within Study Area (acres)	Linear Feet
S-17	R5-UB-1H	0.005	109
Perennial Stream Sub-total		*0.124*	*716*
Unnamed Ephemeral Tributaries			
S-9	R6	0.002	46
S-10	R6	0.004	49
S-11	R6	0.015	107
S-12	R6	0.011	119
S-13	R6	0.091	391
Un-named Ephemeral Tributaries Sub-total		*0.123*	*712*
Garden Creek Sub-total		*1.301*	*1,428*
Aquatic Resource Total		**3.820**	**4,161**

[1] Please note that the aquatic resource delineation was prepared to support the Clean Water Act Section 404 and Section 401 permitting. At the time of preparation, the Navigable Waters Protection Rule was in effect. Therefore, the naming convention for delineated features focused on the hydrology regime of each feature. Therefore, ephemeral features were distinguished from perennial features by using an E rather than an S on the baseline delineation maps. At this time, the Navigable Waters Protection Rule is no longer in effect, so all non-wetland Waters of the U.S. are denoted with an S.

[2] Cowardin Wetland and Deepwater Habitat Classification Codes:

Palustrine System (P) → Class/Subclass: EM = emergent/ 1: persistent, FO = forested/1: broad-leaved deciduous, SS = scrub-shrub/1: broad-leaved deciduous → Modifier: B = saturated, E = seasonally flooded/saturated, K = artificially flooded

Riverine System (R) → Subsystem: 3 = upper perennial, 5 = unknown perennial, 6 = ephemeral → Class: UB = unconsolidated bottom → Subclass: 1 = cobble-gravel → Modifier: H = permanently flooded

Table 2. Baseline Wetlands Functions and Values

Feature ID	NWI Code[1]	Habitat Description	Contiguity	Vegetative Structural Diversity	Edge Relationships	Wildlife Habitat Value	Hydrologic Function	Public Use
BAC Watershed								
W-2	PSS1B	Fringe wetland associated with the narrow floodplain of BAC. Dominant vegetation includes boxelder (*Acer negundo*), mule-fat (*Baccharis salicifolia*), narrowleaf willow (*Baccharis salicina*), water sedge (*Carex aquatilis*), Ferriss' horsetail (*Equisetum ferrissii*), and brome (*Bromus* sp.).	Adjacent to BAC	Moderate structural diversity – supports herbaceous, shrub and tree layers. Dominant vegetation includes boxelder, mule-fat, willow, rough horsetail and water sedge.	The surrounding land use is largely undeveloped except for the adjacent North Kaibab hiking trail. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-3	PSS1B	Fringe wetland associated with the narrow floodplain of BAC. Dominant vegetation includes mule-fat, narrowleaf willow, water sedge and Ferriss' horsetail.	Adjacent to BAC	Low to moderate species diversity across an herbaceous and shrub layer. Dominant vegetation includes mule-fat, narrowleaf willow, water sedge and rough horsetail.	The surrounding land use is largely undeveloped except for the adjacent North Kaibab hiking trail. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-4	PSS1B	Fringe wetland associated with the narrow floodplain of BAC. Dominant vegetation includes mule-fat, narrowleaf willow, water sedge and Ferriss' horsetail.	Adjacent to BAC	Low to moderate species diversity across an herbaceous and shrub layer. Dominant vegetation includes mule-fat, narrowleaf willow, water sedge and rough horsetail.	The surrounding land use is largely undeveloped except for the adjacent North Kaibab hiking trail. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-5	PSS1B	Fringe wetland associated with the narrow floodplain of BAC. Dominant vegetation includes mule-fat, narrowleaf willow, water sedge and Ferriss' horsetail.	Adjacent to BAC	Low to moderate species diversity across an herbaceous and shrub layer. Dominant vegetation includes mule-fat, narrowleaf willow, water sedge and rough horsetail.	The surrounding land use is largely undeveloped except for the adjacent North Kaibab hiking trail. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-8	PSS1B	Artificially irrigated wetland habitat occurs in ditches constructed to irrigate landscaping associated with Phantom Ranch Lodge. Supports primarily emergent species.	Isolated	Low structural diversity within the irrigation ditch. Rough horsetail is the dominant plant species along with other hydrophytic herbaceous species.	Surrounding land use includes the North Kaibab hiking trail and Phantom Ranch Lodge facilities.	Provides limited foraging and refuge habitat for mammals, reptiles, amphibians, and birds.	Provides nutrient cycling and water filtration	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-9	PFO1B	Sloping depression. This habitat type is dominated by Fremont cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii*), mule-fat, and saltgrass (*Distichlis spicata*)	Isolated	Moderate structural diversity – supports herbaceous, shrub and tree layers. Dominant vegetation includes Fremont's cottonwood, Goodding's willow, mulefat and saltgrass.	Surrounding land use includes the North Kaibab hiking trail, Phantom Ranch Lodge facilities and a mule corral.	Provides limited foraging and refuge habitat for mammals, reptiles, amphibians, and birds.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-13	PSS1B	Fringe wetland associated with the narrow floodplain of BAC. Dominant plant species include mule-fat, willow baccharis, California satintail, and saltgrass.	Adjacent to BAC	Low to moderate species diversity across an herbaceous and shrub layer. Dominant vegetation includes mule-fat, willow baccharis, California satintail, and saltgrass.	The surrounding land use is largely undeveloped except for the adjacent North Kaibab hiking trail. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-14	PSS1K	Artificially irrigated wetland habitat occurs in ditches constructed to irrigate landscaping associated with Bright Angel Campground. Wetland supports herbaceous and shrub layers.	Isolated	Low to moderate structural diversity – supports an herbaceous and shrub layer. Dominant vegetation includes willow baccharis, California satintail, and saltgrass	The surrounding land use is largely undeveloped except for the Phantom Ranch Campground facilities. Also connected to adjacent natural uplands.	Provides limited foraging and refuge habitat for mammals, reptiles, amphibians, and birds.	Provides marginal nutrient cycling, water filtration, sediment stabilization, and groundwater recharge or discharge area.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-16	PSS1B	Fringe wetland associated with the narrow floodplain of BAC. Dominant plant species include mule-fat, willow baccharis, California satintail, and saltgrass.	Adjacent to BAC	Low to moderate species diversity across an herbaceous and shrub layer. Dominant vegetation includes mule-fat, willow baccharis, California satintail, and saltgrass.	The surrounding land use is largely undeveloped except for the adjacent North Kaibab hiking trail, BAC pedestrian Bridge, and Phantom Ranch Lodge. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-17	PSS1B	Fringe wetland associated with the narrow floodplain of BAC. Dominant plant species include mule-fat, inland saltgrass, and scouring horsetail (*Equisetum hyemale*).	Adjacent to BAC	Low to moderate species diversity across an herbaceous and shrub layer. Dominant vegetation includes mule-fat, saltgrass.and scouring horsetail.	The surrounding land use is largely undeveloped except for the adjacent North Kaibab hiking trail, BAC pedestrian Bridge, and Phantom Ranch Lodge. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
S-1b Through S-1t	R3UB1H	This habitat includes the unvegetated active channel of BAC. The creek is a perennial tributary to a traditionally navigable water (Colorado River).	BAC connects to the Colorado River	Generally, unvegetated streambed with unconsolidated channel bed	Surrounding land use includes the North Kaibab Trail, Roaring Springs intake and pump station, Phantom Ranch lodge and Campground. Also connected to adjacent natural waterways, wetlands and uplands.	Provides habitat for aquatic invertebrates and vertebrates and terrestrial species for water and foraging	Provides marginal nutrient cycling, water filtration, sediment stabilization, and groundwater recharge or discharge area.	May provide recreational use for wildlife viewing.

Feature ID	NWI Code[1]	Habitat Description	Contiguity	Vegetative Structural Diversity	Edge Relationships	Wildlife Habitat Value	Hydrologic Function	Public Use
[3] S-2 through S-5a	R6	This habitat includes the unvegetated active channel of un-named ephemeral tributaries to BAC.	Ephemeral channels drain into BAC	Generally, unvegetated streambed with unconsolidated channel bed	The surrounding land use is largely undeveloped except for the Phantom Ranch and Cottonwood Campground facilities. Also connected to adjacent natural uplands.	Provides open, often cobbly habitat that many reptiles prefer, act as movement corridors for medium to large sized mammals	Mobilizes and transports biological material for short durations	May provide recreational use for wildlife viewing.
Colorado River Floodplain								
W-20	PSS1E	Fringe wetland associated with the floodplain of the Colorado River. Dominant plant species include mule-fat, willow baccharis, and California satintail.	Adjacent to the Colorado River	Low to moderate structural diversity – supports an herbaceous and shrub layer. Dominant vegetation includes mule-fat, willow baccharis, and California satintail.	Surrounding land use includes the Bright Angel Campground, hiking trails and the pedestrian Silver Bridge, which crosses the Colorado River. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers
R-1b and R-1e	R3UB1H	This habitat includes the unvegetated active channel of the perennial Colorado River.	Colorado River	N/A. This feature consists of the open water/active channel.	Surrounding land use includes the Bright Angel Trail, Phantom Ranch lodge, Bright Angel Campground, Silver Bridge. Also connected to adjacent natural waterways, wetlands and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge	Provides recreational use for wildlife viewing and provides aesthetic value for hikers
Garden Creek Watershed								
W-22	PFO1B	Depressional fringe wetland lined with boulders associated with the floodplain of Garden Creek. Dominant plant species included velvet ash (*Fraxinus velutina*), Fremont cottonwood, Goodding's willow, willow baccharis, and chairmaker's bulrush (*Schoenoplectus americanus*).	Adjacent to Garden Creek	Moderate to high structural diversity – supports an herbaceous, shrub, and tree layer. Dominant vegetation includes velvet ash, Fremont cottonwood, Goodding's willow, willow baccharis, and chairmaker's bulrush.	Surrounding land use includes the Bright Angel Trail and Havasupai Garden Campground facilities. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-23	PEM1E	Spring-fed depressional wetland associated with the floodplain of garden Creek. Dominant plant species include velvet ash, mule-fat, and chairmaker's bulrush.	Adjacent to Garden Creek	Moderate to high structural diversity – supports an herbaceous, shrub, and tree layer. Dominant vegetation includes velvet ash, mule-fat, and chairmaker's bulrush.	Surrounding land use includes the Bright Angel Trail and Havasupai Garden Campground facilities. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
W-24	PEM1B	Spring fed fringe wetland associated with the floodplain of Garden Creek. Dominant plant species include velvet ash, Goodding's willow, and chairmaker's bulrush.	Adjacent to Garden Creek	Low to moderate structural diversity – supports an herbaceous and tree layer. Dominant vegetation includes velvet ash, Goodding's willow, and chairmaker's bulrush.	Surrounding land use includes the Bright Angel Trail and Havasupai Garden Campground facilities. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Provides nutrient cycling, water filtration, sediment stabilization, and provides available groundwater recharge or discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.
S-14a through S-14e, S-17	R5UB1H	This habitat includes the unvegetated active channel of Garden Creek. The creek is a perennial tributary to a traditionally navigable water (Colorado River).	Garden Creek connects to the Colorado River	Generally, unvegetated streambed with unconsolidated channel bed	Surrounding land use includes several hiking trails and Havasupai Garden Campground. Also connected to adjacent natural waterways, wetlands and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Mobilizes and transports biological material for short durations	May provide recreational use for wildlife viewing.
S-16a and S-16b	R5UB1H	This habitat includes the unvegetated active channel of an un-named perennial tributary to Garden Creek.	Un-named perennial tributary to Garden Creek	Generally, unvegetated streambed with unconsolidated channel bed	Surrounding land use includes the Bright Angel Trail and Havasupai Garden Campground facilities. Also connected to adjacent natural waterways and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	Mobilizes and transports biological material for short durations	May provide recreational use for wildlife viewing.
[3] S-9 through S-13	R6	This habitat includes the unvegetated active channel of un-named ephemeral tributaries to Garden Creek.	Ephemeral channels drain into Garden Creek	Generally, unvegetated streambed with unconsolidated channel bed	Surrounding land use includes the Plateau Point Trail. Also connected to adjacent natural waterways and uplands.	Provides open, often cobbly habitat that many reptiles prefer, act as movement corridors for medium to large sized mammals	Mobilizes and transports biological material for short durations;	May provide recreational use for wildlife viewing.
Pipe Creek Watershed								
S-8	R5UB1H	This habitat includes the unvegetated active channel of Pipe Creek. The creek is a perennial tributary to a traditionally navigable water (Colorado River).	Pipe Creek connects to the Colorado River	Low to moderate structural diversity: Bedrock supporting small patches of vegetation including both scrub shrub and emergent species.	Surrounding land use includes the Bright Angel Trail. Also connected to adjacent natural waterways, wetlands and uplands.	Provides foraging habitat, life cycle support, and refuge opportunities for fish, reptiles, amphibians, invertebrates, wading birds and mammals.	provides groundwater discharge areas.	Provides recreational use for wildlife viewing and provides aesthetic value for hikers.

[1]Cowardin Wetland and Deepwater Habitat Classification Codes:
Palustrine System (P) →Class/Subclass: EM = emergent/ 1: persistent, FO = forested/1: broad-leaved deciduous, SS = scrub-shrub/1: broad-leaved deciduous → Modifier: B = saturated, E = seasonally flooded/saturated, K = artificially flooded
Riverine System (R) → Subsystem: 3 = upper perennial, 5 = unknown perennial, 6 = ephemeral → Class: UB = unconsolidated bottom → Subclass: 1 = cobble-gravel → Modifier: H = permanently flooded

[2] BAC = BAC

[3] Please note that the aquatic resource delineation was prepared to support the Clean Water Act Section 404 and Section 401 permitting. At the time of preparation, the Navigable Waters Protection Rule was in effect. Therefore, the naming convention for delineated features focused on the hydrology regime of each feature. Therefore, ephemeral features were distinguished from perennial features by using an E rather than an S on the baseline delineation maps. At this time, the Navigable Waters Protection Rule is no longer in effect, so all non-wetland Waters of the U.S. are denoted with an S.

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4.0 Affected Wetlands

Table 3: Summary of Impacts to Wetland provides the quantity and type of impacts to wetlands that result from the Proposed Action. In total, the Proposed Action would result in unavoidable direct impacts to approximately 0.679 acre of wetlands of which 0.049 acre consists of permanent discharge of fill. However, the permanent discharge of fill does not necessarily result in a loss of wetlands. As detailed further below, following restoration, only 0.008 acre of palustrine wetland and 0.004 acre of perennial stream exhibit permanently diminished aquatic function or are converted to upland. Additionally, as detailed below under Section 4.7 Minimization, in addition to restoration of temporarily impacted waters, the Proposed Action would result in the establishment/relocation of 0.008 acre of palustrine wetland contiguous with BAC in the vicinity of the intake structure and the restoration of about 0.18 acre of perennial stream within BAC upstream of the relocated intake. Therefore, the Proposed Action results in no net loss of wetlands. Figures depicting the location and extent of impacts are provided as **Appendix B: Aquatic Resource Impact Areas**.

Table 3. Summary of Impacts to Wetlands

Project area	Feature ID	Cowardin Class[1]	Discharge of Fill to Wetlands (acres) Temporary	Discharge of Fill to Wetlands (acres) Permanent	Discharge of Fill to Wetlands (acres) Total	Map Page
Project Area 2 Havasupai Garden Distribution Line	Garden Creek W22, W23, W24	PFO1B, PEM1E, PEM1B	0.166	0.003	**0.169**	Appendix B-Sheet 02-WL01
	Garden Creek S17 and S14e	R5UB1H	0.006	<0.001	**0.006**	
		Sub-total	*0.172*	*0.003*	***0.175***	
Project Area 3 Havasupai Garden to Phantom Ranch Pipeline Replacement	Pipe Creek S8	R5UB1H	0.007	0.002	**0.009**	Appendix B Sheets 03-WL02 through 03-WL05
	Garden Creek W22	PFO1B	0.024	<0.001	**0.024**	
	Garden Creek S14 and S16b	R5UB1H	0.006	<0.001	**0.006**	
	Unnamed tributaries to Garden Creek S9, S10, S11, S12, S13	R6	0.052	0.002	**0.054**	
		Sub-total	*0.089*	*0.004*	***0.093***	
Project Area 4 BAC Intake Relocation and Phantom Ranch Distribution Line	BAC W8, W9, W13 and W14	PSS1B, PFO1B, PSS1K	0.122	--	**0.122**	Appendix B -Sheet 04-WL01 through 04-WL03
	BAC W16 and W17[3]	PSS1B	0.019	0.009	**0.028**	
	BAC S1t[3]	R3-UB-1H	0.048	0.033	**0.081**	
	BAC S1t	R3-UB-1H	0.017	--	**0.017**	
		Sub-total	*0.206*	*0.042*	***0.248***	
Project Area 5 Rock Springs to Cottonwood Campground Pipeline Rehabilitation	BAC W2, W3, W4, W5	PSS1B	0.095	--	**0.095**	Appendix B - Sheets 05-WL01 through WL04
	BAC S1b, S1h and S1j	R3-UB-1H	0.029	--	**0.029**	
	Unnamed tributaries to BAC S2, S3, S4, S5a	R6	0.039	--	**0.039**	
		Sub-total	*0.163*	--	***0.163***	
		Total	**0.630**	**0.049[2]**	**0.679**	--

[1]Cowardin Wetland and Deepwater Habitat Classification Codes:
Palustrine System (P) →Class/Subclass: EM = emergent/ 1: persistent, FO = forested/1: broad-leaved deciduous, SS = scrub-shrub/1: broad-leaved deciduous → Modifier: B = saturated, E = seasonally flooded/saturated, K = artificially flooded
Riverine System (R) → Subsystem: 3 = upper perennial, 5 = unknown perennial, 6 = ephemeral → Class: UB = unconsolidated bottom → Subclass: 1 = cobble-gravel → Modifier: H = permanently flooded

[2] Permanent discharge of fill below grade results in no loss of wetlands after restoration (e.g., pipeline replacement and pipeline encasement in concrete at two locations (S-8 and S14), low flow channel reconfiguration for surface water intake construction and installation of bedding materials below grade for two rock vanes upstream of the intake box)

[3] Indicates new areas of construction that were not previously impacted

4.1 Temporary Discharge of Fill

Temporary discharge of fill to 0.426 acre of palustrine wetland, 0.113 acre of perennial stream and 0.091 acre of ephemeral stream consists of excavating and backfilling the channel bed for pipeline replacement or for constructing temporary equipment crossings, surface water diversions or work pads within wetlands. Except for 0.019 acre of palustrine wetland (Feature IDs W-16 and W-17) and 0.048 acre of perennial stream (Feature ID S1t) associated with construction of the new surface water intake at BAC, temporary discharge of fill is restricted to areas previously disturbed by initial waterline construction.

Regardless, given the position of the impacted wetlands on the landscape (e.g., continuity with upstream and downstream reaches remaining unimpacted) and that riverine ecosystems are adapted to periodic disturbance such as flooding and scour during large storm events, the temporary loss of aquatic function associated with the Proposed Action are anticipated to fully recover. Specifically, aquatic function associated with temporary impacts to ephemeral stream would be expected to recover most quickly with recovery of benthic fauna, nutrient cycling and groundwater recharge and discharge within the perennial streams and early successional wetland habitat functions and biogeochemical processes to follow within months (Korsu, 2004).

Riparian habitat is adapted to disturbance and recovers rapidly as long as the natural water flow and sedimentation regimes are intact (USFWS 1998). Based on HDR's experience, pre-project palustrine scrub-shrub and forested wetland function associated with the affected wetlands would be expected to recover within 2-3 years[4]. This recovery timeframe would be consistent with natural disturbance cycles for which the riverine ecosystem is adapted[5]. Therefore, with implementation of post-project restoration as described more thoroughly in Section 4.8 below, temporary discharge of fill for the Proposed Action does not result in a net loss of wetland or aquatic function.

4.2 Permanent Discharge of Fill

Permanent discharge of fill to 0.012 acre of palustrine wetland, 0.035 acre of perennial stream and 0.002 acre of ephemeral stream are further detailed below. Of this, 0.004 acres of palustrine wetland, 0.031 acre of perennial stream and 0.002 acre of ephemeral stream will be restored to

[4] As indicated in Tables 2 and 3 and **Appendix A: Aquatic Resource Delineation Report – Photographs 31 and 33**, the palustrine scrub shrub wetland subject to new impacts consist of narrow strips of fringe wetland that exhibit a cobble bed and support mule-fat, willow baccharis, California satintail, saltgrass and horsetail. Additional species occurring within Bright Angel Creek palustrine scrub shrub wetland include water sedge and narrow-leaved willow. Hydrologic function within temporary impact areas will be restored upon completion of grading, allowing open water areas to provide pre-project hydrologic functions almost immediately. As indicated above biogeochemical processes are expected to recover within months. Finally, the majority of species proposed for use in restoration including mulefat, willow baccharis, California satintail and water sedge are hardy and exhibit rapid growth rates giving this particular fringe community a relatively quick natural recovery time that is further enhanced under active restoration efforts (Holmes 1998, USDA 2022, Theodore Payne Foundation 2014). HDR has experience monitoring various wetland mitigation sites that have exhibited rapid establishment of Baccharis and willow species. For example, a mitigation site in the City of Oceanside (Whelan Lake Project Mitigation Site) was established in spring 2003 and exhibited over 80 percent coverage by summer 2005. Willows on the site averaged 14 feet tall by 2006.

[5] Based upon direct observations made while conducting a variety of field surveys in high order streams (i.e., San Mateo (33.395090°, -117.589362°), Trabuco (33.558395°, -117.653170°) and San Juan (33.522382°, -117.622757°) Creeks) in the arid west following the 2004-2005 El Nino event. Recovery is visible on historic Google Earth imagery at the coordinates above.

pre-project conditions upon project completion (e.g., pipeline and concrete encasement for pipeline), or fill consists of native channel materials placed at grade and results in no loss of aquatic function or surface area of perennial stream (e.g., rock vanes, rock weirs and toe protection embedded within perennial stream, reconfiguration of low flow channel). The remaining 0.008 acre of palustrine wetland and 0.004 acre of perennial stream cannot be restored to pre-project function at the location of impact but are offset by the restoration of pre-project flows within BAC and establishment of 0.008 acre of palustrine wetland in the vicinity of the relocated intake structure. Description of the permanent fill and effects to aquatic function are detailed below.

4.2.1 Havasupai Garden Campground Distribution Improvements

As depicted in **Attachment B: Sheet 02-WL01**, replacement of the potable water distribution lines below grade at Havasupai Garden Campground will result in the permanent discharge of just over 1 cubic yard (CY) of 1-inch to 4-inch polyvinyl chloride (PVC) pipe and gravel bedding material into 0.003 acre of palustrine wetland (Features IDs W22, W23, W24), and <0.1 CY of PVC pipe and gravel bedding material into <0.001 acre/2 linear feet (LF) of perennial stream (Features IDs S17 and S14e) associated with Garden Creek. Upon project completion, all impacted areas will be recontoured and revegetated.

The discharge of fill consists of waterline and bedding material replacement approximately 2-feet below ground. The wetland substrate will be disturbed by excavation and backfilling. However, as described above for temporary discharge of fill, riverine systems are adapted to periodic disturbance and the affected wetland areas are expected to recover pre-project aquatic function. Therefore, with implementation of post-project restoration, permanent discharge of fill for this component of Proposed Action does not result in a net loss of wetland.

4.2.2 Havasupai Garden to Phantom Ranch Pipeline Replacement

Approximately 3 miles of existing 6-inch aluminum water line will be replaced with 8-inch steel water line below grade between Havasupai Garden Pump Station and Phantom Ranch using open trench methods as described above for Havasupai Garden Campground in Section 1.2.1 (see **Appendix B: Sheets 03-WL02 to 03-WL05**). Up to 3 miles of 3 phase electrical cable and 2-inch 16/13 7- way microduct conduit will also be installed below grade in the same trench (see cross section on **Appendix B: Sheet 03-WL05**). The water line, 3 phase electric cable and 16/13 7-way microduct conduit will be encased in concrete where they cross beneath Garden Creek and Pipe Creek to provide protection from future scour (see cross section on **Appendix B: Sheets 03-WL02 and 03-WL04**).

4.2.2.1 Colorado River

At the Colorado River, existing TCWL will be replaced in kind where it is fixed to Silver Bridge. Similarly, the electrical line will be replaced within existing conduit fixed to the bridge. This component of the Proposed Action has no effect on wetlands (**Appendix B: Sheet 03-WL01-A and Sheet 03-WL01- B**).

4.2.2.2 Pipe Creek

As depicted in **Appendix B: Sheet 03-WL02**, replacement of the below grade 6-inch aluminum water line with 8-inch steel water line at Pipe Creek will result in the permanent discharge of up to 5 CY of steel pipe, gravel bedding material and concrete into 0.002 acre of perennial stream associated with Pipe Creek (Feature ID S8).

The discharge of fill consists of pipe and bedding material replacement for the larger waterline, the addition of conduit for future fiber optic and the concrete encasement of the waterline approximately 2-feet below ground. The wetland substrate will be disturbed by excavation and backfilling. However, as described above for temporary discharge of fill, riverine systems are adapted to periodic disturbance and the affected wetland areas are expected to recover pre-project aquatic function. Therefore, with implementation of post-project restoration, permanent discharge of fill for this component of the Proposed Action does not result in a net loss of wetland.

4.2.2.3 Garden Creek

As depicted in **Appendix B: Sheets 03-WL03 through 03-WL05**, replacement of the below grade 6-inch aluminum water line with 8-inch steel water line within the Garden Creek watershed will result in the permanent discharge of up to 1 CY of 8-inch steel pipe and gravel bedding material into <0.001 acre of palustrine wetland (Feature ID W22) and up to 3 CY of steel pipe, gravel bedding material and concrete into <0.001 acre of perennial stream (Feature IDs S14 and S16b) and 0.002 acre of three ephemeral streams associated with Garden Creek (Features IDs S11, S12, S13). All wetlands impacted by waterline and electric line replacement will be recontoured and revegetated following project completion; therefore, this discharge does not result in the loss of wetland.

The discharge of fill consists of pipe and bedding material replacement for the larger waterline, the addition of conduit for future fiber optic and the concrete encasement of the waterline where it passes beneath Garden Creek approximately 2-feet below ground. The wetland substrate will be disturbed by excavation and backfilling. However, as described above for temporary discharge of fill, riverine systems are adapted to periodic disturbance and the affected wetland areas are expected to recover pre-project aquatic function. Therefore, with implementation of post-project restoration, permanent discharge of fill for this component of Proposed Action does not result in a net loss of wetland.

4.2.3 BAC Intake Relocation and Phantom Ranch Distribution Improvements

Direct permanent fill impacts to wetlands for this component are limited to the new surface water intake structure at BAC. As depicted in **Appendix B: Sheet 04-WL03** and **Figures 3 and 4** above, the surface water intake will be constructed within the south end of BAC just north of Phantom Ranch.

4.2.3.1 Intake Structure Impacts

Grading

As depicted in Attachment B: Sheet 04-WL03 and Figures 3 and 4 and detailed in Section 1.2.2 above, grading occurs within BAC, below the OHWM elevation, to narrow the low flow channel to maintain the minimum depth of surface water over the intake screen and provide the volume of water required by the Park. This grading results in the permanent discharge of up to 199 CY of native streambed material 0.019 acre/100 LF of perennial stream (Feature ID S1t) associated with BAC. The low flow channel grading would occur below the OHWM elevation; therefore, there would be no loss in BAC's surface area.

While base flows will be directed through the narrowed low flow channel at the location of the intake, the channel remains unconfined and maintains connectivity with the floodplain. Therefore, channel velocities during storm flows would not be substantially impacted by the grading. Base flow velocities would be expected to increase slightly through the narrowed low flow channel but would not be expected to reach velocities that would induce scour.

Given that channel hydraulics would exhibit minimal change, channel bed composition and surface area would remain unchanged, and that this portion of BAC does not support riparian vegetation, the stream would be expected to recover pre-project aquatic functions. The grading and placement of boulders at grade in the channel will maintain pre-project surface conditions as described further below for the Rock Vanes.

Intake Box

Installation of the intake box to divert water for Park use results in the permanent discharge of 22 CY of concrete and stainless-steel structure and 20 CY of 2-foot to 4-foot diameter rounded to subangular rock from the streambed into 0.002 acre of palustrine wetland (Feature ID W16) and 0.004 acre/25 LF of perennial stream (Feature ID S1t) associated with BAC.

This component of the Proposed Action results in a loss of 0.002 acre of palustrine wetland and 0.004 acre of perennial stream because the intake structure and the boulders stabilizing it would preclude both revegetation and reestablishment of the perennial stream benthic community. Therefore, this component of the Proposed Action is being as a loss of 0.002 acre of palustrine wetland and 0.004 acre of perennial stream, although much of the stream's aquatic function will remain intact.

Rock Vanes

Installation of two rock vanes which will direct low flows toward the intake result in the discharge of 33 CY of rounded to subangular rock from the streambed ranging from 4-inches to 36-inches into 0.001 acre of palustrine wetland (Feature ID W17) and 0.006 acre/14 LF of perennial stream (Feature ID S1t) associated with BAC.

The 2-foot to 3-foot of rock that is above ground would preclude revegetation while the

remainder of each vane would be embedded and available for revegetation. Therefore, this component of the Proposed Action results in the net loss of <0.001 acre of palustrine wetland. As described above, the rock, which would be obtained from the streambed, would be embedded in the channel bottom such that only base flows would be directed to the intake box and pre-project water surface area would be maintained. Although the rock prevents revegetation, it will function as boulders and cobble functions in any perennial stream. Therefore, aquatic functions associated with the perennial stream are anticipated to recover following the Proposed Action and this component of the Proposed Action would not result in the loss of perennial stream

Riprap Slope Protection

Installation of riprap slope protection results in the permanent discharge of 33 CY of rounded to subangular native rock from the streambed ranging from 8-inches to 24-inches in diameter into 0.002 acre of palustrine wetland (Feature W16) associated with BAC.

These impacts result in a loss of 0.002 acre of palustrine wetland because the rock precludes revegetation.

Rock Weirs

The installation of the rock weirs below the intake box for scour protection from large storm events results in the permanent discharge of 21 CY of 2-foot to 4-foot diameter rounded to subangular rock from the streambed into 0.001 acre of palustrine wetland (Features W16 and W17) and 0.004 acre/16 LF of perennial stream (Feature ID S1t) associated with BAC.

These impacts result in a loss of palustrine wetland because the rocks preclude revegetation. However, as described above, the rock, which would be obtained from the streambed, would be embedded in the channel bottom. Although the rock prevents revegetation, it will function as boulders and cobble functions in any perennial stream.

Therefore, this component of the Proposed Action results in the net loss of 0.001 acre of palustrine wetland. However, aquatic functions associated with the perennial stream are anticipated to recover following the Proposed Action and this component of the Proposed Action would not result in the loss of perennial stream.

Toe Protection

The installation of rock from the streambed along the toe of the stream banks as scour protection during large storm events permanently discharges 15 CY of 2-foot to 4-foot diameter rounded to subangular rock into 0.003 acre of palustrine wetland (Feature ID W17) associated with BAC.

These impacts result in a loss of 0.003 acre of palustrine wetland because the rock preclude revegetation.

4.3 Summary of Impacts to Wetlands

In total, the Proposed Action would permanently diminish the aquatic function of or convert 0.008 acre of palustrine wetland and 0.004 acre of perennial stream to upland. However, as detailed above in **Section 4.0** above, in addition to restoration of temporarily impacted wetland and wetland subject to permanent fill with no loss of function, the Proposed Action would compensate for the loss of riverine and palustrine wetland by reestablishing or relocating 0.008 acre of palustrine wetland contiguous with BAC in the vicinity of the intake structure and the restoration of approximately 0.18 acre of perennial stream within BAC upstream of the relocated intake. Therefore, the Proposed Action results in no net loss of wetland.

4.4 Adverse Impacts to the Physical and Biological Conditions at the Intake

Channel morphology will be altered over a 170-foot-long reach of BAC as described above. In order to maintain the 1.5-foot-deep low flows at the intake structure necessary to maintain a stable water supply, two cross vanes will be constructed of natural materials to divert low flows as needed to the low flow channel on the north side of the creek. The low flow channel will also be reduced laterally by up to 4 feet in width and up to 400 sf in total. However, the longitudinal profile will not change. Additionally, only the crowns of the native boulders being used to construct the rock vanes will project above the stream bed. The channel will continue to exhibit an irregular, rocky bed and fringe wetland. Channel velocities will be slightly increased at the intake during low flows due to the narrower cross section. However, the low flow channel will remain unconstrained so that larger storm flows overtop the low flow channel, submerge the rock vanes and proceed along the natural active floodplain with no obstruction or substantial changes to pre-project hydraulics.

The stainless steel intake box will eliminate 0.004 acre of perennial channel bed. The channel bed in the vicinity of the intake box will be stabilized using native materials from the creek. The stabilization is intended to protect the intake, and thus Park water supply, from large storm events that have caused scour in the past. The channel reconfiguration described above will not produce erosive flows. Small amounts of sediment will be diverted from the creek and settle in the pump wetwell where it will be periodically pumped out, transferred to the sediment drying beds and used for trail construction or maintenance. Otherwise, sediment dynamics during all but the largest storms will remain unchanged.

Stabilization will consist of 35 linear feet of riprap on the north bank at the intake, five weirs, and embedded boulders along the toe of the channel bank/margin of the active floodplain. The weirs and toe protection will be constructed at grade using existing channel bed materials. These are expected to blend into the natural rocky stream bottom. However, construction of the riprap, weirs, and the addition of embedded rock at the toe of the channel banks will displace 0.008 acre of palustrine wetland. However, an additional 0.008 acre of palustrine wetland will be established within the impact area so that no net loss of wetland occurs. Fish passage will not be obstructed, but the intake structure could entrain or impinge native aquatic species as further detailed below.

BAC and its tributaries support large populations of native speckled dace *Rhinichthys osculus*), flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*Catostomus discobolus*), and occasionally humpback chub (*Gila cypha*), in addition to several nonnative species that compete with and prey upon the native species. Humpback chub is a federally endangered species. The speckled dace, flannelmouth sucker, and bluehead sucker are listed by the Arizona Game and Fish Department as species of greatest conservation need, and are residents in BAC, spawning each spring. Razorback suckers (*Xyrauchen texanus*) do not occur in BAC, but may occur, although very rarely, downstream in the Colorado River. Direct impacts to these species could include injury or death resulting from the entrainment or impingement of larval fish as they drift past the intake. However, this is anticipated to be a relatively small risk given that the screen slots and approach velocity have been designed to minimize fish impacts as discussed further below. Indirect impacts could result from the restoration of pre-TCWL flows in BAC, which may result in slightly decreased water temperatures in the lower section of BAC below Roaring Springs, and construction activities that could increase sedimentation in the creek.

The perennial low flow channel will be narrowed by approximately 4 feet and deepened by approximately one foot at the intake box. The change in low flow channel morphology extends approximately 100 linear feet. In total, the surface area of the low flow channel will be reduced by approximately 150 sf. The increase in depth could alter temperature and flow velocities within the 100 linear foot segment. However, any changes are expected to fall within the normal range of tolerance for native aquatic species and motile individuals would only be exposed to the changes for a brief time as they passed through the segment.

As previously stated, the intake screen is designed to minimize entrainment of juvenile fish and manage sediment. Specifically, the following design specifications have been incorporated based upon guidance from U.S. Bureau of Reclamation (Pocket Guide to Screening Small Water Diversions, 2014), U.S. Bureau of Reclamation (Fish Protection at Water Diversions Design Manual, 2006), and National Marine Fisheries Service, Northwest Region (nwr.noaa.gov) (Anadromous Salmonid Passage Facility Design, July 2011):

- Maximum approach velocity (Va) ≤ 0.2ft/s (Va = (Maximum Screened Flow)/(Vertical Projection of Screen Area)
- Flow distribution must be consistent across screen face
- If screen is longer than 6 feet, screen must be angled at 45 degrees or less
- If screen is longer than 6 feet, sweeping velocity (Vs) is recommended to be 0.8-3.0 ft/s
- Screen opening size no greater than 1.75 mm (approximately 1/16-inch)
- Maximum (Typical) Screened Flow (Qs) = 700 gpm = 1.56 cfs = 1 mgd
- Vs/Va ratio ≥ 10 (Vs/VA ≥ 20 if possible)
- Screen Type: Profile Bar

As a result of the design parameters above, only larval forms of the native fish species that are present at their earliest life stages are likely to be susceptible to injury or death due to entrainment and impingement on the proposed water intake screen. Additionally, due to naturally high mortality of fish during larval life stages, it is highly unlikely that any fatality of larval native fish because of entrainment into the surface water diversion will have population-level effects or be at a level that

will cause a viability concern. In addition, any larval native fish that drift to lower BAC (where the relocated surface water intake will be installed) will most likely end up in the Colorado River. Native fish survival is also likely to be lower here, than if they remained in BAC, due to potentially higher predation rates in the Colorado River and more exposure to altered habitat conditions (e.g., colder waters, low turbidity). Therefore, as determined by U.S. Fish and Wildlife Service, the adverse direct effects to larger individual larval humpback chub ≥0.9 inch (23 mm), juvenile chub, and adult humpback chub within BAC from the surface water intake are insignificant and discountable. The same would be true for other native species that breed in BAC.

Razorback suckers are not present in sufficient numbers to reproduce in order for suckers small enough (0.9-inch or 23 mm) to be susceptible to entrainment and impingement to occur. Additionally, survey data indicates that razorback suckers are not reproducing in the action area. U.S. Fish and Wildlife Service concurred that the proposed Action may affect but is not likely to adversely affect razorback suckers.

Temperature changes within upper BAC due to the additional 2.8 cfs of surface flows are anticipated to be within the normal tolerance range for native fish which would result in a small decline in the number of suitable days for humpback chub reproduction. The predicted decrease in water temperature in the lower section of BAC may result in more favorable brown trout habitat conditions and there could be an increase in the number of days within the optimum temperature range for brown trout growth. However, the ongoing NPS nonnative fish monitoring and removal efforts are expected to reduce the potential increase in brown trout, and thus predation on humpback chub and other native species, to insignificant levels.

Ground disturbance from construction and staging activities within the BAC drainage could result in some increased sedimentation and turbidity in BAC. However, best management practices to control erosion and sediment will minimize runoff and sediment discharges into the creek. In addition, project staff will recontour disturbed areas outside of designated trails and structure footprints to match existing grades and revegetate the areas with native species to provide long-term soil stabilization following construction.

Creek bed disturbance and sedimentation during construction of the intake will be limited and increased turbidity levels will be temporary. Increased turbidity levels will be minor compared to BAC natural turbidity levels during flood events. Native fish are adapted to turbid conditions and negative effects to native fish will be insignificant as a result of a short-term temporary increase in turbidity.

As previously noted, aquatic function associated with temporary impacts to perennial stream and fringe wetland would be expected to recover quickly with recovery of benthic fauna, nutrient cycling and groundwater recharge and discharge within the perennial streams and early successional wetland habitat functions and biogeochemical processes to follow within months (Korsu, 2004). Additionally, the restoration of approximately 0.18 acre of perennial stream (riverine wetland) resulting from an increase of flows to a 22-acre, nine-mile reach of BAC (described below) will compensate for any impacts from the intake project.

4.5 Indirect Effects on Wetlands

4.5.1 Restoration of Garden Creek

Water from Roaring Springs is currently conveyed by gravity to the Havasupai Garden Pump Station and then water is pumped to tanks on the South Rim through a bore hole. The pumps at Havasupai Garden generally run from 8 PM to 10 AM and when the pumps are not running, the excess water is released into Garden Creek that then flows into Pipe Creek. This overflow is estimated to increase Garden Creek flow by 50%. Changing the location of the intake to BAC and pumping water to Havasupai Garden rather than being gravity fed, would greatly reduce or eliminate TCWL overflows into Garden Creek, resulting in Garden Creek being restored to its natural state.

A series of aerial photographs comparing the reach of Garden Creek between Havasupai Garden Pump Station and Pipe Creek from 1954 and 2017 is presented in **Figures 5A-5D**. The extent of riparian habitat associated with Garden Creek looks remarkably similar suggesting that removing the artificial flows may alter the composition of floral and faunal communities associated with the creek, but the aerial extent of palustrine wetland may not be dramatically impacted. Downstream of the Garden Creek confluence, Pipe Creek does appear to support a higher vegetation cover now than in 1954 and surface flows are visible in the 2017 aerial photograph but not apparent in the 1954 aerial photograph. Monitoring would occur to track the change in the riparian area and NPS could decide to augment the flows by releasing water again from the Havasupai Garden pumphouse or develop another strategy to minimize loss of riparian area if it occurs. Reduction or elimination of artificial flows resulting from the Proposed Action would return Garden and Pipe Creeks to conditions and processes more characteristic of a natural ecosystem.

4.5.2 Restoration of Bright Angel Creek (BAC)

Restoration of natural flows in the 22-acre, nine-mile reach of BAC from Roaring Springs to the intake structure, would occur under the Proposed Action, returning an average of 2.8 cfs back into BAC. It would be expected that the restoration of flows to BAC would increase the depth and width of channel inundation under base flow conditions, even if only by a small increment. Based on a comparison of the expected depths estimated by applying Manning's Equation to a small sample of cross sections, depths of flow could change by 0.5-inch or more.[6] Results of the comparison are provided in **Appendix C**: **Normal Depth Calculator Results**.

Assuming 0.5-inch increase in depth of flow, which would result in a 2-inch increase in the width of inundation for channel banks with 2:1 slopes, the increased inundation area would total 0.18 acre, thus offsetting the loss of 0.004 acre of perennial stream (riverine wetland) for relocating the surface water intake.

[6] Analysis utilized a National Oceanic and Atmosphere Administration Manning's equation calculator available at https://www.weather.gov/aprfc/NormalDepthCalc#:~:text=The%20Mannings%20equation%20is%20an%20empirical%20equation%2 0that,Hydraulic%20Radius%2C%20%28ft%29%20S%20%3D%20Channel%20Slope%2C%20%28ft%2Fft%29

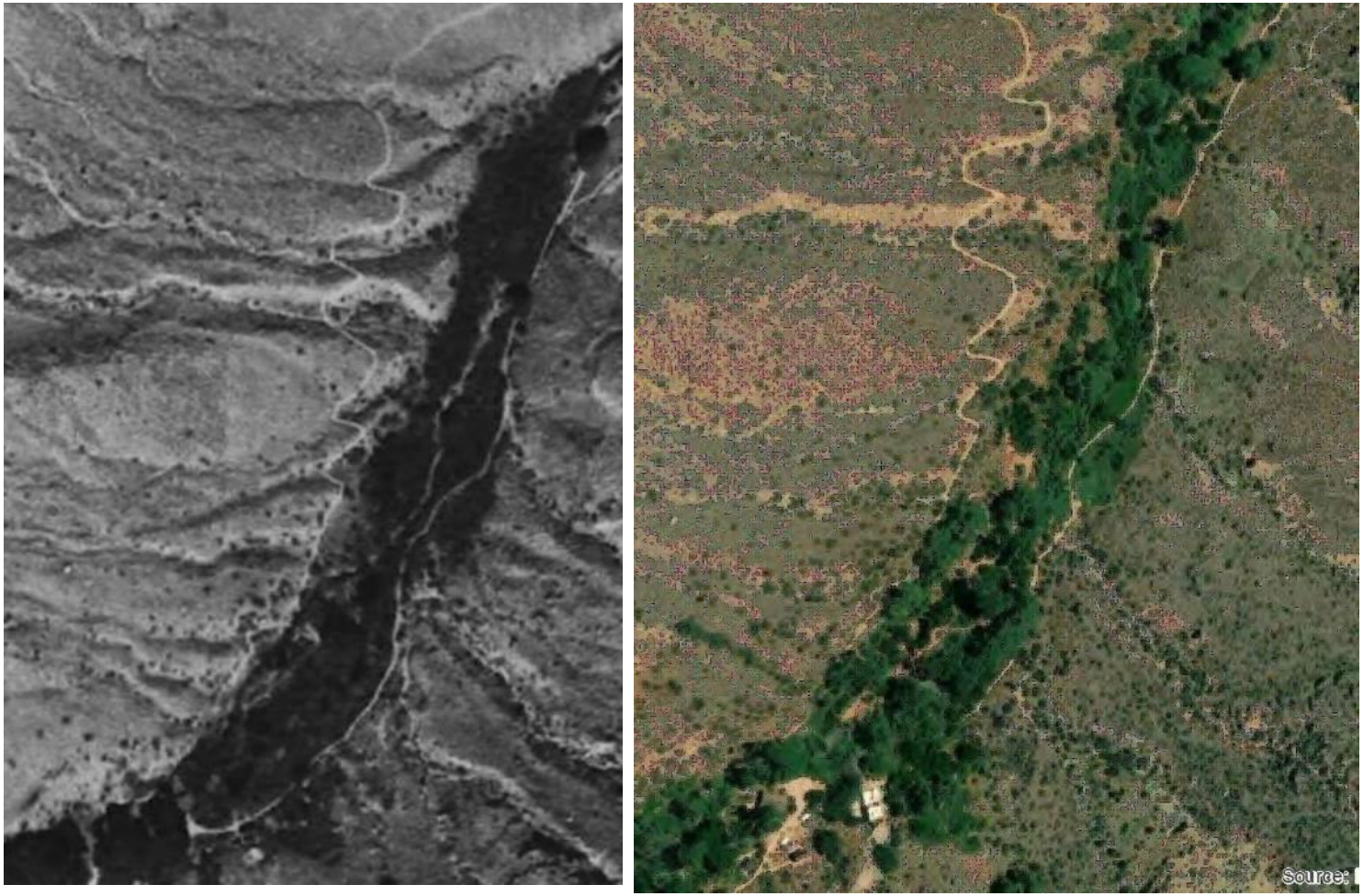

FIGURE 5A: GARDEN CREEK FROM Havasupai Garden PUMP STATION (LOWER LEFT CORNER) NORTH APPROXIMATELY 1,500 LF. 1954 (LEFT), 2017 (RIGHT)

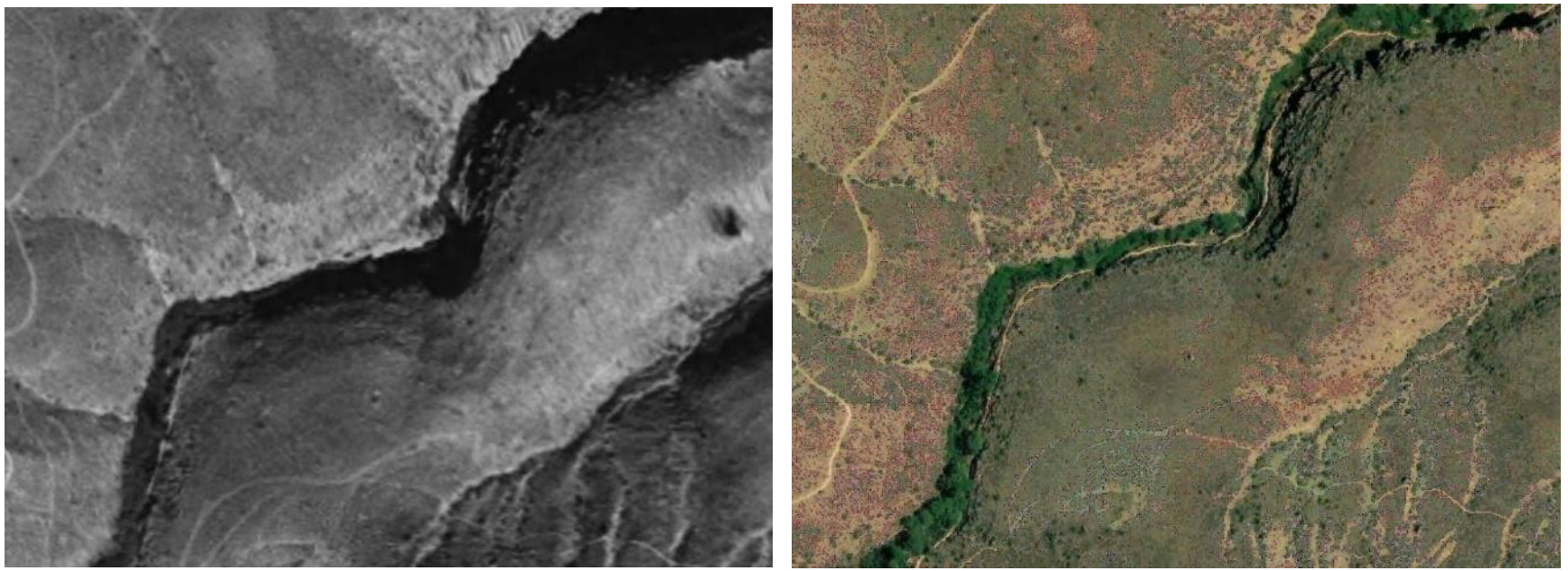

FIGURE 5B: GARDEN CREEK FROM APPROXIMATELY 1,500 FEET NORTH OF Havasupai Garden PUMP STATION TO APPROXIMATELY 3,500 LF NORTH OF THE PUMP STATION. 1954 (LEFT), 2017 (RIGHT)

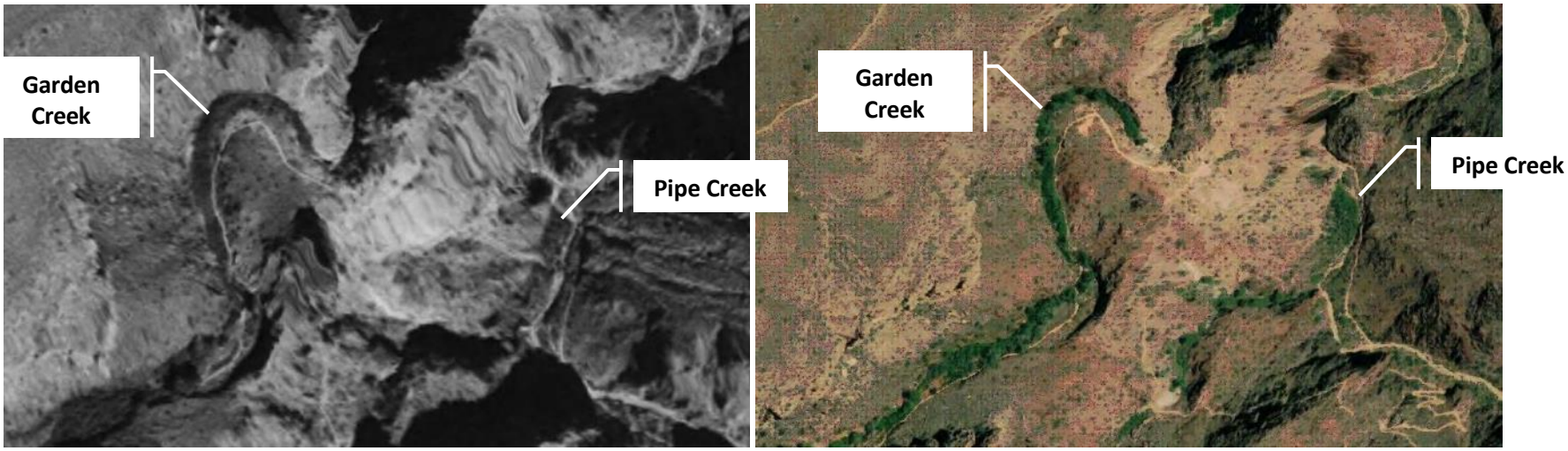

FIGURE 5C: GARDEN CREEK FROM APPROXIMATELY 3,500 FEET NORTH OF Havasupai Garden PUMP STATION TO APPROXIMATELY 6,140 LF NORTH OF THE PUMP STATION. 1954 (LEFT), 2017 (RIGHT)

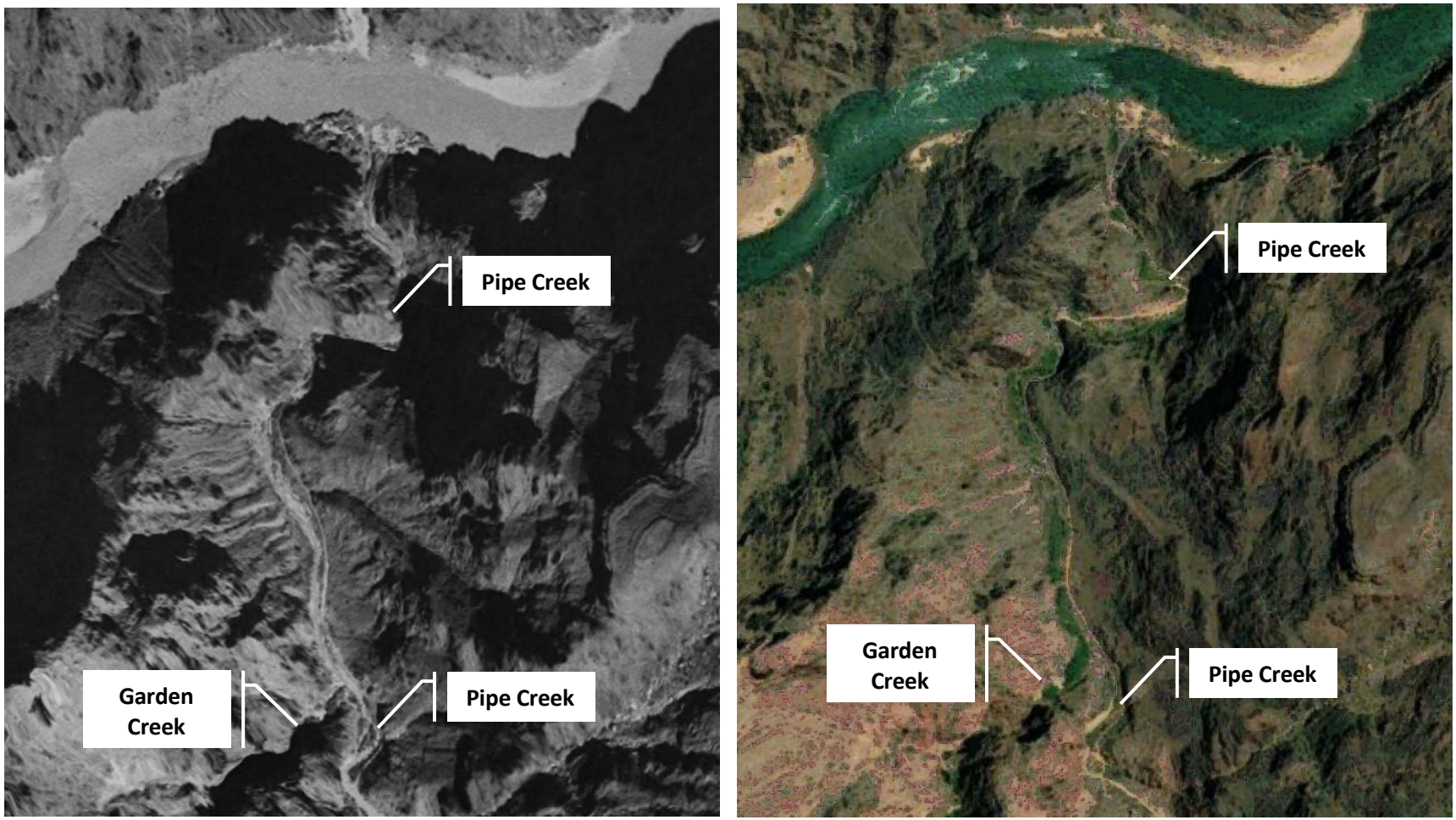

FIGURE 5D: GARDEN CREEK FROM APPROXIMATELY 6,140 FEET NORTH OF Havasupai *Garden PUMP STATION TO THE COLORADO RIVER. 1954 (LEFT), 2017 (RIGHT)*

4.6 Functional Assessment of Affected Aquatic Resources

Table 2 provides descriptions for six wetland and surface water characteristics that are indicative of aquatic function for each affected wetland. These characteristics include:

(1) Contiguity: Contiguity describes the extent to which a wetland is abutting or continuous with other wetlands. Attributes related to contiguity may include entrenchment ratio, the frequency of road crossings, the presence of dams, the extent of a feature loss to storm drain development, etc.

(2) Vegetative Structure Diversity: Vegetative Structural Diversity is related to number and quality of strata present

(3) Edge Relationship: Edge relationship refers to presence or absence of a zone of transition between the immediate margins of a wetland and its surrounding environment that is likely to help protect the wetland from anthropogenic stress

(4) Wildlife Habitat Value: Wildlife Habitat Value is related to the diversity of species that a wetland can support with special attention paid to rare species

(5) Hydrologic Function: Hydrologic Function includes impairment of water source, quantity, and movements, plus the quantities, transport, and fates of water-borne materials, particularly sediment as bed load and suspended load and nutrients

(6) Public Use

These functions will be fully restored for all impacted wetlands with the exception of 0.008 ac palustrine wetland and 0.004 acre of perennial creek at the intake structure. As previously discussed, these impacts will be offset through the relocation/establishment of 0.008 acre of fringe wetland within BAC in the vicinity of the intake and through the restoration of 0.18 acre of riverine wetland within BAC between Roaring Springs and the relocated intake.

4.7 Justification for Use of the Wetlands

The purpose of the Proposed Action is to provide a reliable water delivery system to meet water supply needs at the South Rim and in the Cross Canyon Corridor for a project lifespan of approximately 50 years. The project is needed because the TCWL, which was constructed in the 1960s, is beyond its useful life, experiences frequent failures, and requires continual maintenance to repair leaks. The Proposed Action, including relocation of the intake and replacement of the pipeline within wetlands and waters, is necessary to provide water to the South Rim and inner canyon.

4.8 Minimization

As previously stated, the Proposed Action results in the restoration of pre-project flows to both Garden Creek and BAC. Additionally, relocating the surface water intake to its proposed location allows for abandonment or removal over time of approximately 7.5 miles of water line from Phantom Ranch to Cottonwood Campground and reuse of approximately 1.5 miles of water line to act as conduit for a smaller water line from Cottonwood Campground to Roaring Springs. This approximately 9-mile segment of water line between Phantom Ranch and Roaring Springs requires frequent repairs and maintenance. Both ongoing maintenance and replacement of that nine-mile segment of TCWL likely would have resulted in additional and/or ongoing impacts to wetlands. Several intake alternatives were evaluated, and the least impactful feasible alternative was selected.

Roaring Springs and Cottonwood Campground Waterline Rehabilitation utilize slip lining techniques to avoid and minimize impacts to wetlands.

Best management practices related to wetlands would be implemented, and include:

- Grand Canyon's Parkwide Spill Response Plan would be used by Park employees and contractors to prevent potential poisoning of wildlife, as well as soil and water contamination.
- The Park would monitor temperatures in BAC following relocation of the TCWL intake and increase nonnative fish removal efforts if monitoring indicates that conditions have changed to favor nonnative brown trout.
- Disturbed areas would be rehabilitated, as appropriate, to limit invasion and spread of invasive nonnative plants and mulch would be spread to a depth of 3 to 6 inches, depending on the level of disturbance.
- Equipment and supplies would be staged and stored in already disturbed areas on-site or designated staging areas.
- If erosion-control fencing is used, soil would be piled in front of the fence to avoid creating bare soil and potential for invasive plant species encroachment outside the project area. Erosion control would also reduce the amount of sediment entering wetlands.
- Trenching and construction equipment transported to the site from outside the Park would first be pressure-washed to minimize the potential to import invasive plant seed and material to the site.
- Monitoring would occur to track the change in riparian area below the Havasupai Garden pumphouse.
- Site disturbance would be limited to approved clearing limits. Clearing limits would be demarcated prior to construction using removable flagging or similar methods. Care would be taken to avoid operating equipment, staging equipment and supplies, and walking or disturbing soils, biotic crusts, natural surfaces, grasses, forbs, shrubs, or other natural materials in areas outside approved clearing limits.

- Lay down of rubber mats or plywood boards under the wheels/tracks of the mechanized equipment would be required when crossing sensitive areas including palustrine wetlands.
- Compacted soils would be scarified and original contours reestablished.
- Use of mechanized equipment would be confined to the smallest possible area and would stay within the defined work corridor.
- Aspen fiber, not straw, would be used for all erosion-control products such as wattles. Coconut fiber materials would be used, rather than jute or other fabrics, for erosion-control blankets on slopes greater than 3:1.
- Any fill materials required for the project would be obtained from a Park-approved source in adherence to Standard Operating Procedure 8213-007 *Invasive Plant Free Forage and Construction Materials*. Intact native topsoil from the project area would be retained whenever feasible.

4.9 Restoration of Impacted Wetlands

The restoration plan and specifications for the Proposed Action is included as **Appendix D: Restoration Plan and Specifications**.

The plan and specifications identify restoration areas, plant palettes for each restoration area and installation and maintenance specifications.

In addition to restoring pre-project topography for 0.430 acre of palustrine wetland, 0.144 acre of perennial stream and 0.093 acre of ephemeral stream following completion of the Proposed Action, the 0.430 acre of palustrine wetland will be revegetated as depicted on the restoration plan sheet and erosion control sheets and described in the specifications.

In addition to restoration of wetlands described above, a minimum of 0.008 acre (350 sf) of additional wetland will be established within BAC in the vicinity of the intake structure. Establishment areas are depicted on **Figure 6: Wetland Establishment Areas**, with vegetation established in accordance with **Appendix D: Restoration Plan and Specifications**. The wetland establishment areas would be located at the same elevation as existing wetlands along BAC to match the hydrologic regime of fringe wetland prior to construction.

Furthermore, as previously noted, due to the relocation of the intake from Roaring Springs to Phantom Ranch, stream flows within the nine-mile segment of BAC between Roaring Springs and the proposed intake would be increased, resulting in the restoration of approximately 0.18 acres of BAC.

4.9.1 Performance Standards

At least 0.144 acre of perennial stream and 0.093 acre of ephemeral stream shall meet the following performance standard within a three-year period:

- Restored areas shall exhibit hydrologic indicators evidenced by the presence of an ordinary high water mark (OHWM), including but not limited to the presence of litter and debris, shelving, destruction of terrestrial vegetation, direct observation of discharge, or line impressed upon the bank.

In addition, at least 0.438 acre of palustrine wetland would be required to meet the success criteria identified in Table 4 below in addition to meeting U.S. Army Corps of Engineers definition of wetland.

Table 4. Success Criteria

Criteria	Year 1	Year 2	Year 3
Palustrine Wetland[1] % Cover of Native Plants (relative to baseline)	30%	60%	90%
% Cover of weed species categorized as High or Moderate in the Cal-IPC Invasive Plant Inventory	0%	0%	0%
% Relative Cover of all other weed species	≤ baseline	≤ baseline	≤ baseline

[1] Site will support less than 20% bare ground by end of year 3, otherwise supplemental seeding would occur.

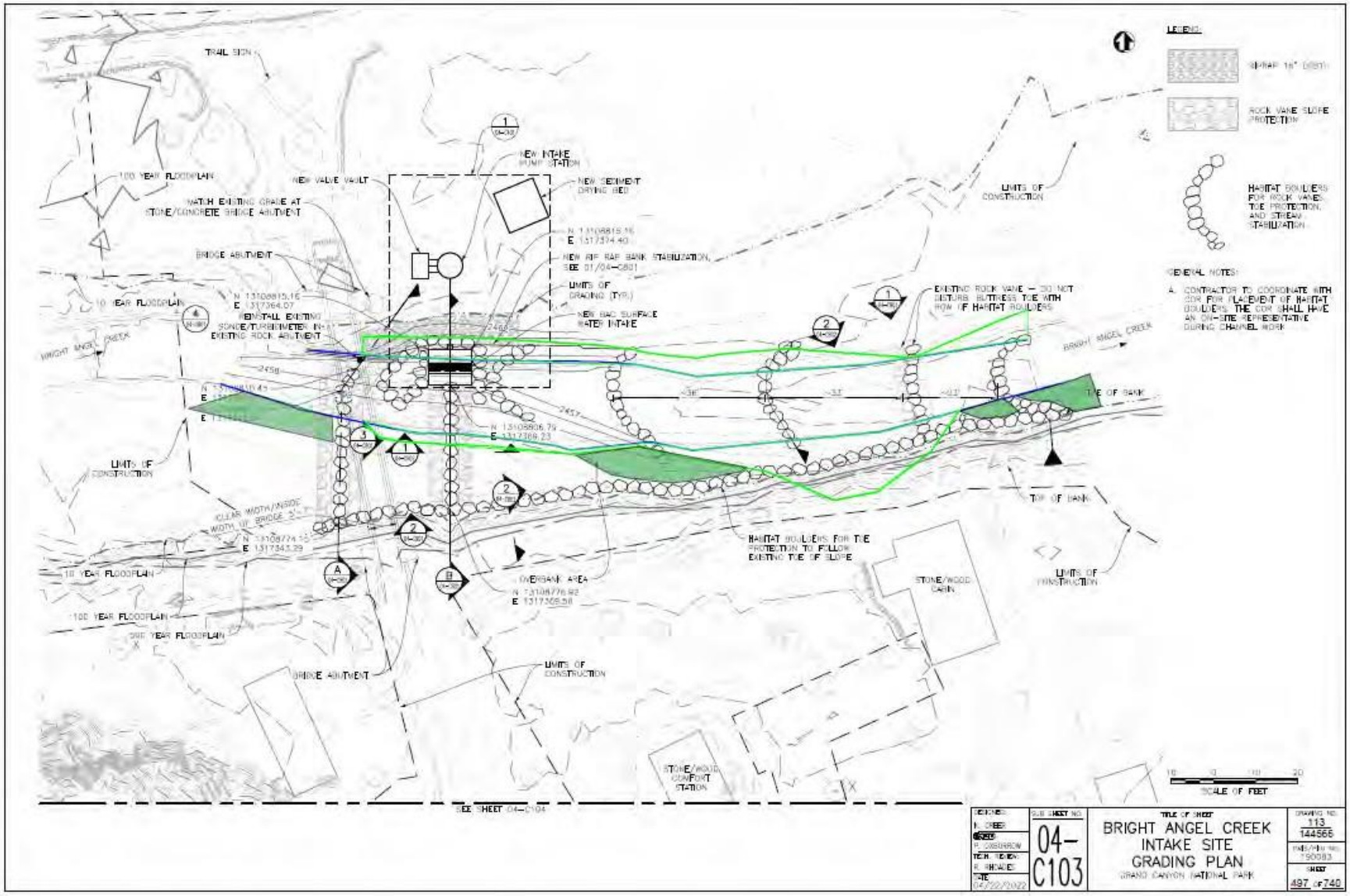

FIGURE 6: WETLAND ESTABLISHMENT (RELOCATION) AREAS (SHOWN IN GREEN SHADING)

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5.0 Conclusion

The NPS finds that the proposed Transcanyon Water Distribution Pipeline Project would provide a reliable water delivery system to meet water supply needs at the South Rim and in the Cross Canyon Corridor. The NPS also finds that there is no practicable alternative that would result in no impacts to wetlands.

Most palustrine and riverine wetland impacts have been avoided and minimized to the extent practicable by reusing the existing pipeline, disturbing wetlands within the original installation zone of disturbance, and by implementing best management practices. The Proposed Action would impact approximately 0.679 acres of wetlands. In addition to restoring 0.430 acre of palustrine wetland, 0.144 acre of perennial stream, and 0.093 acre of ephemeral stream, the improvement to physical and biological conditions resulting from the increased flows in the 22-acre, nine-mile stream reach will be substantial and result in a net gain of 0.18 acre of riverine wetland area and function. Additionally, 0.008 acre of wetlands would be established along BAC near the intake structure. Therefore, this project is consistent with E.O. 11990 and NPS Director's Order #77-1, including the NPS no-net-loss of wetlands policy.

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