

Transcanyon Water Distribution Pipeline Grand Canyon National Park

Environmental Assessment



Public Comment

If you wish to comment on this Environmental Assessment (EA), you may post comments online at: <http://parkplanning.nps.gov/grca> or mail to Grand Canyon National Park, Attn: Transcanyon Pipeline EA, PO Box 129, Grand Canyon, Arizona 86023 or hand deliver comments to Park Headquarters, 20 South Entrance Road, Grand Canyon, Arizona. This EA will be on public review for a minimum of 30 days.

Before including your address, phone number, e-mail address, or other personal identifying information in your comment, you should be aware that your entire comment – including your personal identifying information – may be made publicly available at any time. Although you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so. Comments will not be accepted by fax, email, or in any other way than those specified above. Bulk comments in any format (hard copy or electronic) submitted on behalf of others will not be accepted.

This page intentionally left blank

TABLE OF CONTENTS

INTRODUCTION	1
Purpose and Need	1
Project Objectives	1
Background	1
Issues and Impact Topics.....	2
Impact Topics Retained for Further Analysis.....	4
Impact Topics Dismissed from Further Analysis.....	4
Soils	4
Ponderosa Pine Forest Habitat	4
Garden Creek and Pipe Creek Ecosystem.....	5
Wetlands.....	5
Floodplains	6
Indian Trust Resources and Indian Sacred Sites	6
Environmental Justice	6
ALTERNATIVES	7
Alternative A – No Action	7
Alternative B – Relocate Water Intake (Preferred Alternative)	7
Phantom Ranch Facilities	9
Indian Garden Facilities.....	11
TCWL Replacement.....	12
South Rim WTP	12
Electrical Line from South Rim to Phantom Ranch.....	14
Access and Staging.....	14
Helicopter Operations	16
Pipeline Operation during Construction.....	16
Schedule	16
Alternative C – Replace TCWL in Same Location.....	17
TCWL Replacement.....	17
Access and Staging.....	19
Helicopter Operations	19
Construction Equipment and Pipeline Operation during Construction	20
Schedule	20
Alternatives and Alternative Elements Considered and Dismissed	20
Horizontal Directional Drill Alternatives.....	20
Wells on South Rim	20
Regional Water Solutions	21
Transport Water via Truck or Train	21

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES	22
Bright Angel Creek Native Fish	22
Affected Environment.....	22
Environmental Consequences	23
Special Status Terrestrial Wildlife	26
Affected Environment.....	26
Environmental Consequences	28
Cultural Landscapes and Historic Buildings and Structures	36
Affected Environment.....	36
Environmental Consequences	38
Archaeological Resources, Traditional Cultural Properties, and Ethnographic Resources	43
Affected Environment.....	43
Environmental Consequences	44
Visitor Use and Experience	48
Affected Environment.....	48
Environmental Consequences	50
Wilderness Character	54
Affected Environment.....	54
Environmental Consequences	58
Backcountry Commercial Use Socioeconomics	61
Affected Environment.....	61
Environmental Consequences	61
Soundscape and Acoustic Environment	65
Affected Environment.....	65
Environmental Consequences	65
CONSULTATION AND COORDINATION.....	70
List of Agencies and Tribes Consulted	70
 Appendix A Best Management Practices.....	 A-1
Appendix B Alternatives Comparison.....	B-1
Appendix C Potentially Impacted Special Status Terrestrial Wildlife Species	C-1
Appendix D Acronyms and Abbreviations.....	D-1
Appendix E References	E-1

LIST OF FIGURES

Figure 1. Transcanyon Water Distribution Pipeline and Existing Water Infrastructure.....	3
Figure 2. Alternative B – Relocate Water Intake (Preferred Alternative).....	8
Figure 3. Proposed South Rim WTP.	13
Figure 4. Proposed helibase expansion and contractor operations and staging areas.....	15
Figure 5. Alternative C – Replace TCWL in Same Location	18
Figure 6. Proposed wilderness and existing TCWL.....	56
Figure 7. Maximum sound level of hovering helicopters (logarithmic scale)	67

LIST OF TABLES

Table 1. Construction zone acreage for Alternative B.....	10
Table 2. Construction zone acreage for Alternative C.....	17
Table 3. Potentially impacted special status terrestrial wildlife species	26
Table 4. Impacts on archaeological resources in the current TCWL alignment.....	45
Table 5. Potential impacts on archaeological resources under Alternative B	46
Table 6. Potential impacts on archaeological resources under Alternative C	47
Table 7. Number of commercial backpacking trips for all operators in 2017, by month	61
Table 8. Common sound sources and their sound levels	65
Table 9. Predicted noise levels from construction equipment for the TCWL project.....	66

INTRODUCTION

The National Park Service (NPS) is proposing to relocate the water intake for the Transcanyon Water Distribution Pipeline (TCWL) from Roaring Springs to a new area near Bright Angel Creek at Phantom Ranch and replace portions of the TCWL between Phantom Ranch and the South Rim in Grand Canyon National Park (park). The TCWL supplies water to the South Rim and facilities within the Cross Canyon Corridor in the park.

Purpose and Need

The purpose of the proposed project 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.

Project Objectives

- Improve the TCWL's water delivery reliability and resiliency
- Minimize disruptions to visitor access and services during construction
- Minimize impacts on visitor experience and wilderness character during and after construction
- Maintain the historic character of the Cross Canyon Corridor Historic District (CCCHD)
- Minimize impacts on archaeological sites and ethnographic resources
- Minimize visual and noise impacts on special status wildlife from helicopter use and other construction activities

Background

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.

Water is conveyed by gravity through the 12.5-mile TCWL from Roaring Springs along Bright Angel Creek and the North Kaibab Trail through Phantom Ranch (elevation 2,500 feet), over the Colorado River suspended from a bridge, and up to the Indian Garden Pump Station (elevation 3,800 feet). The Indian Garden Pump Station pumps water to the South Rim storage tanks, which are at an elevation of approximately 7,040 feet. The total elevation change is about 7,310 feet to 2,770 feet from Roaring Springs down to Phantom Ranch and 4,540 feet from Phantom Ranch up to the South Rim. Roaring Springs also supplies water to the North Rim via

the Roaring Springs Pump Station and North Rim pipeline. The TCWL does not include the North Rim water facilities and water supply to the North Rim is not included in this project or evaluated in this document. The pipeline from Indian Garden to the South Rim is also not included and is not considered part of the TCWL. The existing pipeline is shown on Figure 1.

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.

The water supply for Roaring Springs is from a large cave system, which is supplied by snowmelt and precipitation (Jones et al. 2017). Preliminary data suggest that changes in snowpack may affect flow at Roaring Springs (Klos et al. 2014; Schwinning et al. 2008; Seager et al. 2007). The TCWL currently has the capacity to carry about 1 million gallons/day from Roaring Springs to the Indian Garden Pump Station. Current water usage in the Cross Canyon Corridor and on the South Rim is approximately 300,000 to 850,000 gallons per day. An average of about 5% of Roaring Springs flow is captured by the TCWL. Under any alternative, NPS proposes to maintain or reduce water usage by utilizing water conservation techniques and technology and by fixing leaks in the system.

Issues and Impact Topics

When determining whether to retain an issue for more detailed analysis in this Environmental Assessment (EA), considerations included, among other things, whether:

- the environmental impacts associated with the issue are central to the proposal or of critical importance;
- a detailed analysis of environmental impacts related to the issue is necessary to make a reasoned choice between alternatives;
- the environmental impacts associated with the issue are a big point of contention among the public or other agencies; or
- potentially significant impacts on resources are associated with the issue.

Ultimately, decision makers and the public need to understand the impacts that each of the alternatives under consideration would have on specific resources. Therefore, this EA uses “impact topics” as headings to indicate which resources would be affected by each issue and to organize the discussions of the affected environment and environmental consequences (refer to the *Affected Environment and Environmental Consequences* section).

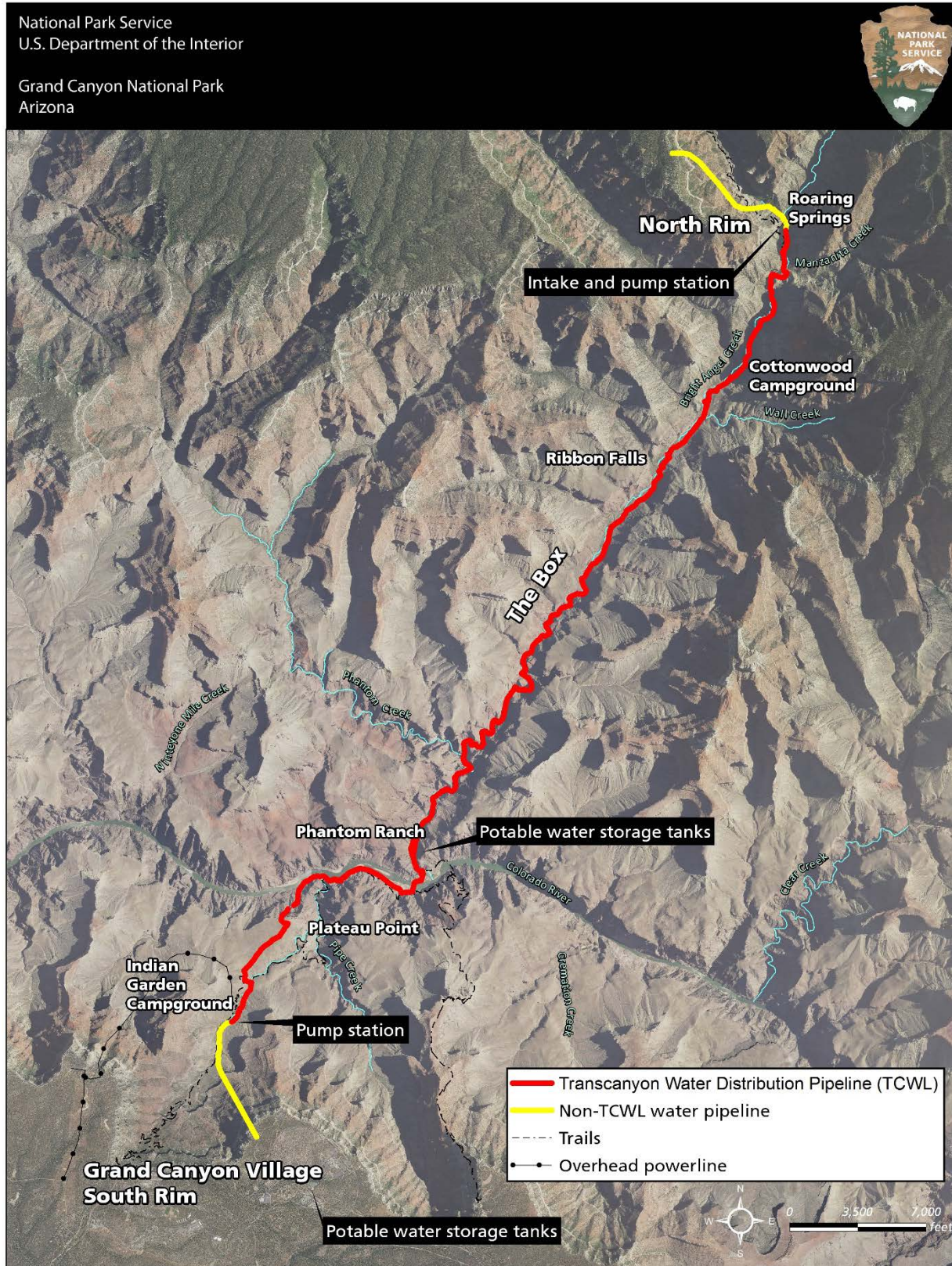


Figure 1. Transcanyon Water Distribution Pipeline and Existing Water Infrastructure.

Impact Topics Retained for Further Analysis

The following topics are carried forward for further analysis in this EA:

- Bright Angel Creek Native Fish
- Special Status Terrestrial Wildlife
- Historic Buildings and Structures and Cultural Landscapes
- Archaeological and Ethnographic Resources and Traditional Cultural Properties
- Visitor Use and Experience
- Wilderness Character
- Backcountry Commercial Use Socioeconomics
- Soundscape and Acoustic Environment

Impact Topics Dismissed from Further Analysis

Using the same considerations noted previously, the interdisciplinary team made up of NPS subject matter experts analyzed the following issues and determined they did not warrant more detailed discussion in this EA.

Soils

Alternative B would impact soil productivity on up to 41 acres through construction activities and Alternative C would impact up to 60 acres. Under either alternative, soil productivity would be permanently lost on up to 16 acres, and additional disturbed areas would be temporary and would be restored following construction. Under the preferred alternative, soil productivity would be affected from construction at Phantom Ranch (about 8 to 9 acres); Indian Garden (about 2 acres); South Rim (about 16 acres); replacement of pipeline and electrical line (up to 11 acres); and potential use of a portion of the pipeline as conduit for a smaller waterline (about 2 to 3 acres). Under Alternative C, soil impacts would occur from replacement of 12 miles of pipeline (about 43 to 44 acres) and development of contractor staging and logistical areas (about 16 acres). The impacted soils on the South Rim would be mostly soils mapped as Pocomate-Pinntank-Toqui complex, 15 to 25% slopes, which are common soils near the South Rim (Lindsay et al. 2003). Best Management Practices (BMPs) would be used to limit the extent of disturbance to soils and to control erosion during construction and revegetation (see Appendix A). Adverse impacts on soil productivity, fertility, and stability are not expected to be substantial because impacts on soils would affect an extremely small portion of the over 1.1 million acres of undeveloped land within the canyon, would primarily occur within disturbed areas, and would be minimized through the use of BMPs. Therefore, this topic was dismissed from detailed analysis in this EA.

Ponderosa Pine Forest Habitat

An expansion of the park helibase, access road, and contractor office and equipment staging area(s) would be constructed on the South Rim under both action alternatives. A total disturbance of up to 15 to 16 acres of previously undisturbed ponderosa pine (*Pinus ponderosa*) forest would occur to construct these support facilities. Alternative B would also impact an additional acre of ponderosa pine habitat for construction of a WTP at the South Rim. The disturbed area would be partially revegetated following construction. Restoration to preconstruction conditions would take many decades given the growth rate of ponderosa pine,

and most of the site would remain unforested. The South Rim of the Grand Canyon and surrounding areas contain one of the largest ponderosa pine forests in existence and this plant community is common in the area. Because the loss of ponderosa pine habitat would occur over a relatively small area and would affect a plant community that is abundant in the park and surrounding areas, this topic was dismissed from detailed analysis in this EA.

Garden Creek and Pipe Creek Ecosystem

Water from Roaring Springs is currently conveyed by gravity to the Indian Garden Pump Station and then water is pumped to tanks on the South Rim through a bore hole. The pumps at Indian 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% (Rihs 2008). Constructing a local WTP and storage tank at Indian Garden would result in a reduction of flow to Garden Creek because the existing overflow from the TCWL at the Indian Garden Pump Station would be eliminated. This would restore Garden Creek to its natural state, prior to construction of the TCWL. Riparian areas along Garden and Pipe Creeks would be reduced and associated plant habitats and communities altered, but the new conditions would be more characteristic of natural conditions and processes for these ecosystems. For these reasons, this topic was dismissed from detailed analysis in this EA.

Wetlands

The alternatives are not expected to measurably impact riparian wetland areas near Indian Garden and Bright Angel Creek at Phantom Ranch and final designs for the project would minimize impacts on wetlands. The water intake would consist of shallow alluvial wells in an upland area near Bright Angel Creek or a surface water intake along the creek or a combination of both. For the surface water intake, up to 450 square feet of riparian vegetation would be removed to install the intake structure and pumps. Armoring would occur along 20 feet of the creek bank upstream of the intake and is not expected to require vegetation removal. Pipeline water crossings would be installed on existing bridges that span wetlands and Bright Angel Creek or would trench across Garden Creek and Pipe Creek, in the same location as the existing pipeline, or adjacent to the existing pipeline. Disturbance from trenching through the creeks and wetland areas would be less than 0.1. Vegetation removal would be minimized and replanting of riparian vegetation would occur as needed. The trenching is not expected to change the function and value of the existing wetland as the pipeline would be replaced in the same or adjacent location. In addition, the stream profile and wetland areas would be restored and revegetated.

Reduction in water overflow from the TCWL at the Indian Garden Pump Station into Garden Creek would reduce the extent of the Garden Creek riparian area. 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 Indian Garden pumphouse is approximately 7 acres and with the reduced flow, it is expected that this riparian area would be reduced. 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 Indian Garden pumphouse or develop another strategy to minimize the reduction in the riparian area.

Restoration of natural flows in Bright Angel Creek would occur under the preferred alternative to relocate the water intake, putting an average of 5% of Roaring Springs flow back into Bright

Angel Creek. Bright Angel Creek flows fluctuate seasonally and the increase in flow from Roaring Springs would still be within the natural variability that occurs in the creek. No impact to the riparian vegetation is expected along the creek.

Actions that restore or reestablish natural ecological processes and maintenance, repair, and renovation of existing facilities that affect 0.1 acres or less of wetlands are excepted from preparing a Wetland Statement of Findings per NPS policy (NPS 2016a). For the reasons discussed and because impacts would be minimal, this topic was dismissed from detailed analysis in this EA.

Floodplains

Bright Angel Creek is subject to periodic flash floods, and the section of the TCWL along the creek has been damaged or destroyed by flooding in the past. A floodplain analysis for Bright Angel Creek was conducted in 2016 (HDR 2016). Aboveground TCWL facilities would be outside the 100-year floodplain and all structures except for the relocated intake would be outside the 500-year floodplain. Most of the pipeline would be buried or installed on existing bridges where it crosses creeks, side drainages, and the Colorado River. Consequently, there would be minimal investment in infrastructure that would be at risk from flooding, natural floodplain values and functions would not be altered and there would be no increased safety risks. Therefore, this topic was dismissed from detailed analysis in this EA and a Floodplain Statement of Findings would not be required per NPS policy (NPS 2017).

Indian Trust Resources and Indian Sacred Sites

There are no Indian trust resources in the park. There are no documented sacred sites in the project area and tribal access would be maintained throughout the project duration unless there were site-specific construction-related safety concerns. If any sacred sites are identified during the project, tribal consultation would occur to avoid them. Even during trail closures, it is expected NPS would work with tribes to allow this access to continue. Therefore, Indian trust resources and Indian sacred sites were dismissed as impact topics in this EA.

Environmental Justice

In accordance with the National Office of Environmental Policy and Compliance Environmental Compliance Memorandum 95-3, Tusayan and other surrounding communities were assessed to contain both minority and low-income populations. However, this EA demonstrates that the impacts that could result from implementation of the alternatives would be few and would not be disproportionately high with regard to human health or environmental impacts on minorities or low-income populations. The Cross Canyon Corridor would remain available for use by all people regardless of race or income, and any construction workforces would not be hired based on race or income. Furthermore, the park staff and planning team actively solicited public participation as part of the planning process and gave equal consideration to all input from persons regardless of age, race, income status, or other socioeconomic or demographic factors. For these reasons, environmental justice was dismissed as an impact topic in this EA.

ALTERNATIVES

Three alternatives, the no action alternative and two action alternatives, were carried forward for evaluation in this EA. A number of options were considered and dismissed (see *Alternatives and Alternative Elements Considered and Dismissed*).

Alternative A – No Action

Under the no action alternative, the park would continue current operation and maintenance of the existing TCWL (Figure 1).

No new facilities, such as water treatment facilities at Phantom Ranch, Indian Garden, and South Rim, would be constructed. Water would continue to be gravity fed from Roaring Springs to Indian Garden and pumped from Indian 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 Indian 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 Indian 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.

Alternative B – Relocate Water Intake (Preferred Alternative)

The NPS proposes to relocate the water intake for the TCWL from Roaring Springs Cave to an area along Bright Angel Creek near Phantom Ranch and replace sections of the TCWL between Phantom Ranch and Indian Garden (Figure 2). Two options are being evaluated for the intake including a shallow alluvial well system and a surface water intake. It is possible that another type of intake would be considered if these two options are determined infeasible through additional data collection and testing. Additional analysis under NEPA may be required for any changes.

With the relocated intake, Bright Angel Creek would provide drinking water to Phantom Ranch, Indian Garden, and the South Rim. Under this alternative, approximately 3 miles of existing TCWL from Phantom Ranch to Indian Garden would be replaced.

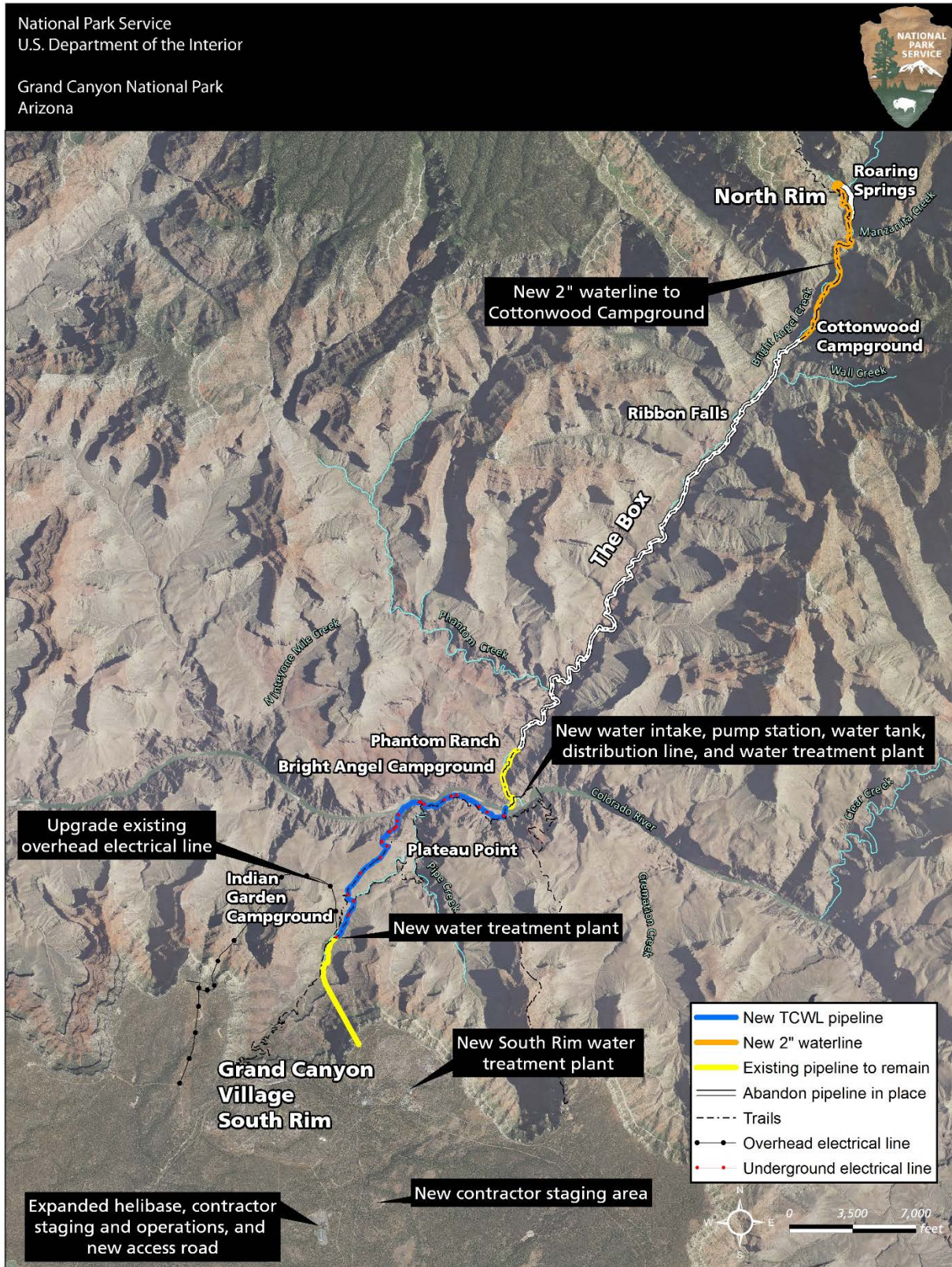


Figure 2. Alternative B – Relocate Water Intake (Preferred Alternative).

Alternative elements would include:

- Phantom Ranch: Relocated water intake, raw water storage tank, booster pump station, pump station, local water treatment plant (WTP), potable water storage tank, and overnight accommodations for employees
- Indian Garden: Local WTP and potable water storage tank
- 3 miles of pipeline replaced from Phantom Ranch to Indian Garden
- 9 miles of pipeline left in place from Roaring Springs to Phantom Ranch
- 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

These alternative elements are described below.

Phantom Ranch Facilities

New facilities at Phantom Ranch would include a water intake, raw water storage tank, 1 million gallon/day booster pump station, WTP, local pump station, potable water storage tank, and overnight accommodations for employees. The architecture of any new buildings or structures would be compatible with historic structures in the area in color, materials, design, massing, and visual scale. Locations would be selected to harmonize with the rustic character of Phantom Ranch and structures would be obscured by vegetation when possible. Approximate building/structure footprints are:

- Water intake (wells or surface water) and waterline to WTP – up to 450 sf
- Raw water storage tank – up to 20-foot-diameter (315 sf)
- Booster pump station, WTP and local pump station – up to 45 feet by 40 feet (1,800 sf)
- Overnight accommodations for employees – up to 3,600 sf and up to 3 units (maximum of 2,000 sf per unit)
- Potable water storage tank – up to 20-foot-diameter (315 sf)

A new water intake would be constructed along Bright Angel Creek. The options for the intake include shallow alluvial wells or a surface water intake, or a combination of wells and surface water intake.

Intake Option 1 – Shallow Alluvial Wells

Up to eight wells, and no less than two, would be installed approximately 60 feet apart and about 30 feet from the Bright Angel Creek shoreline. The wells would be approximately 35 to 45 feet deep. The wells would have an approximately 8-inch-diameter well casing and would be capable of producing 1 million gallons/day with at least one well on standby. In addition to the wells, about 1,800 linear feet of waterline would be installed within the 30-foot-wide construction zone (Table 1).

Intake Option 2 – Surface Water

A surface water intake would be constructed on the south end of Phantom Ranch along Bright Angel Creek which would consist of the intake structure, water control structures in the creek, and a set of below ground pumps.

- Intake structure: The proposed intake would be designed to manage sediment and protect fish. The proposed screen size would be 3/32 inch for wire mesh or perforated

plate or 1.75 mm for slotted plate or wedge wire screens. The intake structure would have an approximate submerged depth of 2 to 3 feet and a width of 5 to 7 feet for a total screened area up to 15 square feet (sf).

- **Water control structures:** Water control structures in the form of rock weirs would be required to keep the screen submerged at minimum stream flows. These would be constructed using materials already present in the creek. Additionally, some armoring of the creek banks would be required to stabilize the channel in the immediate vicinity of the intake.
- **Pump station:** The pump station, consisting of three pumps, would be constructed as part of the intake within a below ground concrete structure. The footprint of the intake structure would be a maximum of 30 feet x 15 feet (450 sf).

Combination of Shallow Alluvial Wells and Surface Water

A combination of shallow alluvial wells and surface water (as previously described) would be considered to provide the flow needed to supply the TCWL.

The 10,000 gallon raw water storage tank, 1 million gallons/day booster pump station, WTP, local pump station and overnight accommodations for employees would be constructed in the Phantom Ranch delta area. The potable water storage tank would be located on the north end of Phantom Ranch or above the ranch to the east.

Table 1. Construction zone acreage for Alternative B

Location	Facilities	Size (acres)	Notes
Phantom Ranch	<ul style="list-style-type: none"> • Water treatment plant (1,800 sf) • Booster pump station (combined with WTP) • Local pump station (combined with WTP) • Alluvial wells/surface water intake (450 sf) • Water tank – raw (315 sf) • Waterlines (1,800 linear feet) • Water tank – potable (315 sf) • Overnight accommodations for employees (3,600 sf) • Electrical line (10,450 linear feet) 	8-9	<p>Electrical and water lines would have a 30-foot-wide construction zone. Buildings would have 20- to 50-foot construction zone on all sides.</p> <p>If electrical and water line are able to be co-located the construction zone could be reduced.</p>
Indian Garden	<ul style="list-style-type: none"> • Water treatment plant (450 sf) • Drying beds (100 sf) • Waterlines (1,800 linear ft) • Water tank – potable (200 sf) 	1-2	Electrical and water lines would have a 30-foot-wide construction zone. Buildings would have 20- to 50-foot construction zone on all sides.
South Rim	<ul style="list-style-type: none"> • Water treatment plant (6,000 sf) • WTP and raw water pipeline (500 linear feet) • Expanded helibase (5.3 acres) • Contractor staging and operations (8.2 acres) • Access road (1.7 acre) 	15-16	Buildings would have 20- to 50-foot construction zone on all sides.
Phantom Ranch to Indian Garden	<ul style="list-style-type: none"> • TCWL (approximately 3 miles) • Electrical line (up to 3 miles) 	11	Electrical and water lines would have a 30-foot-wide construction zone.
Roaring Springs to Cottonwood Campground	<ul style="list-style-type: none"> • TCWL (1.5 miles) 	2-3	Water line would have a 15-foot-wide construction zone.
Total surface disturbance		37-41	

Trenching would be required to run pipes from the water intake to the raw water storage tank, to the booster pump station to the TCWL and the Phantom Ranch WTP for local use. Trenching would also be needed to run electrical and water utilities to the overnight accommodations for employees.

Replacement of water distribution in the Phantom Ranch area would occur as part of this project. Water distribution from the potable water tank to these facilities was addressed in a previous EA (NPS 2004).

In general, construction of the Phantom Ranch facilities is expected to use small and standard equipment and typical construction materials, suitable for helicopter or river transport. Types of equipment used for construction of the Phantom Ranch facilities could include a backhoe, loader, rock crusher, rough terrain fork lift, skid steer loader, excavator, concrete mixer and dry batch plant, and a sonic or track-mounted drill rig.

The construction zone at Phantom Ranch for all of the proposed development would be approximately 8 to 9 acres, which accounts for construction zones for all buildings, facilities, and utility lines. Recontouring soils and revegetation using native plant species would occur after construction is complete.

Indian Garden Facilities

New facilities at Indian Garden would include a local WTP, drying beds, and a potable water storage tank. These facilities would be constructed on the east side of Indian Garden.

Approximate building footprints would be:

- WTP – up to 30 feet by 15 feet (450 sf)
- Drying beds – up to 10 feet by 10 feet (100 sf)
- Potable water storage tank (up to 50,000 gallons) – up to 16-foot-diameter (200 sf)
- New waterlines – 1,800 linear feet (54,000 sf)

Trenching would be required to run waterlines from the existing sedimentation tank to the Indian Garden WTP. Trenching would also occur to run waterlines from the WTP to the potable water storage tank. This tank would be constructed on the south end of Indian Garden. Similar to Phantom Ranch, new water distribution lines would be installed as part of this project. Water distribution from the tank to these facilities was addressed in a previous EA (NPS 2004).

The Indian Garden facilities would be constructed using equipment similar to those described for Phantom Ranch. The architecture of any new buildings or structures would be compatible with historic structures in the areas in color, materials, design, massing, and visual scale. Locations would be selected to harmonize with the rustic character of Indian Garden and structures would be obscured by vegetation when possible.

The construction zone for the WTP storage tank at Indian Garden, drying bed, and associated waterlines would be about 1 to 2 acres (Table 1). Recontouring soils and revegetation using native plant species would occur after construction is complete.

TCWL Replacement

Approximately 3 miles of the TCWL would be replaced from the southern end of Phantom Ranch to the Indian Garden Pump Station. The TCWL would be replaced in the same location, adjacent to, or below the existing pipeline and the existing pipeline would be removed. Bedding would be salvaged where practicable and reused for the new pipeline installation. Additional bedding material would be produced using a rock crusher and screened on-site or off-site materials may be brought in. Rocks would come from active drainages. The amount of new bedding material would depend on what can be salvaged. Recontouring and revegetation would occur in drainages. About 3 miles of pipeline would be replaced within a working corridor up to 30 feet wide, resulting in a construction zone of about 11 acres in addition to the drainages (Table 1). In places where the TCWL is replaced within the existing trail alignment, trail restoration would be necessary. The trail would be restored and if any masonry walls are damaged during pipeline placement, they would be repaired.

Routine maintenance of the Silver Bridge, that suspends the TCWL across the Colorado River, would need to occur to support the new pipeline. Routine maintenance would include replacing broken and missing deck panels, cotter pins, and re-securing safety fencing; removing soil and vegetation from bearing seats and anchorages; resetting bridge expansion system and adding additional bearing restraints to prevent future bridge movement.

Small and standard construction equipment would be used for the work. Should removal of large rock be required, the NPS would use nonexplosive rock breaking methods. Types of equipment for pipeline construction would generally include a mini excavator, excavator, mini loader, loader, track chain saw, rock saw, and rock crusher.

The 9 miles of TCWL from Phantom Ranch to Roaring Springs would not be replaced and instead 1.5 miles may be used as a conduit and the other 7.5 miles from Cottonwood Campground to Phantom Ranch would be removed over time during routine trail work or left in place where sensitive resources exist. The 1.5 mile section of pipeline from Roaring Springs to Cottonwood Campground may be used as a conduit for a smaller waterline to deliver potable water to the campground. The new waterline would follow the existing trail alignment. The new waterline may be pulled through the existing TCWL, which would require excavation along the existing TCWL. The new waterline would be tied into the existing water system connection. A new 2-inch waterline could also be buried directly in the trail, not using the TCWL as a conduit, and would be constructed within a working corridor about 15 feet wide, resulting in surface disturbance of about 2-3 acres (Table 1). The NPS is also looking at other options to provide potable water to Cottonwood Campground such as taking water from Bright Angel Creek and treating it for local use. These other options would be analyzed as a separate project.

South Rim WTP

A new WTP would be constructed at the South Rim (Figure 3). The WTP at the South Rim would have a capacity of 1 million gallons/day and may include a 1 million-gallon raw water tank 40 feet in diameter and a new raw water meter vault. Estimated structure sizes would be:

- WTP – 80-foot by 75-foot building (6,000 sf)
- Raw water tank – 40-foot-diameter tank (1257 sf)
- Water meter vault – 8 feet by 8 feet (64 sf)

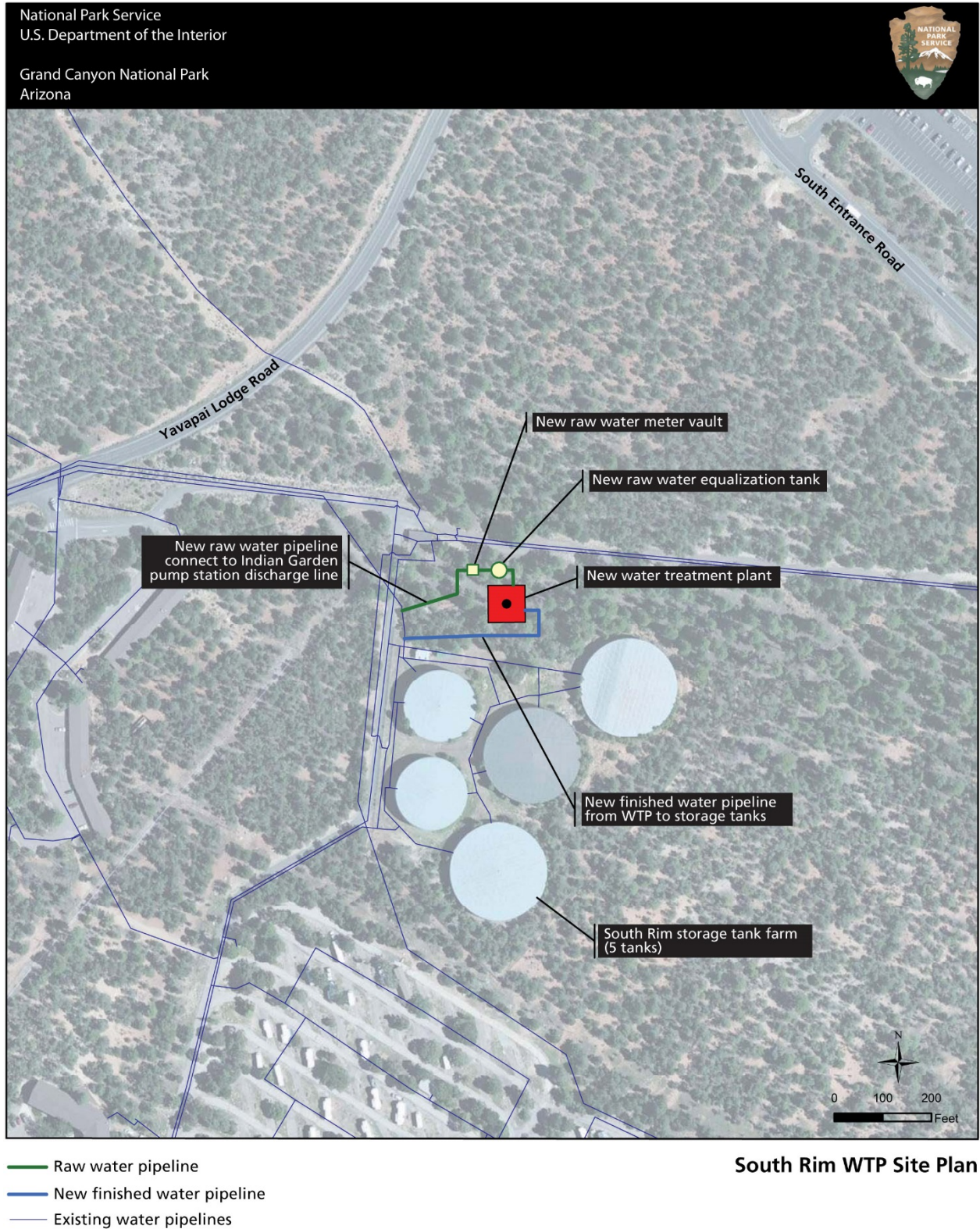


Figure 3. Proposed South Rim WTP.

Equipment such as backhoes, excavators, cranes, cement trucks, and soil compaction equipment would be used for construction. The estimated construction zone would be about 1-2 acres. Recontouring and revegetating with native plants would occur after construction is complete.

Electrical Line from South Rim to Phantom Ranch

An existing aboveground electrical line that starts at the South Rim, runs northwest of “the Battleship” and ends at Indian Garden would be upgraded. The aboveground electrical line is about 2.5 miles long. The existing 20 to 30, 30-35 foot power poles would need to be replaced with new 45 foot power poles. The new power poles would be installed adjacent to the existing poles. No roads exist along the electrical line alignment, so materials and workers would be transported to the site by helicopter.

The existing electrical line buried in the Bright Angel Trail near Indian Garden and the electrical line between Indian Garden and Phantom Ranch would be replaced. Up to 3 miles of electrical line would be replaced within a working corridor about 30 feet wide. Of this, about 500 linear feet would be pole mounted while the rest would be within a trench; poles would be up to feet tall. Some sections would coincide with the replaced waterline. The construction zone for replacement of the underground electrical line is included in the 11 acres to be disturbed by replacement of the TCWL (Table 1).

Primary power cable at Phantom Ranch would be 6,250 linear feet. Secondary cables from the primary to individual buildings would be 4,200 linear feet. Up to 20 transformers and cabinets would also be constructed to support this new power system.

Access and Staging

Up to four construction camps would be established at Manzanita Ranger Station and Day Use Area, Cottonwood Campground, the delta area of Phantom Ranch and at Indian Garden Campground. It is expected that the camps at Phantom Ranch and Indian Garden would house up to 20 people, would include wall tents, and kitchen and shower facilities. Any wastewater would be captured and either treated at Phantom Ranch waste water treatment plant or put into the septic system at Indian Garden. The camps at Manzanita and Cottonwood would house up to 12 people and would have similar facilities, and wastewater would go into the septic system at these locations. These camps would be located in existing disturbed areas or within the construction zone already discussed. Construction staff for the South Rim WTP would be housed in developed areas, inside or outside the park, possibly in Flagstaff, Williams, or other nearby communities.

On the South Rim, an expansion of the existing helibase, a contractor operations and staging area, and a new access road would be constructed. These would all be located near the existing maintenance facility and helibase (Figure 4). Approximate construction zones are:

- Expanded helibase – 5.3 acres
- Contractor staging and operations – 8.2 acres
- New access road – 1 acre

Contractor staging and operations areas would either be gravel or paved and would be used to store equipment and materials and would provide trailer sites for the contractor. If not already in place, water, sewer and electrical utilities would be brought from the adjacent maintenance facility. No permanent buildings would be constructed.

The new access road would be about 1,500 feet long and 30 feet wide with a 24-foot-wide asphalt paved surface and 3-foot-wide drainage on either side. Construction impacts would extend about 10 feet beyond either side of the road.

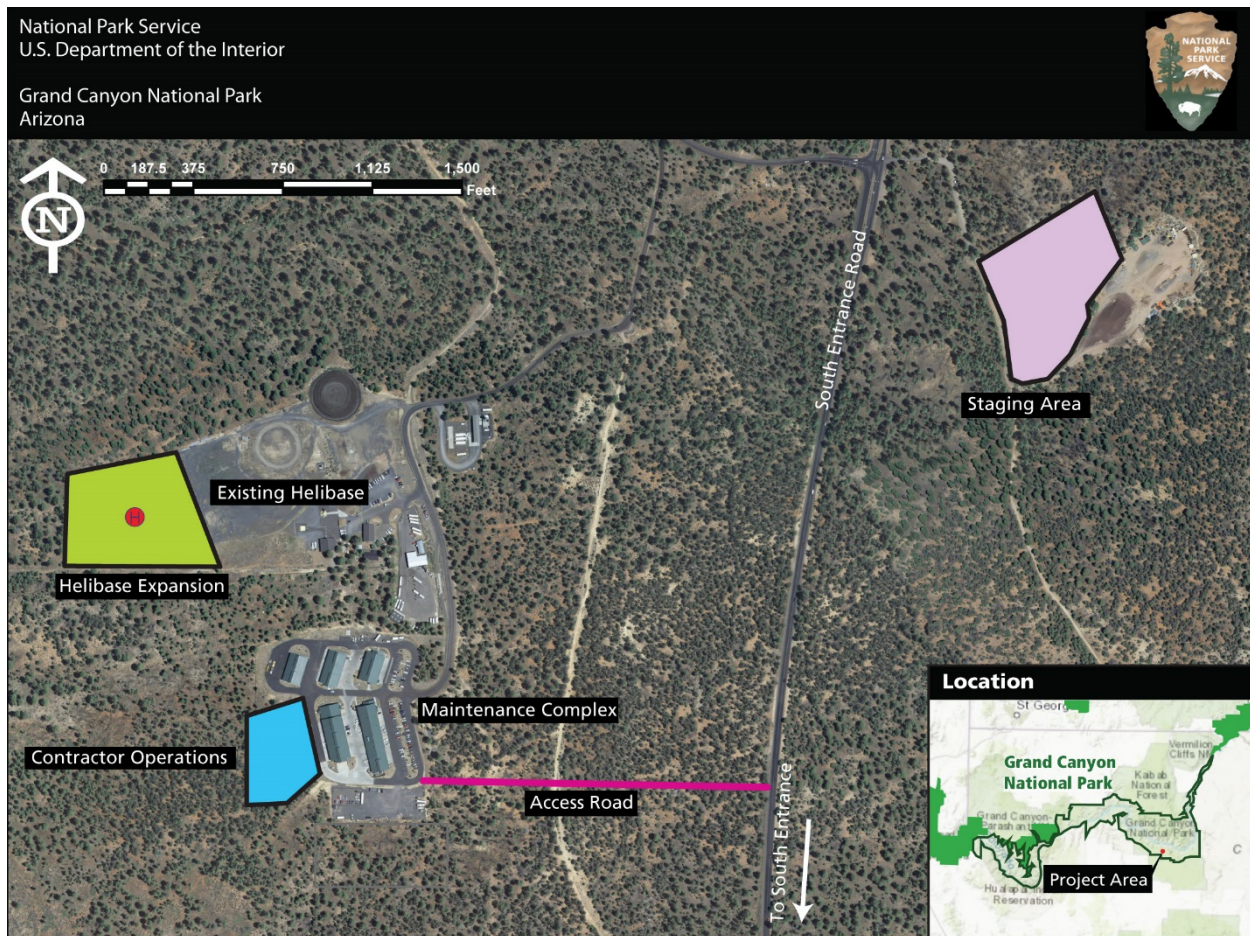


Figure 4. Proposed helibase expansion and contractor operations and staging areas.

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 30-foot-wide construction zone or in previously disturbed areas approved for use by 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.

Trail and campground closures are anticipated throughout the project. Trail closures on the Bright Angel and River Trails would be intermittent and multi-day closures are not expected. Bright Angel Campground and Phantom Ranch may be closed for up to 8 nonconsecutive months during the approximate 3 year inner canyon construction. Indian Garden Campground would be partially utilized by contractors (approximately half of the sites in the campground) for up to 24 months with a full closure of the campground for up to 6 nonconsecutive months. These closures would occur when construction activity, including trenching, is needed in the campgrounds or when there are other logistical or safety reasons to require closure.

Helicopter Operations

Helicopters would be used for the inner canyon work and would include a light-duty (1,000-pound maximum payload); medium-lift (K-max, 4,000-pound maximum payload); and heavy-lift (Chinook, 14,000-pound maximum payload) helicopter. The light-duty helicopter is expected to make multiple flights per day, while the medium-lift helicopter would be used less often and the heavy-lift helicopter would be used infrequently to transport equipment that exceeds the payload capacity of the other helicopters. It is estimated that the light duty helicopter would account for about 66% of total flights, while the medium and heavy-lift helicopters would account for about 30% and 4% of total flights respectively. Based on the weight of material and equipment needed for construction, it is estimated that about 5,500 total helicopter flights would be needed over the 3-year construction period in the inner canyon, with about 7 to 12 round-trip flights per day departing from and returning to the expanded helibase at the South Rim on a typical day when helicopters are active. On busy days up to 20 helicopter flights per day could occur. On a typical day, helicopters would be active for about 6 hours. Helicopters are expected to be active for about 30 nonconsecutive months during construction, as needed, and would be active about 20 days per month, depending on weather, project needs, and staffing.

Pipeline Operation during Construction

During pipeline replacement, the TCWL would need to be periodically shut down and drained. At those times water would no longer be conveyed from Roaring Springs to the storage tanks at the South Rim and Phantom Ranch. During these shutdown periods, water from the storage tanks would be used. During the winter off-peak season, existing storage capacity would allow a maximum shutdown of about 21 days at the South Rim and 3.5 days at Phantom Ranch. During summer peak season, existing storage capacity would allow a maximum shutdown of about 6 to 13 days at the South Rim and 2 days at Phantom Ranch. Phantom Ranch may be able to operate in water conservation mode (for example by restricting showers) or may be shut down to allow longer periods of water availability.

Schedule

Construction would continue for an estimated 4 to 5 years. Work in the inner canyon, including the Cross Canyon Corridor, would occur over an approximately 3-year period.

Alternative C – Replace TCWL in Same Location

TCWL Replacement

Alternative C would replace the TCWL within the existing pipeline corridor (Figure 5). The current water intake at Roaring Springs would be retained and no improvements would be made at Roaring Springs. Alternative C 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 (Table 2):

- Replacement of 12 miles of pipeline
- Development of expanded helibase and contractor staging and operations area and a new access road

Table 2. Construction zone acreage for Alternative C

Location	Facilities	Size (acres)	Notes
South Rim	<ul style="list-style-type: none"> • Expanded helibase (5.3 acres) • Contractor staging and operations (8.2 acres) • Access road (1.7 acres) 	15-16	Electrical and water lines would have a 30-foot-wide construction zone. Buildings would have 20- to 50-foot construction zone on all sides.
Roaring Springs to Indian Garden	<ul style="list-style-type: none"> • TCWL (12 miles) • Electrical line (up to 3 miles) 	43-44	Electrical and water lines would have a 30-foot-wide construction zone.
Total surface disturbance		58-60	

The sections of the TCWL from Roaring Springs to Phantom Ranch and from Phantom Ranch to Indian Garden would be entirely replaced. In general, construction of the new waterline would require removal of the existing pipeline due to the narrow alignment corridor. This is especially true for the portions of the pipeline within the North Kaibab and River Trails. The TCWL is currently aluminum pipe, which would be removed and new steel pipe, or other durable material, would be installed. As described above for Alternative B, 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. Construction methods and equipment would be the same as described above for the TCWL replacement portion of Alternative B.

The section of the TCWL within the North Kaibab Trail crosses numerous ephemeral intermittent side drainages that flow into Bright Angel Creek. The TCWL would be designed to maintain the drainage profile and would allow for unimpeded flows. The existing TCWL has seven aerial crossings where the existing pipeline is suspended from bridges over Bright Angel Creek and the Colorado River. The new pipeline would be suspended in a similar manner as the existing TCWL.

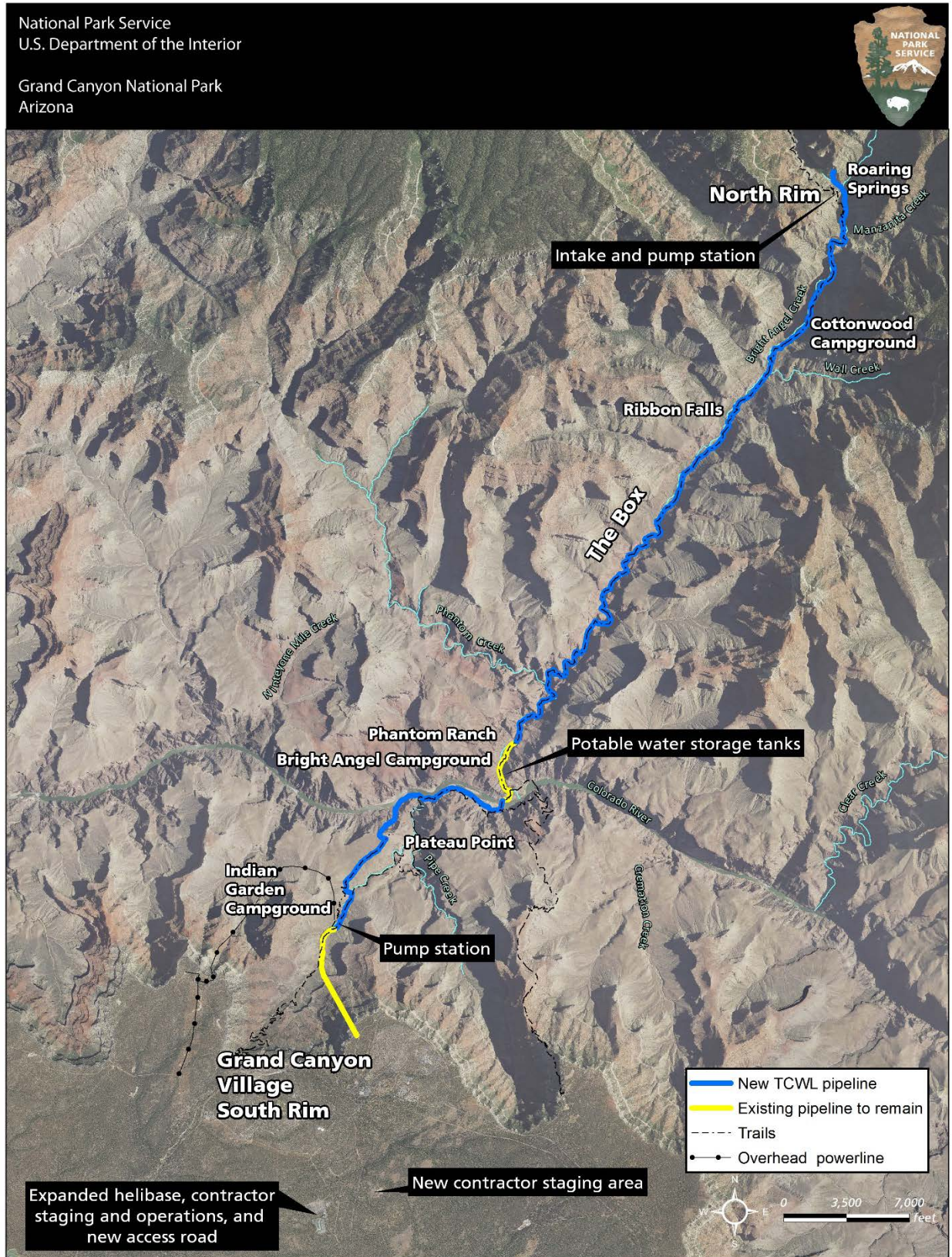


Figure 5. Alternative C – Replace TCWL in Same Location

As described for Alternative B, the existing TCWL would remain in service during construction along the Plateau Point cliff face. Replacement methods of the pipeline along the cliff face would be the same as described for Alternative B.

The existing electrical line between Roaring Springs Pump Station and the NPS ranger residence is immediately adjacent to the TCWL and, in many cases, fastened directly to the pipeline. Replacement of the pipeline in this section would also likely require replacement of the electrical line. As described for Alternative B, the existing electrical lines buried in the Bright Angel Trail near Indian Garden and between Phantom Ranch and the Pipe Creek Resthouse would be replaced because they are immediately adjacent to the TCWL.

The Bright Angel Trail, River Trail, and North Kaibab Trail would be restored following construction in places where the TCWL is replaced within the existing trail alignment as described above for Alternative B.

Access and Staging

Construction camps and worker access would be as described for Alternative B, with the exception that additional material staging areas would be needed during replacement of the TCWL between Roaring Springs and Phantom Ranch. Staging areas would be located within the 30-foot construction zone for the pipeline or in previously disturbed areas. NPS resource staff would review staging areas prior to use.

Trail and campground closures are anticipated throughout the project. Trail closures on the Bright Angel and River Trails would be intermittent and multi-day closures are not expected. Bright Angel Campground and Phantom Ranch may be closed for up to 12 nonconsecutive months during the approximate 4-5 year inner canyon construction. Indian Garden Campground would be partially utilized by contractors (approximately half of the sites in the campground) for up to 36 months with a full closure of the campground for up to 8 nonconsecutive months. These closures would occur when construction activity, including trenching, is needed in the campgrounds or when there are other logistical or safety reasons to require closure.

Helicopter Operations

Helicopter operations for construction would be provided by the construction contractor and a helibase expansion would be constructed on the northwest side of the park helibase property on the South Rim, as described for Alternative B. Contractor operations and staging areas and a new access road would be constructed at the South Rim as described under Alternative B (Figure 4). Similar to Alternative B, the light-duty helicopter is expected to make multiple flights per day, while the medium-lift and heavy-lift helicopters would be used less frequently. Based on the weight of material and equipment needed for construction, it is estimated that about 11,500 total helicopter flights would be needed, with an average of 14 to 24 round-trip flights per day departing from and returning to the new South Rim helibase. On busy days, up to about 30 round-trip flights could occur. Helicopters would be active for up to 14 hours per day, which could include more than one helicopter operating at a time. Helicopters are expected to be active for about 48 nonconsecutive months during construction and would be active about 20 days per month, depending on weather, project needs, and staffing.

Construction Equipment and Pipeline Operation during Construction

Construction equipment would be the same as described for Alternative B. Pipeline operation during construction would be the same as described for Alternative B, with the exception that replacement of the pipeline would require more frequent and numerous TCWL system shutdowns and restarts because of the much greater length of pipeline replaced. The number of shutdowns that would be needed cannot be accurately estimated. During these shutdown periods, water from the storage tanks would be used. As described for Alternative B, during the winter off-peak season, existing storage capacity would allow a maximum shutdown of about 21 days at the South Rim and 3.5 days at Phantom Ranch. During summer peak season, existing storage capacity would allow a maximum shutdown of about 6 to 13 days at the South Rim and 2 days at Phantom Ranch. Phantom Ranch may be able to operate in water conservation mode (for example by restricting showers) or may be shut down to allow longer periods of water availability.

Schedule

Construction would continue for an estimated 5 to 6 years with 4 to 5 years of construction in the Cross Canyon Corridor.

For a comparison of alternatives see Appendix B.

Alternatives and Alternative Elements Considered and Dismissed

The following alternatives were considered for project implementation, but were dismissed from further analysis, as described below.

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.

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.

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.

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.

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This section describes the affected environment (existing setting or baseline conditions) and analyzes the potential environmental consequences (impacts or effects) that would occur as a result of implementing the no action and action alternatives.

Bright Angel Creek Native Fish

Affected Environment

Bright Angel Creek is a tributary to the Colorado River located entirely within the park. The creek has been modified by human activities including diversion of a portion of its flow to the TCWL at Roaring Springs and partial channelization of the creek to accommodate the TCWL and North Kaibab Trail. An additional ungauged diversion from Bright Angel Creek is also present just upstream of Phantom Ranch that is used for irrigation. The creek has also been partially channelized with gabions to accommodate structures and buildings at Phantom Ranch and the Bright Angel Campground. Withdrawal of water at Roaring Springs is about 2.8 cubic feet per second (cfs) and is estimated to be 5% of the total flow in Bright Angel Creek (Bair et al. 2014). The analysis area for Bright Angel Creek native fish is Bright Angel Creek and the Colorado River within the park. The Colorado River upstream and downstream of Bright Angel Creek is included because of the potential for native fish and nonnative trout to travel from Bright Angel Creek to these areas.

Bright Angel Creek and its tributaries historically supported large populations of native speckled dace (*Rhinichthys osculus*), as well as native flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*Catostomus discobolus*), and occasionally humpback chub (*Gila cypha*) (Minckley 1978; Carothers and Minckley 1981), bonytail (*Gila elegans*) and razorback sucker (*Xyrauchen texanus*). The US Fish and Wildlife Service (USFWS) has collected humpback chub from the lower reaches of Bright Angel Creek as recently as 1994 and 1998 (Stone, pers. comm. 2018), and adults were translocated to Bright Angel Creek in May 2018 (Schelly et al. 2018-in prep). Bonytail chub has been extirpated from Grand Canyon and razorback sucker may utilize the lower reaches of Bright Angel Creek for spawning, but that has not been confirmed. The speckled dace, flannelmouth sucker, and bluehead sucker are listed by the Arizona Game and Fish Department as species of greatest conservation need, and the NPS is a signatory on interagency range-wide and state-wide conservation agreement and strategy documents for these species. These species are residents in Bright Angel Creek, spawning each spring.

The humpback chub is federally listed as endangered. Humpback chub were first scientifically described from specimens collected in or near Bright Angel Creek. The park population of humpback chub has been estimated at 9,000 to 12,000 individuals (NPS 2013b), is the largest remaining population in this species' range in the Colorado River Basin, and is the only population left in the lower basin below Glen Canyon Dam. This population consists of at least nine aggregations, with most individuals found in and near the Little Colorado River (Valdez and Ryel 1995), which is the largest tributary to the Colorado River in the park. A small aggregation of humpback chub is also found in the Colorado River near the confluence with Bright Angel Creek. One hundred twenty adults were released approximately 4 miles upstream

of Phantom Ranch in May, 2018, but it is unknown if fish have spawned as of summer, 2018 (NPS, unpublished data). Park data suggest that humpback chub have been expanding their range and growing in number outside the Little Colorado River, especially in the western portion of the park (Kegerries et al. 2017). The aggregations are increasing in number, and a reproducing population has been established in Havasu Creek through translocations. Adult humpback chubs have a high fidelity for site-specific habitats in the Colorado River and generally remain within a 0.6-mile area, except during spawning ascents of the Little Colorado River in spring.

In recent years, Bright Angel Creek's fish community has been dominated by nonnative brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) and the creek has become the main spawning site for brown trout in the park. Predation by and competition with the large number of nonnative trout are contributing factors in the decline of native fish in the Colorado River and its tributaries (Valdez and Ryel 1995; Marsh and Douglas 1997; Coggins et al. 2002). Much of the diet of brown trout in the park consists of other fish, including in Bright Angel Creek (Whiting et al. 2014); thus, the presence of brown trout likely has affected the native fish population in the Colorado River and Bright Angel Creek.

In an effort to reduce nonnative fish populations in Bright Angel Creek, the park conducts ongoing removal of brown and rainbow trout under the park's Comprehensive Fisheries Management Plan (NPS 2013b; Healy et al 2018). Nonnative fish removal efforts include using a weir and fish trap installed in Bright Angel Creek downstream of Phantom Ranch and using electrofishing in Bright Angel Creek and its tributaries. Recent studies by the park suggest that nonnative fish removal has successfully reduced the number of nonnative trout in Bright Angel Creek by 89% which has led to substantial increases in numbers of native fish such as the flannelmouth and bluehead suckers and speckled dace (Schelly et al. 2017; Healy et al. 2018).

Environmental Consequences

Impacts of Alternative A – No Action

Direct and Indirect Impacts

Under the no action alternative, there would be no change to the existing diversion at Roaring Springs and no new impacts on native fish in Bright Angel Creek. Water flow and temperature in the creek would be unchanged. The TCWL between Roaring Springs and Phantom Ranch would continue to experience periodic breaks, which would require repairs that could result in minimal sedimentation in the creek which would not impact native fish as they are adapted to turbid conditions.

Cumulative Impacts

Because there would be no direct or indirect impacts on Bright Angel Creek native fish, there would be no cumulative impacts.

Impacts of Alternative B – Relocate Water Intake (Preferred Alternative)

Direct and Indirect Impacts

Ground disturbance from construction and staging activities within the Bright Angel Creek drainage would expose soils to erosion, which could result in increased sedimentation and turbidity in Bright Angel Creek. However, BMPs would be employed to minimize runoff and sediment discharges into the creek. The TCWL crossing of Bright Angel Creek at Phantom Ranch would have the highest potential for sedimentation and turbidity impacts on fish. The crossing would be completed in 1 to 2 days and would disturb a relatively small (15- to 20-foot-wide) corridor. Consequently, creek bed disturbance and sedimentation would be limited and increased turbidity levels would be temporary. Increased turbidity levels and extent would be not be measureable compared to Bright Angel Creek turbidity levels throughout the creek during high-flow flood events. Native fish in Bright Angel Creek are adapted to turbid conditions and negative impacts on native fish would not occur. Therefore, no adverse impacts on native fish are expected from turbidity and sedimentation.

Relocating the intake for the TCWL from Roaring Springs to Bright Angel Creek near Phantom Ranch would result in an additional 2.8 cfs of water in Bright Angel Creek following completion of the project compared to current conditions. This would be a permanent change and would restore flows in Bright Angel Creek to conditions that existed before construction of the TCWL.

Research has shown that water flow from Roaring Springs provides some stabilization of temperature in the creek over both daily and annual time frames (Bair et al. 2014). Bair et al. (2014) conducted an assessment of potential changes to habitat for native and nonnative fish species from adding flow from Roaring Springs to Bright Angel Creek. Initial results of this study found that habitat may increase for both native and nonnative fish, but variations would exist between species for different seasons and life stages. There would be an increase in the number of days suitable for growth of the humpback chub, which would benefit this species. There would also be a slight decline in the number of days suitable for humpback chub to reproduce, but the decline in suitable days for reproduction would not impact the success of reproduction in the creek. The study also found that rearing habitat for humpback chub would increase, which would benefit this species, especially when combined with the increase in the number of days suitable for growth.

Temperatures would potentially decrease slightly in the lower reaches of Bright Angel Creek, resulting in more favorable conditions for brown trout. Temperatures in the lower reaches of the creek could decrease below a threshold that would favor the growth of juvenile brown trout. There could also be an increase in the number of days within the optimum temperature range for brown trout growth. These would be permanent changes. It is possible that relocating the TCWL intake could result in increased trout populations in Bright Angel Creek, leading to increased predation by brown trout on native fish species in the Colorado River.

Because Bright Angel Creek has been a major source of brown trout in the Colorado River in the past, any change that increases the brown trout population has the potential to increase predation on native fish, including speckled dace, flannelmouth sucker, bluehead sucker, humpback chub, and razorback sucker. The park would monitor temperatures in Bright Angel Creek following relocation of the TCWL intake and increase nonnative fish removal efforts if monitoring indicates that conditions have changed to favor nonnative brown trout. This

mitigation measure is expected to reduce these impacts so that there would not be adverse effects on the native fish community.

The surface water intake proposed in the stream channel would have direct effects on early life stages of all native fishes present in the creek including speckled dace, humpback chub, flannelmouth sucker and bluehead sucker. After hatching, larval native fish drift passively in the stream current, or weakly swim with the current, along the shoreline (Robinson et al. 1998) before developing fully formed fins and stronger swimming abilities. Drifting in the current is an evolutionary mechanism for dispersal in Colorado River native fishes. The instream water intake would likely entrain larval fish, or larval fish may be trapped against the screen. The impact to larval fishes would vary by species, developmental stage, and depend on the timing of spawning, number of adults spawning, flows (flood frequency and timing), and stream hydraulics. Due to naturally high mortality of fish during larval life stages (more than 90%), it is likely that the mortality of larval native fish as a result of entrainment into the surface water diversion will not have impacts to the populations that would be at a level that would cause a viability concern (Pine et al. 2013). It is estimated that native fishes would produce hundreds of thousands of larval fish each year and it is possible that several thousand of these larval fish could suffer mortality per year. These impacts would be adverse and greater than the lack of impact in Alternative A, but again, would not threaten the populations.

Cumulative Impacts

The impacts of past, present, and reasonably foreseeable future actions on Bright Angel Creek native fish would result from ongoing routine trail corridor work and ongoing nonnative trout removal. Trail maintenance actions have had, and would continue to have, beneficial effects on Bright Angel Creek native fish from correcting erosion problems. Turbidity impacts from trail work would be negligible because BMPs would be used to reduce sedimentation, disturbances would be temporary, and the areas disturbed would be relatively small. Ongoing trout removal efforts have resulted in a very important benefit for native fish populations by reducing predation and competition from nonnative trout. The surface water intake would have adverse impacts to native fishes. The impacts of the surface water intake would add to the loss of larval fish that would result in adverse impacts. When the effects of Alternative B are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would be beneficial with Alternative B slightly offsetting these beneficial impacts.

Impacts of Alternative C – Replace TCWL in Same Location

Direct and Indirect Impacts

Under Alternative C, there would be no change to the existing water intake at Roaring Springs, and water flow and temperature in the creek would be unchanged. As described for Alternative B, ground disturbance from construction and staging activities within the Bright Angel Creek drainage would expose soils to erosion, which could result in increased sedimentation and turbidity in Bright Angel Creek. Although a larger area would be disturbed than under Alternative B because the entire pipeline from Roaring Springs to Phantom Ranch would be replaced, BMPs would minimize runoff and sediment discharges into the creek. The TCWL crossing of Bright Angel Creek at Phantom Ranch would be the same as described for Alternative B and would have the potential to increase turbidity levels temporarily, for 1 or 2 days. As described for Alternative B, no adverse effects on native fish are expected from turbidity and sedimentation because increased turbidity levels and extent would not exceed the turbidity levels that occur in Bright Angel Creek during high-flow flood events and because

native fish in the creek are adapted to turbid conditions. There would be no impact to Bright Angel Creek Native Fish therefore Alternative C would have less impact than Alternative B.

Cumulative Impacts

Because there would be no direct or indirect impacts on Bright Angel Creek native fish, there would be no cumulative impacts.

Special Status Terrestrial Wildlife

Affected Environment

Special status terrestrial wildlife species are wildlife species that are federally or state listed, species of concern, or other species the park has identified as warranting special monitoring or management (Table 3 and Appendix C). For the purposes of this EA, special status terrestrial wildlife potentially impacted by the project include California condor, Mexican spotted owl, desert bighorn sheep, and several bat species. Special status fish species are addressed under the *Bright Angel Creek Native Fish* impact topic, above. The analysis area for special status terrestrial wildlife is the TCWL pipeline alignment, facility construction sites, a 1,200-foot buffer where noise could affect species, and flight paths for project helicopters.

Table 3. Potentially impacted special status terrestrial wildlife species

Species	Status
California condor (<i>Gymnogyps californianus</i>)	Federal - Nonessential experimental population
Mexican spotted owl (<i>Strix occidentalis lucida</i>)	Federal - Threatened
Desert bighorn sheep (<i>Ovis canadensis nelsoni</i>)	State - SGCN ¹
Allen's lappet-browed bat (<i>Idionycteris phyllotis</i>)	State - SGCN
Greater western mastiff bat (<i>Eumops perotis</i>)	Other - SC
Long-legged myotis (<i>Myotis volans</i>)	Other - SC
Mexican free-tailed bat (<i>Tadarida brasiliensis</i>)	State - SGCN
Mexican long-tongued bat (<i>Cheronycteris Mexicana</i>)	State - SGCN
Pocketed free-tailed bat (<i>Nyctinomops femorosaccus</i>)	Other - SC
Spotted bat (<i>Euderma maculatum</i>)	State - SGCN
Townsend's big-eared bat (<i>Corynorhinus townsendi</i>)	Other - SC
Western red bat (<i>Lasiurus blossevilli</i>)	State - SGCN

¹ Species Codes: SGCN = Species of greatest conservation need in Arizona; SC = Species of concern (some information showing vulnerability or threat, but not enough to support listing under the Endangered Species Act).

California Condor

In 1996, the USFWS established a nonessential experimental population of California condors in northern Arizona (USFWS 1996a). California condor nesting habitat includes various rock formations such as caves, crevices, overhung ledges, and potholes. The active breeding season for condors is designated as February 1 to September 30. Roost sites include cliffs, tall trees, and snags (USFWS 1996b). California condors typically forage in open terrain, although in the park foraging on deer and elk carcasses occurs in forested areas.

Within the park, California condor nesting habitat is generally limited to cliffs and caves in the redwall limestone of the inner canyon. Condors are active year-round at the park; however, they are at rim level less frequently in winter and are more often seen along the river corridor during this time. During the 2016 breeding season, two condor pairs nested at the park near the South

Rim. Four condor nests were confirmed in the park in 2017. Only one of these produced a chick, which did not fledge. The nearest condor nest to the TCWL is within the Indian Garden corridor (Garden Creek drainage). The next closest condor nests have occurred on the northwest side of the Battleship, which is outside of the Garden Creek drainage. No other nests occur within 1 mile of the TCWL, although the four nests west of the Battleship are within 0.5 mile or less from the existing overhead electrical line that will be upgraded as part of the project.

Mexican Spotted Owl

Mexican spotted owls are a federally listed threatened species and are generally found in habitat that includes mixed conifer and pine-oak forests, riparian woodlands, and sandstone canyonlands (USFWS 1995). Nest and roost sites of Mexican spotted owls are primarily in closed-canopy forests or rocky canyons that provide the cool microclimates the owls prefer. Breeding occurs from March to August annually. Protected activity centers (PACs) surround known Mexican spotted owl sites and are intended to protect an owl or breeding pair's territory (USFWS 2012).

Several of the park's 54 PACs are found within or near the construction zone. Mexican spotted owls have been documented foraging at Indian Garden Campground where small mammals are likely abundant adjacent to campsites and facilities. Although the TCWL passes through a Mexican spotted owl PAC, no work on the pipeline is planned within this PAC. The next closest Mexican spotted owl PAC is west of Indian Garden with the large Battleship formation between the project and the PAC. No pipeline construction would occur within a Mexican spotted owl PAC; however, an existing overhead electrical line passes through a portion of a Mexican spotted owl PAC and would be upgraded by replacing and upgrading the conductors. At the northern end of the construction zone, the boundaries of three Mexican spotted owl PACs are less than 0.5 mile from the TCWL.

Desert Bighorn Sheep

Desert bighorn sheep are listed by the Arizona Game and Fish Department as species of greatest conservation need and are a species of management concern for the park. Bighorn sheep in the park are believed to belong to one of the largest naturally persisting populations of desert bighorn sheep (NPS 2015a). The park population is also unique among desert bighorn populations in never having been subjected to direct translocations of bighorn sheep from other areas. Currently, there is no reliable population estimate for bighorn sheep in the park. The primary lambing season in the park likely occurs from February to May, with a peak in March and April.

Bighorn sheep are distributed in low densities throughout the inner canyon, occupying habitat from the river to the canyon rim. Preliminary information collected by the park indicates that the greatest densities of bighorn sheep occur along the river bottom, where abundant free water is accessible year-round (NPS 2015a). The highest densities of bighorn sheep along the Colorado River corridor are found between river miles 120 and 170, about 30 river miles west of the project area (NPS 2015a). These congregations along the river bottom occur primarily during breeding season in the summer and fall. When not using habitat along the river, bighorn sheep in the park are generally sparsely distributed across the landscape. The Tonto Platform, which includes Indian Garden, and geologic layers above the Tonto Platform are used more frequently during winter months. Bighorn sheep do not typically congregate at Indian Garden, Phantom Ranch, or in between.

Special Status Bats

Eight special status bat species have been documented in the TCWL corridor. Species that typically roost in caves and cliff crevices include Allen's lappet-browed bat, greater western mastiff bat, Mexican free-tailed bat, pocketed free-tailed bat, spotted bat, and Townsend's big-eared bat. The long-legged myotis roosts in tree foliage or bark, while the western red bat roosts only in tree foliage. These bat species forage in a variety of habitats and are nocturnal and insectivorous. During hibernation, bats are highly susceptible to disturbance, making hibernacula an important focus for management and protection efforts. While no bat hibernacula are known in the project areas, several caves in the area could provide hibernation sites. Additionally, bats are highly susceptible to disturbance during day roosts and may abandon roost sites, including maternity roosts, if disturbance is too high.

In the TCWL corridor, the nearby canyon walls provide abundant roosting sites for cave and cliff crevice roosting species. Large cottonwood trees at Indian Garden, along Garden Creek, at Phantom Ranch, and along Bright Angel Creek provide roosting sites for foliage and tree roosting species. Special status bat species forage in a wide variety of habitats. Allen's lappet-browed bat, long-legged myotis, Mexican free-tailed bat, spotted bat, Townsend's big-eared bat, and western red bat also potentially forage in ponderosa pine habitat found on the South Rim. Because of the presence of open water, the riparian areas along Garden Creek and Bright Angel Creek support relatively large populations of flying insects compared to the surrounding drier habitats and, thus, provide foraging habitat for special status bat species.

Environmental Consequences

Impacts of Alternative A – No Action

Direct and Indirect Impacts

California Condor

Potential direct and indirect effects on California condors under Alternative A include noise and human presence during pipeline repairs that could result in flushing birds from perching, roosting, or scavenging sites or temporarily disrupting foraging and reproductive behavior for a few minutes to a few hours. Impacts from noise on condor breeding and nesting would be minimal because helicopters and human activities associated with pipeline repairs would stay at least 1 mile away from active condor nest locations except when human safety would be compromised. Each individual condor is radio tagged and closely monitored on a regular basis, which allows NPS biologists to be aware of any nesting attempts in the park thereby ensuring the 1-mile buffer is maintained.

Helicopter use in condor foraging areas could displace individual birds. Displacement would require condors to expend more energy, although given the large size of their home ranges, it would not affect foraging success or survival.

The possibility exists that a condor could collide with a project-related helicopter. The park currently operates 1,200 to 1,500 helicopter flights per year from the South Rim for administrative purposes, and no collisions or near misses of condors have been reported. Regular communication between the park's wildlife staff and helibase crew would reduce the likelihood of shared airspace with condors. Any collision with a condor would be a catastrophic accident for both the bird and the aircraft. Helicopters would maintain at least a 1,200-foot

buffer from condors in the air. If condors approach a helicopter, the aircraft would move away, reducing potential disturbance and risk of collision. Although the chance of an aircraft strike exists, the likelihood is very low.

Because of the small number of California condors in existence, even a single failed nesting attempt or mortality of a condor because of the project would have a large negative impact on this species. However, for the reasons described above, including the implementation of mitigation measures, the likelihood of negative effects on condors from repairing the pipeline would be very low.

Mexican Spotted Owl

Potential direct and indirect effects on Mexican spotted owls could include increased noise from repair activities and helicopter flights which would result in flushing or changes in normal roosting behavior. These impacts would occur during helicopter flights (average of 18 minutes each) and the number of flights would vary based on the number of pipeline breaks each year (between 5 and 30 breaks). If foraging or roosting owls were displaced (flushed) due to construction or helicopter noise, they would go to an area outside the project area where there is ample foraging and roosting habitat. Construction projects that are more than 0.5 mile from the nearest known nest or roost site, or are more than 0.5 mile from the nearest PAC boundary if the nest or roost location is not known, are unlikely to result in impacts to breeding owls.

Desert Bighorn Sheep

Repair activities would result in increased noise from human activity and helicopters. Impacts from increased human presence are expected to be minimal because the Cross Canyon Corridor is already heavily used, most increased human activity would occur along existing trails and developed areas in the project area, and bighorn sheep do not typically congregate in these areas. Increased noise would occur during construction, when crews were working in the construction zone, and during helicopter flights. The number of short (average of 18 minutes each) helicopter flights would vary based on the number of pipeline breaks each year (generally between 5 and 30). Potential effects on bighorn sheep from increased noise could include increased physiological stress, changed behavior such as less time foraging and more time watching the surroundings, and changed movement patterns (displacement to nearby habitat).

Special Status Bat Species

Potential direct and indirect impacts on special status bats could include increased noise during roosting and hibernation. Pipeline repair occurs during the day and there would be no vegetation removal, therefore repair of the pipeline is not expected to adversely impact bats.

Cumulative Impacts

The impacts of past, present, and reasonably foreseeable future actions on special status terrestrial wildlife would result from ongoing routine trail corridor work and past and future prescribed fire and forest thinning on the North and South Rims. These impacts would be small because BMPs would be used to reduce impacts from helicopters and the areas disturbed would be relatively small. Effects from prescribed fire would be beneficial over the long term by reducing the risk of catastrophic wildfire and improving habitat conditions. Overall, cumulative impacts would be small and adverse. As described above, the no action alternative would result in adverse effects to special status terrestrial wildlife from ongoing repairs of pipeline breaks and the associated human activity and helicopter flights that may cause some noise disturbance or displacement of Mexican spotted owls, California condors, bighorn sheep, and special status bat

species. Thus, when the effects of the no action alternative are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would continue to be adverse, with a slight adverse incremental contribution from the no action alternative.

Impacts of Alternative B – Relocate Water Intake (Preferred Alternative)

Direct and Indirect Impacts

California Condor

Potential direct and indirect effects on California condors include disturbance from noise; attraction to human activity; and risk of collision with aircraft.

Noise from project activities over the 4 to 5 year project duration could result in flushing birds from perching, roosting, or scavenging sites or temporarily affecting foraging and reproductive behavior for up to 6 hours almost every day of the 4 to 5 year project duration. In the past two years, no reports have been received by the park's wildlife biologists of condors landing or occurring in the project area, but they do occur nearby and in the cliffs above the project area. To reduce noise impacts from helicopters, helicopters associated with the project would stay at least 1 mile away from active condor nest locations except when human safety would be compromised (USFWS 1996b). This would minimize potential impacts on condor breeding and nesting.

As described for Alternative A, it is possible that a condor could collide with a project-related helicopter, however, no collisions or near misses of condors have ever been reported by NPS helicopter pilots. The total number of helicopter flights would increase from 1,200-1,500 to about 3,300 per year for a 3-year construction period in the inner canyon. It is assumed that the increased number of helicopter flights under this alternative would increase the overall risk of a collision. Since condors are highly visible due to their size, it should be possible to avoid collision. Regular communication between the park's wildlife staff and helibase crew would also reduce the likelihood of shared airspace with condors. Any collision with a condor would be a catastrophic accident for both the bird and the aircraft. Helicopters would maintain at least a 1,200-foot buffer from condors in the air. If condors approach a helicopter, the aircraft would move away, reducing potential disturbance and risk of collision. Although the chance of an aircraft strike exists, the likelihood is very low.

Because of the small number of California condors in existence, even a single failed nesting attempt or mortality of a condor because of the project would be an important negative impact on this species. However, for the reasons described above, including the implementation of mitigation measures, the likelihood of negative effects on condors from the project would be very low.

Mexican Spotted Owl

Potential direct and indirect effects on Mexican spotted owls would occur from removal of and changes to habitat for prey species and noise from helicopters and construction equipment.

Removal of vegetation and ground disturbance in the project areas would degrade the quality of foraging habitat. PACs were established to contain the foraging area closest to the nest and include the highest use roosting and foraging areas. The project occurs outside of all PAC

boundaries, therefore, the project would avoid impacts on the most important Mexican spotted owl habitat. The project would remove up to 15 acres of ponderosa pine forest habitat near the existing maintenance facility at the South Rim for construction of an expanded helibase, contractor operations, and contractor staging areas and about 1-2 acres of ponderosa pine habitat for construction of the South Rim WTP. These areas are more than 0.5 mile from the boundary of the nearest PAC and are not likely to be used extensively as foraging habitat by Mexican spotted owls.

The reduction of flow to Garden Creek would be eliminated with the relocated water intake and this would restore Garden Creek to its natural state, prior to construction of the TCWL. Riparian areas along Garden and Pipe Creeks may be reduced and associated plant habitats and communities altered, but the new conditions would be more characteristic of natural conditions and processes for these ecosystems. Although riparian vegetation along Garden and Pipe Creeks may be altered by the project, these changes are not expected to substantially affect foraging by Mexican spotted owls because foraging habitat is abundant and, in the case of Garden Creek, because Mexican spotted owl use of the area is suspected to be related to increased rodent activity in the campground nearby not the riparian area itself.

Noise and activity from construction during the breeding season may affect individual owls. Construction work would occur year-round during daylight hours for 4 to 5 years (3 of which would be in the Cross Canyon Corridor), including during the Mexican spotted owl nesting season. The normal breeding and roosting behavior of Mexican spotted owls may be affected by these activities for the project duration. The use of mechanized equipment and helicopters would occur more than 0.5 mile from Mexican spotted owl sites (PAC boundary or known nest or roost site), with a few exceptions. Work to upgrade the existing electrical line between the South Rim and Indian Garden would occur within a PAC; however, work on the electrical line would not affect breeding Mexican spotted owls because all work on this component of the project would occur outside the Mexican spotted owl breeding season. Noise from construction work at Indian Garden is not expected to negatively affect Mexican spotted owls because although the work would occur within 0.5 mile of a PAC boundary, the nearest nest is more than 0.5 mile away and there is currently extensive human activity at Indian Garden. The 2-inch waterline from Roaring Springs to Cottonwood Campground is within 0.5 mile of a PAC boundary, and the nest location in this PAC is not known. Use of mechanized equipment and noise from groups of people working on the 2-inch waterline daily for 6 months would have some negative effects on Mexican spotted owls similar to those described above, for construction noise and helicopters, on breeding and roosting behavior.

Alternative B would result in an increase in helicopter flights from the current level of about 1,200 to 1,500 per year (up to 12 flights per day) to about 3,300 per year for a period of 3 years (approximately 5,500 total for the project) during construction in the inner canyon. Helicopters would remain at least 1,200 feet from the boundary of any designated PAC or above the PAC during the breeding season to avoid impacts on Mexican spotted owls. Larger, louder helicopters would stay 2,000 feet from PAC boundaries during breeding season (Figure 7) in *Soundscape and Acoustic Environment*). Based on the distance from PACs and implementation of BMPs, noise impacts on roosting or nesting Mexican spotted owls would be minimized to the extent that negative effects from helicopter overflights are not expected to occur. Because Mexican spotted owls are nocturnal, and construction and helicopter flights would occur only during the day, foraging by Mexican spotted owls is unlikely to be affected by project activities.

The potential adverse impacts described could impact up to 5 PACs out of 54 PACs parkwide. It is not expected that the local population would be measurably affected especially with implementation of mitigation measures which greatly reduce the chances of any adverse impacts.

Desert Bighorn Sheep

Potential effects on bighorn sheep from construction noise could include increased physiological stress, changed behavior such as less time foraging and more time watching the surroundings, and changed movement patterns (displacement to nearby habitat). Impacts from increased human presence are expected to be minimal because the Cross Canyon Corridor is already heavily used, most increased human activity would occur along existing trails and developed areas in the project area, and bighorn sheep do not typically congregate in these areas.

Use of helicopters would create additional noise that could affect bighorn sheep over a period of about 6 hours per day during the 3-year construction period in the inner canyon. As a BMP, helicopters would remain at least 1,500 feet from the ground except when approaching a landing site or dropping a sling load. Use of helicopters, less than 1,500 above ground level, could disturb bighorn sheep and reduce their foraging efficiency by causing the animals to expend more energy reacting to the helicopters while foraging. There are several water sources within the project area and bighorn sheep would be displaced from frequenting these locations during times of helicopter use, however other water sources would be available. These effects may discourage bighorn sheep from using areas along or near the helicopter flight path during the 3-year construction period in the inner canyon.

The most sheep would be impacted by helicopter noise during the winter months (October to February) when bighorn sheep use the areas from the canyon rim to the Tonto Platform more frequently than other times of the year. Helicopter use in lower elevation areas in the canyon during the February to May lambing season could result in increased stress and vigilance of individual female bighorn sheep which would result in reduced reproduction. Within the approximately 13,000-acre area potentially affected by the project, bighorn sheep may experience reduced reproductive success and may abandon these areas due to the repeated helicopter overflights. Bighorn sheep would move to other areas during construction and may eventually return to these areas after construction is complete. These impacts are more likely to occur when the helicopter is flying less than 1,500 above ground level which would be when the helicopter is approaching a landing site or dropping a sling load.

No known bighorn concentration areas would be affected. In the context of the larger bighorn population in the Grand Canyon, more than 1 million acres below the canyon rim in the park and on surrounding public and tribal lands are available for bighorn use; therefore, parkwide or regional populations would not be impacted, especially when mitigation measures are implemented such as requiring helicopters to maintain a distance of 1,500 feet above ground level when flying over bighorn sheep habitat.

Special Status Bat Species

Potential direct and indirect impacts on special status bats could include noise disturbance during roosting and hibernation, tree removal during construction, impacts on foraging habitat, and reduction in insects. The primary impact on bat species would be from intermittent noise

and vibration from project activities over the 4 to 5 year project duration. For cave and cliff crevice-dwelling bat species (Allen's lappet-browed bat, greater mastiff bat, long-legged myotis, Mexican free-tailed bat, Mexican long-tongued bat, pocketed free-tailed bat, spotted bat, and Townsend's big-eared bat), impacts from intermittent noise and vibration over 3 years in the inner canyon could include roost abandonment, including maternity roosts or hibernation sites, that could adversely reduce localized populations in the TCWL area. Effects would be most likely for the section of the TCWL below Plateau Point where the pipeline would be replaced on a cliff face. Bat species that roost or hibernate in trees (long-legged myotis, western red bat, and sometimes Allen's lappet-browed bat) would be similarly affected by intermittent construction noise at Indian Garden and Phantom Ranch for up to 3 years. Repeated disturbance at a roost or hibernation site may cause bats to abandon the site and move into a less favorable alternative site. Many species of bats incorporate multiple roost or hibernation sites in a specific area, so effects may only be short-term until they relocate to these sites. Although no known maternity roosts or hibernation sites are located in the project area, disturbance to cave or cliff roosting bats, resulting in roost abandonment is discussed in this analysis because it would reduce local populations of special status bats. Because of the large size of the park and abundance of cave and cliff roosting and hibernation sites, as well as tree roosting and hibernation sites, available, these effects would be limited mostly to the local area around the TCWL.

Tree removal during construction, specifically removal of trees that provide roosting habitat, could negatively affect tree roosting bat species. Ponderosa pine habitat would be removed from up to 15 acres for construction of the expanded helibase and other contractor facilities at the South Rim and 1-2 acres for construction of the South Rim WTP. Bats could be directly injured or displaced to alternative roost sites if their roost trees were removed. These impacts would be mitigated by removing trees on the South Rim in the winter when tree roosting bats are less likely to be present. Roosting in trees on the South Rim is less likely to occur during the winter months because most species migrate to warmer locations, either farther south or at lower elevations during the winter. Potential impacts on roosting bats at Indian Garden and Phantom Ranch would be avoided by restricting tree removal in these areas.

Reduction of water flow in Garden Creek, due to no longer releasing overflow water from Roaring Springs, would result in changes to the insect community, which is a food source for foraging bats, including changes in insect availability, abundance, or species composition. This could lead to reduced foraging success for bats. Given the wide-ranging foraging behavior of most bat species and extensive similar habitat nearby, foraging habitat loss is not expected to have a discernable negative effect on these species.

Impacts to special status terrestrial wildlife would be greater under Alternative B when compared to Alternative A because of the increased helicopter flights and vegetation removal.

Cumulative Impacts

As previously described for the no action alternative, past, present, and reasonably foreseeable future actions would result in adverse impacts from ground disturbance, helicopter overflights, and displacement from increased noise and human activity. These impacts would be small because BMPs would be used to reduce impacts from helicopters and the areas disturbed would be relatively small. Effects from prescribed fire would be beneficial over the long term by reducing the risk of catastrophic wildfire and improving habitat conditions. Overall, cumulative impacts from past, present, and reasonably foreseeable future actions are small and adverse. As previously described, Alternative B would contribute negative effects on special status terrestrial

wildlife from removing foraging habitat for bats and Mexican spotted owl and from noise disturbance from construction and helicopter flights on California condor, Mexican spotted owl, bighorn sheep and bats. Thus, when the effects of Alternative B are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would be negative, with a slight adverse incremental contribution from Alternative B.

Impacts of Alternative C – Replace TCWL in Same Location

Direct and Indirect Impacts

California Condor

Potential direct and indirect effects on California condors would be similar to impacts from Alternative B with two exceptions. Under Alternative C, the existing electrical line from the South Rim to Indian Garden would not be upgraded, so there would be no impacts on condor nests on the west side of the Battleship.

Also, under Alternative C, increasing the number of helicopter flights from the current level of about 1,200 to 1,500 per year to about 3,800 per year (up to 11,500 for the 4 or 5 years of inner canyon work) and up to 14 hours per day for a period of 4 to 5 years during construction would increase the potential for foraging condors to be displaced. However, given the large size of their home ranges, impacts would be small in scale and would not affect foraging success or survival. Potential impacts on foraging condors would occur over the 4- to 5-year construction period in the inner canyon, when helicopters are in use, and would end when construction is complete.

It is assumed that the increased number of helicopter flights associated with Alternative C would increase the overall risk of a collision. There would be up to 11,500 project flights compared to 5,500 estimated for Alternative B. Although the chance of a collision with a helicopter exists, the likelihood is very low because pilots would maintain at least a 1,200-foot buffer from condors in the air. Therefore, impacts on condors would be extremely unlikely to occur because BMPs would be implemented.

Mexican Spotted Owl

Impacts would be the same as described for Alternative B with three exceptions. There would be fewer impacts on Mexican spotted owl foraging habitat because there would not be a decrease in riparian habitat at Garden Creek or removal of ponderosa pine habitat at the South Rim WTP. About 16 acres of ponderosa pine forest habitat would be removed on the South Rim and these areas are not likely to be used extensively as foraging habitat.

Additionally, work to replace the TCWL between Roaring Springs and Cottonwood Campground has the potential to affect nesting spotted owls by causing them to flush from the nest, which could potentially affect nesting success. Though these negative effects on Mexican spotted owls are expected to be minimal because activities in this area would be limited to excavation using light construction equipment in the existing trail corridor, they would be expected to be slightly greater than under Alternative B because the extent of excavation would be greater and the duration of work would be longer.

Alternative C also would result in an increase in helicopter flights from the current level of about 1,200 to 1,500 per year to about 3,800 per year and would more than triple the number of flights per year for a period of 4 to 5 years during construction. BMPs described for Alternative B

would also be applied under Alternative C and would minimize helicopter impacts to Mexican spotted owls. Overall impacts from helicopters would be the similar to those described for Alternative B; however, impacts would occur for up to 5 years in the inner canyon as opposed to 3 years for Alternative B.

As previously described under Alternative B, impacts on foraging habitat are not expected to be important at the individual or population level because of the large amounts of Mexican spotted owl foraging habitat in the area. Reduced nesting success as a result of noise disturbance could result in adverse impacts; however, with implementation of BMPs, negative impacts are not likely to reach the level where nesting success is affected.

Desert Bighorn Sheep

As described for Alternative B, helicopters and other project activities would create additional noise that could affect bighorn sheep.

Impacts from helicopters would be greater than those described in Alternative B because the larger project area would have impacts across up to 15,000 acres and helicopter use would occur over a period of up to 14 hours per day for the 4 to 5 year construction period in the inner canyon. For these reasons, and because of the longer construction period, impacts under Alternative C could be slightly greater than under Alternative B. These impacts would be reduced by requiring helicopters to fly at least 1,500 feet above ground level when entering and exiting the canyon, as described for Alternative B.

As previously described, a reduction in lamb survival would be an adverse impact on individuals or small groups of bighorn sheep in the areas along the helicopter flight path. No known bighorn concentration areas would be affected under Alternative C. Because of the large amount of habitat below the canyon rim in the park and on surrounding lands, impacts would not be discernable at the parkwide or regional scale, especially when mitigation measures are implemented such as requiring helicopters to maintain a distance of 1,500 feet above ground level when flying over bighorn sheep habitat.

Special Status Bat Species

The potential for disturbance from noise and vibration during roosting and hibernation would be greater than described for Alternative B because the project would cover a larger area due to the replacement of 9 miles of pipeline along the North Kaibab Trail and would extend over 4 to 5 years. However, because of the large size of the park and abundance of cave and cliff roosting sites available, impacts would be limited mostly to the local area around the TCWL.

Impacts from clearing ponderosa pine habitat on the South Rim to construct the expanded helibase and other contractor facilities would be similar in kind but less in magnitude than those described for Alternative B because vegetation clearing for the South Rim WTP, Indian Garden facilities, and Phantom Ranch facilities would not occur. Changes in flow to Garden Creek, as described for Alternative B would not occur either under Alternative C.

Impacts to special status terrestrial wildlife would be greater under Alternative C when compared to Alternative B because of the increased helicopter flights.

Cumulative Impacts

As previously described for Alternative A, past, present, and reasonably foreseeable future actions would result in adverse impacts from ground disturbance, helicopter overflights, and displacement from increased noise and human activity. Collectively, impacts from past, present, and reasonably foreseeable future actions are small and adverse. As previously described, Alternative C would contribute negative effects on special status terrestrial wildlife from noise disturbance from construction and helicopter flights which impact California condor, Mexican spotted owl, bighorn sheep and bats. Thus, when the effects of Alternative C are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would be negative, with a slight adverse incremental contribution from Alternative C.

Cultural Resources

The following sections address the current status of cultural resources that may be impacted by ongoing repair or replacement of the TCWL; these resources include historic buildings and structures, cultural landscapes, archaeological resources, traditional cultural properties and ethnographic resources.

Cultural Landscapes and Historic Buildings and Structures

Affected Environment

The TCWL project would affect two historic districts, the Cross Canyon Corridor Historic District (CCCHD) and the Transcanyon Water Line Historic District (TCWL Historic District).

Cross Canyon Corridor Historic District and Cultural Landscape

The CCCHD encompasses 485 acres including the four primary corridor trails – the Bright Angel Trail, South Kaibab Trail, North Kaibab Trail, and the Colorado River Trail (NPS 2013a). There are six developed areas within the district. Contributing resources within the district boundaries include 36 buildings, 25 structures, and 2 sites, one of which represents a broader cultural landscape (described more below). Character defining features of the district include historic trails, buildings, bridges, vegetation, circulation, topography, cultural traditions, archeological sites, and scenic quality.

The CCCHD was determined eligible for National Register listing by the NPS and the Arizona State Historic Preservation Officer (SHPO) in 1980. The 2013 Cultural Landscape Inventory (CLI) recommended that the CCCHD's boundaries and contributing features be expanded. In 2015, the Arizona State Historic Preservation Officer concurred with the NPS National Register determination of eligibility (Logan Simpson Design 2015), that the expanded CCCHD was eligible for listing on the National Register at the national level of significance for its association with early Euro-American exploration and early development of commercial tourist operations in the region, as well as the shift from private interests to public enjoyment and resource protection to fulfill the requirements of the Organic Act. The district is also eligible for its association with Mary Jane Colter, who designed the original buildings at Phantom Ranch and for significant technical accomplishments specific to the construction of the South Kaibab Trail, Colorado River Trail, and Kaibab Suspension Bridge. The period of significance for the district began in 1890 when entrepreneurs began developing the Bright Angel Trail for prospectors and tourists and ended in 1942 when the Civilian Conservation Corps completed their developments within the area.

The 2015 National Register determination of eligibility included a broader cultural landscape as a principle component of the CCHD. The NPS defines a cultural landscape as “a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values” (Birnbaum 1994).

The 2013 CLI (NPS 2013a), which contributed to the 2015 determination of eligibility, identifies elements of the cultural landscape that include the circulation of the primary corridor trails; clusters of development at Indian Garden, Phantom Ranch, campgrounds, and rest areas; diverse vegetation; and rich history are some of the key elements of this cultural landscape.

Distinctive characteristics of the cultural landscape include:

- Buildings and structures associated with NPS and Civilian Conservation Corps undertakings, rustic architectural style and efforts to blend buildings and structures with the natural environment, and minimal design, minimal use of locally sourced materials, and craftsmanship of stone masonry.
- Aspects of landscape design and constructed features and the site’s geography, NPS efforts to lead visitors to specific lookout points, and building organization and design to limit intrusions on the natural views in visitor areas and at lookout points.
- Design and method of construction in a challenging topographic setting.
- Settings and views incorporate natural Mohave Desert scrub vegetation, panoramic views of the Cross Canyon Corridor, and named geologic features.
- Trail corridors are characterized by:
 - Heavily maintained trail grades designed to accommodate natural features and utility systems including electrical lines and the TCWL.
 - Design, placement, and orientation of rest areas, lookout points, and stone masonry that represent NPS and Civilian Conservation Corps workmanship.
 - Design standards for permanency because of the need to maintain utility systems and facilitate maintenance and repairs due to heavy use, erosion, and natural deterioration.
 - Associated stone retaining walls and steps are contributing features to the trail landscape areas but are designed to be temporary so the NPS can remove, replace, or reconstruct as needed (NPS 2013a:165).

Transcanyon Water Line Historic District

The NPS determined the TCWL Historic District eligible for listing in the National Register for its association with the early Mission 66 and Parkscape capital development programs, significant accomplishments in engineering, and distinctive architectural design. “The pipeline is exceptionally important as a singular engineering feat in a premier National Park, fundamentally changing water-resource management and visitor accommodations in the park, and closing the Mission 66 program at Grand Canyon with a crowning infrastructure achievement unmatched by any other National Park” (NPS 2015b; Steely 2015). The SHPO concurred on 8/24/15 with the NPS National Register determination. The historic district is nationally significant and eligible for National Register listing for its association with a major federal undertaking to locally source and convey fresh water through adverse topography in an arid environment and its characteristics that represent distinctive engineering and architectural design. The period of significance for the district begins with the NPS design of the TCWL in 1963 and ends in 1986,

when the park completed construction and improvements to the TCWL. The TCWL District lies within the CCCHD. The TCWL and its associated structures are noncontributing elements to the CCCHD because they were constructed after the period of significance for the CCCHD (1890-1942). An exception is the Indian Garden South Pumphouse, which is a contributing feature to the CCCHD and the TCWL Historic District.

The TCWL Historic District includes the TCWL itself from its source at Roaring Springs to the Indian Garden South Pumphouse. Contributing structures and buildings in the historic district include the Roaring Springs Cave Intake Complex, the Roaring Springs Pumphouse developed area, the Roaring Springs Residence and associated developed area, the Indian Garden North and South Pumphouses, and all valves and pumps along the pipe (Steely 2015). There are 20 contributing resources within the district including:

- Roaring Springs Cave
- steel and aluminum pipe
- four valves, controls, and pumps
- nine bridges (six bridges over Bright Angel Creek north of the Colorado River, Silver Bridge over the Colorado River, and two bridges below Plateau Point)
- sedimentation tank at Indian Garden
- four buildings (1932 Indian Garden South Pumphouse and adjacent 1966 North Pumphouse, Roaring Springs Pumphouse, and Roaring Springs Quarters)

The materials used to construct the pipeline and its spatial organization are contributing resources to the TCWL Historic District (Steely 2015). The lightweight aluminum pipe represents a distinctive use of materials to construct the pipe in difficult topography and to allow placement by helicopter. Defining aspects of engineering and design are represented in the spatial organization and association between major pipeline structures and between the TCWL system and Roaring Springs, developed areas, trails, and the topographic challenges of the Cross Canyon Corridor. The TCWL's design to conceal the pipe and some associated structures is also a defining characteristic.

Environmental Consequences

Impacts of Alternative A – No Action

Direct and Indirect Impacts

Under the no action alternative, the park would continue current operations and would repair the TCWL as needed. The TCWL would continue to provide water to the Cross Canyon Corridor and the South Rim. Water would continue to be gravity fed to Indian Garden with excess water released into Garden Creek. No new construction or alterations to historic districts are anticipated.

Cross Canyon Corridor Historic District and Cultural Landscape

Periodic in-kind repairs and maintenance of the pipeline often require park maintenance staff to dig up a section of trail (North Kaibab, Colorado River or Bright Angel Trail) because the TCWL is buried in the trail for much of its extent. Repair and maintenance work could adversely affect trail features such as the historic trail alignment or retaining walls that are contributing elements to the CCCHD. Retaining walls would be repaired in-kind if damaged during work to repair the TCWL and would retain integrity as a cultural resource and

contributing element to the CCCHD. Similarly, any impacts to the historic trail alignment would be minimal, such as short reroutes, and would not alter the trail so much that it would impact eligibility for National Register listing. Construction activities to repair or replace damaged pipe would continue to be short in duration, generally 1 to 10 days.

Transcanyon Water Line Historic District

Maintenance of the TCWL would retain its functionality and would not include any changes to the TCWL that would affect its eligibility for National Register listing. Replacement of sections of pipe over time may have some adverse impacts from replacing the original pipe with new materials. However, much of the original pipe would remain in place in its original location; therefore, the integrity of the pipe would not be impacted.

Cumulative Impacts

Past, present, and reasonably foreseeable future actions with the potential to impact the CCCHD and the TCWL Historic District include past routine utilities maintenance, past replacement of sections of pipe and materials on co-located electrical lines, past and proposed addition of water and waste water management infrastructure, future bridge and trail maintenance and repair, and future building rehabilitation. Past projects have resulted in the incremental introduction of modern materials to the CCCHD and TCWL Historic Districts which diminishes the historic feeling, materials, and workmanship (aspects of integrity) of these districts. However, these materials have not diminished either district enough to impact their eligibility for National Register listing because enough of the original materials would remain to convey the significance of the districts. Present and reasonably foreseeable future actions include routine vegetation management and maintenance on trails that contribute to the CCCHD, and repairs to the Black Suspension Bridge (Kaibab Suspension Bridge, a contributing feature to the CCCHD) over the Colorado River (proposed 2018-2019). Vegetation management and maintenance activities have had, and would continue to have, beneficial impacts long-term because they will preserve structures, such as the Black Suspension Bridge. Collectively, the past, present and reasonably foreseeable future actions would have adverse impacts. The no action alternative would result in adverse impacts from trenching in the historic trails and replacement of pipe over time. When the effects of the no action alternative are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would be adverse, with a slight contribution of adverse impacts from the no action alternative.

Impacts of Alternative B – Relocate Water Intake (Preferred Alternative)

Direct and Indirect Impacts

Cross Canyon Corridor Historic District and Cultural Landscape

Under Alternative B, potential impacts to the CCCHD would occur from introduction of new buildings and structures, overall trenching and ground disturbance, and excavation of the existing pipeline within the trail footprint. Up to 5 new buildings and 3 water tanks are proposed for construction in the CCCHD. At Phantom Ranch up to 4 new buildings and 2 water tanks including a raw water storage tank, booster pump station and local water treatment plant, potable water storage tank, and 1-3 units for overnight accommodations would be constructed. At Indian Garden, 1 new building, 1 water tank, and drying beds would be constructed.

The construction of these new buildings and structures would have a visual impact on the CCCHD. At Phantom Ranch the new buildings and the raw water tank would be located in the delta area near the existing WWTP and would be within view of or close proximity to several contributing structures and buildings. There are also several non-contributing structures, to the CCCHD, in the delta area so the addition of new non-contributing structures would not be considered precedent setting. The potable water tank at Phantom Ranch would be located on the north end of the developed area near the existing water tanks or to the east above Phantom Ranch. The tank would be visible from Phantom Ranch Lodge in either location. As described in the alternative description, the architecture of any new buildings or structures would be compatible with historic structures in the areas in color, materials, design, massing, and visual scale. Locations would be selected to harmonize with the rustic character of Phantom Ranch and structures would be obscured by vegetation when possible. Introduction of a new water intake along Bright Angel Creek would also have visual impacts on the CCCHD because it would be in view of the North Kaibab Trail and possibly other contributing buildings or structures in the area. However, the water intake would be low profile and would not be obvious on the landscape. Introduction of these new structures would be a permanent, adverse effect due to the number and proximity to contributing elements of the CCCHD and would impact the setting in the district. However, these impacts would not degrade the district enough to impact its eligibility for National Register listing, because enough of the original materials would remain to convey the significance of the district.

Replacement of approximately 3 miles of pipeline would require trenching. Much of the existing pipeline to be replaced is located under the Colorado River and Bright Angel Trails. Excavation of the trail and removal of the pipe would be needed to install new pipe. Temporary visual impacts would occur from this trenching during the 36 to 48 months of construction. After placing the new pipe, the trail would be reconstructed in-kind. Historic walls would be avoided, but if damage were to occur repairs would be made in-kind. In addition, ground disturbing activities have the potential to uncover and disturb previously unidentified cultural resources, however, BMPs would be implemented to minimize impacts to these resources. The pipeline itself is a modern, non-contributing structure to the CCCHD (Logan Simpson Design 2015) therefore the removal and replacement of the pipe would not be considered an adverse effect to the CCCHD.

The potential installation of 1.5 miles of 2-inch waterline from Roaring Springs to Cottonwood Campground would also require some trenching. The existing pipeline may be used as a conduit for this smaller pipeline which would require some trenching to pull the new pipe through, but would not require the entire 1.5 miles to be dug up. Impacts would be the same as those described above for trenching and would not be considered adverse long term.

Contractor camps would be established at Phantom Ranch, Indian Garden Campground, Cottonwood Campground, and Manzanita Day Use Area; and staging areas would be interspersed within developed areas and along the TCWL alignment. Camps and staging areas would cause short-term visual impacts to the CCCHD during the 3 year construction period. However, no long-term impacts are expected from these actions because no permanent structures would be constructed and any areas of grading for construction staging in the existing TCWL corridor would be recontoured and revegetated as appropriate.

The proposed helicopter flight schedule would cause temporary audible impacts on the overall CCCHD setting, lasting approximately 18 minutes per flight with multiple flights (up to 20) on almost every day for the 3 year inner canyon construction period.

Transcanyon Water Line Historic District

Activities with the potential to impact contributing resources to the TCWL Historic District include pipeline replacement, repair and maintenance of the Silver Bridge, and construction of new water treatment systems.

Of the 12.5 mile TCWL, approximately 3 miles would be replaced with steel pipe, .5 miles of new pipeline installed at Phantom Ranch would remain in place, 7.5 miles would be left in place initially and removed over time during routine trail work, and 1.5 miles may be used as a conduit for a 2-inch waterline from Roaring Springs to Cottonwood Campground or left in place initially and removed over time. The replacement of the pipeline would directly impact one of the defining characteristics of the pipe, the material, by replacing aluminum materials with steel. Replacement would preserve the structure's function and association, spatial relationships, and engineering and design. However, the removal of the existing pipe and replacement of the pipe with steel would have a permanent, adverse effect to the historic district.

Three valve boxes are present in the TCWL Historic District and would either be abandoned or removed. If abandoned in place, there would not be an impact to the TCWL Historic District. If removed, there would be a permanent adverse effect to the district because the valve boxes are contributing elements to the TCWL district.

In order to partially mitigate the adverse effects, the park commissioned Historic American Engineering Record (HAER) documentation for the TCWL Historic District in 2015 (HAER No. AZ-95; NPS 2015b); NPS would work with the State Historic Preservation Officer (SHPO) to determine where representative samples of the original pipeline should remain in place as historical materials and NPS would design interpretive signs and materials to convey the significance of the pipeline to visitors and staff.

Replacement of or upgrades to existing electrical lines and introduction of new infrastructure in proximity to contributing pumphouses, tanks, and pipe appurtenances in developed areas would introduce new permanent visual elements to the TCWL Historic District.

The new materials and elements described above would have an adverse impact on the feeling, setting, workmanship, and materials (aspects of integrity) of the TCWL Historic District, but would not diminish it enough to impact eligibility for National Register listing, because enough original materials would remain to convey the significance of the district.

Routine maintenance of the Silver Bridge would be needed to suspend the new pipeline. This would include replacing broken and missing deck panels, cotter pins, and re-securing safety fencing; removing soil and vegetation from bearing seats and anchorages; resetting bridge expansion system and adding additional bearing restraints to prevent future bridge movement. These actions would be beneficial for this contributing structure to the TCWL Historic District and the beneficial impacts would last until the bridge requires maintenance again, which is expected to be about 10 years.

When compared to Alternative A, Alternative B would result in greater adverse impacts to the CCCHD and TCWL Historic District due to the introduction of additional buildings and structure to the districts and changes to the TCWL system.

Cumulative Impacts

Impacts from past and reasonably foreseeable future actions on historic buildings and structures from routine maintenance under Alternative B would be same as the no action alternative. Collectively, past, present and reasonably foreseeable future actions have had and would have adverse impacts. Alternative B would cause temporary impacts during construction on visual and audible characteristics as well as long term adverse impacts from introduction of new structures in the CCCHD and replacement of the pipeline in the TCWL Historic District. When the effects of Alternative B are combined with other past, present, and reasonably foreseeable future impacts, the total cumulative impacts on historic districts, would be adverse. The impacts of Alternative B would contribute slightly to these adverse impacts.

Impacts of Alternative C – Replace TCWL in Same Location

Direct and Indirect Impacts

Under Alternative C, 12 miles of 6-inch aluminum TCWL (.5 miles previously completed) would be replaced with an 8-inch-diameter steel pipe. The .5 mile section of pipeline that was replaced at Phantom Ranch would remain in place. No new water treatment buildings or structures would be introduced into the TCWL Historic District or CCCHD.

Cross Canyon Corridor Historic District and Cultural Landscape

Under Alternative C, impacts from open-trench pipe removal and replacement would be the same as those described for Alternative B except they would occur along the 12 miles pipeline. These impacts would not affect the integrity of the district or the trails themselves and would not impact eligibility for National register listing.

Transcanyon Water Line Historic District

The replacement of the pipeline would directly impact one of the defining characteristics of the pipe, the material, by replacing aluminum materials with steel. Replacement would preserve the structure's function and association, spatial relationships, and engineering and design. However, the removal of the existing pipe and replacement of the pipe with steel would have a permanent, adverse effect to the historic district. Although Alternative C would result in adverse impacts, these impacts would not affect eligibility for National Register listing.

Also described under Alternative B, as partial mitigation for the adverse effects described above, the park commissioned HAER documentation for the TCWL Historic District in 2015 (HAER No. AZ-95; NPS 2015c2015b). NPS would also work with the State Historic Preservation Office (SHPO) to determine where representative samples of the original pipeline should remain in place as historical materials to convey significance and NPS would design interpretive signs and materials to convey the significance of the pipeline to visitors and staff.

Similar to Alternative B, construction contractor camps, construction staging, and helicopter access would have a temporary indirect visual impact on the TCWL Historic District and CCCHD. These actions would contribute to the overall adverse effect that would result from implementation of this alternative.

Alternative C would result in less adverse impacts when compared to Alternative B because there would be less development in the CCCHD and the TCWL would continue to function as it was designed even though it would be replaced with new materials.

Cumulative Impacts

As described for Alternative A, past, present, and reasonably foreseeable future actions have had, and would have, both adverse and beneficial impacts on historic buildings and structures and historic districts, including the CCCHD cultural landscape. As previously described, Alternative C would cause temporary impacts on visual and audible characteristics as well as long term adverse impacts from replacement of the pipeline in the TCWL Historic District. When the effects of Alternative C are combined with other past, present, and reasonably foreseeable future impacts, the total cumulative impacts on historic districts, would be adverse. The impacts of Alternative C would contribute slightly to these adverse impacts.

Archaeological Resources, Traditional Cultural Properties, and Ethnographic Resources

Affected Environment

Archaeological Resources

Grand Canyon National Park has offered refuge and resources to people throughout the 12,000 years of human use and occupation of the landscape. The Grand Canyon remains significant for its ongoing role in the lives and traditions of American Indians of the region. Archaeologists generally divide the human history of the Grand Canyon into six broad periods; Paleoindian, Archaic, formative, late prehistoric, protohistoric, and historic. Each period is represented in the human story of Grand Canyon's past.

Prehistoric and historic archaeological sites are located in the Cross Canyon Corridor and some are immediately adjacent to the pipeline. During construction of the existing pipeline, some of the archaeological sites were disturbed by construction activities. Archaeological resources are any material remains or physical evidence of past human life or activities which are of archaeological interest, including the record of the effects of human activities on the environment. Archaeological resources managed by the park are those places, sites, and objects generally 50 years old or older that retain integrity and are eligible for listing on the National Register. Through the study of archaeological materials scientific and humanistic information can be revealed as well as strengthening the connections of American Indian people to their history here (NPS 2006 Management policies PP:156).

The most current information regarding the condition of archaeological sites in the Cross Canyon Corridor has taken place over the last decade in a series of efforts including the 2017 North Kaibab Trail monitoring project, Phantom Ranch to Cottonwood (NPS 2017 Grand Canyon Archaeological Site Database), the 2009-2012 Corridor Trails inventory (Collette et al. 2009 and 2012), and the 2008 North Kaibab Trail archaeological site monitoring project from Roaring Springs to Cottonwood (NPS 2008 Grand Canyon Archaeological Site Database). The entire Cross Canyon Corridor has been surveyed for archaeological resources. Twenty-eight archeological resources have been documented in the analysis area (area of potential effect for Section 106) including 13 habitation sites, 4 historic and prehistoric artifact/lithic scatters, 4 food processing sites, 3 rock writing sites, 2 storage features, and 2 historic developments.

National Register eligibility is unknown for these sites. Site condition assessments provide generalized conditions as good, fair, or poor; 23 sites are in good condition, 3 sites are in fair condition, 1 site is in poor condition, and one site is in unknown condition.

Traditional Cultural Properties and Ethnographic Resources

A traditional cultural property can be defined generally as an ethnographic resource eligible for or listed on the National Register that is significant because of its association with the cultural practices or beliefs of a living community that are rooted in that community's history and are important to maintaining the continuing cultural identity of the community (Steely 2015). Ethnographic resources include landscapes, objects, plants and animals, or sites and structures that are important to a people's sense of purpose or way of life. Ethnographic resources are both natural and cultural resources that have a special importance for specific peoples or groups different from that enjoyed by the public (Steely 2015).

American Indian tribes traditionally associated (NPS 2006) with the Grand Canyon include the Havasupai, Hopi, Hualapai, Navajo, Kaibab Band of Paiute Indians, Paiute Indian Tribe of Utah, Las Vegas Paiute, Moapa Band of Paiute Indians, San Juan Southern Paiute, Yavapai-Apache, and the Pueblo of Zuni. These tribes believe that the entire Grand Canyon is a Traditional Cultural Property. The park is currently documenting the components of this Traditional Cultural Property including the Colorado River, cultural resources (including archaeological sites), sacred sites, natural features, and native plants and animals in the Grand Canyon area, including the Cross Canyon Corridor. Many of the traditionally associated tribes also typically consider ancestral archaeological sites to be traditional cultural properties.

Tribes have a long history with all of the Grand Canyon and the Cross Canyon Corridor. Of particular significance to the tribes are Indian Garden, part of the original homeland of the Havasupai people, and the Bright Angel and North Kaibab trails that served as trade routes for some of the tribes and a the path to the place of emergence for the Zuni people. Early prehistoric peoples and modern tribes used a route that traced the Bright Angel Fault for millennia before the first European-Americans visited Grand Canyon. There were multiple routes in the area of the Bright Angel Trail that were used over time. The exact locations of all of these early routes are unknown. It is known that the Bright Angel Trail follows the most frequented route to Indian Garden. Indian Garden and the South Rim of the Grand Canyon were part of the Havasupai traditional homelands that once extended from Grand Canyon, south and west to Flagstaff and Williams, Arizona, and beyond. The Havasupai, and their ancestors, seasonally occupied Indian Garden for its perennial springs, level lands suitable for agriculture, and nearby sheltering caves. The Havasupai tribe has cultural and archaeological sites of importance throughout the entire project area, including Indian Garden, Phantom Ranch, trails to the North and South Rim (Havasupai Tribal Council 2017).

Environmental Consequences

Impacts of Alternative A – No Action

Direct and Indirect Impacts

Under the no action alternative, the TCWL would continue to break and require emergency repairs. The activities associated with emergency repair, including digging up the trail, could result in potential direct adverse impacts on 9 archaeological resources that are bisected by the TCWL (Table 4). Impacts could include minor disturbances from water erosion due to a

pipeline break to complete destruction from ground disturbing construction-related impacts. However, the repairs that occur on a case-by-case basis are unlikely to require enough trenching and ground disturbance to destroy any of these sites. If a break were determined to be in close proximity to one of these sites, NPS would develop a mitigation strategy to minimize impacts to the sites. For example, data recovery of site could occur in order to preserve archaeological information that contributes to the site's meaning, significance, and interpretation. The recovery of archaeological information is considered the primary mitigation for reducing impacts to archaeological resources.

Impacts to archaeological resources would also be considered impacts on ethnographic resource and traditional cultural properties. In addition, impacts on ethnographic resources and traditional cultural properties would include impacts on vegetation, wildlife, and springs described in other sections of this document (i.e., Bright Angel Creek Fish).

Table 4. Impacts on archaeological resources in the current TCWL alignment

Site Type and Number of Sites	Impacts	Impact	Location Relative to the TCWL
Habitation (7 sites)	Direct	Ground disturbance	TCWL bisects site
Food processing (1 site)	Direct	Ground disturbance	TCWL bisects site
Storage (1 site)	Direct	Ground disturbance	TCWL bisects site

Cumulative Impacts

Past, present, and reasonably foreseeable future actions with the potential to impact archaeological and ethnographic resources and traditional cultural properties include ongoing routine trail operations and maintenance. Present and reasonably foreseeable future actions and project areas with the potential to affect cultural resources would be surveyed by archaeologists to identify archaeological, ethnographic resources, and traditional cultural properties and minimize impacts as much as possible. Collectively, these actions would have very little adverse effects because monitoring or other means would be implemented to ensure avoidance or minimizing of impacts. Because monitoring would occur and resources would be identified very few adverse impacts would be anticipated, however, some adverse impacts could occur to previously unknown or buried archaeological and ethnographic resources. As previously described, the no action alternative could result in adverse effects on archaeological, ethnographic resources, and traditional cultural properties if repeated pipeline failure occurs. Thus, when the effects of the no action alternative are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would be adverse, with a small contribution from the no action alternative.

Impacts of Alternative B – Relocate Water Intake (Preferred Alternative)

Direct and Indirect Impacts

Activities at the Phantom Ranch facilities, South Rim WTP, Roaring Springs and Cottonwood Campground facilities, electrical line from South Rim to Indian Garden, and access and staging areas for these activities have potential for direct or indirect impacts from ground disturbance (Table 5). One archaeological site is near the project area, but would be avoided. In addition, archaeological resources were discovered during the excavation for the WWTP construction and it is possible that additional archaeological resources would be uncovered during construction in the Phantom Ranch delta area. If additional resources are uncovered, BMPs would be implemented to stop work and protect the resources if possible which would lessen adverse impacts and maintain the integrity of the resources for listing on the National Register.

Proposed activities at Indian Garden have the potential to directly and permanently impact three other archaeological sites located in close proximity to the TCWL alignment, two of which were disturbed during original pipeline construction. Impacts would occur from trenching activities and could be so damaging that the sites would no longer retain integrity for listing on the National Register. Mitigation measures such as data recovery could be implemented to preserve archaeological information that contributes to the sites' meaning, significance, and interpretation. Potential indirect effects would occur to six other archaeological sites that are within approximately 50' of the TCWL alignment. These potential adverse effects could occur from erosion or visual impacts (for example a new building in view of an archaeological site, ethnographic site, or traditional cultural property) to sites from construction activities that would impact these sites in the future and it is unlikely that the impacts would be so great to affect National Register eligibility. Overall, the proposed facilities at Indian Garden would disturb approximately 1 to 2 acres. Due to the importance of the area to the Havasupai, the tribe has requested to have a monitor on site during ground-disturbing activities to identify sensitive resource areas and minimize the potential for impacts to ethnographic resources and traditional cultural properties.

Ground disturbance on up to 16 acres would occur to construct the WTP, contractor operations and staging areas, and expanded heliport on the South Rim. Ground disturbing activities would take approximately 12 months. The South Rim area is particularly important to the Havasupai tribe, therefore NPS will work closely with them to identify any resource concerns or monitoring needs. Having a monitor onsite would minimize the potential for inadvertent damage to an archaeological resource, ethnographic resource or traditional cultural property.

When compared to Alternative A, Alternative B would result in greater adverse impacts on archaeological resources, ethnographic resources and traditional cultural properties because it would impact more resources.

Impacts on ethnographic resources and traditional cultural properties would also include impacts on vegetation, wildlife, and springs described in other sections of this document (i.e., Bright Angel Creek Fish).

Table 5. Potential impacts on archaeological resources under Alternative B

Site Number	Site Type	Condition	Impacts	Type	Location Relative to the TCWL
B:16:0035	Habitation	Good	Indirect	Visual intrusion	30 feet from TCWL
B:16:0162	Habitation	Good	Direct	Ground disturbance	TCWL bisects site
B:16:0164	Habitation	Fair	Indirect	Erosion	44 feet from TCWL
B:16:0165	Historic developments	Good	Direct	Ground disturbance	16 feet from TCWL
B:16:0177	Prehistoric lithic scatter	Good	Indirect	Visual intrusion	100 feet from TCWL
B:16:0252	Historic artifact scatter	Unknown	Direct	Ground disturbance	Disturbed during previous pipeline work
B:16:0259	Food processing	Fair	Indirect	Visual intrusion	72 feet from TCWL
B:16:1202	Habitation	Good	Indirect	Visual intrusion	45 feet from TCWL
B:16:1230	Prehistoric artifact scatter	Good	Indirect	Visual intrusion	52 feet from TCWL

Cumulative Impacts

As described for the no action alternative, impacts from past, present, and reasonably foreseeable future actions on archaeological and ethnographic resources and traditional cultural properties would be adverse from direct impacts that occur or have occurred during pipeline

and trail work. Alternative B would result in potential direct adverse effects on three archaeological sites and indirect adverse effects on six archaeological sites from construction of the facilities at Indian Garden and from removal and replacement of the TCWL from Phantom Ranch to Indian Garden. Thus, when the effects of Alternative B are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would continue to be adverse. The impacts of Alternative B would contribute slightly to the cumulative adverse effects.

Impacts of Alternative C – Replace TCWL in Same Location

Direct and Indirect Impacts

Under Alternative C, construction methods and equipment would be the same as described for the TCWL replacement portion of Alternative B. Replacing the TCWL within the existing alignment using small mechanized equipment and replacing electric lines that are immediately adjacent to the TCWL would potentially result in disturbance to previously undisturbed ground and would directly impact archaeological resources located in the 30-foot-wide construction corridor, some of which have been previously disturbed. Direct damage to sites could affect the sites' integrity and eligibility for listing on the National Register. As mentioned previously, mitigation measures such as data recovery may be implemented to document the site(s) and minimize adverse impacts. Indirect effects would include increased erosion near archaeological resources located within and immediately adjacent to the construction corridor from construction and vegetation removal and visual impacts to the resources from construction. Under Alternative C, 13 archaeological resources would be both directly and indirectly impacted and 9 archaeological resources would be subject to only indirect effects (Table 6).

Ribbon Falls, near the North Kaibab Trail is a very important location to the Zuni tribe. Access to this location is expected to continue throughout construction. However, adverse impacts could occur if access is restricted or noise from helicopter flights cannot be halted during tribal visits. The potential for adverse impacts is great than in Alternatives A and B, because of the greater number of flights. NPS would work closely with the Zuni tribe to coordinate access and would provide notification about any closures. NPS may also limit helicopter flights if requested by the tribe. This would minimize any potential impacts on ethnographic resources or traditional cultural properties.

At Indian Garden, the adverse impacts for replacement of the pipeline would be the same as those described for Alternative B. However, none of the buildings would be constructed and therefore there would be no related ground disturbing impacts. As previously mentioned Indian Garden is very important to the Havasupai and the tribe has requested to have a monitor on site during ground-disturbing activities to identify sensitive resource areas and minimize the potential for impacts to ethnographic resources.

Table 6. Potential impacts on archaeological resources under Alternative C

Site Number	Site Type	Condition	Impacts	Type	Location Relative to the TCWL
B:16:0026	Habitation	Good	Direct	Ground disturbance	Directly adjacent to TCWL
B:16:0035	Habitation	Good	Indirect	Visual intrusion	30 feet from TCWL
B:16:0111	Habitation	Good	Direct	Ground disturbance	TCWL bisects site
B:16:0133	Habitation	Good	Direct	Ground disturbance	Site is 10' from TCWL
B:16:0162	Habitation	Good	Direct	Ground disturbance	TCWL bisects site
B:16:0164	Habitation	Fair	Indirect	Visual intrusion	44 feet from TCWL

Site Number	Site Type	Condition	Impacts	Type	Location Relative to the TCWL
B:16:0165	Historic developments	Good	Direct	Ground disturbance	16 feet from TCWL
B:16:0177	Prehistoric lithic scatter	Good	Indirect	Visual intrusion	100 feet from TCWL
B:16:0252	Historic artifact scatter	Unknown	Direct	Ground disturbance	Disturbed during previous pipeline work
B:16:0259	Food processing	Fair	Indirect	Visual intrusion	72 feet from TCWL
B:16:0409	Habitation	Good	Direct	Ground disturbance	TCWL bisects site
B:16:0411	Rock writing	Good	Direct	Disturbance	Directly adjacent to TCWL
B:16:0413	Food processing	Fair	Direct	Ground disturbance	Directly adjacent to TCWL
B:16:0416	Habitation	Good	Direct	Ground disturbance	TCWL bisects site
B:16:0417	Prehistoric habitation	Good	Direct	Ground disturbance	Directly adjacent to TCWL
B:16:0418	Habitation	Good	Indirect	Visual intrusion	27 feet from TCWL
B:16:0422	Habitation	Good	Indirect	Visual intrusion	32 feet from TCWL
B:16:0423	Habitation	Good	Indirect	Visual intrusion	43 feet from TCWL
B:16:0425	Food processing	Good	Indirect	Visual intrusion	66 feet from TCWL
B:16:0493	Storage	Poor	Direct	Ground disturbance	5 feet from TCWL
B:16:1202	Habitation	Good	Indirect	Visual intrusion	45 feet from TCWL
B:16:1230	Prehistoric artifact scatter	Good	Indirect	Visual intrusion	52 feet from TCWL

When compared to Alternative B, Alternative C would result in greater adverse impacts on archaeological resources, ethnographic resources and traditional cultural properties because it would impact more resources.

Cumulative Impacts

Impacts from past, present, and reasonably foreseeable future actions on archaeological and ethnographic resources and traditional cultural properties would be adverse as previously described for the no action alternative and Alternative B from pipeline and trail work.

Alternative C would result in potential adverse effects on 22 archaeological sites from removal and replacement of the TCWL from Phantom Ranch to Indian Garden and Phantom Ranch to Roaring Springs. Thus, when the effects of Alternative C are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would be adverse with a relatively large adverse cumulative effect from Alternative C.

Visitor Use and Experience

Affected Environment

Visitor use and experience encompasses the way in which people use, participate in, and perceive the facilities and amenities in the park. The park's high-quality natural and cultural features provide unique and diverse visitor experiences and attract visitors from around the world.

Although park visitation fluctuates from year to year, over 6 million visitors entered the park in 2017. Park visitors have a number of activities to enjoy, including day hiking, backpacking, cycling, camping, trail running, river-assisted backcountry travel (RABT), sightseeing, canyoneering, stock use, and wildlife viewing (NPS 2015e). A backcountry permit is required for all overnight campers, including backpackers, campers with private stock animals, and RABT and off-river camping.

The analysis area for visitor use and experience includes all recreation and visitor facilities along the TCWL pipeline alignment and associated facilities construction sites, and flight paths for project helicopters. Recreation and visitor facilities included in the analysis area are described below.

South Rim

A portion of the Greenway paved pedestrian and bicycle trail is located north of the South Rim WTP, between the South Entrance Road and the Yavapai Lodge Road. Visitors can walk or cycle on the paved path.

Inner Canyon

The Bright Angel Trail begins at the Bright Angel Trailhead, located west of the Bright Angel Lodge and the Verkamps Visitor Center along the South Rim of the canyon. The trail continues past two resthouses (1½-Mile Resthouse and 3-Mile Resthouse) to Indian Garden Campground (4.8 miles from the Bright Angel Trailhead). The Indian Garden Campground includes 15 campsites, the Indian Garden ranger station, emergency phone, year-round potable water, and toilets.

Between October 2016 and September 2017 about 91,059 visitors were counted along the Bright Angel Trail.

From Indian Garden, visitors can travel about 2 miles along the Plateau Point Trail to Plateau Point located on the Tonto Platform, or continue down to the Colorado River on the Bright Angel Trail. Plateau Point provides visitors panoramic views of the Colorado River in the canyon below. The Bright Angel Trail continues 2.9 miles down the canyon to the River Resthouse, which has an emergency phone and toilets. From there, the River Trail travels 1.5 miles to the Silver Bridge across the Colorado River.

South Rim mule trips are offered year-round through a park concessioner.

The North Kaibab Trail is the least visited and most difficult of the three maintained trails in the park. Nearly 1,000 feet higher at the trailhead than the South Rim trails, hikers on the North Kaibab Trail pass through every ecosystem found between Canada and Mexico, including mixed conifer forests at the rim to riparian and desert vegetation near the Colorado River (NPS n.d.a).

The trail begins at the North Kaibab Trailhead, 1.5 miles north of the Grand Canyon Lodge on Highway 67. The trailhead is generally not accessible during the winter months, typically October 15 until May 15. The trail steeply descends via a series of switchbacks to the Coconino Overlook and the Supai Tunnel, where potable water (available mid-May to mid-October) and pit toilets are available. From the tunnel, the trail switchbacks down to the junction with the trail to Roaring Springs Day Use Area. Visitors can see the waters of Roaring Springs coming out of the cliffs.

Further down the North Kaibab Trail, visitors pass the Manzanita Rest Area, which affords access to the creek, a toilet, drinking water, and shaded benches. The next developed area is Cottonwood Campground which offers 12 campsites, a toilet, drinking water, and emergency phone. A little over a mile from the Cottonwood Campground is the junction to Ribbon Falls, a waterfall and small desert oasis on the west side of Bright Angel Creek. The trail then enters the

Inner Gorge, a narrow canyon where the trail is boxed in on either side by black rock. The trail then passes Phantom Ranch, a concessioner-operated ranch with cabins. About 0.2 mile down the trail to Phantom Ranch is a ranger station, followed by the Bright Angel Campground. The Bright Angel Campground is located along Bright Angel Creek and includes 33 campsites, year-round potable water, and toilets.

From October 2016 to September 2017, about 19,767 visitors were counted along the North Kaibab Trail. Visitation is highest in the fall months and May just after the North Rim opens. Due to the winter closure of the North Rim, visitation numbers are very low, compared to the South Rim trails, from November to April each year.

Visitation at the Cottonwood and Bright Angel Campgrounds is higher in the spring and fall months and lower in the summer and winter months. Overall, Bright Angel Campground has higher visitation rates than Cottonwood and Indian Garden Campgrounds.

Environmental Consequences

Impacts of Alternative A – No Action

Direct and Indirect Impacts

Under the no action alternative, visitor access to the facilities in the vicinity of the proposed project would continue, and visitor use counts are likely to remain the same. Periodic interruptions from repairing the TCWL would continue to adversely affect visitors from intermittent (currently between 5 and 30 per year) water interruptions in the canyon; however, visitors would still have access to water, though it might have to be rationed during longer pipeline breaks. Visitor experience would also be adversely affected by noise generated from helicopters that would fly necessary equipment and personnel to complete the repairs. Impacts from helicopters would occur only during the flights which are approximately 18 minutes long. For these pipeline repairs, generally between 2 and 10 flights per day would occur for 1-10 days. In some cases, a pipeline break would last longer than 10 days and helicopters would impact visitor experience for the duration of the repair. However, the noise would not be so great that visitors couldn't enjoy listening to the natural sounds around them or engage in normal conversation.

Cumulative Impacts

Although other past, present, and reasonably foreseeable future actions have affected, or could have the potential to affect, visitor use and experience in the analysis area, the no action alternative would have no new impacts and, therefore, there would be no cumulative impacts.

Impacts of Alternative B – Relocate Water Intake (Preferred Alternative)

Direct and Indirect Impacts

Under Alternative B, temporary direct adverse impacts on visitor use and experience would occur due to temporary closures of trails and visitor facilities during construction. Trail closures are not expected to exceed a few days at a time. During closure of the Bright Angel Trail, the South Kaibab Trail would be used as a detour for hikers. The Plateau Point trail would be closed periodically during replacement of the TCWL directly in the trail. Trail closures on these trails could last hours or days depending on the type of work being completed along the trail. These periodic closures of trails would have adverse impacts on visitor use and experience because

they would affect access and the quality of visitors' experience and visitors may choose to hike on different trails. All other trails would remain open to the public. The park would advertise trail closures and detours in advance, which would reduce impacts on visitors by allowing visitors to adjust their plans.

During construction and closures along the Bright Angel and North Kaibab Trails, mule trips from the South and North Rims would be cancelled because operation of construction equipment and additional helicopter flights could scare the mules, creating a safety issue for guests. Additionally, due to the difficulty and steepness of the South Kaibab Trail, mule trip operators cannot safely descend the South Kaibab Trail into the canyon. The cancellation of this activity would adversely impact visitors wanting to participate in mule rides to Phantom Ranch for up to 3 years.

Depending on the time of year, closure of the Bright Angel Trail during construction could increase trail users on the South Kaibab and North Kaibab Trails from 2,700 to 15,300 visitors per month. Unlike the North Kaibab and Bright Angel Trails, the South Kaibab does not have any water available and very little shade which would adversely impact visitors, requiring them to carry additional water. The increase in trail users could result in crowding and congestion specifically on the South Kaibab Trail. After construction of Alternative B, all trails would reopen and visitor use is anticipated to return to existing conditions.

During construction, the Indian Garden Campground would be closed up to a total of 6 nonconsecutive months and Phantom Ranch would be closed up to a total of 8 nonconsecutive months (e.g. 2 weeks, 2 months, or 4 months at a time). These closures could occur throughout the year and could occur during peak visitation periods. With these closures, it is possible that visitors would be displaced and would seek backcountry permits for areas outside the Cross Canyon Corridor. In addition, construction personnel may be housed at Phantom Ranch and Indian Garden for approximately 24 months, reducing the number of cabins and backcountry campsites available for visitors. During this time, approximately half of the 15 campsites at Indian Garden would be used by construction personnel, and half would remain open to the public. During installation of the new pipeline near Indian Garden Campground, the entire campground could be closed to the public for up to 6 months. Over the 3-year inner canyon construction period, about 8 to 15 campsites out of 60 in the inner canyon would be unavailable for up to 24 months. It is also possible that Bright Angel Campground and Indian Garden Campground would be completely closed to visitors for short periods of up to two weeks during construction. With these closures, it is possible that visitors would seek backcountry permits for areas outside the corridor. All of these closures and limitations on campsites in the inner canyon would adversely impact visitor use and experience particularly because the Cross Canyon Corridor is the most popular and sought after place to backpack in the Grand Canyon. Adverse impacts on visitors would be somewhat mitigated by advertising closures in advance on the park's website.

During removal and replacement of portions of the TCWL, periodic shutdowns of the TCWL would be required. If water in existing storage tanks at Phantom Ranch, Indian Garden and South Rim was depleted, some visitor facilities (including those with potable water, ranger stations, and running water toilets) could be closed until water was restored which would impact visitors by displacing them outside the park or to other areas in the park for several days. Where possible, water would be trucked in from other sources; however, water would not be trucked to supply Indian Garden or Phantom Ranch. Because all backcountry visitors are

encouraged to carry water filtration, some backcountry visitors may not be adversely affected by water shutdowns. These closures would adversely affect visitor access, use, and the overall visitor experience.

During construction Alternative B would result in an increase in helicopter flights from the current level of administrative flights of about 1,200 to 1,500 per year (up to 12 flights per day) to approximately 5,500 flights total for a period of 3 years between the South Rim and the Inner Canyon. Flight durations are anticipated to be similar to existing administrative flights. Up to 20 flights per day would occur on the busiest days including administrative and construction flights. Visitor experience would be adversely impacted by the increase in flights from the helicopter noise and from seeing helicopters in the canyon.

On the South Rim, visitors would be impacted by noise and construction traffic primarily in the vicinity of the proposed water treatment plant that is near the Grand Canyon Visitor Center and the concessioner operated Trailer Village. Work would occur during the day and the construction area is located in a developed area with existing vehicle noise. Noise impacts on visitors would be adverse during the 6 to 12 month construction period and would cease after construction. However, because the construction area is located near development and roads the construction is not expected to change visitor activities and use of the park.

After construction of Alternative B, visitor access and use of all facilities in the vicinity would reopen. Implementation of Alternative B would improve the long-term reliability of the water distribution and delivery to all visitor facilities in the analysis area, resulting in a beneficial impact on visitor use and experience. Benefits would affect more than 6 million annual visitors to the South Rim and Cross Canyon Corridor. These benefits would extend for the lifespan of the project, which is expected to be about 50 years.

Compared to Alternative A, Alternative B would result in greater short term adverse impacts from closures, but would also result in greater long term beneficial impacts from an improved water delivery system.

Cumulative Impacts

Past, present, and reasonably foreseeable future actions have the potential to contribute to cumulative impacts on visitor use and experience. Past actions in the analysis area that have impacted visitor use and experience include installation of a composting toilet at Phantom Ranch, trail maintenance, and prescribed burns on the South Rim. Current on-going administrative activities in the analysis area that impact visitor use and experience include trail maintenance, administrative helicopter and fixed-wing aircraft flights, and prescribed burns on the South Rim. Future projects include demolition and reconstruction of the Maswik Lodge and rehabilitation of the El Tovar Hotel, both located on the South Rim, and repair of the Black Bridge, a suspension bridge spanning the Colorado River on the South Kaibab Trail. Construction and implementation of the current and reasonably foreseeable future actions would have or have had adverse impacts on visitor use and experience due to temporary facility closures and increased noise from construction activities. In addition, past, present, and reasonably foreseeable future actions such as trail maintenance and rehabilitation activities described above have resulted in, and would continue to result in, beneficial impacts on visitor use and experience by providing visitors improved facilities such as potable water, toilets and trails. Cumulatively these actions have had, and would continue to have, a beneficial cumulative impact on visitor use and experience.

The impacts of Alternative B on visitor use and experience would be adverse during construction, but beneficial after construction is complete. When the effects of Alternative B are combined with other past, present, and reasonably foreseeable future impacts, the total cumulative impacts would be beneficial. The incremental impacts of Alternative B would contribute slightly to these beneficial impacts.

Impacts of Alternative C – Replace TCWL in Same Location

Direct and Indirect Impacts

Due to the longer construction schedule when compared to Alternative B, Alternative C would result in more closures of trails and visitor facilities. During the 4- to 5-year construction period, periodic and temporary closures of inner canyon visitor facilities are anticipated to occur. Replacing the TCWL along the North Kaibab Trail would result in more closures compared to closures of the Bright Angel Trail or the River Trail due to the length of replacement (9 additional miles) and the narrow section on the North Kaibab Trail. Unlike Alternative B, no detour would be provided during closure of the North Kaibab Trail, and all other trails would remain open to the public.

Mule trips from the South and North Rims would be cancelled during construction along the Bright Angel Trail for up to 5 years during the inner canyon construction and helicopter use which is 2 years longer than Alternative B.

In addition to the campground closures described for Alternative B, Cottonwood Campground would be subject to full closure for 2 years and partial closure for 6 months due to the installation of a longer segment of the TCWL along the North Kaibab Trail. Over the 5 year inner canyon construction period, about 10 to 27 campsites out of 60 in the inner canyon would be unavailable for public use, depending on the stage of construction. Closures of campsites in the highly popular Cross Canyon Corridor would adversely impact visitor use and experience by limiting access during closures. After construction, all facilities would reopen and visitor use is anticipated to return to existing conditions. As described for Alternative B, campsite closures would be advertised in advance to reduce impacts on visitor use and experience.

Construction of Alternative C would require more TCWL shutdowns than Alternative B. Existing water storage capacity would be the same as described under Alternative B. Similar to Alternative B, depletion of existing water supplies could result in closure of visitor facilities such as Phantom Ranch Lodge which would adversely impact visitors for the duration of the closure.

During construction Alternative C would result in an increase in helicopter flights from the current level of about 1,200 to 1,500 per year (up to 12 flights per day) to about 11,500 total flights for a period of 4 to 5 years between the South Rim and the Cross Canyon Corridor. Impacts to visitor experience from noise would be greater than impacts from Alternative B since the project would occur for approximately 1 to 2 years longer.

After construction of Alternative C, all facilities would reopen, resulting in the same benefits from improved reliability of the water supply as described for Alternative B, including long-term reliability of the water distribution and delivery to visitor facilities between Phantom Ranch and the South Rim would be improved, resulting in a substantial beneficial impact on visitor use and experience.

Compared to Alternative B, Alternative C would result in greater short term adverse impacts to visitors from longer and more closure locations and would result in the same long term beneficial impacts from an improved water delivery system.

Cumulative Impacts

The impacts of past, present, and reasonably foreseeable future actions on visitor use and experience would be beneficial, as described above for Alternative B. These benefits would result from providing visitors improved visitor facilities and trail infrastructure. As described for Alternative B, the direct and indirect impacts of Alternative C on visitor use and experience would be adverse during construction due to limited access, closures, and noise, but beneficial after construction. When the effects of Alternative C are combined with other past, present, and reasonably foreseeable future impacts, the total cumulative impacts would continue to be beneficial. The incremental impacts of Alternative C would contribute slightly to these beneficial impacts.

Wilderness Character

Affected Environment

The analysis area for wilderness character includes the TCWL pipeline alignment and associated facilities construction sites in the Cross Canyon Corridor and on the South Rim, a 1,200-foot buffer where construction noise could affect visitors within proposed wilderness, overhead electrical line from South Rim to Indian Garden, and flight paths for project helicopters. The Cross Canyon Corridor is a nonwilderness corridor, which also includes the aboveground electrical line, and the South Rim project locations are outside of proposed wilderness (Figure 6). The projects helicopter flights would occur partially over proposed wilderness.

A wilderness recommendation for the park was signed in 1980 and updated in 1993 and 2010 (NPS 2015e). Under the 2010 Draft Update, about 94% of the park (approximately 1,143,918 acres) qualifies for wilderness designation as described in the 1964 Wilderness Act and NPS *Management Policies 2006* (NPS 2015e). While the 2010 wilderness recommendation has not been forwarded to Congress, the park is prohibited by NPS Management Policies from taking any action that would diminish wilderness eligibility. Park management decisions that affect proposed wilderness areas will be made in expectation of eventual wilderness designation (NPS 2013c).

Untrammeled

An untrammeled wilderness is essentially one that is unhindered and free from the intentional actions of modern human control or manipulation.

The untrammeled quality is preserved or sustained when actions to intentionally control or manipulate the components or processes of ecological systems inside wilderness (e.g., suppressing fire, stocking lakes with fish, installing water catchments, or removing predators) are not taken. The untrammeled quality is further degraded by actions that intentionally manipulate the biophysical environment (e.g., the removal of nonnative species, collaring and tagging of animals, intervention in the behavior or lives of native plants and animals, projects to

restore the natural conditions of wilderness, and interference in natural processes and energy flows).

The Grand Canyon wilderness remains one of the most self-willed, untrammelled landscapes in the continental United States. Ruggedness, inaccessibility, and exposure to the elements rendered many early mining, grazing, and logging attempts unprofitable. Due to its vastness and remoteness, the Grand Canyon wilderness constituted a sanctuary for life, containing remnants of dwindling ecosystems such as boreal forest and desert riparian communities, and a multitude of plants, animals and fish –some of which are found nowhere else on Earth (Nickel 2018).

Natural

A natural wilderness is one where ecological systems are substantially free from the effects of modern civilization.

The natural quality is preserved when there are only indigenous species and natural ecological conditions and processes, and may be improved by controlling or removing nonindigenous species or by restoring ecological conditions. The natural quality is degraded by human-caused change to the natural environment (i.e., human-caused effects on plants, animals, air, water, ecological processes, etc.).

The Grand Canyon wilderness contains some of the nation’s cleanest air, protected as a Class 1 Airshed by the Clean Air Act (42 U.S.C. § 7401 et seq.). Clean air allows for expansive vistas that are an important component of the Grand Canyon wilderness.

Much of the astounding biological diversity depends on Grand Canyon’s tributaries and springs, which represent some of the least altered water resources in the Southwest (Zaimes et al. 2007; Barnes 2013). These waters support rare desert riparian ecosystems, which have disproportionately high value for their limited spatial extent and nurture a high percentage of the park’s plants and animals (Webb et al. 2007; Zaimes et al. 2007; Barnes 2013).

The vegetation of Grand Canyon consists largely of intact, functioning native plant communities that vary from cool, moist subalpine forests and meadows between 8,000 and 9,000 feet to hot, dry deserts at elevations as low as 1,200 feet (Kearsley et al. 2015). The wilderness contains six vegetation zones: riparian, desert shrub, pinyon-juniper woodland, ponderosa pine forest, spruce/fir forest, and mountain meadows in the subalpine zone (NPS 2017). A wide range of microhabitats are known to support at least 1,732 vascular plant species, 64 moss species, 195 lichen species, and 167 fungi species (NPS 2018). There are several plant species that are endemic to the wilderness, while only about 11% of the flora is exotic (NPS 2009).

The Grand Canyon wilderness also serves as a valuable wildlife refuge due to the immense primitive areas, the topographic character, and the relatively unfragmented landscape. The park provides important habitat for at least 91 mammals, including mule deer, desert bighorn sheep, mountain lion, coyote, bobcat, and 22 species of bats, as well as 58 reptile and amphibian species, over two dozen fish species, and thousands of different invertebrates (NPS 2018). With over 350 bird species and its riparian habitat valuable to avifauna, the entire Grand Canyon National Park has been designated as a Globally Important Bird Areas. Additionally, there are numerous endemic animal species known only to exist in the park (NPS 2017).

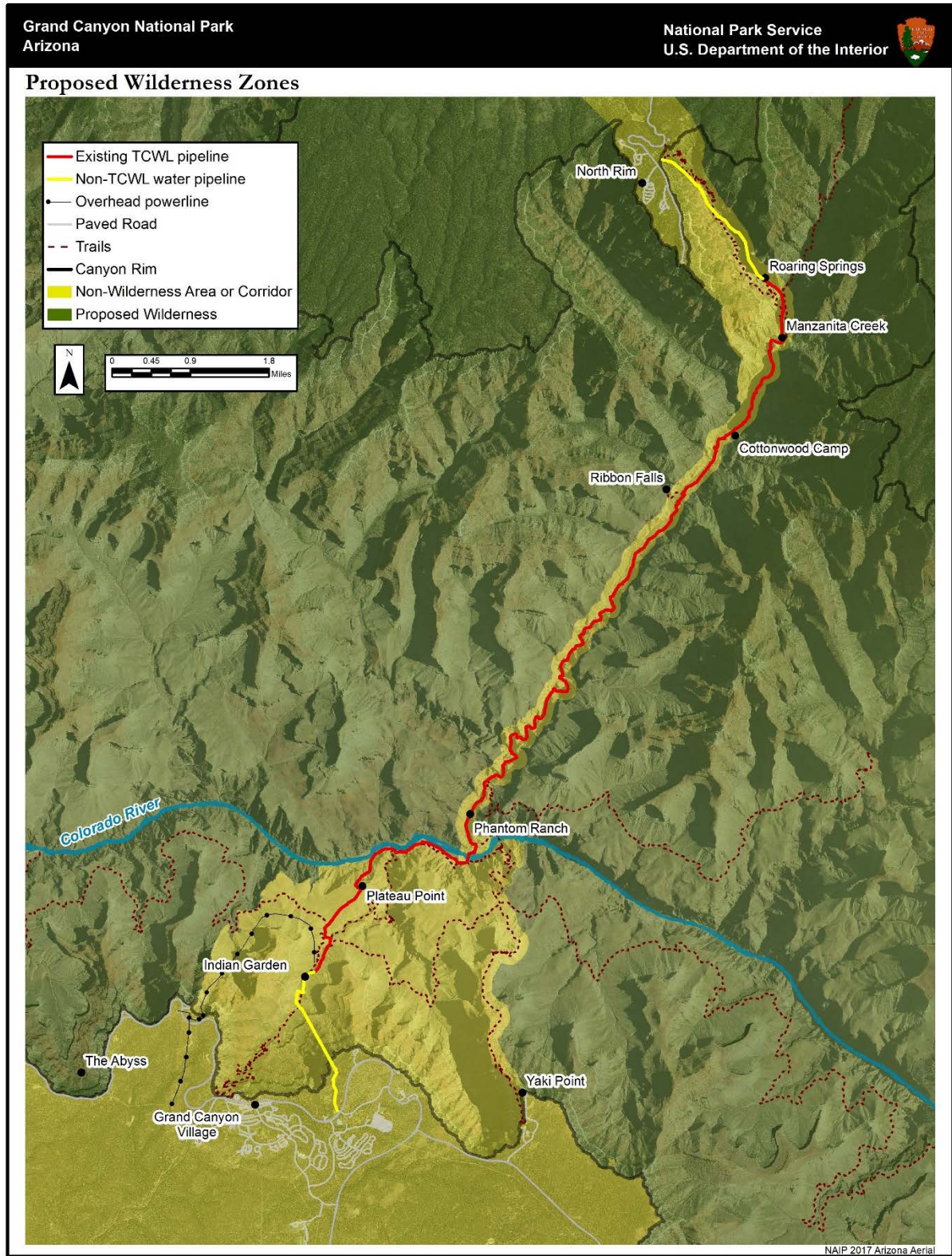


Figure 6. Proposed wilderness and existing TCWL.

Undeveloped

An undeveloped wilderness is essentially one without permanent improvements or the sights and sounds of modern human occupation.

The undeveloped quality is preserved or sustained when modern structures, installations, habitations, motor vehicles, motorized equipment, or other mechanical transport is not used in wilderness. It is improved when these prohibited uses are removed or reduced.

Nearly all structures, signs roads and other developments in the park are concentrated in the 6% of the park outside of proposed wilderness. Remnants of historic mining attempts are few and far between. Modern day installation in proposed wilderness are primarily scientific monitoring equipment, wildlife cameras and collars, trail counters, other instruments. The remoteness and topography of Grand Canyon have made roads rare. Since the first wilderness study, over two hundred miles of road have been abandoned (NPS 2010). The Colorado River within Grand Canyon National Park is an unbroken stretch of river that remains free of impoundments and is accessible only by trail in some places, with its shorelines for the most part as primitive and rugged.

Solitude or Primitive and Unconfined Recreation

Wilderness provides outstanding opportunities for recreation in an environment that is relatively free from the encumbrances of modern society, and the benefits and inspiration derived from self-reliance, self-discovery, physical and mental challenge, and freedom from societal obligations.

The solitude or primitive and unconfined recreation quality is preserved or improved by management activities that reduce visitor encounters, reduce signs of modern civilization inside wilderness, remove agency-provided recreation facilities, or reduce management restrictions on visitor behavior. The solitude or primitive and unconfined recreation quality is degraded by sights and sounds of human activity (solitude), and by facilities that decrease self-reliant recreation and management restrictions on human behavior (primitive and unconfined).

Grand Canyon’s expansive wilderness provides outstanding opportunities for experiencing solitude in remote areas of the park. These unspoiled reaches of wilderness provide an arena where wilderness purists can find tranquility and escape reminders of mechanized society, and where individuals can be truly alone in the enormity of the natural world. The scale of the Grand Canyon sparks an undeniable sense of self-reflection and wonder – immeasurable but fundamental aspects of wilderness character that simply cannot be quantified. There is little question – the Grand Canyon landscape speaks to something elemental and timeless in the human spirit. Immersed in this vast landscape, visitors begin to exist as something beyond their everyday cares and worries (Nickel 2018).

Other Features of Value

This quality captures important elements or “features” of a particular wilderness that are not covered by the other four qualities, and are truly unique and essential to the character of that wilderness.

The Wilderness Act states that wilderness “may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.” Typically, other features of value occur in a specific wilderness location, such as archaeological, historical, or paleontological

features; some, however, may occur over a broad area such as an extensive geological or paleontological area, or a cultural landscape. This quality is preserved when these “other features of value” are preserved. The other features of value quality are degraded by deterioration or loss of integral site-specific features of value.

Environmental Consequences

Impacts of Alternative A – No Action

Direct and Indirect Impacts

Under the no action alternative, the park would continue current operations and maintenance of the existing TCWL. The TCWL is not in proposed wilderness and no prohibited uses under the Wilderness Act would be proposed in Wilderness under this alternative (Figure 6).

Therefore, there are no impacts to the *untrammelled, undeveloped*, and other features of value wilderness characteristics.

The operations and maintenance would require administrative flights over proposed wilderness areas. There are approximately a total of 1,200 to 1,500 administrative flights per year. Only a portion of those total flights are used during the 5 to 30 pipeline breaks a year and operation and maintenance. Flights leave the helibase, located in South Rim Developed Area and fly west across nonwilderness to an area close to the Abyss, along the west rim, and then fly below the rim a short distance over proposed wilderness to the nonwilderness Cross Canyon Corridor. Although these flights would be visible and produce noise that would continue to adversely affect *opportunities for solitude and primitive and unconfined recreation*, there are no trails directly under the flight path. These short-term (average 18 minutes per flight over a portion of proposed wilderness) adverse effects would continue to impact proposed wilderness areas. However, the ongoing adverse effects on *solitude and primitive and unconfined recreation* would not permanently alter or compromise this wilderness value.

These short distance (20-30 mile round trip) administrative flights over proposed wilderness would also have a short term (average 18 minutes per flight over a portion of proposed wilderness) adverse impact to the *natural* wilderness values due to the potential of displacing wildlife. However, these ongoing adverse effects on *natural* would not permanently alter or compromise this wilderness value. Of the 1.1 million acres of proposed wilderness in Grand Canyon National Park, it is estimated that 13,000 acres would be impacted by helicopter flights.

Cumulative Impacts

Past actions in the analysis area that have impacted wilderness character include administrative flights over proposed wilderness to the Cross Canyon Corridor (i.e., search and rescue). Current activities in the analysis area that impact wilderness character include flights associated with trail maintenance, and operation and maintenance of the TCWL and related facilities within the Cross Canyon Corridor, and administrative helicopter and fixed-wing aircraft flights in support of park operations. Future activities in the analysis area include flights over proposed wilderness in support of operation and maintenance improvements, and visitor facility improvements. The impacts of past, present, and reasonably foreseeable future actions include increased noise, loss of solitude, potential displacement of wildlife and degradation to overall aesthetics, especially in proposed wilderness areas located adjacent to the Cross Canyon Corridor. Collectively, all of these actions have had, and would continue to have, small adverse cumulative impacts on the wilderness qualities of *natural* and *solitude and primitive and unconfined recreation* and would

not permanently alter or compromise the associated wilderness characteristics and values. As previously described, the impacts of the no action alternative would result from administrative flights over proposed wilderness areas, which produce noise and adversely affect *natural* and *opportunities for solitude and primitive and unconfined recreation*. The incremental impacts of the no action alternative would contribute slightly to, but would not substantially change, the adverse impacts that are already occurring.

Impacts of Alternative B – Relocate Water Intake (Preferred Alternative)

Direct and Indirect Impacts

Under Alternative B, the park would relocate the water intake from Roaring Springs Cave to Bright Angel Creek in Phantom Ranch, replace pipeline between Phantom Ranch and Indian Garden, perform maintenance to the existing power line and Silver Bridge and install new water treatment facilities which are all in Cross Canyon Corridor nonwilderness area. No direct impacts from construction on proposed wilderness areas would occur and the *untrammeled, undeveloped, and other features of value* wilderness characteristics would be preserved.

Compared with Alternative A that would generally only use a light-duty helicopter, this alternative would utilize three types of helicopters including light-duty, medium-lift, and heavy-lift. The light-duty helicopter is expected to make multiple flights per day, while the medium-lift helicopter would be used less often and the heavy-lift helicopter would be used infrequently.

Similar to Alternative A the flight path for the increased number of flights (5,500 over 3 years) from the helibase to the Cross Canyon Corridor would occur over a small portion of proposed wilderness with no trails directly under flight path, potentially increasing visual encounters with and noise from aircraft and adversely affecting the *natural* and *opportunities for solitude and primitive and unconfined recreation* wilderness values. This adverse effect would impact both visitors and wildlife (see *Special Status Terrestrial Wildlife*). Visitors may have their wilderness values impacted in the short term (average 18 minutes per flight-only a portion over proposed wilderness) and could result in up to 6 hours of flight time per day. Other days there would not be any flights. Visitors along portions of the Tonto Trail or off trail in proposed wilderness areas would experience adverse impacts on the high flight days. However, visitors would still have opportunities for *solitude and primitive and unconfined recreation* because much of their day would be free of flight noise. Wildlife may be displaced during helicopter flights overhead. However, the adverse effects on *natural* and *opportunities for solitude and primitive and unconfined recreation* would not permanently alter or compromise the wilderness characteristics and desired conditions of the surrounding wilderness areas. Of the 1.1 million acres of proposed wilderness in Grand Canyon National Park, it is estimated that 13,000 acres would be impacted by helicopter flights.

When compared to Alternative A, Alternative B would result in greater adverse impacts to wilderness character due to the increased number of helicopter flights.

Cumulative Impacts

As described above for the no action alternative, past, present, and reasonably foreseeable future actions have had, and would continue to have, small adverse cumulative impacts on the wilderness qualities of *natural* and *solitude and primitive and unconfined recreation* and would not permanently alter or compromise the associated wilderness characteristics and desired conditions. The collective adverse impacts of past, present, and reasonably foreseeable future

actions include increased noise, loss of solitude, and degradation to overall aesthetics, especially in wilderness areas located adjacent to the North Rim and South Rim corridor areas, and developed South Rim (nonwilderness areas). As previously described, Alternative B would increase noise levels from helicopter flights over proposed wilderness, adversely affecting the *natural* and *opportunities for solitude and primitive and unconfined recreation*. The incremental impacts of Alternative B would contribute slightly to, but would not substantially change, the adverse impacts on wilderness character that are already occurring.

Impacts of Alternative C – Replace TCWL in Same Location

Direct and Indirect Impacts

Under Alternative C, similar to Alternative B, no direct impacts on proposed wilderness areas would occur and the, *untrammeled, undeveloped, and other features of value* wilderness qualities of proposed wilderness in the vicinity would be preserved. However, Alternative C would result in an increase in helicopter flights from Alternative B of 5,500 flights over 3 years to about 11,500 total flights for a period of 4 to 5 years during construction in the nonwilderness Cross Canyon Corridor.

The additional helicopter flights under Alternative C would have a greater effect on *natural* and *opportunities for solitude and primitive and unconfined recreation* in proposed wilderness areas than Alternative B because these flights would occur over a period 1 to 2 years longer.

Although, the impacts from Alternative C would be greater than Alternative B and the no action alternative since the impacts of construction noise from the inner canyon into the proposed wilderness would occur over a longer period. These short-term adverse impacts on *solitude and primitive and unconfined recreation* and *natural* wilderness characteristics would not permanently alter or compromise these wilderness values. As under Alternative B, of the 1.1 million acres of proposed wilderness in Grand Canyon National Park, it is estimated that 13,000 acres would be impacted by helicopter flights.

Cumulative Impacts

As described for the no action alternative, past, present, and reasonably foreseeable future actions have had, and would continue to have, small adverse cumulative impacts on the wilderness qualities of *natural* and *solitude and primitive and unconfined recreation* and would not permanently alter or compromise the associated wilderness characteristics and desired conditions. As previously described, Alternative C would increase noise levels from helicopter flights over proposed wilderness, adversely affecting the *natural* and *opportunities for solitude and primitive and unconfined recreation*. The incremental impacts of Alternative C would contribute to, but would not substantially change, the adverse impacts on wilderness character that are already occurring.

When compared to Alternative B, Alternative C would result in greater adverse impacts to wilderness character due to the increased number of helicopter flights.

Backcountry Commercial Use Socioeconomics

Affected Environment

The affected environment includes both the park concessioner that operates in the Cross Canyon Corridor as well as commercial companies that hold commercial use authorization (CUA) permits to guide day hiking and backpacking in the backcountry, including the Cross Canyon Corridor.

The park concessioner Xanterra operates Phantom Ranch, which includes a lodge with cabins and a restaurant. Xanterra also offers overnight mule trips from the South Rim, with visitors staying at overnight at Phantom Ranch. As noted in the 2015 solicitation for the hospitality contract that Xanterra was awarded, gross receipts for the contract, which also includes a variety of operations on the South Rim, exceed \$66 million annually.

Commercial companies can obtain annual CUA permits to operate commercial backpacking trips in the park and the number of companies varies each year. In 2017, about 20 companies offered overnight backpacking services in the park's backcountry. In 2017, about 9.8% of backcountry use (measured in user nights) was made up of visitors and guides on commercial trips. These commercial trips accounted for about 8.6% of total backcountry use in the Cross Canyon Corridor and 11.6% outside the corridor.

In 2017, total gross revenue of backcountry commercial operators (or activities) was approximately \$3.5 million with approximately \$2.3 million of that generated on trips in the Cross Canyon Corridor. The average revenue for each commercial trip/permit in the corridor is approximately \$7,062. The commercial use of the corridor varies throughout the year, Table 7 illustrates when the 331 commercial backpacking trips occurred in 2017.

Table 7. Number of commercial backpacking trips for all operators in 2017, by month

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
11	10	23	25	45	28	29	26	45	42	33	14

Environmental Consequences

Impacts of Alternative A – No Action

Direct and Indirect Impacts

Under the no action alternative, the backcountry commercial use socioeconomics would continue unchanged. The risk of periodic interruptions from TCWL failures would continue. Concessioner operations would continue as stipulated in their existing contract. The risk of depleting the 2- to 3-week water supply for South Rim visitor and concessioner facilities, including Phantom Ranch lodge and cantina, would continue, potentially adversely affecting concessioners' facilities and services. The depletion of the water supply could result in the closure of some concessioner facilities and cancellation of visitor reservations and, thus, result in a reduction in concessioner revenues. This loss could be between \$175,000 and \$250,000 for a two-week closure of Phantom Ranch, depending on time of year. These unplanned events would have an adverse effect on commercial use, both for the concessioner and commercial use

authorization holders. However, these impacts would last only as long as the closure and therefore would generally last no more than a week or two based on previous events.

Cumulative Impacts

Past actions in the analysis area that have impacted backcountry commercial use socioeconomics include replacement of about .5 miles of the TCWL with new 8-inch-diameter steel pipe at Phantom Ranch and installation of a composting toilet at Phantom Ranch. Current activities in the analysis area that impact backcountry commercial use socioeconomics include trail maintenance, and operation and maintenance of the TCWL and related facilities. Future activities in the analysis area include pump replacement at Indian Garden and a clean out of the sediment tank at Indian Garden. All of these past and future projects have had and would have beneficial impacts on facilities and trails that support visitor and commercial use in the Cross Canyon Corridor and would therefore have economic benefits to commercial entities. As previously described, the direct and indirect effects of the no action alternative would be adverse from periodic TCWL failures, which could affect backcountry commercial use if closures occur. When the effects of the no action alternative are combined with other past, present, and reasonably foreseeable future impacts, the total cumulative impacts on backcountry use socioeconomics would continue to be beneficial, with a slight adverse contribution from the no action alternative.

Impacts of Alternative B – Relocate Water Intake (Preferred Alternative)

Direct and Indirect Impacts

Under Alternative B, direct impacts on the backcountry commercial use socioeconomics include changes in visitor use and spending and concessioners' revenue during and after construction.

Implementation of Alternative B would require periodic closures of the Bright Angel, Colorado River, and North Kaibab Trails, and closure of Phantom Ranch for up to 8 nonconsecutive months over a 3-year period. These impacts could reduce visitor use and therefore revenue for Xanterra. Based on estimated revenue, Xanterra could lose up to \$3.5 million of their gross annual revenue if Phantom Ranch were closed for the eight busiest months of one year. If the closures were spread out across 3 years, with 2-3 of the busiest months closed each year, lost gross annual revenue for Xanterra could be approximately \$1 to 1.5 million.

Commercial companies that operate backpacking trips in the Cross Canyon Corridor would be impacted by the closure of the Phantom Ranch area as well as Indian Garden, including Bright Angel Campground for up to 8 nonconsecutive months, Indian Garden Campground for up to 6 nonconsecutive months, and half of Indian Garden Campground for up to 24 consecutive months. The average revenue for a commercial trip/permit is \$7,062 and the number of corridor permits per month is shown in Table 7.

The following calculations were made using the 8 month closure assuming all commercial trips spend at least one night at Bright Angel Campground. Although Indian Garden Campground would be partially closed for up to 24 months, both commercial and noncommercial groups would be able to stay in the other 7-8 campsites during that time. Impacts over three years could result in a loss of \$1 to 2 million dollars in revenue depending on when closures occur. This is an average of approximately \$333,000 to \$667,000 per year for the three year project duration or approximately a 9-19% loss of total annual revenue for all CUA holders.

NPS has been talking with CUA holders and expects impacts to be on the low end or below these estimates because of the communication that has already occurred regarding potential closures. It is likely that CUA holders will choose other backpacking trips outside the corridor or other types of commercial trips such as day hiking or transportation tours during the closures. Also, due to the intense construction for the project it is possible that there will be less demand for corridor trips, both commercial and noncommercial. Even if impacts are on the lower end, they would be adverse and would last up to 8 nonconsecutive months. This alternative is not expected to impact the viability of individual businesses.

Periodic shutdowns of the TCWL would be required during construction, and water stored in existing storage tanks would be used. Depending on the time of year, water may not be available as the storage tanks can supply water for 2 to 3 days at Phantom Ranch and 2 to 3 weeks at the South Rim. The risk of depleting existing water supplies at Phantom Ranch and the South Rim could result in cancellations of visitor reservations and in turn a reduction in concessioner revenues. This risk would be reduced to low by planning shutdowns to avoid the busiest times at the South Rim and avoid depleting water supplies. Backpacking groups could continue to obtain and treat water from Bright Angel Creek at Phantom Ranch or Garden Creek at Indian Garden therefore there would not be an impact to commercial backpacking trips during pipeline shutdowns.

Completion and implementation of Alternative B would provide concessioners and backcountry commercial operators a more reliable water delivery system. This would result in a long-term beneficial impact. When compared to Alternative A, Alternative B would result in greater adverse impacts to the concessioner and CUA holders from closures during the construction period, but would result in greater long term beneficial impacts from the improved water system.

Cumulative Impacts

As described above for the no action alternative, past, present, and reasonably foreseeable future actions have had, and would continue to have, beneficial cumulative impacts on backcountry commercial use and socioeconomics. As previously described, the direct and indirect impacts of Alternative B on backcountry use and socioeconomics would be adverse from lost revenue due to trail and facility closures. When the effects of Alternative B are combined with other past, present, and reasonably foreseeable future impacts, the total cumulative impacts on backcountry use and socioeconomics would be beneficial long term, with Alternative B adding an incremental adverse contribution from inner canyon closures and long term beneficial contribution from construction of a more reliable water delivery system.

Impacts of Alternative C – Replace TCWL in Same Location

Direct and Indirect Impacts

Under Alternative C, direct impacts on the backcountry commercial use and socioeconomic environment would be similar to Alternative B, and would include changes in visitor use and spending and concessioner revenue during and after construction.

Similar to Alternative B, implementation of Alternative C would require periodic closures of the Bright Angel, Colorado River, and North Kaibab Trail, and closure of Phantom Ranch for up to 12 nonconsecutive months over a 4 to 5-year period. These impacts could reduce visitor use and

therefore revenue for Xanterra. Based on estimated revenue, Xanterra could lose approximately \$1 million of their total annual revenue if Phantom Ranch were closed for the 2 of the busiest months every year for 6 years or could lose about \$2.5 million per year if the closure was 6 months for two of the project years and during the busiest months.

Commercial companies that operate backpacking trips in the Cross Canyon Corridor would be impacted by the closure of the Phantom Ranch area as well as Indian Garden, including Bright Angel Campground for up to 12 nonconsecutive months, Indian Garden Campground for up to 8 nonconsecutive months, and half of Indian Garden Campground for up to 36 consecutive months. The following calculations were made using the 12 month closure assuming all commercial trips spend at least one night at Bright Angel Campground. Impacts over 4 to 5 years could result in a loss of \$1.5 to 3 million dollars in gross revenue depending on when closures occur. This is an average of approximately \$250,000 to \$600,000 per year for the project duration or approximately a 7-17% loss of total annual gross revenue for all CUA holders. While these numbers are lower than Alternative B, impacts would occur for 4-5 years as opposed to three under Alternative B. Also, as previously mentioned for Alternative B, NPS has been talking with CUA holders and expects impacts to be on the low end or below these estimates. Even if impacts are on the lower end or below, they would be adverse and would last up to 12 nonconsecutive months. This alternative is not expected to impact the viability of individual businesses.

Installation of the TCWL would require periodic water shutdowns, during which water stored in existing storage tanks would be used. Under Alternative C, more frequent and numerous shutdowns would be required than Alternative B and the no action alternative. The risk of depleting existing water supplies at Phantom Ranch and the South Rim could result in cancellations of visitor reservations and, thus, additional reduction in concessioner revenues. Impacts on commercial backcountry operators is anticipated to be less since all backcountry travelers are encouraged to carry individual water filtration.

Similar to Alternative B, completion and implementation of Alternative C would provide existing concessioners and backcountry commercial operators a more reliable water delivery system, reducing the risk of future periodic interruptions from failure of the TCWL. This would have a long term beneficial impact.

When compared to Alternative B, Alternative C would result in greater adverse impacts to the concessioner and CUA holders from closures, but would result in greater long term beneficial impacts from the improved water system.

Cumulative Impacts

As described for the no action alternative and Alternative B, past, present, and reasonably foreseeable future actions have had, and would continue to have, beneficial cumulative impacts on backcountry commercial use and socioeconomics. As previously described, the direct and indirect impacts of Alternative C on backcountry use and socioeconomics would be adverse from lost revenue due to trail and facility closures. When the effects of Alternative C are combined with other past, present, and reasonably foreseeable future impacts, the total cumulative impacts on backcountry use and socioeconomics would continue to be beneficial long term, with Alternative C adding an incremental adverse contribution during closures and long term beneficial contribution from construction of a more reliable water delivery system.

Soundscape and Acoustic Environment

Affected Environment

An intact natural soundscape enhances visitor experience and allows for natural functioning of wildlife communication. NPS policies require park managers to protect and restore the natural conditions and soundscapes of parks including those that have been affected by unnatural and unacceptable noise.

In the analysis area the ambient sound level at Phantom Ranch is estimated to be 30 dBA and 29 dBA in the undeveloped South Rim area. Each year there are approximately 1,200 to 1,500 administrative helicopter flights into the Cross Canyon Corridor. Generally, a light duty helicopter is used for administrative flights. The medium and heavy lift helicopters are brought in 1 to 2 times per year for larger projects. In addition to helicopters, noise in the developed Cross Canyon Corridor is generated by pumps, air conditioners on buildings, human voices, and the Colorado River.

Environmental Consequences

Methodology

The relative loudness of sounds as perceived by the human ear is expressed in A-weighted decibels, abbreviated dBA (OSHA 2013). A table of common sound sources and their sound levels is provided below.

Table 8. Common sound sources and their sound levels

Common Sound Sources	Similar Sounds Sources from other NPS Units	Sound Level (dBA)
Train horn at 1 meter	Military jet at 100 meters AGL (Yukon-Charley Rivers National Preserve)	120
Jackhammer at 2 meters	Thunder (Arches National Park)	100
Curbside of busy street	Cruiser motorcycle at 15 meters (Blue Ridge Parkway)	80
Busy restaurant	Conversation at 5 meters (Whitman Mission National Historic Site)	60
Residential area at night	Crickets at 5 meters (Zion National Park)	40
Whispering	Leaves rustling (Canyonlands National Park)	20
Human breathing at 3 meters	Volcano crater (Haleakalā National Park)	10

The following values illustrate some key sound level thresholds and the effects that they have on humans:

- Natural Ambient Sound Level (dBA) – Baseline for current conditions
- Existing Ambient Sound Level (dBA) – Baseline for assessment of impacts
- 52 dBA – Raised voice speech interference at 10 meters (Environmental Protection Agency, EPA 1974)
- 60 dBA – Normal voice speech interference at 2 meters (EPA 1974)

This document provides an analysis of the park potentially affected by noise based on the L_{\max} and L_{eq} metrics. L_{\max} is the maximum sound energy and L_{eq} is the total sound energy over a given period of time. The L_{\max} analysis allows for comparison with specific wildlife impact metrics such as the Mexican spotted owl disturbance criteria and allows for a comparative analysis of maximum potential noise impacts. This is appropriate, however, for construction equipment and administrative helicopter noise that is limited in duration.

Potential Noise Impacts from Equipment Used in Construction Operations. In order to estimate L_{\max} and L_{eq} values, a limited number of standard operational conditions were assumed. Potential noise impacts were estimated using Federal Aviation Administration (FAA), Federal Highway Administration (FHWA), and NPS reports. Noise level values for a generator, front end loader, excavator, and auger drill rig were taken from the FHWA Roadway Construction Noise Model version 1. 1 and User's Guide (FHWA 2006).

Analysis of Potential Noise Impacts. Based on reported data (FAA 1982) shown in the following plot, the L_{\max} from a large hovering transport helicopter would be approximately 88-90 dBA at 500 feet (Figure 7). At a slant distance of 500 feet, approximately 18 acres could be impacted with L_{\max} at or above 88-90 dBA. Helicopter noise would affect the acoustic environment over distances of up to approximately 6 miles (across a flat surface) before maximum sound levels attenuate to ambient levels. Based on the canyon topography and terrain shielding it is likely that sound from the helicopter would attenuate to ambient levels within 2 to 3 miles when below the canyon rim. Helicopter noise would likely not be noticeable to humans and wildlife beyond this distance. To ensure Mexican spotted owl thresholds are not exceeded, a large transport helicopter would need to remain at least 2,000 feet from Mexican spotted owl PACs.

Predicted noise levels from construction equipment are shown in Table 9 (FHWA 2006).

Table 9. Predicted noise levels from construction equipment for the TCWL project

Equipment	Usage Factor	L_{\max} (dBA)	L_{eq} (dBA)
Auger Drill Rig	20%	84.4	77.4
Concrete Batch Plant	15%	83.0	74.8
Excavator	40%	80.7	76.7
Front End Loader	40%	79.1	75.1
Generator	50%	72.8	69.8
Total		84.4	82.4

The attenuation of noise from helicopters, construction equipment, and generators at construction areas would be affected by topography, vegetation, atmospheric pressure, and in the case of helicopters, speed of travel.

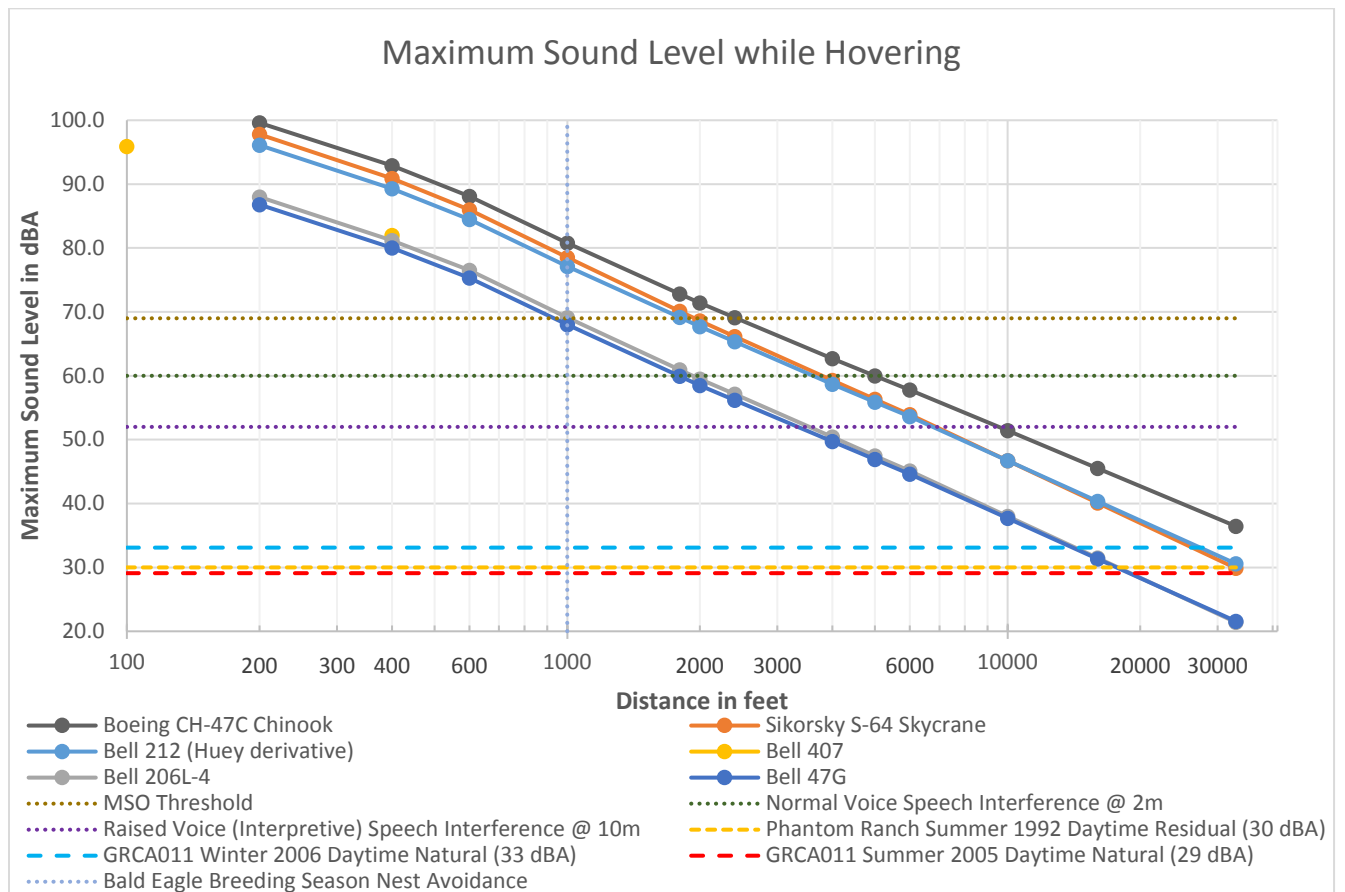


Figure 7. Maximum sound level of hovering helicopters (logarithmic scale)

Impacts of Alternative A – No Action

Direct and Indirect Impacts

Continued repairs to the TCWL would result in intermittent adverse impacts to the acoustic environment. Helicopters would continue to be utilized to transport people, equipment and supplies for pipeline breaks and subsequent repairs. The number of pipeline breaks varies between 5 and 30 per year. Generally, each break can take up to 10 days to repair and may require multiple flights each day. If between 2 and 10 flights per day would be needed, continued repairs would require up to 1,500 flights (30 breaks x 10 days x average of 5 flights/day) per year depending on the number and severity of breaks. The number of breaks is expected to increase in the future as the pipeline continues to age.

Pipeline repairs generally utilize the park's helicopter which is equivalent to the Bell 47G in Figure 7. Using linear extrapolation for that type of aircraft, noise impacts would range from approximately 60 dBA when flying from the helibase on the South Rim into the canyon to 86.8 dBA when the aircraft is dropping a sling load or landing to drop off passengers and/or supplies. However, these sound levels do not take into account variable atmospheric conditions, topography, and vegetation which can affect the distance that sound travels. Noise from helicopters generally carries farther when the aircraft is directly over the canyon whereas the noise from the aircraft is only heard locally when dropping sling loads or landing in a canyon, such as at Phantom Ranch or Indian Garden. Adverse impacts to the acoustic environment

would occur during the helicopter flights that average 18 minutes each and would last generally no more than 10 days to repair the pipeline, therefore these impacts are considered minimal.

Cumulative Impacts

The impacts of past, present, and reasonably foreseeable future actions on soundscape and the acoustic environment would result from administrative helicopter use and routine trail work in the Cross Canyon Corridor. Trail maintenance activities have had and would continue to have adverse effects on the acoustic environment from use of gas powered tools. Administrative helicopter use to support trail work, remove waste from composting toilets, support search and rescue, and support routine maintenance of buildings in the Cross Canyon Corridor would also result in adverse effects. Overall, collective impacts from past, present, and reasonably foreseeable future actions would be adverse. Alternative A would contribute some adverse effects to the acoustic environment. Therefore, when the effects of Alternative A are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would continue to be adverse, with a variable contribution from Alternative A depending on the number of pipeline breaks in any given year. Current administrative helicopter flights in the Cross Canyon Corridor are approximately 1,500 which included approximately 160 flights (~10% of total administrative flights) in 2017 for pipeline repairs.

Impacts of Alternative B – Relocate Water Intake (Preferred Alternative)

Direct and Indirect Impacts

Impacts to the acoustic environment would occur from the use of helicopters, construction equipment, and generators. Helicopter flights would generate sustained noise over a period of up to 6 hours per day over a 3-year period when helicopters are used in the inner canyon. Vehicles and equipment at construction areas could generate noise over the full duration of daylight hours; however, noise levels would vary over the course of a day depending on whether vehicles and equipment are running. The noise from vehicles and equipment would occur throughout the project duration (4 to 5 years) at the various project locations including South Rim, North Kaibab Trail, Phantom Ranch, and Indian Garden.

Alternative B would utilize several types of helicopters including the equivalent to the Bell 47G, Sikorsky S-64 Skycrane, and Boeing CH-47C Chinook (Figure 7). Using linear extrapolation for these types of aircraft, noise impacts would range from approximately 60 dBA (for smallest, most utilized aircraft) when flying from the helibase on the South Rim into the canyon to 99.6 dBA when the largest, least utilized aircraft is dropping a sling load or landing to drop off passengers and/or supplies. Sound attenuation or the distance the sound of the helicopter would travel would differ by location based on the canyon's topography. Based on complex terrain and limited line of sight, distance of attenuation to ambient within the canyon would likely not extend beyond approximately 2 to 3 miles. However, these sound levels do not take into account variable atmospheric conditions, topography, and vegetation which can affect the distance that sound travels. Noise from helicopters generally carries farther when the aircraft is directly over the canyon whereas the noise from the aircraft is only heard locally when dropping sling loads or landing in a canyon, such as at Phantom Ranch or Indian Garden.

In addition to helicopters, construction equipment described in Table 9 would be used for the duration of the project on both the South Rim and in the inner canyon. Noise levels from this equipment would range from 69.8 to 84.4 dBA and sound would attenuate to ambient within .5 miles. Adverse impacts from helicopters and construction equipment would occur most days

during the 3-year construction period and then would cease after the project is completed. Impacts of Alternative B would be greater than Alternative A based on the extended duration of helicopter use over 3 years.

Cumulative Impacts

The impacts of past, present, and reasonably foreseeable future actions on soundscape and the acoustic environment would result from administrative helicopter use and routine trail work in the Cross Canyon Corridor. Trail maintenance activities have had and would continue to have adverse effects on the acoustic environment from use of gas powered tools. Administrative helicopter use to support trail work, remove waste from composting toilets, support search and rescue, and support routine maintenance of buildings in the Cross Canyon Corridor would also result in adverse effects. Overall, cumulative impacts from past, present, and reasonably foreseeable future actions would be adverse. As previously described, Alternative B would contribute adverse effects on the acoustic environment. Therefore, when the effects of Alternative B are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would continue to be adverse, with a considerable contribution from Alternative B which would increase annual administrative helicopter flights in the Cross Canyon Corridor from approximately 1,500 to approximately 3,300 for the anticipated 3 years of inner canyon work.

Impacts of Alternative C – Replace TCWL in Same Location

Direct and Indirect Impacts

Direct impacts to the acoustic environment would occur from the use of helicopters, construction equipment, and generators. Helicopter flights would generate sustained noise over a period of up to 14 hours per day for the 4 to 5 year construction period in the inner canyon. Vehicles and equipment at construction areas could generate noise over the full duration of daylight hours; however, noise levels would vary over the course of a day depending on whether vehicles and equipment are running. The noise from vehicles and equipment would occur throughout the project duration at the various project locations including South Rim, North Kaibab Trail, Phantom Ranch, and Indian Garden. Impacts from all project-related noise sources would occur during project implementation and cease at the end of construction.

Adverse impacts from helicopters and construction equipment would be the same as B with added duration. These noise impacts would occur most days during the 4 to 5-year construction period and then would cease after the project is completed. Impacts of Alternative C would be greater than Alternative B based on the extended duration of helicopter use over 4 to 5 years.

Cumulative Impacts

As described for Alternative B, the impacts of past, present, and reasonably foreseeable future actions on soundscape and the acoustic environment would result from administrative helicopter use and routine trail work in the Cross Canyon Corridor. Overall, cumulative impacts from past, present, and reasonably foreseeable future actions would be adverse. Alternative C would contribute adverse effects on the acoustic environment over the 4-5 year construction period. Therefore, when the effects of Alternative C are combined with the effects of other past, present, and reasonably foreseeable future actions, the total cumulative impacts would continue to be adverse, with a considerable contribution from Alternative C which would increase annual administrative helicopter flights in the Cross Canyon Corridor from approximately 1,500 to approximately 3,800 for the anticipated 4-5 years that project work would occur in the inner canyon.

CONSULTATION AND COORDINATION

List of Agencies and Tribes Consulted

The following American Indian tribes and agencies were contacted and were invited to participate in the planning process:

American Indian Consultation

- Havasupai Tribe
- Hualapai Tribe
- Hopi Tribe
- Kaibab Band of Paiute Indians
- Pueblo of Zuni
- Paiute Indian Tribe of Utah
- Yavapai Apache Nation
- Las Vegas Tribe of Paiute Indians
- Navajo Nation
- San Juan Southern Paiute Tribe
- Moapa Band of Paiute Indians

Advisory Council on Historic Preservation
U.S. Fish and Wildlife Service
Arizona State Historic Preservation Officer

Appendix A

Best Management Practices

The following practices would be implemented under Alternative B or Alternative C.

Wildlife

- 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.
- Project sites would be cleaned up at the end of each day the work is being conducted (i.e., trash disposed of/secured appropriately and scrap materials picked up) to minimize the likelihood of California condors (*Gymnogyps californianus*) visiting the site. Park wildlife program staff would conduct periodic spot checks to ensure adequate project clean-up measures are being appropriately undertaken.
- Trash and recycling receptacles and all dumpsters would be wildlife proof certified and would be tightly covered to avoid wildlife access.
- Wildlife would not be fed or approached.
- Project staff would be instructed to avoid interaction with condors and to immediately contact park wildlife program staff or park dispatch if condors visit a project site.
- If condors visit a project site, project activities would cease until the condors leave on their own or until techniques, such as hazing, are employed by permitted park personnel that result in the condors leaving the area.
- Because condors are less active in the morning hours, pilots would be encouraged to conduct flights prior to 10 am when possible.
- Pilots would minimize aircraft use along the rim and cliffs to the greatest extent possible.
- Except for authorized biologists trained in survey techniques, helicopters and fixed-wing aircraft would avoid operating within 1,000 feet of eagle nests during the breeding season (currently there aren't any known nests in Grand Canyon National Park). Potentially disruptive activities would be minimized in the eagles' direct flight path between their nest and roost sites and important foraging areas. Regardless of season, aircraft corridors will be located no closer than 1,000 feet vertical or horizontal distance from communal eagle roost sites, where possible.
- The Project Lead would contact Grand Canyon's Wildlife Program Manager concerning the presence/absence of threatened or endangered species using nearby cliffs/canyons. The park's Wildlife Program Manager will be contacted a minimum of 2 weeks prior to project commencement and regularly throughout the project to determine if additional avoidance measures are needed due to condor and Mexican spotted owl (*Strix occidentalis lucida*) locations.

- Helicopters would stay at least 1 mile away from active condor nest locations and vicinities except when human safety would be compromised. The active nesting season is February 1 to September 30. These dates may be modified based on the most current information regarding condor nesting activities (e.g., roosting and fledging) and coordination with the US Fish and Wildlife Service (USFWS).
- Work on the existing aboveground electrical line between the South Rim and Indian Garden, including associated helicopter flights, would occur outside the condor and Mexican spotted owl nesting seasons. The active condor nesting season is February 1 to September 30. The Mexican spotted owl nesting season is from March to August. These dates may be modified based on the most current information regarding condor and Mexican spotted owl nesting activities (roosting, fledging, etc.) and coordination with the park's Wildlife Program Manager, Section 7 Coordinator, and USFWS.
- Helicopters would stay at least 1,200 feet away from condors in the air or on the ground or cliffs unless safety concerns override this restriction.
- If airborne condors approach aircraft, aircraft would give up airspace to the extent possible, as long as this action does not jeopardize human safety.
- In order to minimize noise disturbance within Mexican spotted Owl Protected Activity Center (PAC), light helicopters would remain at least 1,200 feet from the boundary of any designated PAC during the Mexican spotted owl breeding season (March 1 through August 31). This distance would increase to 2,000 feet for a S-64 Skycrane or equivalent, and to 2,400 feet for a CH-47 Chinook. If non-breeding is inferred or confirmed during approved-protocol surveys in a PAC during the breeding season, restrictions on noise disturbances should be relaxed depending on the nature and extent of the proposed disturbance.
- To reduce noise impacts on bighorn sheep, helicopters would remain at least 1,500 feet above ground level and maintain that distance while in the canyon, except during takeoff, landing or dropping off or picking up sling loads.
- Following completion of the project, NPS fisheries staff would monitor Bright Angel Creek for changes in water temperature. If monitoring indicates that substantial temperature changes that could favor brown trout are occurring in the creek, the park would increase removal of nonnative fish.
- Following the completion of the project, NPS wildlife staff would monitor Bright Angel and Garden Creeks for changes in creek morphology that directly impacts habitat availability for amphibians and bats.
- Project staff shall comply with the Migratory Bird Treaty Act (16 United States Code 703). Any active bird nest shall be left in place and undisturbed until the young hatch and depart. Vegetation clearing shall be avoided to the greatest extent possible during the primary nesting season between early April and mid-August. If vegetation clearing must occur within the primary nesting season, surveys for the active nests shall be conducted by a qualified biologist. Vegetation clearing within the primary nesting season shall only be allowed after the qualified biologist determines that no nests are present or they are inactive.

- Disturbance of northern goshawks during the breeding season would be avoided by prohibiting vegetation removal and subsequent construction activity from the proposed contractor equipment and storage area from April 1 through July 31. If vegetation removal is required during this time, a goshawk survey would be conducted for nests. If a nest is found, construction activity and vegetation removal would not occur within a 0.5-mile radius of the nest until the birds have fledged.
- If using erosion netting, biodegradable matting with a large-diameter natural fiber shall be used to prevent entrapment of wildlife.
- Park wildlife biologists will train contractor staff, at the preconstruction meeting, to avoid disturbance to any wildlife species (reptiles, migratory birds, raptors, or bats) found nesting, hibernating, estivating, or otherwise living in, or immediately nearby, worksites.
- For any projects involving trenching or digging holes, provisions (generally in the form of ramps, with a slope less than 45°) must be made every 20 to 50 feet to allow for the escape of animals that may fall into these recesses, and/or they must be covered in such a way as to prevent animals (vertebrates) from falling into them.
- Overall, night work would not be permitted as part of this project, however, there may be some instances when crews mobilize to/from the work site at dawn or dusk, or may need to finish a task at the end of the day. Such instances would only be permitted if they would be short term, require minimal equipment, and would not occur within .5 miles of Mexican spotted owl PAC boundaries.
- Before removing trees on the South Rim, the park would conduct bat surveys to identify which bat species are present. To protect tree roosting bat species, tree removal on the South Rim would occur only during the winter months (November through February).
- The park would monitor temperatures in Bright Angel Creek following relocation of the TCWL intake and increase nonnative fish removal efforts if monitoring indicates that conditions have changed to favor nonnative brown trout.

Soundscapes

- To reduce noise impacts on sensitive wildlife and areas with natural or wilderness characteristics when flying to and from the work area, helicopters would maintain a minimum 2,000 foot altitude where possible, per FAA Advisory Circular 91-36D Visual Flight Rules (VFR) Flight Near Noise-Sensitive Areas (FAA 2004).
- Helicopter pilots would be encouraged to use quieter maneuvers (ones that produce less noise), wherever possible, according to the Fly Neighborly training available at <https://go.usa.gov/xQPCW> and <https://www.rotor.org/operations/flyneighborly.aspx>
- Where possible, pumps and generators that do not exceed 60 dB(A) at 50 feet, would be selected, per the NPS Audio Disturbances rule (36 CFR 2.12).
- Except in emergencies, work in the vicinity of campgrounds would be limited to the hours of 6:00 am - 10:00 pm, to reduce disturbance during established quiet hours at any campsites that may be affected.

Vegetation

- All revegetation efforts would use site-adapted native seed and plants provided by the park's Vegetation Management Program.
- 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.
- 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.
- Pruning necessary for the project would adhere to the park's pruning guidelines with the goal of retaining the health and integrity of trees and shrubs treated. Damage to trees or roots in or adjacent to project sites during construction would be avoided as much as possible and, if avoidance is not possible, root pruning guidelines provided by the park's Vegetation Management Program would be followed.
- Vegetation material removed during the project that is unusable for revegetation efforts would be cut and shredded on-site for use as mulch in the project area.
- Monitoring would occur to track the change in riparian area below the Indian Garden pumphouse.

Soils

- 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 in sensitive areas.
- 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.
- Water would be applied for dust abatement at project sites.

Cultural Resources

- A cultural resources specialist would monitor all ground-disturbing activities such as excavation or grading. Such work would not proceed without a cultural resource specialist present.
- A tribal resource monitor from the Havasupai Tribe, per the tribe's request, will be invited to be on-site when work is occurring at and near Indian Garden and other areas of interest.
- If during construction previously unknown archaeological resources were uncovered, a park cultural resource specialist would be contacted immediately. All work in the immediate vicinity of the discovery would be halted until the resources could be identified and documented and an appropriate mitigation strategy developed in consultation with the State Historic Preservation Officer and associated American Indian tribes.
- In the unlikely event that human remains, funerary objects, sacred objects, or objects of cultural patrimony are discovered during construction, provisions outlined in the Native American Graves Protection and Repatriation Act and the park's *Memorandum of Agreement Regarding Collections, Inadvertent Discovery, and Intentional Excavation of Native American Human Remains, Funerary Objects, Sacred Objects, and Objects of Cultural Patrimony* (NPS 2007) would be followed.
- All mitigation measures developed as part of the Programmatic Agreement with the State Historic Preservation Officer and tribes to guide project implementation would be followed in coordination with the park Section 106 Coordinator and the park Tribal Program Manager.
- The *Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for the Treatment of Cultural Landscapes* and DO 28: *Cultural Resources Management* would be followed for this project.
- All workers would be informed of the penalties of illegally collecting artifacts or intentionally damaging any archaeological or historic property.

Paleontological Resources

- A preconstruction survey for paleontological resources would be conducted.
- Activities would be conducted in a way that would not damage or move inventoried paleontological resources. If concealed paleontological resources are encountered during project activities, all necessary steps would be taken to protect them.

- Although there is no surface evidence of paleontological resources, if concealed paleontological resources are encountered during project activities, all necessary steps would be taken to protect them and an appropriate mitigation strategy would be developed.
- Resource monitors on the project would be trained to identify paleontological resources.

Visitor Use and Experience

- Project activities, including trail closures, would be communicated to affected staff and the public through public notification channels.

Night Sky

- The minimum required amount of new lighting would be considered and selected fixtures would meet criteria identified in the park's lighting policy.
- Lighting in the project area would be evaluated to determine if it is necessary and that it meets the park lighting policy to protect the night sky.

Appendix B

Alternatives Comparison

Project Facility or Feature	Alternative A – No Action	Alternative B – Relocate Water Intake (Preferred Alternative)	Alternative C – Replace TCWL in Same Location
Phantom Ranch	<ul style="list-style-type: none"> Existing infrastructure related to the TCWL would continue to be used including three water storage tanks at Phantom Ranch (20,000 gallons total) 	<ul style="list-style-type: none"> Up to 8 alluvial wells or a surface water intake along Bright Angel Creek shoreline About 1,800 linear feet of waterline Raw water storage tank, booster pump station, and WTP 50,000-gallon potable water storage tank 	<ul style="list-style-type: none"> No new facilities
Indian Garden	<ul style="list-style-type: none"> Existing infrastructure would continue to be used, including one water storage tank at Indian Garden (10,000 gallons) 	<ul style="list-style-type: none"> Local WTP New waterline from the existing sedimentation tank to WTP New potable water storage tank (up to 50,000 gallons) New waterline from WTP to new potable water storage tank 	<ul style="list-style-type: none"> Same as the no action alternative
TCWL between Roaring Springs and Phantom Ranch	<ul style="list-style-type: none"> No change 	<ul style="list-style-type: none"> Existing TCWL removed during routine trail maintenance or left in place where sensitive resources exist 	<ul style="list-style-type: none"> Replace 9 miles of existing pipeline with 8-inch-diameter pipe Existing pipe generally removed
TCWL between Phantom Ranch and Indian Garden	<ul style="list-style-type: none"> No change 	<ul style="list-style-type: none"> Replace 3 miles of existing pipeline with 8-inch-diameter pipe Existing pipe generally removed 	<ul style="list-style-type: none"> Same as Alternative B
South Rim WTP	<ul style="list-style-type: none"> Existing infrastructure would continue to be used, including five water storage tanks at the South Rim (14 million gallons total) 	<ul style="list-style-type: none"> New WTP at the South Rim May include new 1 million-gallon raw water tank and new raw water meter vault 	<ul style="list-style-type: none"> Same as the no action alternative
Roaring Springs and Cottonwood Campground	<ul style="list-style-type: none"> No change 	<ul style="list-style-type: none"> New 2-inch waterline from Roaring Springs Pump Station to Cottonwood Campground within the existing trail alignment 	<ul style="list-style-type: none"> No change

Project Facility or Feature	Alternative A – No Action	Alternative B – Relocate Water Intake (Preferred Alternative)	Alternative C – Replace TCWL in Same Location
Electrical line from South Rim to Indian Garden	<ul style="list-style-type: none"> No change 	<ul style="list-style-type: none"> Existing 2.5-mile-long aboveground electrical line northwest of “the Battleship” would be upgraded using the existing power poles; materials and workers would be transported to the site by helicopter Existing electrical line would be buried in the Bright Angel Trail near Indian Garden and the electrical line between Indian Garden and Phantom Ranch would be replaced; about 3 miles of electrical line would be replaced 	<ul style="list-style-type: none"> Existing electrical line would be buried in the Bright Angel Trail near Indian Garden and the electrical line between Indian Garden and Phantom Ranch would be replaced; about 3 miles of electrical line would be replaced
Access and staging	<ul style="list-style-type: none"> Access for repairs would generally be by helicopter and by foot 	<ul style="list-style-type: none"> Three or four construction camps for workers at Manzanita Ranger Station and Day Use Area, Cottonwood Campground, the delta area of Phantom Ranch, and Indian Garden Campground Expanded helibase on the South Rim New contractor staging and operations areas on the South Rim New access road constructed between the maintenance complex and South Entrance Road Access to work sites would be through a combination of helicopter flights, hiking, and small ATV use Material staging areas for pipeline construction would be within the 15-foot-wide construction zone Some locations along the alignment would require helicopter delivery of pipe material because the topography does not allow for vehicle access 	<ul style="list-style-type: none"> Same as Alternative B, except additional material staging areas would be needed during replacement of the TCWL between Roaring Springs and Phantom Ranch

Project Facility or Feature	Alternative A – No Action	Alternative B – Relocate Water Intake (Preferred Alternative)	Alternative C – Replace TCWL in Same Location
Helicopter operations	<ul style="list-style-type: none"> Helicopter flights to support repairs would continue to be needed and are highly variable based on the extent of the break 	<ul style="list-style-type: none"> Approximately 5,500 total helicopter flights would occur over the 3-year construction period in the inner canyon About 7 to 12 round-trip flights per day Up to 20 helicopter flights per day on busy days On a typical day, helicopters would be active for about 6 hours 	<ul style="list-style-type: none"> Approximately 11,500 total helicopter flights would occur over the 4- to 5-year construction period About 14 to 24 round-trip flights per day Up to 30 helicopter flights per day on busy days On a typical day, helicopters would be active for about 14 hours
Disturbance area	<ul style="list-style-type: none"> Varies, depending on location and extent of pipeline break 	<ul style="list-style-type: none"> Up to 41 acres 	<ul style="list-style-type: none"> Up to 60 acres
Schedule	<ul style="list-style-type: none"> Not applicable 	<ul style="list-style-type: none"> Estimated 4- to 5-year construction period 	<ul style="list-style-type: none"> Estimated 5- to 6-year construction period

Appendix C

Potentially Impacted Special Status Terrestrial Wildlife Species

Species Common and Scientific Name	Federal Status ¹	State Status	Other Status	Habitat Description and Occurrence in the Park
Federally Listed Species				
California condor <i>Gymnogyps californianus</i>	EXP	SGCN		California condor nesting habitat includes various rock formations such as caves, crevices, overhung ledges, and potholes. Roost sites include cliffs, tall trees, and snags. This species is known to nest in the park and is regularly observed in the project area.
Mexican spotted owl <i>Strix occidentalis lucida</i>	T	SGCN		Mexican spotted owls are found in steep-sided canyons with old growth mixed conifer forests. Nesting occurs on cliff ledges or caves along canyon walls in shady/cool canyons below the canyon rim. Mexican spotted owls have infrequently been documented foraging above the canyon rim. This species and its critical habitat are known to occur in the project area.
Other Species of Concern				
Desert bighorn sheep <i>Ovis canadensis nelsoni</i>		SGCN		Bighorn sheep occur throughout the park in the inner canyon, from the canyon rim to the Colorado River. This species is known to occur in the pipeline corridor.
Allen's lappet-browed bat <i>Idionycteris phyllotis</i>			SC	Allen's lappet-browed bats typically roost in caves or cliff crevices and may also roost in large ponderosa pine snags. Typical habitat includes ponderosa pine, pinyon/juniper, and riparian areas. This species is known to occur in the pipeline corridor and could occur in ponderosa pine habitat on the South Rim.
Greater western mastiff bat <i>Eumops perotis</i>		SGCN	SC	Greater western mastiff bats typically roost in caves or crevices in vertical cliffs. Foraging typically occurs in desert scrub habitat. This species is known to occur in the pipeline corridor.
Long-legged myotis <i>Myotis volans</i>			SC	The long-legged myotis is found in pinyon-juniper and ponderosa pine on both rims, but are more common on the South Rim. These bats roost in dense foliage, beneath exfoliating bark, or in tree cavities and will also roost in cave, mine, and rock crevices. They typically feed along forest edges or in small clearings. This species is known to occur in the pipeline corridor and could occur in the project area on the South Rim.
Mexican free-tailed bat <i>Tadarida brasiliensis</i>		SGCN		Mexican free-tailed bats typically roost in caves or cliff crevices. They forage in a wide variety of habitats. This species is known to occur in the pipeline corridor and could forage on the South Rim.

Species Common and Scientific Name	Federal Status ¹	State Status	Other Status	Habitat Description and Occurrence in the Park
Mexican long-tongued bat <i>Cheronycteris mexicana</i>		SGCN		Mexican long-tongued bats are found primarily in desert scrub and agave habitat. They roost in caves or abandoned buildings during the day. This species is uncommon in the park and is not likely to occur in the pipeline corridor in substantial numbers.
Pocketed free-tailed bat <i>Nyctinomops femorosaccus</i>			SC	Pocketed free-tailed bats roost in crevices high on cliff faces in rugged canyons. They forage over ponds, streams, or arid desert habitats. This species rarely ranges into the park, but is known to occur in the pipeline corridor.
Spotted bat <i>Euderma maculatum</i>		SGCN	SC	Spotted bats typically roost in caves or cliff crevices. They use dry desert scrub and ponderosa pine as foraging areas. This species is known to occur in the pipeline corridor and could occur in ponderosa pine habitat on the South Rim.
Townsend's big-eared bat <i>Corynorhinus townsendi</i>			SC	Townsend's big-eared bats are insectivorous and typically roosts in caves or cliff crevices. Foraging occurs in desert scrub, pinyon/juniper forests, and other coniferous forests. This species is known to occur in the pipeline corridor and could occur in ponderosa pine habitat on the South Rim.
Western red bat <i>Lasiurus blossevillei</i>		SGCN		Western red bats roost only in tree foliage. They typically feed over a wide variety of habitats including grasslands, shrublands, open woodlands and forests, and croplands. This species is known to occur in the pipeline corridor and could occur in ponderosa pine habitat on the South Rim.

¹**Status Codes:** **T**=federally listed threatened; **EXP**=nonessential experimental population (note: California condor is treated as threatened within the park); **SGCN**=Species of greatest conservation need in Arizona; **SC**=Species of concern (some information showing vulnerability or threat, but not enough to support listing under the Endangered Species Act).

Appendix D

Acronyms and Abbreviations

ATV	All-Terrain Vehicle
BMP	Best Management Practices
CCCHD	Cross Canyon Corridor Historic District
cfs	Cubic Feet Per Second
dBA	A-weighted Decibels
EA	Environmental Assessment
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
HAER	Historic American Engineering Record
HDD	Horizontal Directional Drilling
L _{eq}	Equivalent Continuous Sound Level
L _{max}	Maximum Sound Level
NPS	National Park Service
PAC	Protected Activity Center
Park	Grand Canyon National Park
RABT	River-Assisted Backcountry Travel
SOI	Secretary of the Interior
TCWL	Transcanyon Water Distribution Pipeline
USFWS	US Fish and Wildlife Service
WTP	Water Treatment Plant

Appendix E

References

- Bair, R., E. Schenk, B. Tobin, and H. Childres. 2014. Potential Impacts on Native and Invasive Fish Habitat in Bright Angel Creek (AZ) With the Redesign of Grand Canyon Water Intake Infrastructure. Geological Society of America Abstracts with Programs. Vol. 48, No. 7. Available at: <https://gsa.confex.com/gsa/2016AM/webprogram/Paper282429.html>.
- Barnes, J. C. 2013. Protecting wild waters in the Grand Canyon. *International Journal of Wilderness* 19(1):4–8. Available at: <http://ijw.org/april-2013/> (accessed 09 January 2018).
- Birnbaum, C. 1994. Preservation Brief 36. *Protecting Cultural Landscapes: Planning Treatment and Management of Historic Landscapes*. Prepared for the US Department of the Interior, National Park Service.
- Carothers, S.W. and C.O. Minckley. 1981. A survey of the fishes, aquatic invertebrates and aquatic plants of the Colorado River and selected tributaries from Lee's Ferry to Separation Rapids. Final Report, U.S. Bureau of Reclamation Contract 7-07-30-X0026, Lower Colorado Region, Boulder City, NV. Museum of Northern Arizona, Flagstaff. pp. 401.
- Coggins, L., M. Yard, and C. Paukert. 2002. Piscivory by nonnative salmonids in the Colorado River and an evaluation of the efficacy of mechanical removal of nonnative salmonids. Grand Canyon Monitoring and Research Center, U.S. Geologic Survey, Flagstaff, AZ.
- Environmental Protection Agency (EPA). 1974. Information on Levels of Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety. Report No. 550/9-74-004. Prepared by the EPA Office of Noise Abatement and Control. Washington, D.C.
- Etchberger, R.C. and P.R. Krausman. 1999. Frequency of birth and lambing sites of a small population of mountain sheep. *The Southwestern Naturalist* 354-360.
- Federal Aviation Administration (FAA). 1982. Helicopter Noise Exposure Curves for Use in Environmental Impact Assessment. Report No. DOT-FAA-EE-82-16. November 1982. Accessed online August 15, 2018 at <http://www.dtic.mil/dtic/tr/fulltext/u2/a123467.pdf>
- Federal Highway Administration (FHWA). 2006. FHWA Roadway Construction Noise Model Version 1.1 and User Guide. Accessed online August 15, 2018 at https://www.fhwa.dot.gov/environment/noise/construction_noise/rcnm/
- Havasupai Tribal Council. 2017. Tribal comment letter in response to a council meeting explaining the NEPA process for the Transcanyon Pipeline.
- HDR. 2014. Replace Transcanyon Water Pipeline from Roaring Springs to Indian Gardens Pump Station Design Services for Predesign and Schematic Design Documents. Grand Canyon National Park, Coconino County, AZ.

- HDR. 2016. Transcanyon Waterline Replacement Bright Angel Creek Floodplain Assessment. Technical Memorandum prepared by HDR, Fort Collins, CO. Prepared for National Park Service. NPS – GRCA 190083.
- Healy, B., R. Schelly, C. Nelson, E. O. Smith, M. Trammell, and R. Koller. 2018. Review of Effective Suppression of Nonnative Fishes in Bright Angel Creek, 2012 -2017, with Recommendations for Humpback Chub Translocations.
- Jones, C.J.R., A.E. Springer, B.W. Tobin, S.J. Zappitello, and N.A. Jones. 2017. Characterization and hydraulic behavior of the complex karst of the Kaibab Plateau and Grand Canyon National Park, USA. *In*: Parise, M., Gabrovsek, F., Kaufmann, G. & Ravbar, N. (eds) *Advances in Karst Research: Theory, Fieldwork and Applications*. Geological Society, London, Special Publications, 466. Available at: <https://doi.org/10.1144/SP466.5>.
- Kearsley, M. J., K. Green, M. Tukman, M. Reid, M. Hall, T. J. Ayers, and K. Christie. 2015. Grand Canyon National Park–Grand Canyon / Parashant National Monument vegetation classification and mapping project. Natural Resource Report NPS/GRCA/NRR—2015/913. National Park Service, Fort Collins, Colorado.
- Kegerries, R.B., B.C. Albrecht, E.I. Gilbert, W.H. Brandenburg, A.L. Barkalow, M.C. McKinstry, H.E. Mohn, B.D. Healy, J.R. Stolberg, E.C. Omana Smith, C.B. Nelson, and R.J. Rogers. 2017. Occurrence and Reproduction by Razorback Sucker (*Xyrauchen texanus*) in the Grand Canyon, Arizona. *The Southwestern Naturalist* 62(3):227-232.
- Klos, P.Z., T.E. Link, and J.T. Abatzoglou. 2014. Extent of the rain-snow transition zone in the western U.S. under historic and projected climate. *Geophys. Res. Lett.*, 41, 4560–4568.
- Lindsay, B.A., R.K. Strait, and D.W. Denny. 2003. Soil Survey of Grand Canyon Area, Arizona, Parts of Coconino and Mohave Counties. United States Department of Agriculture, Natural Resources Conservation Service, in cooperation with the United States Department of the Interior, National Park Service.
- Logan Simpson Design. National Register of Historic Places Nomination Form, Cross Canyon Historic District, Grand Canyon National Park.
- MacArthur, R. A., R. H. Johnson, and V. Geist. 1979. Factors influencing heart rate in free ranging bighorn sheep: a physiological approach to the study of wildlife harassment. *Canadian Journal of Zoology* 57:2010-2021.
- Maddux, H.R., L.A. Fitzpatrick, and W.R. Noonan. 1993. Colorado River endangered fishes critical habitat: Biological Support Document. U.S. Fish and Wildlife Service, Salt Lake City, UT. 225 pp.
- Marsh, P.C. and M.E. Douglas. 1997. Predation by introduced fishes on endangered humpback chub and other native species in the Little Colorado River, Arizona. *Transactions of the American Fisheries Society* 126:343–346.
- Minckley, C.O. 1978. A report on aquatic investigation conducted during 1976-1977, on Bright Angel, Phantom, and Pipe Creeks, Grand Canyon National Park, Coconino County, Arizona. Annual investigators report submitted to Grand Canyon National Park.

Department of Biological Sciences, Northern Arizona University, and Biology Department, Museum of Northern Arizona, Flagstaff.

Montgomery and Associates, 1999, Supplemental assessment of hydrogeologic conditions and potential effects of proposed groundwater withdrawal, Coconino Plateau groundwater subbasin, Coconino County, Arizona, Appendix of Final Environmental Impact Statement for Tusayan Growth, Kaibab National Forest, Williams, Arizona, 256p.

National Park Service (NPS). 2004. Environmental Assessment – Upgrade Corridor Area Fire Protection. Grand Canyon National Park.

National Park Service (NPS). 2006. Management Policies 2006. Accessed February 2018. Available at: https://www.nps.gov/policy/MP_2006.pdf.

National Park Service (NPS). 2007. Memorandum of Agreement Regarding Collections, Inadvertent Discovery, and Intentional Excavation of Native American Human Remains, Funerary Objects, Sacred Objects, and Objects of Cultural Patrimony at Grand Canyon National Park, Arizona." Document on file, Science and Resource Management, Grand Canyon National Park, AZ.

National Park Service (NPS). 2009. Exotic plant management plan: Grand Canyon National Park. National Park Service, Grand Canyon, Arizona.

National Park Service (NPS). 2010. Final wilderness recommendation, 2010 draft update: Grand Canyon National Park. National Park Service, Grand Canyon, Arizona.

National Park Service (NPS). 2013a. Cultural Landscape Inventory, Cross Canyon Corridor Historic District, Grand Canyon National Park. Prepared by Logan Simpson for the U.S. Department of the Interior.

National Park Service (NPS). 2013b. Biological Assessment and Comprehensive Fisheries Management Plan. Grand Canyon National Park and Glen Canyon National Recreation Area. May.

National Park Service (NPS). 2013c. Director's Order #41: *Wilderness Stewardship*. Accessed February 2018. Available at: https://www.nps.gov/policy/DOrders/DO_41.pdf.

National Park Service (NPS). 2015a. Ecology of Desert Bighorn Sheep in Grand Canyon National Park. 2014 Progress Report.

National Park Service (NPS). 2015b. National Register of Historic Places Nomination Form, Cross Canyon Historic District, Grand Canyon National Park.

National Park Service (NPS). 2015e. Grand Canyon National Park Backcountry Management Plan, Draft Environmental Impact Statement. Accessed February 2018. Available at: <https://parkplanning.nps.gov/parkHome.cfm?parkID=65&CFID=18194479&CFTOKEN=c377035720fdef20-3E5B1D4A-155D-AD0C-C3CF86FB1EDA8824>. November 2015.

National Park Service (NPS). 2016a. NPS Procedural Manual #77-1: Wetland Protection.

National Park Service (NPS). 2016b. Unpublished Mexican spotted owl survey data.

- National Park Service (NPS). 2017. NPS Procedural Manual #77-2: Floodplain Management. Available at: <https://www.nature.nps.gov/Rm77/floodplain.cfm>.
- National Park Service (NPS). 2018. Acid sensitive species in Grand Canyon National Park. Available at: <https://irma.nps.gov/NPSpecies/Reports/Systemwide/Acid-sensitive%20Species%20in%20a%20Park> (accessed 02 March 2018).
- National Park Service (NPS). n.d.a. National Park Service Visitor Use Statistics, Park Reports, Grand Canyon NP (GRCA). Accessed February 2018. Available online: <https://irma.nps.gov/Stats/Reports/Park/GRCA>.
- National Park Service (NPS). n.d.b. North Kaibab Trail, Grand Canyon National Park. Accessed February 2018. Available online: https://www.nps.gov/grca/planyourvisit/upload/North_Kaibab_Trail.pdf.
- National Park Service (NPS). n.d.c. Communication Infrastructure Plan. Accessed February 2018. Available online: <https://parkplanning.nps.gov/projectHome.cfm?parkID=65&projectID=70290>.
- Nickel, Tobias (in review). 2018. Grand Canyon wilderness character narrative and baseline monitoring assessment. National Park Service, Grand Canyon Arizona.
- Occupational Safety and Health Administration (OSHA). 2013 OSHA Technical Manual – Noise. Accessed online via the OSHA website October 30, 2015 at https://www.osha.gov/dts/osta/otm/new_noise/index.pdf.
- Pine, W. E., B. Healy, E. O. Smith, M. Trammell, D. Speas, R. Valdez, M. Yard, C. Walters, R. Ahrens, R. Vanhaverbeke, D. Stone, and W. Wilson. 2013. An individual-based model for population viability analysis of humpback chub in Grand Canyon. *North American Journal of Fisheries Management* 33(3):626–641.
- Rihs, J. 2008. External Threats to Water Resources. Internal Report. Grand Canyon National Park. National Park Service.
- Robinson, A. T., R. W. Clarkson, and R. E. Forrest. 1998. Dispersal of larval fishes in a regulated river tributary. *Transactions of the American Fisheries Society* 127(5):772–786.
- Schelly, R., E.O. Smith, R. Koller, and B. Healy. 2017. Bright Angel Creek Comprehensive Brown Trout Control Project October 18, 2016 – February 7, 2017, Season Report. Grand Canyon National Park, National Park Service. Report prepared for the Upper Colorado Region, Bureau of Reclamation, Interagency Agreement Number: 09-AA-40-2890. August 9.
- Schwinning, S., J. Belnap, D.R. Bowling, and J.R. Ehleringer. 2008. Sensitivity of the Colorado Plateau to change: climate, ecosystems, and society. *Ecology and Society* XX(YY): ZZ. Available online: <http://www.ecologyandsociety.org/volXX/issYY/artZZ/>.
- Seager, R., M. Ting, I. Held, Y. Kushnir, J. Lu, G. Vecchi, H.P. Huang, N. Harnik, A. Leetmaa, N. Lau, C. Li, J. Velez, and N. Naik. 2007. Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America *Science* 316, 1181 (2007).
- Steely, J. 2015. Transcanyon Water Line National Register of Historic Places Registration Form. Prepared for Grand Canyon National Park.

- Stockwell, C.A., G.C. Bateman, and J. Berger. 1991. Conflicts in national parks: a case study of helicopters and bighorn sheep time budgets at the Grand Canyon. *Biological Conservation* 56, 317-328.
- Stone, D. 2018. Personal communication from D. Stone, USFWS, to B. Healy, NPS. February 12.
- Swarthout, E.C.H. and R. Steidl. 2001. Flush responses of Mexican spotted owls to recreationists. *J. Wildl. Manage.* 65(2):312-317.
- US Fish and Wildlife Service (USFWS). 1995. Recovery plan for the Mexican spotted owl: Vol. 1. Albuquerque, NM. 172 pp.
- US Fish and Wildlife Service (USFWS). 1996a. Endangered and Threatened Wildlife and Plants; Establishment of a Nonessential Experimental Population of California Condors in Northern Arizona. 61 Federal Register 54044, October 16, 1996, Volume 61, Number 201, pp. 54043-54060.
- US Fish and Wildlife Service (USFWS). 1996b. California Condor Recovery Plan, Third Revision. Portland, OR. 62 pp.
- US Fish and Wildlife Service (USFWS). 2012. Recovery Plan for the Mexican Spotted Owl, First Revision. U.S. Fish and Wildlife Service, Albuquerque, NM. 376 pp.
- Valdez, R.A. and R.J. Ryel. 1995. Life history and ecology of humpback chub (*Gila cypha*) in the Colorado River, Grand Canyon, Arizona. BIO/WEST, Inc. Final report (TR-250-08) to the Bureau of Reclamation, Salt Lake City, UT.
- Webb, R. H., S. A. Leake, and R. M. Turner. 2007. The ribbon of green: Change in riparian vegetation in the southwestern United States. University of Arizona Press, Tucson, Arizona.
- Whiting, D. P., C. P. Paukert, B. D. Healy, and J. J. Spurgeon. 2014. Macroinvertebrate prey availability and food web dynamics of nonnative trout in a Colorado River tributary, Grand Canyon. *Freshwater Science* 33(3):872-884.
- Zaimes, G., M. Nichols, D. Green, and M. Crimmins, editors. 2007. Understanding Arizona's riparian areas. Arizona Cooperative Extension. University of Arizona, College of Agriculture and Life Sciences, Tucson. Available at: <https://extension.arizona.edu/pubs/> (accessed 09 January 2018).