TRANSCANYON WATER LINE
(Trans-Canyon Water Pipeline)
Grand Canyon National Park
Beginning 5 miles below North Kaibab Trail and .14 miles east of Roaring Springs and extending to Indian Garden and Indian Garden Pumphouses
Grand Canyon vicinity
Coconino County
Arizona

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

FIELD RECORDS

HISTORIC AMERICAN ENGINEERING RECORD
INTERMOUNTAIN REGIONAL OFFICE
National Park Service
U.S. Department of the Interior
12795 West Alameda Parkway
Denver, CO 80228
HISTORIC AMERICAN ENGINEERING RECORD

TRANSCANYON WATER LINE
(Trans-Canyon Water Pipeline)
HAER No. AZ-95

Location: Beginning 5 miles below North Kaibab Trailhead and .14 mile east of Roaring Springs, continuing along North Kaibab Trail through Cottonwood Campground and Phantom Ranch. Crosses Colorado River at Silver Bridge and follows Colorado River Trail and beyond to a cliff face, ascending to Plateau Point. Follows Plateau Point Trail to Bright Angel Trail, terminating at Indian Garden and Indian Garden pumphouses.

USGS Bright Angel Point, Grand Canyon, Phantom Ranch Quadrangles, UTM Coordinates (Beginning; End):
Roaring Springs Cave: 407016 E - 4006098 N;
Indian Garden North Pumphouse: 398540.9 E - 3993231 N.


Present Use: Waterworks, Outdoor Recreation.

Significance: Grand Canyon National Park’s Transcanyon Water Line is a critical and historically significant component of the park’s infrastructure, supplying water since 1970 for the South Rim’s visitor and management facilities. The 12.4-mile pipeline can transport up to 17 percent—about 1 million gallons per day—of naturally flowing spring water from the North Rim’s Roaring Springs Cave directly to the water-short South Rim. Engineer Ralph Stratton of the NPS Western Office of Design and Construction in San Francisco led the team beginning in 1963 that produced engineering drawings and specifications for the pipeline, financed by the bureau’s mid-century Mission 66 improvement program. Elling B. Halvorson and Lent’s Inc. of the Seattle area contracted with NPS in 1965 to build the structure of extruded-aluminum pipe and small aluminum bridges, with cast iron fixtures and the galvanized-steel Colorado River suspension bridge. All parts were by flown helicopter into remote segments of the park’s Bright Angel Fault trails system and the Colorado River gorge. As the pipeline neared completion in December 1966, a “1,500-year flood” in Roaring Springs and Bright Angel Creeks washed out 5 miles of the new pipeline and the carefully rebuilt North Kaibab Trail that covered it. With repair funding under the Mission 66-successor Parkscape USA initiative, the pipeline finally linked Roaring Springs and existing waterworks at Indian Garden in 1970, meeting the South Rim’s substantial water demands and allowing for decades of expanded park-visitor capacity.
Improvements to the operation and efficiency of the pipeline continued through 1986 with cathodic protection, pumping and monitoring stations, and re-designs of troubled segments.

**Historian:**

**Project Information:**
Grand Canyon National Park (GRCA) and NPS Denver Service Center staff initiated this documentation in 2014 in anticipation of replacing parts and eventually all of the 1965–70 Pipeline, a structure anticipated by the pipe manufacturer to last thirty years (through c. 1995–2000). GRCA Cultural Resource Program Manager Ellen Brennan prepared initial research in the form of a Preliminary Determination of Eligibility on the National Register of Historic Places (NRHP) Registration Form. Mr. Steely expanded the NRHP documentation to current standards and for Section 110 compliance; produced this affiliated HAER historical report; coordinated all large-format photography; and conducted the North Rim photography fieldwork. Historian and Historical Archeologist Annie Lutes, from SWCA’s Flagstaff office, performed research in the GRCA Museum Collection Archives, and assisted with the copy-stand reproduction of Pipeline engineering drawings and with the North Rim photography fieldwork. Photographer Jessica Maggio conducted the copy-stand reproduction of engineering drawings, as well as the South Rim photography fieldwork assisted by Tim Hauck, both based at SWCA’s Flagstaff office. Ms. Maggio labeled the HAER negatives, prints, and mounting boards. Hidden Light photography lab in Flagstaff provided the copy-stand for engineering drawing copies, developed the HAER black & white negatives, and processed the archival-paper prints.
Part I. Historical Information

A. Physical History:

1. Dates of construction:

   - 1963–64, planning and design of Pipeline by NPS (Anderson 2000; Grand Canyon National Park Staff 1971)
   - 1965–66, initial construction of Pipeline (Grand Canyon National Park Staff 1971)
   - 1968–70, re-building and completion after flooding (Grand Canyon National Park Staff 1971)
   - 1979, completion of Roaring Springs facility upgrades (Denver Service Center 1977; Aiken 2005)
   - 1986, Indian Garden and Plateau Point improvements (Denver Service Center 1985; McLaughlin Water Engineers 1986)

2. Engineers:

   - Ralph Stratton (see below), Transcanyon Water Line system-design engineer of record, NPS Western Office of Design and Construction, aka Western Service Center (Grand Canyon National Park Staff 1971)
   - Kennedy Engineers, design, Colorado River Bridge, 1964 (Grand Canyon National Park Staff 1971)
   - McLaughlin Water Engineers Ltd., Plateau Point Reroute, including non-trail truss Bridge Nos. 8 and 9 (McLaughlin Water Engineers 1986)

Ralph Merritt Stratton (1922–87) was born in Milo, Missouri, and attended public schools in Garden City, Kansas, where he joined the U.S. Army National Guard upon graduation. His Guard unit activated as part of the 35th Infantry Division during World War II, and Stratton received several decorations including the Purple Heart for wounds in 1944 during the Battle of the Bulge in Belgium. Following the war he attended the University of Arkansas, Fayetteville, with GI Bill assistance, and received a civil engineering degree about 1949. Following engineering jobs in Texas and Kansas, Stratton began work for the National Park Service in 1954 at the Western Office of Design and Construction (WODC) in San Francisco. During assignments to Grand Canyon National Park, he suffered medical emergencies three different times, each time airlifted from the canyon by helicopter to care. “For a while” thereafter, wrote his wife Evelyn about his career, “family and office dreaded to hear that he had to go to Grand Canyon” (ancestry.com 2015). Stratton supervised utility construction directly in several western National Parks and then became “supervisor of all utilities west of the Mississippi River,” according to Evelyn (ancestry.com 2015), probably the NPS position he held in 1963 as the Transcanyon Water Line commenced its design development.
When WODC moved to Denver in 1971, “Ralph was put in charge of all utilities for the whole USA,” recalled Evelyn, “and held that position until he retired” in 1978. “So when you visit a National Park,” she concluded, “Ralph Stratton probably was there ahead of you and improved or built something” (ancestry.com 2015).

3. Builder/Contractor/Supplier:

- Reynolds Metals Company, Phoenix, Arizona, extruded-aluminum pipe supplier (Grand Canyon National Park Staff 1971)
- Construction Erectors Inc., subcontractor, Colorado River bridge, 1966 (Grand Canyon National Park Staff 1971)
- US Steel, galvanized-steel Colorado Bridge components supplier (Grand Canyon National Park Museum Collection drawings)
- Slavin and Shafer Inc., cathodic protection upgrade (Grand Canyon National Park 1972)
- McLaughlin Water Engineers Ltd., Plateau Point Reroute, including non-trail truss Bridge Nos. 8 and 9, 1986 (McLaughlin Water Engineers 1986)

4. Original plans and construction:

As conceived in 1963, the 12.4-mile Transcanyon Water Line would transport up to 17 per cent—about 1 million gallons per day (gpd)—of Roaring Springs daily output directly to the water-short South Rim. WODC completed engineering drawings in 1964 (WODC 1964; full set available at GRCA Museum Collection) and issued notice for Transcanyon Water Line construction bids in a press release on October 21, describing the future Pipeline as designed to:

...take water from Roaring Springs on the north side of the Grand Canyon, down Bright Angel Canyon, across the Colorado River suspended from a pedestrian walkway, and up out of the 1,500-foot-deep inner gorge to the pumping station at Indian Gardens [sic], 3,200 feet below the South Rim, all gravity flow. From this point, it will be pumped to Grand Canyon Village and stored in reservoirs...The pipe will be welded steel, aluminum, or ductile iron, depending on most favorable bid (USDOI 1964).

Contractor Halvorson-Lent’s field-bent and -welded the Pipeline structure from 40- and 50-foot lengths of extruded-aluminum pipe, supported by small aluminum-plate bridges, cast iron fixtures, and the steel suspension bridge. Helicopters transported all these components in pieces flown into remote segments of the North Kaibab Trail, River Trail, Plateau Point Trail, and Bright Angel Trail.
As the Pipeline neared completion in December 1966, a “1,500-year flood” (Halvorson 2004) in Roaring Springs and Bright Angel Creeks washed out 5 miles of the new Pipeline and the carefully rebuilt North Kaibab Trail that covered it. WODC updated the 1963 drawings (WODC 1968; full set of update available at Denver Service Center), primarily showing new alignments under the re-located North Kaibab Trail, and corresponding new and rebuilt trail bridges across Bright Angel Creek. The repaired Pipeline linked Roaring Springs and existing waterworks at Indian Garden in 1970 (Grand Canyon National Park Staff 1971).

NPS installed a more robust cathodic protection system that improved degradation problems in 1972 (Grand Canyon National Park 1972), upgraded the Roaring Springs Cave intake and chlorination piping in 1979 (Denver Service Center 1977), and replaced the Plateau Point ascent with steel pipe in 1986 (McLaughlin Water Engineers 1986).

5. Alterations and additions:
   - 1972, cathodic protection system upgrade (Grand Canyon National Park 1972)
   - 1979, completion of Roaring Springs facility upgrades (Aiken 2005)
   - 1986, Indian Garden and Plateau Point improvements (Denver Service Center 1986; McLaughlin Water Engineers 1986)

B. Historical Context

*WATER FOR THE SOUTH RIM*

Grand Canyon’s center of visitation and management at the South Rim grew into Grand Canyon Village only after the Atchison, Topeka & Santa Fe Railway arrived in 1901 and brought its own daily water supply on tank car trains from wells under Arizona’s Chino Valley 125 miles south. When 1,279 square miles of Grand Canyon and its north and south rims became a National Park in 1919, the Santa Fe hauled up to 100,000 gallons per day to the village for the railroad’s own steam power and generators in the park, and for railroad-affiliated Fred Harvey hotel facilities and other visitor accommodations. The Park built a water reclamation plant in 1926, drastically lowering costs for steam boilers and other non-drinking uses (Anderson 2000). In 1927 the Park gained control of Indian Garden and its substantial spring below the South Rim, and in 1932 the Santa Fe built a Pumphouse and facilities there for moving Indian Garden water 3,200 feet up to the South Rim. By 1934 the Santa Fe completed this system that piped up to 150,000 gallons per day to Grand Canyon Village storage tanks. Supplemented by summer-season tank car trains and million-gallon storage tanks, the South Rim’s water supply remained adequate for about 40 more years (Anderson 2000, John Milner Associates 2005).

Meanwhile, a combination of automobile popularity and durability, better roads, and the Union Pacific Railroad’s interest in expanding its own affiliated Utah Parks Company visitor-services concessionaire led to extensive upgrades of North Rim visitor facilities
starting in 1927. Utah Parks bought out private claims and built a water system for its Grand Canyon Lodge and adjacent cabin village from the prolific source of Roaring Springs Cave about 3,800 feet below the rim (Anderson 2000).

Grand Canyon administrators counted 1 million Park visitors in 1956 and anticipated 1.7 million visitors to the Park by 1966, the majority concentrated at South Rim Village. The projected 1966 visitation figure exceeded the Indian Garden and railroad-supplemented water supply, and planners summarized grimly that “the answer is this simple—to keep pace with visitation, we must find more water.”

If additional supplies are found, we should decentralize [South Rim services away from Grand Canyon Village]. If, on the other hand, no new sources of water are made available, we need not decentralize, and the limits on accommodations for visitors will be automatic. In that case, from an operational sense, the park will have to be geared predominantly to day use (Anderson 2000, quoting the Park’s 1956 “Mission 66 Prospectus”).

The Santa Fe Railway had turned its Grand Canyon Village and Indian Garden physical plant over to NPS in 1954, and by the early 1960s Union Pacific signaled interest in divesting its North Rim facilities. Working from studies dating back to the early 1940s to bring Bright Angel Creek (fed primarily by Roaring Springs) water to the South Rim, NPS in 1963 worked out a deal with Utah Parks to divert some of its more than sufficient North Rim surplus of Roaring Springs water into a new pipeline to the South Rim (Anderson 2000).

MISSION 66 and PARKSCAPE PROGRAMS

The “Mission 66” program (1956-66), an innovation of longtime NPS Director (1951–64) Conrad L. Wirth, resulted in park planning and development of facilities and infrastructure to meet the needs of increased visitation, concluding with the 50th anniversary of NPS in 1966. The “Parkscape USA” program (1966-72) projected similar popular and political momentum under NPS Director (1964–72) George B. Hartzog Jr., and continued national planning and development activities, including those within Grand Canyon National Park. Nationwide, Mission 66 ultimately cost $1 billion and resulted in 100 visitor centers, 250 administrative buildings, 650 single-family residences, and 122 multiple-housing units (Anderson 2000).

Mission 66 infrastructure modernization also added to the National Parks: 578 miles of roads, 1,080 parking lots, and 360 “water, sewer, and power systems” (Anderson 2000). Conrad Wirth (1980) more specifically credited Mission 66 with “535 additional water systems” and “additions...to 301 old water systems,” with Grand Canyon’s Transcanyon Water Line likely falling into both categories. “Improving the ability to maintain and service park infrastructure throughout the National Park system,” confirmed authors of the nationwide Mission 66 Historic Context (Carr et al. 2013), “was one of the identified goals of the Mission 66 program.”

The Grand Canyon superintendent in 1956 issued his “Mission 66 for Grand Canyon National Park”—abbreviated as the Park’s program “prospectus”—relying heavily on
proposed additional water supply to expand services at the South Rim. The $25 million, 10-
year program for the Park became its Mission 66 master plan, calling for the
“decentralization” of Grand Canyon Village with a new park headquarters to the east, and
elsewhere a new community building, hospital, 33 family homes for staff, more than 140
multiple-unit dwellings, and two trailer parks. Improvements included visitor facilities at
Grand Canyon Village and nearby, and at Desert View, Indian Garden, Phantom Ranch, and
the North Rim’s Bright Angel Point. Additional staff would serve visitors from the new
facilities, and from roads, trails, power lines, and water system upgrades that served
everyone.

In 1957 NPS contracted with Arizona Mining Supply Corporation to build water and sewer
lines to Grand Canyon Village’s new extensions, and to set the stage for an increased water
supply by erecting two 2-million-gallon water storage tanks and one 300,000-gallon tank,
then in 1961 a 3-million-gallon tank (Anderson 2000).

DESIGNING AND CONSTRUCTING THE PIPELINE

NPS civil engineer Ralph Stratton (see A. 2. Above) led the federal infrastructure design
team at the San Francisco-based Western Office of Design and Construction (WODC,
nicknamed Western Service Center toward the end of the Transcanyon Water Line project)
(Grand Canyon National Park Staff 1971). NPS engineers surveyed the pipeline route in
1963, primarily along North Kaibab, River, Plateau Point, and Bright Angel Trails, and
Stratton’s WODC team completed corresponding engineering drawings and specifications in
1964. Arrangements with the Santa Fe Railway resumed supplemental water deliveries by
tank car during the interim of planning and construction of the Pipeline (Anderson 2000).

The 1965 construction-bid notice laid out further aspects of the job, including the need to
bury the pipe under at least 8 miles of hiking trails to prevent disturbance of the park’s
adjacent natural resources. Locations where the line could not be buried had been selected
by WODC engineers “in such a way that the pipeline will be hidden by shrubs and trees
whenever possible.” NPS as early as 1958 considered the installation a “major engineering
project” due to conditions of the inner canyon environment such as summer heat and
extremely rugged terrain, its remote nature, and the logistical challenges that the remoteness
of the job corridor imposed on the contractor. NPS expected the contractors to finish the job
within 18 months, with the duration of construction from January 26, 1965 to July 19, 1966
(Western Office of Design and Construction c.1963; United States Department of the Interior
1965).

WODC awarded the general contract in late 1964 to the joint venture of Elling Halvorson
Inc. and Lent’s Inc., with work commencing on January 26, 1965. Even after change orders
pushed the completion date to December 1966, the Transcanyon Pipeline remained Grand
Canyon’s signature, if hardly visible, Mission 66 project (Grand Canyon National Park Staff
1971). The initial Transcanyon Water Line contract cost of $2.4 million (more than $18
million in 2015 dollars) represented almost 10 percent of Grand Canyon’s 10-year Mission
The Transcanyon Water Line contractor, subcontractors, and NPS personnel addressed a relatively simple scope—moving water 12.4 miles from its source to its greatest Park-operation need—with a complex structural system built under extremely rough conditions. The initial Pipeline construction in 1965–66 and rebuilding in 1968–70 depended on skilled and pragmatic workers, and upon a number of specialized machines. In addition to employing helicopters of popular design and routine maintenance, in 1965 the contractor assembled a motor pool of devices conforming to the project specifications, including working areas confined in many places to the 3’-width of hiking trails (details below from Western Construction Magazine 1965, Avery 1965, Grand Canyon National Park Staff 1971, and Halvorson 2004).

- **Helicopters.** In the 1960s, helicopter technology had advanced to machines capable of carrying much more than 750 pounds, but the contractor kept costs down by employing several aircraft with that capacity, primarily the Bell Model 47, whose distinctive glass-bubble cockpit first appeared in 1946. Films of the Pipeline construction also show a Bell 204B, the manufacturer’s civilian turboshift helicopter of 1956 introduction that became the Vietnam War military workhorse of the 1960s. And Elling Halvorson (2004) recalled leasing the much larger twin-turboshaft Sikorsky S-61 civilian aircraft, first flown for the U.S. Navy in 1959. The larger machines lifted loads up to 8,000 pounds, and project descriptions imply that these aircraft delivered the Colorado River Bridge’s suspension cables in 1965. They also transported very large machinery into Grand Canyon during the 1968–70 rebuilding (see below) that liberally expanded the Bright Angel Canyon construction zone to the heavily flood-damaged creek bed.

- **Crawler-tractor with rock drill and air compressors.** Halvorson mounted an air-operated 1.5” Atlas-Copco drill on a small Agritrac crawler-tractor, pulling two Athey wagons (rolling on two sets of small crawler tracks, each around two small wheels, to distribute heavy weight along the trail surface) each carrying a gasoline-powered English Holman 85 cubic feet per minute air compressor. Two Atlas-Copco hand-operated jackhammers supplemented the effort. Dynamite charges dropped into lines of drilled holes, 30” deep at 18” intervals, along the trails broke up the bedrock to create the specified 24” wide by 30” deep trench.

- **Crawler-tractor backhoe and front-end loader.** Halvorson acquired an Oliver OC-4 crawler tractor with a 3’-wide front loader, and mounted on the rear a Davis hydraulic backhoe. This compact machine dug out rock debris from the freshly blasted trench and dumped the debris into the rock crusher (see next), which followed the Oliver’s path and re-filled the trench. After Pipeline installation, the OC-4 covered the installed pipe and smoothed the final trail surface. Construction photographs c. 1965 also show an Oliver crawler-tractor with a hydraulically powered clamshell-bucket on the rear.

- **Wheeled rock crusher.** Halvorson commissioned Amelio Mayorga of Flagstaff, Arizona, to design and build a portable rock crusher for the narrow trail. Mayorga assembled his 22’6”-long, 3’-wide machine with a 30-horsepower Wisconsin prime mover and hydraulic pump on a single I-beam frame, hydraulically moved and steered by a Jeep differential on one end and a Chevrolet differential on the other, along an 8’9” wheelbase. Above the frame, he mounted a hydraulically powered
8"x10" crusher under a shaker screen, fed by a conveyor belt independently powered by a small Briggs & Stratton lawnmower-size engine. Mayorga’s contraption crushed 5 cubic yards per hour and produced 1” and smaller gravel for backfilling the Pipeline’s trenches. The resulting large sharp-edged gravel inspired NPS to amend Halvorson’s contract to include wrapping the Pipeline in thick protective felt prior to installation.

- **Trencher.** *Western Construction* (1965) described the step of re-opening the trench, to accept the finished welded Pipeline, as performed by a “David trencher.” This machine is not mentioned or pictured elsewhere, but was likely another small tracked vehicle with another pipeline-industry attachment of a rotary or belted trenching device.

- **Pipe bender.** Halvorson acquired a portable pipe-bending machine made by PEMCO (Pipeliners Equipment Manufacturing Corporation) of Houston, Texas, still inventoried at the Park (in 2015). Its sturdy steel sled supports a hinged pendulum against which the pipe section is bent in increments until the desired angle is achieved. The device rolls on two small sets of Athey-type tracks, pushed by hand or pulled behind any of the contractor’s narrow trail vehicles. Although no longer in use, the machine still has helicopter-sling cables attached, as it did when transported directly to the leak-repair crew for decades after completion of the Pipeline. (The Park now flies broken pipe sections back to its South Rim shop for shaping replacement sections on a larger stationary PEMCO bender that is hydraulically powered.)

- **Portable Welder.** Halvorson employed a small two-man Miller MIG—microwire inert (argon) gas—welder that rode on monorail wheels atop the continuously assembled Pipeline. The machine’s argon gas dispelled incompatible oxygen from each aluminum weld. Halvorson’s crew x-rayed each joint for success, and when tested under pressure at completion only one “slow seeping leak” appeared in the 12.4-mile installation (Grand Canyon National Park Staff 1971).

- **Concrete mixers.** The general contractor and Silver Bridge subcontractor employed portable concrete-mixing machines. Their details are not included in the several written summaries of Pipeline construction, but c. 1965 photographs show during Silver Bridge construction what appeared to be a Koehring Dandie concrete mixer, fed by a Uni-Batch sand screener, loading cement into a large (perhaps Cam-Lever) cam-release bucket. The crew positioned the bucket over foundation framework via the overhead-cable erection system that spanned the river banks.

- **Garden tractors and wagons.** Halvorson bought two small rubber-tired tractors, a John Deere 110 and a Case 100, to haul small trailers that delivered tools and supplies including valve assemblies, dynamite, and concrete to the construction train.

- **Motorcycles.** The contractor introduced 10 “Mighty Burro” scooters, each 8 horsepower on thick rubber tires, made by Angle Lake Cyclery in Seattle to move workers quickly up and down the host trails.

- **Highline, or High Wire/Aerial Tramway, assembly of Silver Bridge.** Subcontractor Construction Erectors Inc. strung temporary steel cables between bluffs on the north and south sides of the Colorado River, higher than the tallest components of the bridge, to move and position components, concrete buckets, and workers.
The suspension bridge for the Colorado River crossing followed an entirely new trail alignment, connecting Phantom Ranch directly with the River Trail on the south bank. The new bridge was about .5 mile downstream (west) of the Kaibab Trail “Black Bridge” that connected the South Kaibab Trail directly with the north since 1928. Kennedy Engineers of San Francisco designed the 522-foot span in 1964, probably under direct contract to WODC. Construction Erectors Inc. of Seattle subcontracted to Halvorson Inc. and Lent’s Inc. to erect the complicated span. As noted above, Halvorson leased a heavy-lift helicopter to carry the bridge’s suspension cables to the Phantom Ranch staging area, considered the heaviest single loads of the entire project. When finished, the bridge’s bright galvanized steel components brought the lasting nickname “Silver Bridge,” the most visible, expensive, and complicated component of the Transcanyon Water Line (Grand Canyon National Park Staff 1971, Johnson and Johnson 1980, Halvorson 2004).

1966 FLOOD AND 1968–70 REBUILDING

As the project neared completion in December 1966, an unusually wet storm made its way over Northern Arizona and the Grand Canyon, bringing heavy rains to the North Rim for three days. By the end of the storm, the area had received some 15 inches of precipitation that resulted in massive flooding along Bright Angel Creek. At least 40 percent of the pipeline was destroyed including 5 miles of North Kaibab Trail and several of its bridges spanning Bright Angel Creek. The contractor lost all his construction equipment. The flood severely damaged or destroyed Park facilities, including the North Rim’s 1928 pumphouse below Roaring Springs, and USGS buildings at and near Phantom Ranch. Elling Halvorson suffered serious injuries while surveying the damage to the project, when the helicopter he was riding in stuck a wire at the Phantom Ranch heliport and crashed (Halvorson 2004).

Because NPS had designed and staked the path of the pipeline, the contractors believed the Park was entirely responsible for damage to the line. NPS, on the other hand, felt since the project was still in its construction phase, the contractor held responsibility to repair the line. Following legal wrangling the two parties came to an agreement in early 1968, and construction resumed in August with an additional $1.6 million NPS infusion that rebuilt and completed the Pipeline.

For the rebuilding, NPS allowed the contractor to import much heavier equipment for repairing and finishing the Pipeline. Halvorson and the Park brought in a Caterpillar D-7 bulldozer; a Lull front-end loader mounted on wheeled tractor; 3 John Deere crawler-tractors each with backhoe and loader; several dump trucks and 10 Army-surplus pickup trucks; and large trailer-mounted air compressors (Grand Canyon National Park Staff 1971).

As rebuilt between full resumption of work in August 1968 and completion in July 1970, the Pipeline retained its general statistics of length and capacity. It changed in design with several additions and upgrades to the water delivery system, primarily with the shifted alignment of North Kaibab Trail away and at a higher elevation from Bright Angel Creek (Grand Canyon National Park Staff 1971; WODC 1971):
Construction of a new 102-foot-long North Kaibab Trail and Pipeline through-truss bridge of Corten (self-oxidizing copper-alloy) steel at the Roaring Springs development, on the newly carved channel of Bright Angel Creek below its confluence with Roaring Springs Creek, near the former 1928 Pumphouse. This 1969 span is “Bridge No. 1” in this document, following the water-direction, north-to-south Pipeline structure and auxiliary resources descriptions.

Relocation and rebuilding of the Pipeline, its control-valve system, and North Kaibab Trail at locations washed away by the flood. In most cases in the broader canyon around Cottonwood Campground and in the canyon’s Box, the trail and Pipeline co-location moved several feet up and away from Bright Angel Creek wherever possible. NPS consequently moved Cottonwood Campground campsites higher in the floodplain as well.

“Undercutting” of cliff faces in the Box to create a new, higher ledge for the trail and Pipeline. Swauger Contractors of Evanston, Wyoming, performed this work.

Construction of many new mortared stone and dry-laid riprap retaining walls along North Kaibab Trail, resulting from rebuilding the trail and Pipeline co-location and raising some of its elevations.

Replacing and rebuilding the four bridges in the Box—in this document, Bridge Nos. 2 through 5. Bridge No. 2 is a Corten steel, bolted angle-stock, pony truss, 80 feet long. Bridge No. 3 is constructed of original aluminum girders, but raised and lengthened to 94 feet with girders and parts from other damaged bridges. Bridge No. 4 is a Corten steel, bolted angle-stock, pony truss, 60 feet long. Bridge No. 5 is the original at its location, constructed of aluminum girders 75 feet long, but raised 6 feet above the original position (WODC 1971).

The “lower” bridge at Bright Angel Campground in Phantom Ranch, an aluminum-girder span installed in 1966 on 1936 stone abutments, remained in place and is here designated the Transcanyon Water Line’s Bridge No. 6. The Colorado River suspension span, here designated Bridge No. 7, was not damaged in the 1966 or subsequent floods.

NPS engineers conducted the final Transcanyon Water Line inspection on July 24, 1970, and the Park dedicated the Pipeline in a ceremony the following day (Grand Canyon National Park Staff 1971). The late 1960s contract change orders and rebuilding thus brought the total project cost in 1970 to about $5 million, adjusted for inflation more than $30 million in 2015 (Bureau of Labor Statistics 2015).

IMPROVEMENTS / 1972–86

Beginning year-round service in July 1970, the Transcanyon Water Line moved a typical maximum of 450,000 gallons per day from Roaring Springs to the South Rim via Indian Garden. The Park’s operations staff developed an understanding of its character, and soon learned that occasional leaks occurred typically at welded joints and in the dense series of pipe bends through the Box (HDR 2014).

Staff observation of the line also revealed pipe deterioration at joints of aluminum with cast iron; in soils reacting chemically with the aluminum pipe; and through damaging cathodic
charges where a buried 12kv electrical line ran parallel to the Pipeline from Indian Garden north to Phantom Ranch. The Pipeline’s original PVC-tape wrap and magnesium anodes proved inadequate to combat such corrosive attacks on the aluminum. In January 1972 NPS awarded a contract to Slavin and Shafer Inc. to replace all insulated couplings between cast-iron valves and the aluminum pipe, and to install a low-electrical-charge Cathodic Protection system for the Pipeline. The work included “band stations on all valves, 16 anode stations, and 22 test stations,” completed in one month by mid-February 1972 (Grand Canyon National Park 1972). 

Another early lesson learned from daily Transcanyon Water Line operation led to placement of a full time system manager or ranger at Roaring Springs. Denver Service Center (DSC) designer Rudy B. Labato drafted the new wood-frame 33’x48’ Roaring Springs “Quarters” in 1977. When NPS built the new Quarters in 1979, it demolished the old operator’s house that had accompanied the 1928 Pumphouse but survived the 1966 flood. The Park continued to use the operator’s dwelling as a seasonal ranger residence after 2005 when Transcanyon Water Line operator Bruce Aiken retired (Aiken 2005).

Also in 1977 Lobato designed a new Roaring Springs Pumphouse, built in 1979 below the Cave and near the temporary Transcanyon Pipeline chlorination station. The resulting fireproof building houses permanent pumps for the North Rim, and chlorination piping for both the North Rim and Transcanyon lines. The building is strictly utilitarian but is tucked into the Roaring Springs Canyon wall mostly hidden from North Kaibab Trail hikers. Its 24’x56’ foundation supports 2 pumps and the chlorination room, behind walls of 4’x10’ vertical concrete panels. The split-gable roof on steel (as designed; possibly built with wood) trusses creates a clerestory panel of windows and vents into the work space; cedar roof shakes help the building blend into the landscape. During the Pumphouse project, in 1979 the Park installed outside Roaring Springs Cave a lockable entry door and surrounding panels of steel bars (Denver Service Center 1977).

The Plateau Point Reroute in 1986 replaced the entire vertical section of aluminum pipe from the Colorado River’s south bank up to Plateau Point with about 1,500 feet of 8” steel pipe. The “reroute” for this Pipeline section followed generally the original path, but partly buried the line in natural scree near the bottom of the canyon wall, carried it across two deep ravines with two steel box-trusses—in this document designated as Bridge Nos. 8 and 9—and delivered it to the Plateau Point summit partly underground and hidden from view at the popular public overlook (HDR 2014; McLaughlin Water Engineers 1986).

Also in 1986 the Denver Service Center, assisted by consulting electrical and water engineers, drafted extensive refitting of both Indian Garden Pumphouses (McLaughlin Water Engineers 1985). The 1932 stone-finished South Pumphouse received a new 750 horsepower, 650 gallons per minute (gpm), electric pump dubbed Pump #3 following the 1966 Pump #s 1 and 2—each 600 hp, 550 gpm—next door. The 1966 North Pumphouse, originally textured in tan-painted stucco, received a stone-veneer finish on its east, north, and west elevations for sound-proofing and NPS-Rustic revival styling to blend better with the adjacent 1932 building. Both buildings received additional sound proofing on their interiors with fiberglass under metal panels (McLaughlin Water Engineers 1985).
Part II. Structural/Design Information

A. General Statement:

1. Dates of construction: 1965–86

B. Description:

The Transcanyon Water Line, designed, installed, and improved between 1963 and 1986 in Grand Canyon to carry the National Park’s main water supply from the North Rim to the South Rim, is approximately 12.4 miles in length from Roaring Springs south to Indian Garden. The Pipeline begins below the North Rim with water-collection facilities inside the natural spring source of Roaring Springs Cave at an elevation of 5,200 feet, and moves chlorinated water by gravity south and down Bright Angel Canyon, across the Colorado River, and up to Indian Garden at an elevation of 3,767 feet. As constructed, aluminum extruded pipe of 6-inch and 8-inch diameters, and typically 50-foot lengths, formed the original continuous conduit through welded connections and various cast iron valves spaced for regulating functions along the Pipeline. Built with an internal pressure maximum of 2000 pounds per square inch (psi), the still-functioning (in 2015) Pipeline normally sustains 1210 psi at its lowest point at the Colorado River crossing, and delivers 650 to 700 gallons per minute (gpm) to the two Pumphouses (built in 1932 and 1966) and adjacent 15,000-gallon Sedimentation Tank (built in 1932) in the Indian Garden day use area. From Indian Garden about 500,000 gallons per day—during strategic time to minimize pump-noise disturbance of visitors—are pumped to storage tanks that supply South Rim Village and other Park facilities.

Materials and their Dimensions

The Transcanyon Water Line is composed of a number of materials, most chosen for their light weights and small sizes that could be transported into Grand Canyon by helicopters with maximum lifts of 750 pounds per load (most details below from Grand Canyon National Park Staff 1971):

- **Extruded aluminum-alloy pipe**, originally about 7 miles of 6” diameter and about 5.5 miles of 8” diameter, based on Pipeline locations of geography and Demand Points (valves for local use such as Cottonwood Campground and Phantom Ranch). The pipe arrived by truck at the South Rim’s Yaki Point staging lot in 40’ and 50’ lengths from the Reynolds Metals Company plant in west Phoenix, Arizona. Helicopters then transported the pipes two at a load, suspended under the aircraft by slings that held the pipes securely under tension with quickly attached and detached end-caps. The contractor bent and welded the pipe along its course, then wrapped the pipe with two layers of 10-mil polyvinyl chloride (PVC) tape for cathodic protection. To protect the pipe and ensure no breaks in the tape, NPS instructed the contractor to wrap the continuous assembly with “American Sisal-Craft” asphalt
paper. Film of construction shows this thick wrap secured onto the pipe with periodic strips of narrow adhesive tape (Halvorson 2004). The contractor replaced North Kaibab Trail sections in the 1968–70 repairs with 8” Reynolds aluminum pipe.

- **Cast-iron valves**, collectively included in specification literature as “appurtenances,” primarily about 90 manual Air Release Valves, and 13 manual Isolation Valves. Designers intended that the Air Release Valves would eliminate air pockets at apex points of the undulating Pipeline, but they proved unnecessary and are not used. Only two major valves—Isolation Valve 445 (at station 445+00) below Cottonwood Campground, and the Drain Valve at station 98+20 below Plateau Point—are in frequent use to halt water delivery during leak repairs.

- **Steel pipe at Roaring Springs Cave and Plateau Point ascent.** For additional strength at the initial vertical drop from the Cave, and possibly because of fire potential in the host canyon, in 1965–66 the contractor replaced the 1928 wood-stave intake pipe first with aluminum, then with 8” steel pipe for the initial flow from the diversion box at the Cave intake. During the 1986 “reroute” of the Colorado River to Plateau Point vertical section, contractors replaced the original 8” aluminum pipe with 8” steel pipe, carried over two deep ravines with steel box trusses, Bridge Nos. 8 and 9.

- **Bridge girders and smaller assembly components of aluminum alloy.** Since the 1965 construction work moved most materials by relatively light-capacity helicopter, the contractor chose aluminum for bridge components of all 5 short spans across Bright Angel Creek at its Colorado River delta and in its host canyon. In early December 1966, all these bridges stood completed as aluminum-girder trail bridges carrying the Pipeline beneath. In the 1968–70 repairs, only Bridge Nos. 3, 5 and 6 remained aluminum.

- **Bridge members of Corten copper-alloy steel.** During the 1968–70 Pipeline rebuilding, requiring longer replacement bridges over Bright Angel Creek in several locations, the contractor assembled two new pony trusses—Bridge Nos. 2 and 4—and one through truss—Bridge No. 1—of bolted angle stock rolled from Corten steel. The material’s surface oxidizes naturally, resulting in a rusty appearance that remains stable under extreme conditions.

- **Colorado River Bridge components of galvanized (zinc-coated) steel.** Extreme conditions of wind and water at the Colorado River crossing dictated Transcanyon Water Line specifications for an extremely durable suspension bridge. The US Steel Corporation fabricated galvanized steel bridge members in small sections for helicopter transport, highline positioning, and bolting assembly, resulting in the 522’-long Silver Bridge. The hot-dip zinc coating of high-strength steel results in a stable surface under extreme conditions, and the somewhat shiny silver-gray appearance of all bridge components.

- **Concrete for bridge abutments and cable anchors** for thrust-stabilization of Pipeline extreme angles, building foundations and walls, and other permanent installations. As critical Pipeline construction materials, reinforcing steel and concrete mix in weight-distributing sacks arrived at the contractor’s construction sites by helicopter. With water, sand, and aggregate abundant in Grand Canyon, the dry concrete mix
depended on local materials for its ultimate applications requiring extreme strength and durability.

- Other “appurtenances,” including pumps. The Pipeline depends on many materials in special configurations for successful operation, from the chlorination piping to the electric-service line to Phantom Ranch, and the complex electrical wiring at the Indian Garden Pumphouses. Panels of Transite—a sturdy and fireproof cement material reinforced with asbestos—completed the 1966 North Pumphouse roof at Indian Garden. The current 3 Indian Garden pumps (specifications above)—consisting of large electric motors coupled to large impeller pumps—are said to follow U.S. Navy marine-pump specifications for installation in capital ships, possibly a result of the Halvorson and Lent’s contractors hailing from Washington towns near the Puget Sound Naval Ship Yard (Tim Jarrell 2014).

The Pipeline as completed in December 1966 contained 41,800 linear feet of 6” pipe and 19,595 linear feet of 8” pipe, laid along the Cross Canyon Corridor using tools, equipment, and methods adapted or invented specifically for the job (see Workmanship in Section 7, and Invention below). NPS construction inspectors described the Pipeline as “extremely crooked,” and estimated that the pipe proceeded through 700 horizontal bends and 1,400 vertical bends along its drop of 2,480 feet in elevation between Roaring Springs and Phantom Ranch, and subsequent gain of 1,500 feet on the way up to Indian Garden. Some 50-foot lengths of pipe, the inspectors noted, “would have a combination of three to six vertical and horizontal bends” (Grand Canyon National Park Staff 1971).

Bright Angel Creek bridges for the Water Line, all designed to complement the host trail and sling the Pipeline beneath, followed two basic designs for the creek’s relatively short spans. Halvorson installed “Type A” aluminum-girder spans with 2'-9½” girder webs, and “Type B” aluminum-girder spans with slightly lighter 2'-1½” girders for shorter spans. Natural-stone veneers hid reinforced-concrete abutments on bedrock. The abutment drawings instructed, “typical rock pattern, stone available at each site shall determine pattern,” in a nod to NPS Rustic styling, a federal standard dating back to the 1920s, and even earlier for concession architects such as the Santa Fe’s Mary E.J. Colter (WODC 1964, Carr 2007).

Dimensions of the Pipeline Alignment

The linear boundary of the Transcanyon Water Line extends from its beginning at Roaring Springs Cave 12.4 miles to its terminus at the two Indian Garden Pumphouses. Based on the 1980 (Johnson and Johnson) boundaries for the recreational trails hosted by the Cross Canyon Corridor Historic District, the mostly buried Pipeline’s boundary is:

- Generally a 100-foot-wide strip, generally 50 feet on each side of host North Kaibab Trail, Colorado River Trail, Plateau Point Trail, and Bright Angel Trail. This width also captures the Pressure Reduction Valves at Roaring Springs Quarters, Cottonwood Campground, and Phantom Ranch; and all bridges including Silver Bridge.
Teri Cleeland (1986) further defined the Cross Canyon Corridor’s boundary by acknowledging four types of trail—and here, Pipeline—characteristics: 1) 50 feet on each side “on flat, open land,” 2) “Natural features less than 50 feet from the trail centerline,” such as cliffs and walls, 3) full canyon widths when 200 feet wide or less, and 4) “On exposed slopes (25 feet beyond turns, encompassing all switchbacks).”

The exceptions to these linear boundary guidelines are, in the direction of the water flow:

- Roaring Springs Cave and Intake Complex, encompassing the Cave entrance and its internal intake structures.
- Pipeline for 650 feet from Cave to Roaring Springs Pumphouse, 50 feet on each side of the vertical pipe.
- Pipeline for 2,300 feet, 50 feet on each side of the generally horizontal pipe (after which the Pipeline enters the North Kaibab Trail’s 100-feet-wide corridor and continues as noted above).
- Pipeline out of the Colorado River Trail between Silver Bridge and Plateau Point, 50 feet on each side of the exposed horizontal pipe along the Colorado River and exposed 1,600 feet of vertical pipe ascending to Plateau Point.
- Indian Garden North and South Pumphouses and the Sedimentation Tank, the buildings’ and structure’s footprints and their leveled platforms, sidewalks, and connecting stairways.

Layout

The two below-rim National Recreation Trails following Bright Angel Fault—North Kaibab and Bright Angel Trails—define the Cross Canyon Corridor for its Park visitors. The trails also host key parts of the Park’s utility system developed by visitor concessionaires and NPS during the 20th century. When NPS planners in 1963 surveyed the Transcanyon Water Line route to bring Roaring Springs water to the much larger year-round population of the South Rim, they chose the Cross Canyon Corridor and its trails themselves as the alignment, and as the disguise, for most of the Pipeline’s distance. Thus, as an industrial fixture the Water Line is part of the Corridor setting at the Pipeline’s occasional locations visible to the public—Roaring Springs Pumphouse, valve-access points in and along the trails, exposed Pipeline along the Colorado River bank, and Indian Garden Pumphouses. The Pipeline is integral with its host trails and shares their settings, through the physical environment as seen by visitors from the trails, and experienced as scenic grandeur preserved in a National Park.

Auxiliary Structures

The Pipeline is associated with auxiliary structures, sites, and buildings: the Pipeline and appurtenances (valves and other controls); Roaring Springs Cave (a site); Roaring Springs Pumphouse (a building housing chlorination equipment for the spring water diverted here to both the North and South Rims); Roaring Springs Quarters (building); Bright Angel Creek Bridge Nos. 1 through 6 between Roaring Springs and the Colorado
These auxiliary resources are part of the National Register of Historic Places district identified for the Transcanyon Water Line property, but they are not individually documented for this HAER report as “structures within a complex.” For clarity of recording the Pipeline for HAER as an engineering structure, only the 12.4-mile welded-pipe assembly is the primary subject of this documentation.

Inventory

Pipeline features are inventoried in the following table. The Park’s location-numbering system for Transcanyon Water Line structures is based on standard engineering stations (100-foot increments, e.g. 0+00 to 1+00) that begin at Indian Garden and proceed north to Roaring Springs, the opposite direction to the flow of water from Roaring Springs to Indian Garden. In the table and throughout this document, Pipeline features are instead identified in the direction of the water, and bridges are given numbers—1 through 9—in the same southerly direction for clarity of describing their positions, dates, designs, and materials. Bridge station numbers are at the approximate center of each structure, with exception of 522-foot-long Silver Bridge, with its beginning and end points noted.

<table>
<thead>
<tr>
<th>Feature / Location (beginning to end/north to south)</th>
<th>Station Number/c. Length</th>
<th>Date Installed</th>
<th>Description, Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roaring Springs Cave Intake Complex</td>
<td>654+52</td>
<td>1928; 1966; 1979</td>
<td>Isolation dams rebuilt annually with spring snowmelt; locked entry installed 1979.</td>
</tr>
<tr>
<td>12” Steel Pipe transitioning at a Diversion Box to 8” Aluminum Pipe</td>
<td>650 feet (approximate length between stations)</td>
<td>1966</td>
<td>Exposed on canyon wall; 8” pipe replaced after campfire damage during construction.</td>
</tr>
<tr>
<td>8” Aluminum Pipe</td>
<td>3,210 feet</td>
<td>1966</td>
<td>First 2,300 feet above grade; balance under North Kaibab Trail.</td>
</tr>
<tr>
<td>Roaring Springs Quarters</td>
<td>616+25</td>
<td>1979</td>
<td>Replaced 1928 pumphouse quarters; demand point: pressure reduction valve.</td>
</tr>
<tr>
<td>Feature / Location</td>
<td>Station Number / c. Length</td>
<td>Date Installed</td>
<td>Description, Comments</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-----------------------------</td>
<td>----------------</td>
<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8” Aluminum Pipe</td>
<td>1,200 feet</td>
<td>1966</td>
<td>Under North Kaibab Trail</td>
</tr>
<tr>
<td>Bridge No. 1: Steel-angles polygonal through truss</td>
<td>613+50</td>
<td>1969</td>
<td>102 feet; replacement bridge after 1966 flood.</td>
</tr>
<tr>
<td>8” Aluminum Pipe</td>
<td>6,950 feet</td>
<td>1969</td>
<td>Under Bright Angel Trail; includes isolation valve at Station 554+97.</td>
</tr>
<tr>
<td>Valve Box at Cottonwood Campground</td>
<td>542+58</td>
<td>1969</td>
<td>Demand point: pressure reduction valve; also drain valve.</td>
</tr>
<tr>
<td>8” Aluminum Pipe</td>
<td>8,265 feet</td>
<td>1969</td>
<td>Replaced after 1966 flood; under North Kaibab Trail.</td>
</tr>
<tr>
<td>6” Aluminum Pipe</td>
<td>2,765 feet</td>
<td>1966</td>
<td>Reused after 1966 flood; under North Kaibab Trail.</td>
</tr>
<tr>
<td>Isolation Valve 445</td>
<td>445+00</td>
<td>1966</td>
<td>Drains the system during leak repairs in the “box.”</td>
</tr>
<tr>
<td>6” Aluminum Pipe</td>
<td>7,675 feet</td>
<td>1966</td>
<td>Reused after 1966 flood; under North Kaibab Trail; built-up trail and “bog bridge” crossing of wetland (c. 2005).</td>
</tr>
<tr>
<td>6” Aluminum Pipe</td>
<td>2,330 feet</td>
<td>1966</td>
<td>Reused after 1966 flood; under North Kaibab Trail.</td>
</tr>
<tr>
<td>Bridge No. 3: Aluminum girders</td>
<td>344+32</td>
<td>1966, 1969</td>
<td>94 feet; extended with parts from other bridges damaged in 1966 flood.</td>
</tr>
<tr>
<td>6” Aluminum Pipe</td>
<td>9,080 feet</td>
<td>1966</td>
<td>Reused after 1966 flood; under North Kaibab Trail.</td>
</tr>
<tr>
<td>Bridge No. 4: Steel-angles pony truss</td>
<td>242+36</td>
<td>1969</td>
<td>Replacement after 1966 flood.</td>
</tr>
<tr>
<td>6” Aluminum Pipe</td>
<td>1,300 feet</td>
<td>1966</td>
<td>Reused after 1966 flood; under North Kaibab Trail.</td>
</tr>
<tr>
<td>Bridge No. 5: Aluminum girders</td>
<td>229+42</td>
<td>1966, 1968</td>
<td>78 feet; original span raised 6 feet, per drawings.</td>
</tr>
<tr>
<td>6” Aluminum Pipe</td>
<td>4,000 feet</td>
<td>1966</td>
<td>Reused after 1966 flood; under North Kaibab Trail.</td>
</tr>
<tr>
<td>Valve Box at Phantom Ranch Dining Hall</td>
<td>189+21</td>
<td>1966</td>
<td>Demand point: pressure reduction valve.</td>
</tr>
<tr>
<td>6” Aluminum Pipe</td>
<td>2,795 feet</td>
<td>1966</td>
<td>Original installation, under North Kaibab Trail.</td>
</tr>
<tr>
<td>Feature / Location (beginning to end/ north to south)</td>
<td>Station Number/ c. Length</td>
<td>Date Installed</td>
<td>Description, Comments</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>---------------------------</td>
<td>----------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Bridge No. 6: Aluminum girders</td>
<td>162+75</td>
<td>1966</td>
<td>54 feet, replaced 1936 CCC bridge on original stone abutments.</td>
</tr>
<tr>
<td>6&quot; Aluminum Pipe</td>
<td>220 feet</td>
<td>1966</td>
<td>Original installation, under North Kaibab Trail.</td>
</tr>
<tr>
<td>Valve Box at River Ranger Residence</td>
<td>160+64</td>
<td>1966</td>
<td>Demand point: pressure reduction valve.</td>
</tr>
<tr>
<td>6&quot; Aluminum Pipe</td>
<td>550 feet</td>
<td>1966</td>
<td>Original installation, buried under NPS corral and trail.</td>
</tr>
<tr>
<td>Silver Bridge (Colorado River Bridge; Bridge No. 7)</td>
<td>154+40~ 159+41 (520 feet)</td>
<td>1966</td>
<td>Pipeline suspended under bridge.</td>
</tr>
<tr>
<td>6&quot; Aluminum Pipe</td>
<td>5,075 feet</td>
<td>1966</td>
<td>Partly exposed along south bank, partly in sandbar, partly under River Trail.</td>
</tr>
<tr>
<td>Pipe Creek Crossing</td>
<td>98+04</td>
<td>1966</td>
<td>Armored with mortared stone across creek at grade.</td>
</tr>
<tr>
<td>6&quot; Aluminum Pipe</td>
<td>1,570 feet</td>
<td>1966</td>
<td>Partly buried in rock, partly at grade; off River Trail; drain valve at 98+20.</td>
</tr>
<tr>
<td>Bridge No. 8: Steel-angles box truss</td>
<td>c. 88+28</td>
<td>1986</td>
<td>Part of 1986 Plateau Point Reroute; off trails.</td>
</tr>
<tr>
<td>8&quot; Steel Pipe</td>
<td>335 feet</td>
<td>1986</td>
<td>At grade; off trails.</td>
</tr>
<tr>
<td>Bridge No. 9: Steel-angles box truss</td>
<td>c. 82+22</td>
<td>1986</td>
<td>Part of 1986 Plateau Point Reroute; off trails.</td>
</tr>
<tr>
<td>8&quot; Steel Pipe</td>
<td>620 feet</td>
<td>1986</td>
<td>Attached to canyon wall; replaced original in 1986.</td>
</tr>
<tr>
<td>Garden Creek Crossing</td>
<td>23+60</td>
<td>1966</td>
<td>Partly exposed pipe.</td>
</tr>
<tr>
<td>North Pump House at Indian Garden Campground</td>
<td>0+00</td>
<td>1966; 1986</td>
<td>Pumps #1 and #2; 3 exterior walls clad in stone 1986.</td>
</tr>
<tr>
<td>South Pump House</td>
<td>0+00.19</td>
<td>1932; 1986</td>
<td>Interior rebuilt 1986 with new Pump #3.</td>
</tr>
<tr>
<td>Sedimentation Tank</td>
<td>1932</td>
<td></td>
<td>Stages water from pipeline and pumps, for delivery to South Rim.</td>
</tr>
</tbody>
</table>
C. Mechanicals/Operation:

At 5,200 feet above sea level, Roaring Springs Cave’s water-intake complex—first developed in 1928 for the North Rim’s water system—collects water inside the cave behind 5 small rock dams. The dams are built on redwood-plank cores and placed at strategic points along the cave’s natural channels. The Cave’s average flow of 5.8 million gpd is more than sufficient to divert about 17 percent—up to 1 million gpd—into two intake pipes that converge into a 12” diameter steel pipe that exits the West Cave entrance and commences the Transcanyon Water Line, beginning at station 654+52. Some of this maximum diversion goes to the North Rim in summer months; South Rim actually accepts up to 500,000 gpd because the Indian Garden pumps run only about 12 hours per day. The balance of spring water free-flows out the East Cave entrance and drops as a waterfall to Roaring Springs Creek below. The West Cave’s 12” steel pipe enters a Diversion Box on the cliff below, and then flows into the first length of 8” diameter steel pipe that guides the water almost vertically down to Roaring Springs Creek (Denver Service Center 1989).

As completed in December 1966, the Transcanyon Water Line passed through a new 8’x8’ prefabricated Chlorination Building on Roaring Springs Creek, and proceeded south along the creek past the 1928 stone Roaring Springs Pumphouse (not extant). The Pumphouse, acquired in 1965 by the National Park Service from the Utah Parks Company subsidiary of the Union Pacific Railroad, pumped Roaring Springs’ local supply northwest and up about 3,800 feet to visitor facilities on the North Rim (Anderson 2000). A contractor built the DSC-designed Roaring Springs Pumphouse in 1979 to replace the temporary chlorination and North-Rim pumping facilities with permanent fixtures (see IMPROVEMENTS/1972–86 above).

The Transcanyon Water Line continues to move water under gravity flow south of the Pumphouse along Roaring Springs Creek to Bright Angel Creek, and within its specified 24”x30” trench under the North Kaibab Trail. Both trail and Pipeline in 1966 meandered very close to Bright Angel Creek along its east bank for about 4 miles through Cottonwood Campground, location of a Demand Point valve, approaching the narrow Bright Angel Canyon’s “Box” cut through its dense 2-billion-year-old Vishnu Schist. In the Box, the trail and Pipeline first crossed to the west side of the creek via the “Fourth Bright Angel Creek Crossing North of Phantom Ranch” at station 356+85 (a measurement from the Pipeline’s original description from south to north in the opposite direction of its water) (Western Office of Design and Construction 1964). The trail and Pipeline proceed south through the Box and across three more bridges that shift the route back and forth across the creek, and finally to Bright Angel Creek’s east bank upon entering Phantom Ranch. The Pipeline’s general contractor replaced and rebuilt much of the Bright Angel Creek Pipeline and these bridges following the December 1966 flood (see 1966 FLOOD AND 1968–70 REBUILDING above).

At the Phantom Ranch Dining Hall, station 189+21, a Pressure Reduction Valve steps the Transcanyon Pipeline pressure from about 1200 psi down to 60 psi and delivers water to Phantom Ranch visitor and staff facilities through local plumbing along Bright
Angel Creek. The Pipeline trench also accommodates Phantom Ranch’s 12kv electrical service in a buried cable, installed by the Pipeline contractor in 1965, running parallel to the Pipeline from Indian Garden 3.5 miles south. The Pipeline and trail cross the final Bright Angel Creek span—part of the Civilian Conservation Corps (CCC) Rock House Bridge or “lower bridge” first built in 1936 and heavily damaged through flooding in the 1950s—over the creek to its west (south) bank at the lower end of Bright Angel Campground. A few feet south of the bridge is a Pressure Reduction Valve at station 160+64 where the Pipeline provides water to the River Ranger Station (former Packer Cabin). While the trail connection diverts around the National Park Service Corral near the river, the Pipeline is buried under the mule corral and rejoins the trail about 270 feet from the Colorado River Bridge (Anderson et al. 1997).

Under at least 1210 psi at its lowest point on the river approach—2,445 feet elevation—the Pipeline advances to saddles beneath the 522-foot-long Colorado River “Silver Bridge,” built in 1966 as part of the Pipeline contract, and exits onto the river’s south bank sandbar. The Colorado River Bridge, built of galvanized steel and dubbed Silver Bridge shortly after its construction, is a 522 feet long wire-cable suspension bridge. The towers on each river bank are 61 feet tall, assembled of short 13’x16’ bracing members delivered by helicopter and bolted together on site. The bridge’s suspended pony truss is a bolted linear assembly of 28 3-dimensional panels, each 4’1½”x9’ wide at the base and 6’6”x9’ on each side. The deck is open-grid, flanked by protective chain-link fencing fixed to the pony truss panel sides, all of galvanized steel. Saddles securing the Transcanyon Water Line to the base of the pony truss are assembled of bent angle-stock bolted to the truss-panel frames (Western Office of Design and Construction 1964).

The Pipeline continues west in 6” aluminum pipe secured with surface anchors along the Colorado River sandbar, then buried in the sandbar, then joins the River Trail in a trench to Pipe Creek at station 98+04. Leaving the trail and buried under Pipe Creek (Photograph 12), the pipeline moves several hundred feet west along the river bank, then turns at a right angle south and up the canyon wall, rising some 1,600 feet to Plateau Point (Photograph 13). A contractor replaced and rebuilt much of the Plateau Point vertical Pipeline in 1986 (see IMPROVEMENTS / 1972–86 above). Special hangers attached to the dense wall of Zoroaster granite and Tapeats sandstone grip the pipe with wire-mesh sleeves to distribute the vertical stresses of weight and calculated flexing (Western Office of Design and Construction 1964).

At 3,802 feet elevation, the Pipeline enters the standard 24”x30” trench in Plateau Point Trail, passes under Garden Creek and into a trench under Bright Angel Trail, and terminates with 1000 psi at Indian Garden pumping facilities, 3,767 feet above sea level. With installation of upgraded electrical service in 1966 at Indian Garden through an above-ground transmission line from the South Rim, the Transcanyon Water Line contract included laying the 12kv electrical cable noted above, in the Pipeline’s path north 3.5 miles to Phantom Ranch for that area’s own upgraded electrical service (Grand Canyon National Park Staff 1971).
Installed in 1966 inside the new “North Pumphouse” building, new Transcanyon Pump #s 1 and 2 work in tandem with the existing pump inside the renamed “South Pumphouse” and adjacent Sedimentation Tank, both built in 1932. The 1932 system, built by the Santa Fe Railway and operated by its Park concessionaire partner Fred Harvey Company, originally lifted Indian Garden’s 150,000 daily gallons of Garden Spring water up 3,000 feet to storage tanks at South Rim Village. In 1970 the completed Transcanyon Pipeline’s water replaced the Garden Spring source, and the new pumps more than tripled potable water-delivery capacity to the South Rim, up to 500,000 gallons per day (Grand Canyon National Park Staff 1971). A contractor in 1986 installed a new pump inside the 1932 South Pumphouse, reconfigured the exterior of the 1966 North Pumphouse, and added sound insulation inside both Pumphouses (see IMPROVEMENTS / 1972–86 above).

D. Site Information:

Grand Canyon hosts the west-trending Colorado River, principal drainage of the Colorado Plateau physiographic region of the southwestern United States and northern Arizona. While the canyon’s North Rim is part of the Kaibab Plateau and the opposite, slightly lower South Rim is part of the Coconino Plateau, the two sub-regions are united at a series of geologic faults concentrated around the confluence of Bright Angel Creek and the Colorado River. The longest and straightest of these misalignments is Bright Angel Fault, running southwest to northeast from rim to rim, almost at a right angle to its crossing of the Colorado River. Below the North Rim, Bright Angel Fault created the Colorado River’s side canyon hosting Bright Angel Creek, and below the South Rim the fault resulted in the course of Garden Creek draining into the Colorado River after joining another side canyon draining Pipe Creek. The river and the side canyons have exposed during at least 725 million years of erosion the geologic record of perhaps 1.2 billion years (Grand Canyon Association 2015).

Beginning at the Colorado River’s inner gorge, including entry of Bright Angel and Pipe Creeks, the host Vishnu schist and Zoroaster granite are as old as 2 billion years. Moving up in time and elevation, the Tapeats sandstone, Bright Angel shale, and Muav limestone populate a geologic setting with colors, textures, and density that have emerged through eons of erosion from water, wind, and the roots of hearty vegetation. Above these levels are the varied strata that provide observers with the signature depths and palate of Grand Canyon: Temple Butte Formation, Redwall limestone, Supai Group, Hermit shale, Coconino sandstone, Toroweap Formation, and finally in most parts of the rims’ plateaus, Kaibab limestone (Chronic 1983; HDR 2014).
Part III. Sources of Information

A. Primary Sources:

Aiken, Bruce

Denver Service Center (DSC)


Grand Canyon National Park

Grand Canyon National Park Staff
1971 “Completion Report, Supplemental Water Supply.” Copy from Denver Service Center. This c. March 1971 document describes the Transcanyon Water Line’s original and 1968 specifications, characteristics, change orders, and contract management in non-technical prose. Its author was anonymous, but likely a Park staff member—perhaps O.K. Zimmerman, the NPS project inspector (Western Construction Magazine 1965)—closely associated with the project from 1965 through completion of the Pipeline in 1970.

Halvorson, Elling

McLaughlin Water Engineers

United States Department of the Interior (USDI)

Western Office of Design and Construction (WODC)

B. Secondary Sources:

ancestry.com

Anderson, Michael F.


Anderson, Michael F., and Debra Sutphen
Avery, Ben

Bevis, Kenneth A.

Brennan, Ellen
2013 “Preliminary Determination of Eligibility of the Transcanyon Pipeline, Grand Canyon National Park.” Manuscript initiating the Determination of Eligibility task resulting in this host document.

Bureau of Labor Statistics

Carr, Ethan

Chronic, Halka

Cleeland, Teri

Geiger, Tom

Grand Canyon Association

HDR
John Milner Associates, Inc.

Johnson, Ronald, and Tony Johnson
1980  “Cross Canyon Corridor Historic District.” National Register of Historic Places Registration Form. NPS Denver Service Center. Submitted to the NRHP Keeper for a determination of eligibility for the district.

Logan Simpson Design
2013  “National Park Service, Cultural Landscape Inventory, April 2013, Cross Canyon Corridor Historic District.” Copy available at Grand Canyon Museum Collection.

McClelland, Linda Flint

Papillon

Roberts, Matthew, Charlie Schlinger, and Steve Mead

*Western Construction* Magazine

Wirth, Conrad

Zeman, Amanda
C. Likely Sources Not Yet Investigated:

Oral Histories:

- Elling Halvorson. The 1965–70 general contractor of the Pipeline is living (in 2015), but likely has not been formally interviewed on the engineering aspects of constructing the Transcanyon Water Line.
- Mel Martinez. The retired GRCA maintenance worker specialized in repairs of the Transcanyon Water Line.
- Kelly Confer. This current (in 2015) GRCA maintenance worker is assigned to repairs of the Pipeline.
- Bruce Aiken. The 1972–2005 Roaring Springs water operator and resident is living (in 2015), but likely has not been formally interviewed on the operational details of the Transcanyon Water Line during its first decades of function and upgrades.
- NPS employees who designed the Transcanyon Water Line at Western Office of Design and Construction, and upgrades at Denver Service Center.

Research:

- Mission 66 infrastructure projects’ locations, details, and costs. Extensive scholarship is available on the 1956–66 program’s proliferation of architecture and landscape features, but little has been written on the large percentage of the program’s civil engineering accomplishments such as the Transcanyon Water Line.
Figure 1: Location Map
Figure 2: Appendix, 1971 "As Constructed" Engineering Plans Cover Sheet (WODC 1971).

(See Field Records for Enlarged View)
Figure 3: Appendix, Pipeline Overview, Birdseye from O&M Manual (DSC 1989).

(See Field Records for Enlarged View)
Figure 4: Appendix, Roaring Springs Cave security-gates details, constructed in 1979 (DSC 1977).

(See Field Records for Enlarged View)
Figure 5: Appendix, Pipeline Appurtenances (WODC 1964).

(See Field Records for Enlarged View)
Figure 6: Appendix, Plateau Point details (McLaughlin Water Engineers 1986).

(See Field Records for Enlarged View)
Figure 7: Appendix, Indian Garden Pumphouses, 1966 and 1986 (DSC 1986).

(See Field Records for Enlarged View)