AWWA-PNWS

Abrasive Situation: Rehab and Protection of 21-foot Diameter Raw Water Supply Piping

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Topics

- CAP Overview and Location of Siphons
- Current Practice & Problem Statement
- Life Cycle Cost Analysis
- Multi Criteria Analysis Results
- Recommended Alternative
- LCCA’s
- Next Steps

CAP Overview & Locations of Siphons

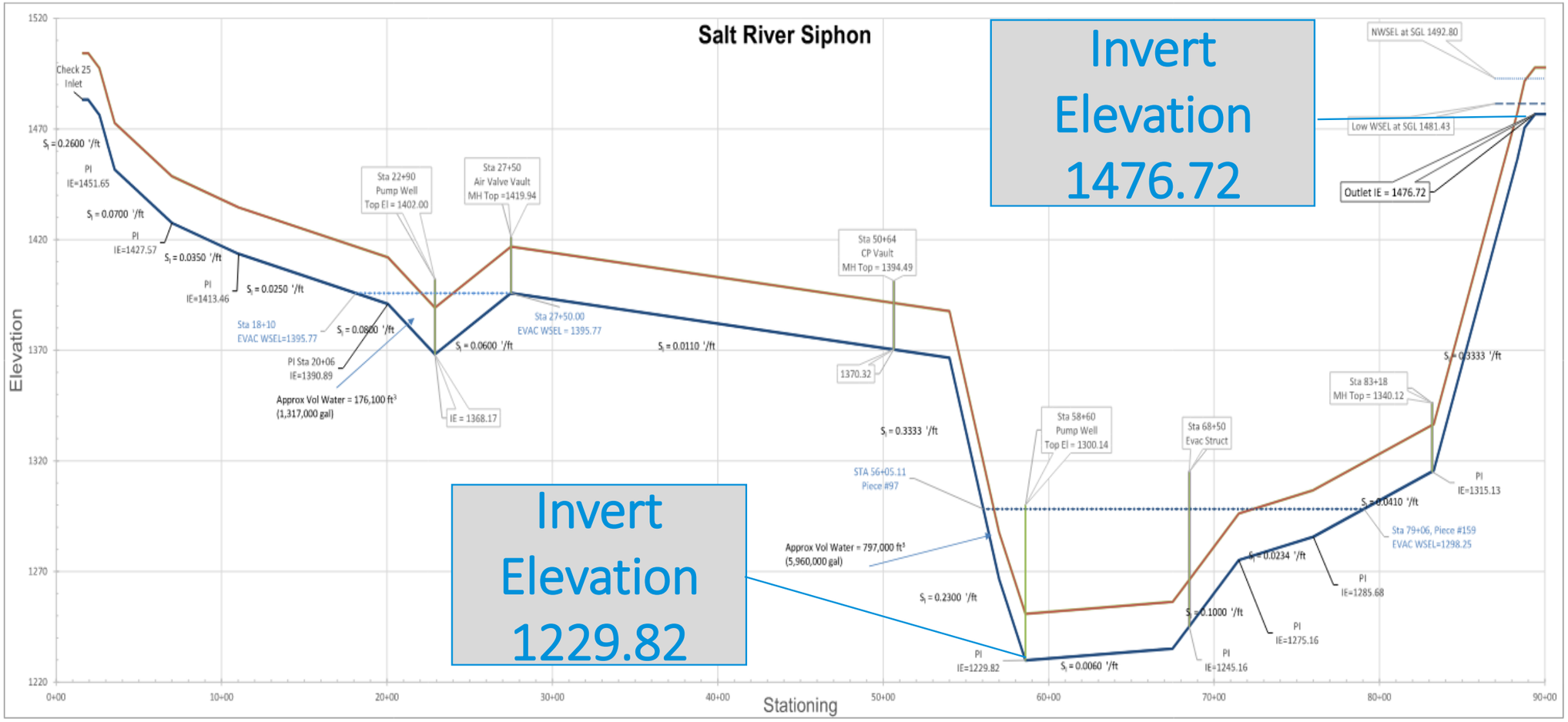
CAP Overview

- 336 miles long
- ~1.5 MAF of water delivered annually in normal year (AZ apportionment is 2.8 MAF)
- Water lifted nearly 3,000 feet through 13 pumping plants
- Municipal, industrial, agricultural, tribal customers
- Serves 3 counties where 80% of population lives
- $4B original construction cost; began in 1973, complete 1993

Locations of Siphons

- 7 siphons
- Agua Fria & Salt River Siphons are the focus of the Study
- 21’ diameter steel pipelines
- Constructed in mid-1990’s to replace pre-stressed concrete pipes
- Each just under 10,000 feet

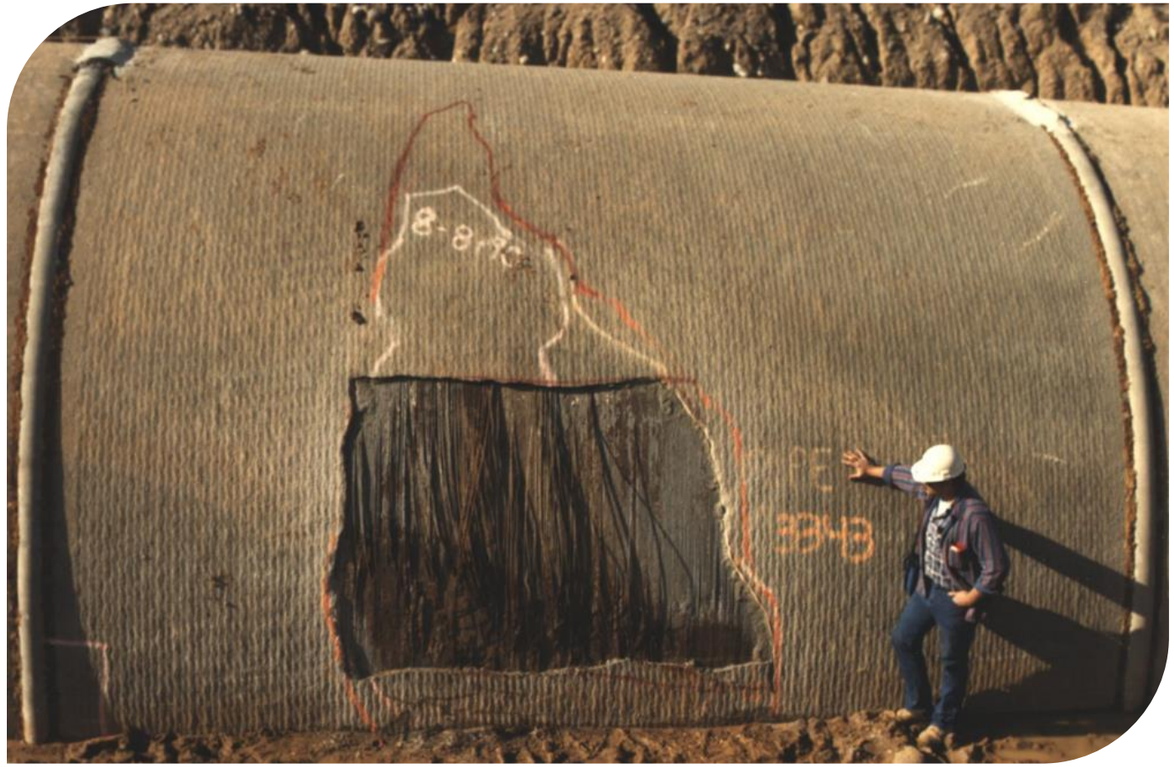
Profile View of Salt River Siphon (SRS)



Current Practice & Problem Statement

Background

- Late 1970's – Prestressed concrete pipelines constructed
- Early 1990's - Decision to replace prestressed concrete pipelines
- Latter 1990's – Current steel pipelines constructed and commissioned
- Late 1990's/Early 2000s – Conducted extensive repairs to the liner
- 2018 – Inspected Steel Pipelines – Found significant loss of liner and corrosion of the substrate
- 2019 – Repairs/replaces liner in <10% of Salt River Siphon ~ $5.5 Million in 6-week outage
    - **Determined to be unsustainable**



Example of Prestressed Concrete Pipe with Corrode Prestressing Wires

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Current Maintenance Strategy

Salt River Siphon (SRS)

- On-line in 1996
- Warranty work 1999
- Extensive repair work to liner in 2001
- 2009 inspection indicated 10 more years before any work necessary
- 2018 inspection revealed extensive damage to liner & substrate

SRS Invert

Interior Coating Failure and Pitted Steel

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Current Maintenance Strategy

Agua Fria River Siphon (AFRS)

- On-line in 1997
- Warranty work 2000
- Extensive repair work to liner in 2003
- 2018 inspection revealed extensive damage to liner & substrate
- No plans to address liner or steel yet

Scaffolding for Inspection

The Problem Statement

- Cost prohibitive and labor intensive to sufficiently repair linings in 6-week allowable outage
- Low capital cost of replacing abandoned PCP pipelines with steel pipelines did not consider full life cycle costs and extensive labor for maintenance
- Seek alternative based upon life cycle cost and ability of CAP labor force to maintain the pipelines

PCP Installation 1979

Photo credit: Joan Rennick -- Citizen

LCCA Alternatives Original Scope of Work

1. Continue with regular, periodic steel pipeline maintenance.

2. Continue using the existing steel siphons and install smaller diameter pipeline(s) to parallel the main steel pipeline to allow for extended outage durations so a larger section of the steel siphon can be repaired during an outage.

3. Complete replacement of the steel pipeline with an equal capacity pipeline requiring less maintenance

CAP Tunnel at Lake Havasu

Photo Credit: Central Arizona Project, Bureau of Reclamation

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LCCA Evaluation – Refined Scope-of-Work

Alternative 1: Continue regular, periodic steel pipeline maintenance – remove pipeline from service and spot repairing or replace as much lining possible during a 6-week outage (3,000 cfs peak flow capacity)

Alternative 2B, Continue using the existing steel siphons but replace the epoxy liner with 6-inch-thick reinforced cement-mortar lining, reducing capacity to ~2,700 cfs.

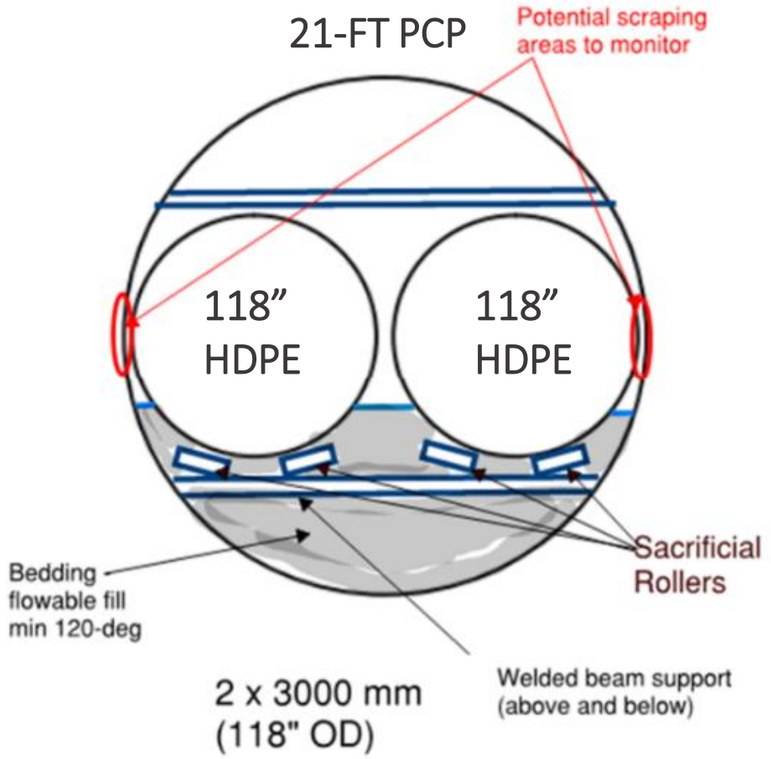
- Install 12-inch-thick structural pressure-rated concrete liner in the abandoned PCP pipeline.

Alternative 3: Construct a new separate monolithic concrete pipeline (MCP) with a capacity of 3,000 cfs to replace the steel siphon pipes.

Alternative and Materials Considered

Other Pipelines/Construction Considered

- **CAP requested the team evaluate – chemical coating option with and without providing a bypass.**
  - Without a bypass – canal could be shut down for 6 weeks every five years.
  - With a bypass of 1,000 cfs the canal could be shutdown up to 16 weeks every 5 years
- **Bypass options**
  - Install a pipe or pipes inside the abandoned PCP
  - Construct a bypass by direct bury (trenching) - ruled out due to excessive excavation and dewatering costs.
- **Consor/Sonoran Alternative**
  - Install structural liner in abandoned PCP
  - 2,000 cfs bypass allowing for eight month canal/steel pipe shut down



Bypass Concept -- Pipes in Existing PCP

Other Pipelines/Construction Considered

- CAP Proposed Coating Options – Existing Steel
  - Epoxies
  - Poly Urea
  - Polyurethane
  - Cement Mortar
- Bypass Pipe Options
  - Monolithic Concrete
  - High Density Polyethylene (HDPE)
  - Fiberglass Reinforced Plastic (Hobas)

Example Piping Lining Application

Other Coatings Considered

- Consor/Sonoran considered:
  - Poly Ureas
  - Polyamides
  - Poly Urethanes
  - Epoxies
  - Abrasion resistant cement mortar
- No chemical coatings had proven track records greater than 30 years
- Cost of the material was almost incidental to installation costs
- CAP chose to keep their current coating (Coal Tar Epoxy) as the chemical coating for evaluation

Example Pipe Lining Shotcrete Application

What is an LCCA?

An Approach that assesses the total cost of an asset over its life cycle including initial Capital Costs, maintenance costs, operating costs, and the asset's potential residual or salvage value at the end of its life.

An infrastructure asset's life cycle, such as a pipeline, can be divided into four stages:

- Planning and Design
- Procurement & Construction
- Operations and Maintenance
- Demolition or Abandonment

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LCCA

100-Year LCCA Summary – Agua Fria and Salt River Siphons

Facility Alternative	Estimated Ownership Costs (LCCA)[1,2]	Total Number of Outages[3]
Alternative 1 – Agua Fria	$688,200,000	62
Alternative 1 – Salt River	$618,665,000	58
Alternative 2B – Agua Fria	$247,202,000	2
Alternative 2B – Salt River	$249,197,000	2
Alternative 3 – Agua Fria	$317,563,000	10
Alternative 3 – Salt River	$346,891,000	10

(1) Rounded to nearest $1,000,000

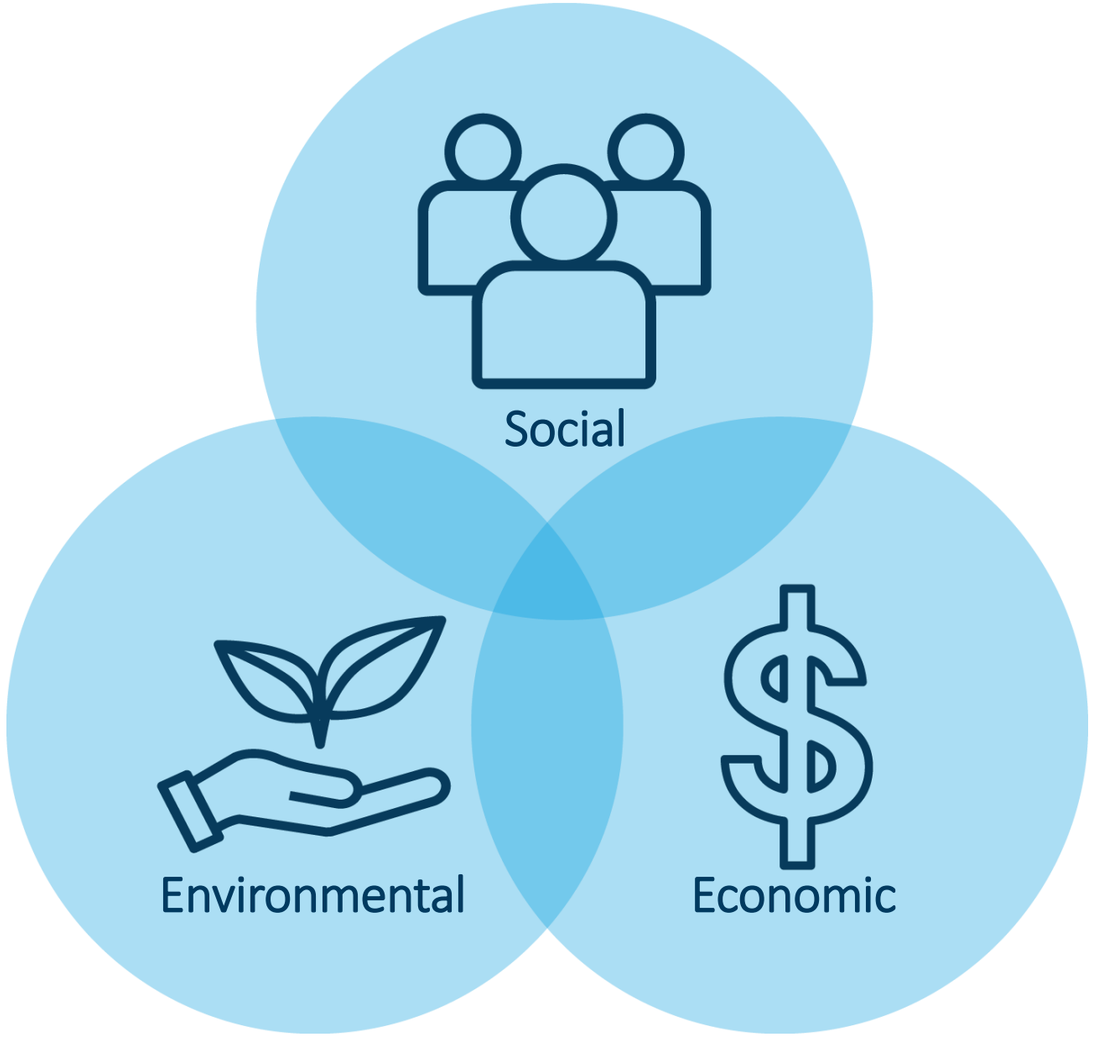
(2) 2022 Dollars

(3) Number of times pipeline dewatered to access interior over 100-year period

Multi-Criteria Analysis Result

Alternatives Evaluation

- Scope included a multi-criteria decision support tool that considers TBL criteria
  - Economic, Social, and Environmental
- Evaluation of criteria that are important but more difficult to quantify than construction costs
- These factors may be more important than overall costs in making the decision
  - Project Planning
  - Constructibility
  - Costs
  - Operations & Resiliency



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Criteria		(A) Criteria Weight (1 - 10)	Alternative 1		Alternative 2		Alternative 3	
			Continue spot repair of steel pipeline		Line Exist PCP with Structural Concrete Lining, Reline Steel Pipeline with Cement Mortar - Monolithic Concrete Bypass connections		Construct a new Monolythic Concrete Pipeline	
			(B) Score (1 - 10)	Weighted Score (1 -100)	(B) Score (1 - 10)	Weighted Score (1 -100)	(B) Score (1 - 10)	Weighted Score (1 - 100)
Project Planning								
P1	Allowable Outages	9	1	9	10	90	9	81
P2	Schedule Risks	6	1	6	10	60	8	48
P3	Outage planning	5	2	10	9	45	8	40
P4	Cost Risks	4	2	8	6	24	8	32
	Project Planning Weighted Score			33		219		201
Constructability								
C1	Safety and Risk Management	8	2	16	6	48	7	56
C2	Tie-ins to Existing Infrastructure	8	10	80	6	48	7	56
C3	Unforeseen Conditions	5	9	45	5	25	4	20
C4	Construction Timelines	7	2	14	5	35	4	28
C5	Utility Coordination	2	10	20	6	12	7	14
	Constructability Weighted Score			175		168		174
Costs								
$1	Material volatility	7	2	14	4	28	3	21
$2	Site Logistics	4	9	36	5	20	5	20
$3	Initial Installation Costs	8	10	80	8	64	4	32
$4	Temporary Infrastructure	5	10	50	6	30	3	15
$5	Maintenance Costs	10	1	10	7	70	10	100
$6	Utilizes assets	9	4	36	10	90	1	9
	Costs Weighted Score			226		302		197
Operations and Resiliency								
R1	Redundancy of Facilities	9	2	18	10	90	2	18
R1	Potential for Future Increased Capacity	9	2	18	10	90	2	18
R1	Operations and Maintenance	8	1	8	7	56	10	80
R1	CAP Labor Intensity (effort)	8	1	8	7	56	10	80
	Operations and Resiliency Weighted Score			52		292		196
(C) **Total Weighted Score**			Opt 1 =	486	Opt 2 =	981	Opt 3 =	768

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Recommended Alternative

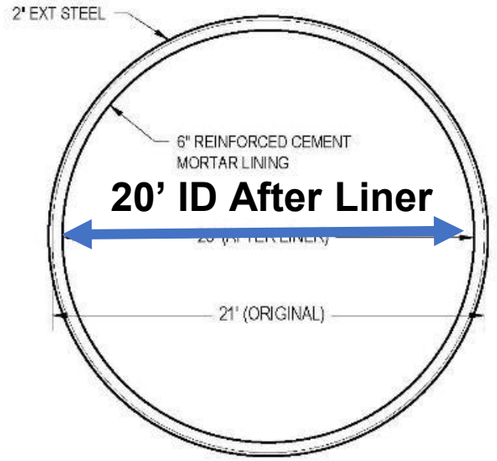
Recommended Alternative: 2B

Existing Steel -- Replace the epoxy liner with a 6-inch-thick concrete liner

Abandoned PCP – reinforce with 12-inch-thick structural concrete liner.

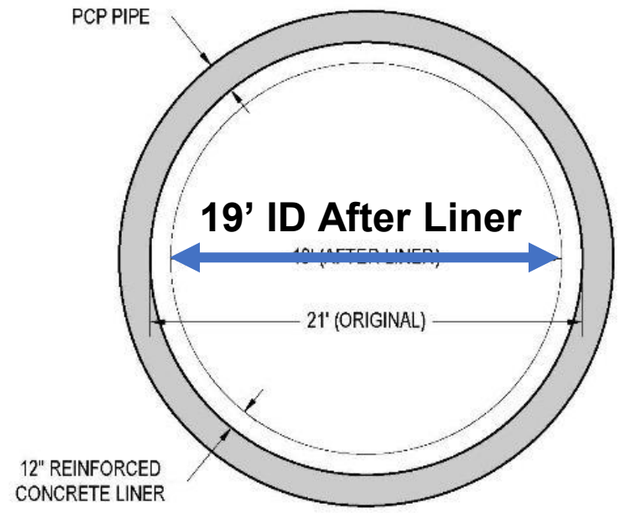
- Provides the lowest cost of ownership over the 100-year evaluation period
- Has the highest score from the decision support evaluation
- Provides redundancy of critical infrastructure

21-FT Steel Pipe



STEEL

21-FT PCP

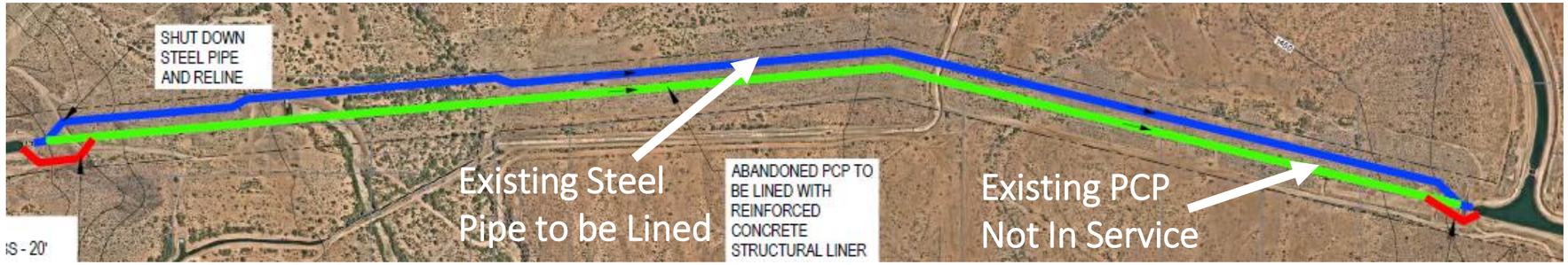


PCP

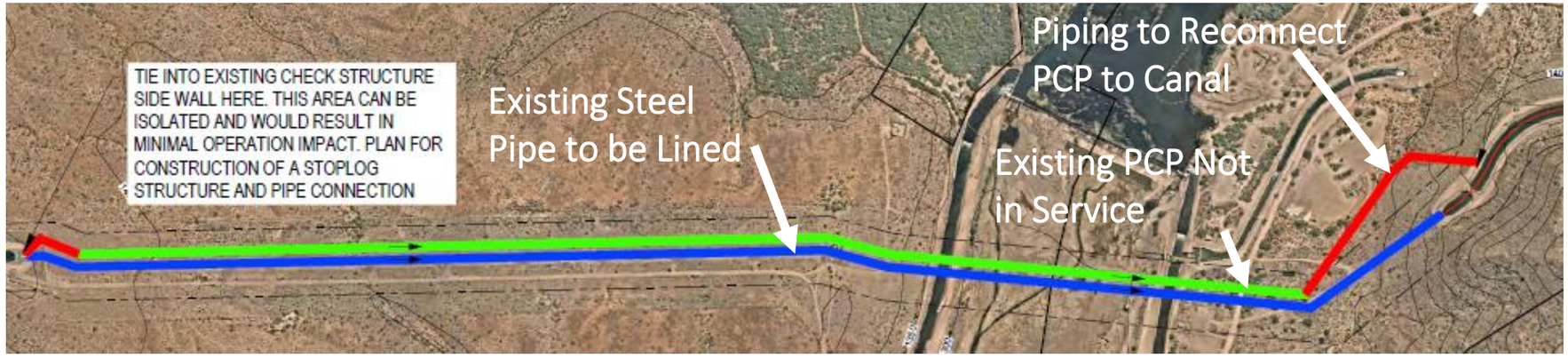
Alternative 1: Continue sport repairs of steel pipelines with epoxy (current Maintenance program)	*486*
Alternative 2B: Install structural concrete liner in PCP for bypass, use monolithic concrete pipelines for canal tie-ins and use cement mortar to line the steel pipelines	*981*
Alternative 3: Construct a new monolithic concrete pipeline	*761*

Alternative 2B
Pipeline Alignments

Salt River Siphon (SRS)

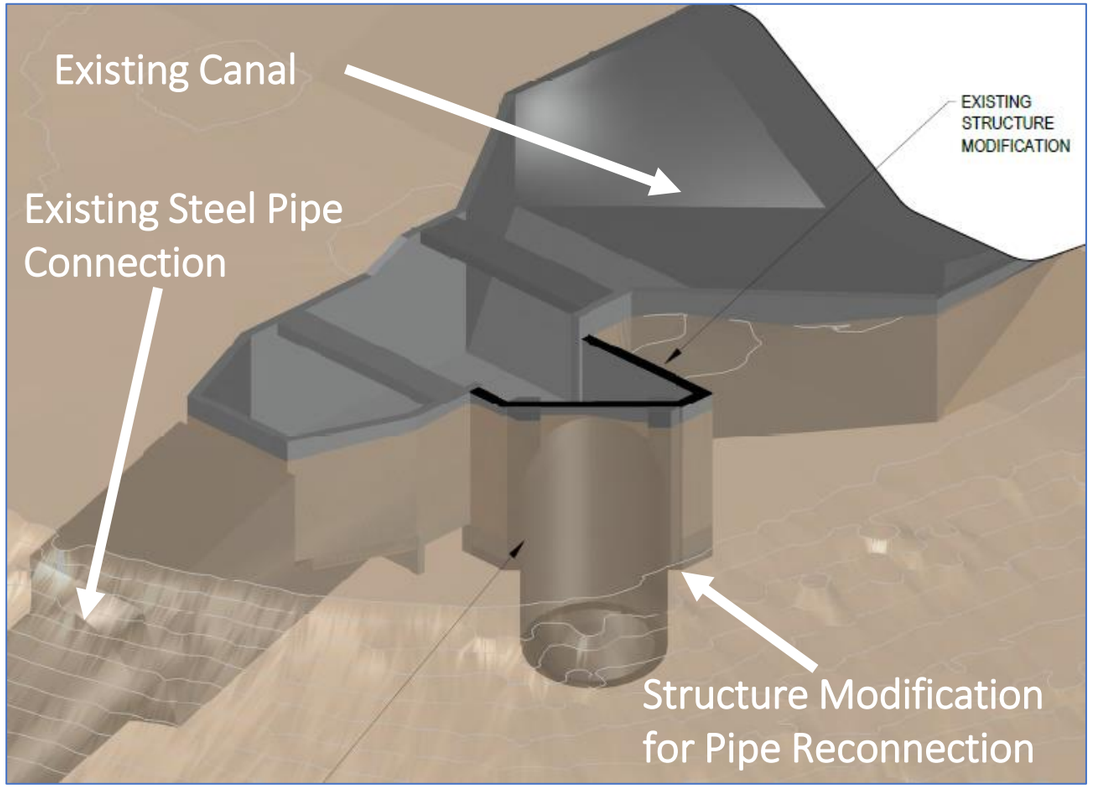


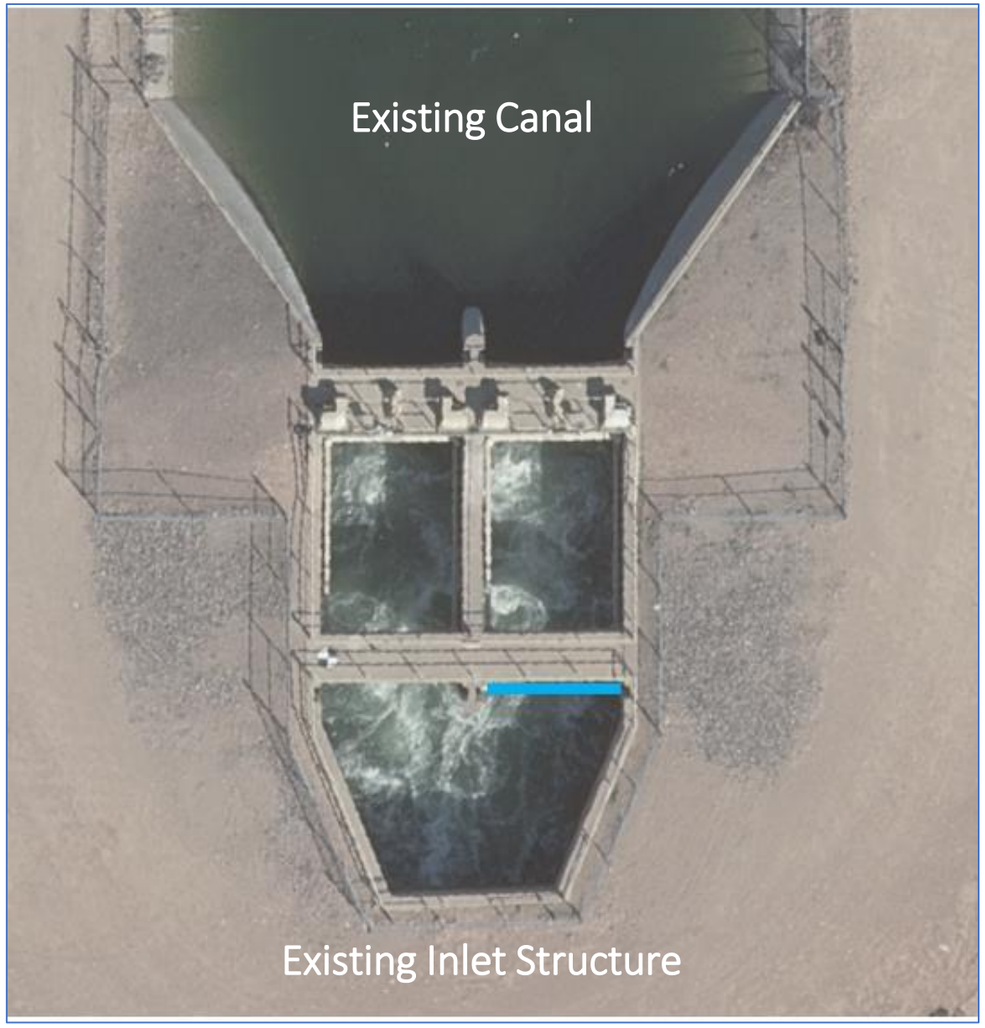
Aqua Fria Siphon



Alternative 2B
Pipeline Connections

Example Inlet:

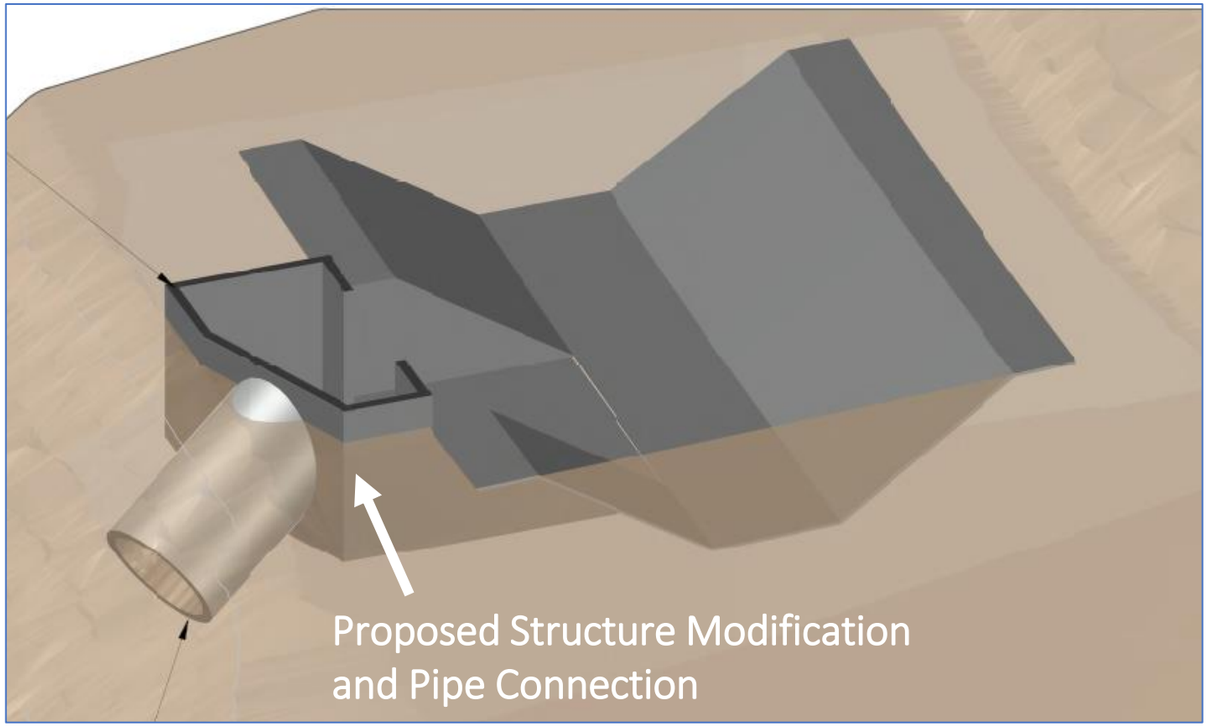




Salt River Siphon (Check Structure 25) Upstream End

Alternative 2B
Pipeline Connections

Example Outlet:



Salt River Siphon Downstream End

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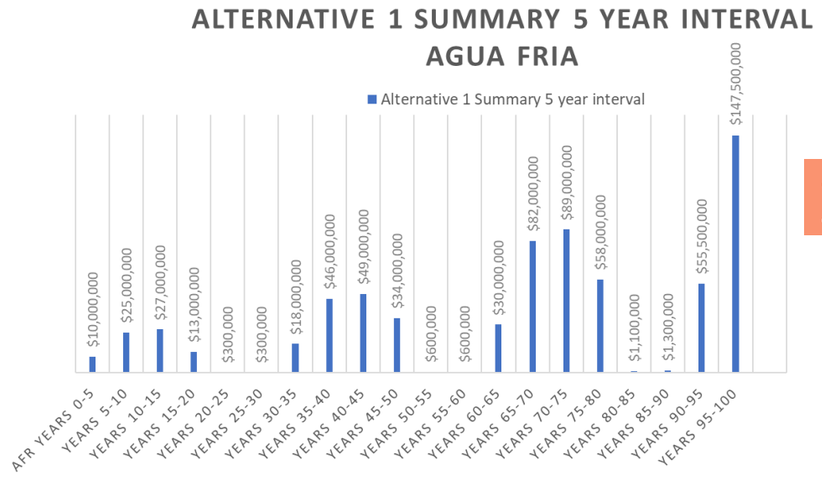
Life Cycle Cost Analysis

LCCA Alternatives

		2022 LCCA
Alt 1	Continue to Reline Agua Fria River Siphon	$688,200,000
Alt 1	Continue to Reline Salt River Siphon	$618,655,000
Alt 2B	**Reline Agua Fria River Siphon & Bypass**	**$247,202,000**
Alt 2B	**Reline Salt River Siphon & Bypass**	**$249,197,000**
Alt 3	Construct New Monolithic Concrete - Agua Fria River	$317,563,000
Alt 3	Construct New Monolithic Concrete - Salt River	$346,891,000

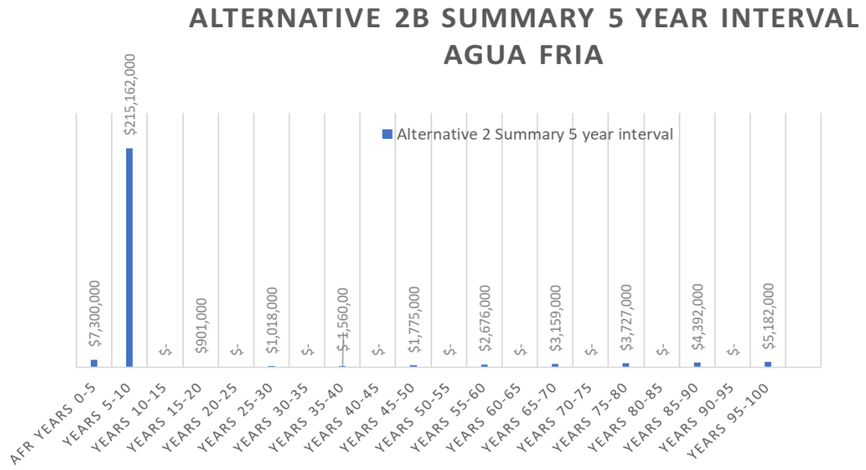
2022 LCCA
5% Inflation Rate & 3% Discount Rate
Used current concrete construction costs of $2,000 yd^3 – difference is ~$120,000,000
Evaluated Bypass options
Evaluated cement-mortar lining
Used $110/gal for epoxy

Cash Flow Comparison: Agua Fria River Siphon



∑ $688,200,000

AFRS	Alternative 1 Summary 5 year interv	
YEARS 0-5		$10,000,000
YEARS 5-10		$25,000,000
YEARS 10-15		$27,000,000
YEARS 15-20		$13,000,000
YEARS 20-25		$300,000
YEARS 25-30		$300,000
YEARS 30-35		$18,000,000
YEARS 35-40		$46,000,000
YEARS 40-45		$49,000,000
YEARS 45-50		$34,000,000
YEARS 50-55		$600,000
YEARS 55-60		$600,000
YEARS 60-65		$30,000,000
YEARS 65-70		$82,000,000
YEARS 70-75		$89,000,000
YEARS 75-80		$58,000,000
YEARS 80-85		$1,100,000
YEARS 85-90		$1,300,000
YEARS 90-95		$55,500,000
YEARS 95-100		$147,500,000



AFRS	Alternative 2B Summary 5 year interv	
YEARS 0-5	$	7,300,000
YEARS 5-10	$	215,162,000
YEARS 15-20	$	901,000
YEARS 25-30	$	1,018,000
YEARS 35-40	$	1,560,000
YEARS 45-50	$	1,775,000
YEARS 55-60	$	2,676,000
YEARS 65-70	$	3,159,000
YEARS 75-80	$	3,727,000
YEARS 85-90	$	4,392,000
YEARS 95-100	$	5,182,000

∑ $247,202,000

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Next Steps

- Develop Concept Document & Present to the Project Steering Committee
- Develop Planning Document
- Preliminary Studies 2024-2025
- Design 2026-2027
- Construction 2028-2029

Q&A

Thank You

Connecting—far and wide