

Online tools for the San Joaquin River Restoration Program:

An example of design thinking & co-creation for online tools on SacPAS

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1 SAN JOAQUIN RIVER RESTORATION PROGRAM

BUREAU OF RECLAMATION

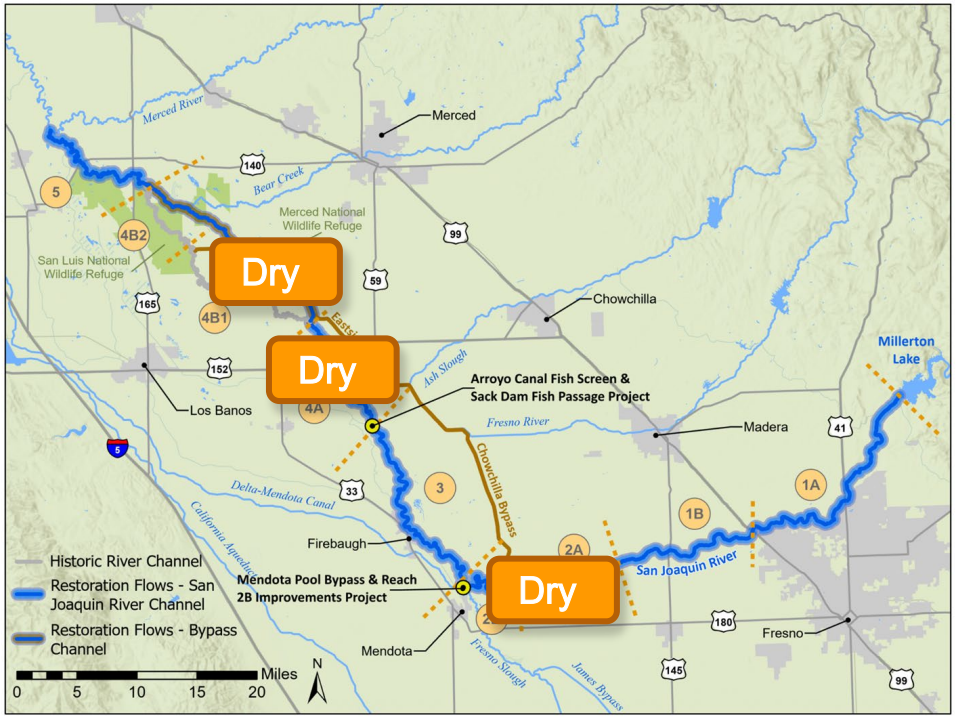
2 SacPAS CENTRAL VALLEY PREDICTION AND ASSESSMENT OF SALMON

COLUMBIA BASIN RESEARCH

UNIVERSITY of WASHINGTON

San Joaquin River Restoration Program

Releases from Friant Dam to rewet river to confluence with Merced River

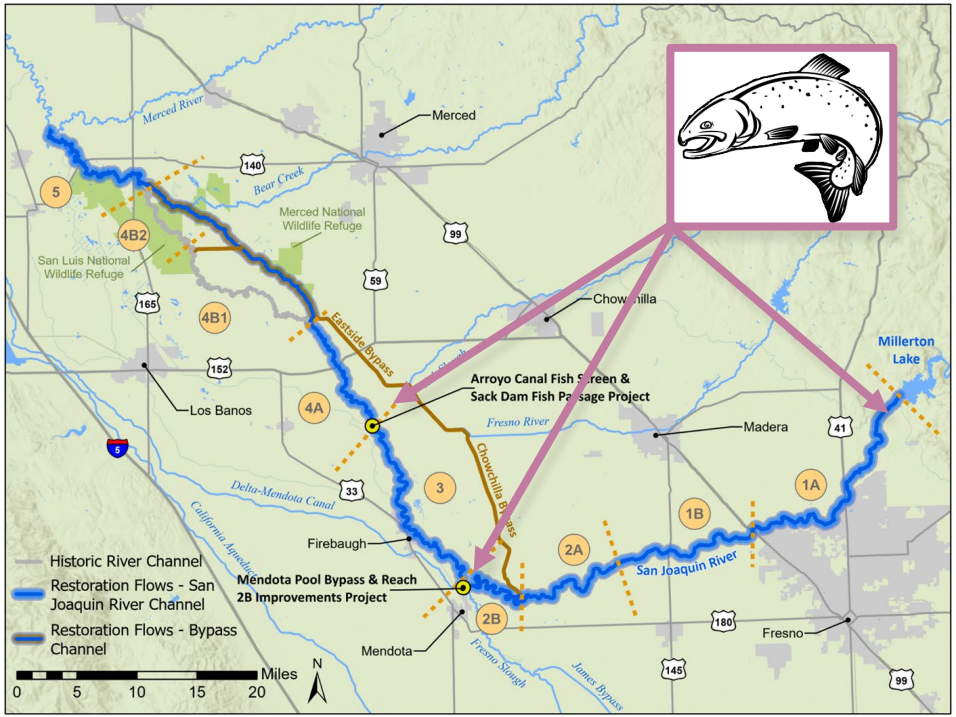


San Joaquin River Restoration Program

Releases from Friant Dam to rewet river to confluence with Merced River

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Modify diversion dams for salmon passage, salmon hatchery near Friant Dam



San Joaquin River Restoration Program

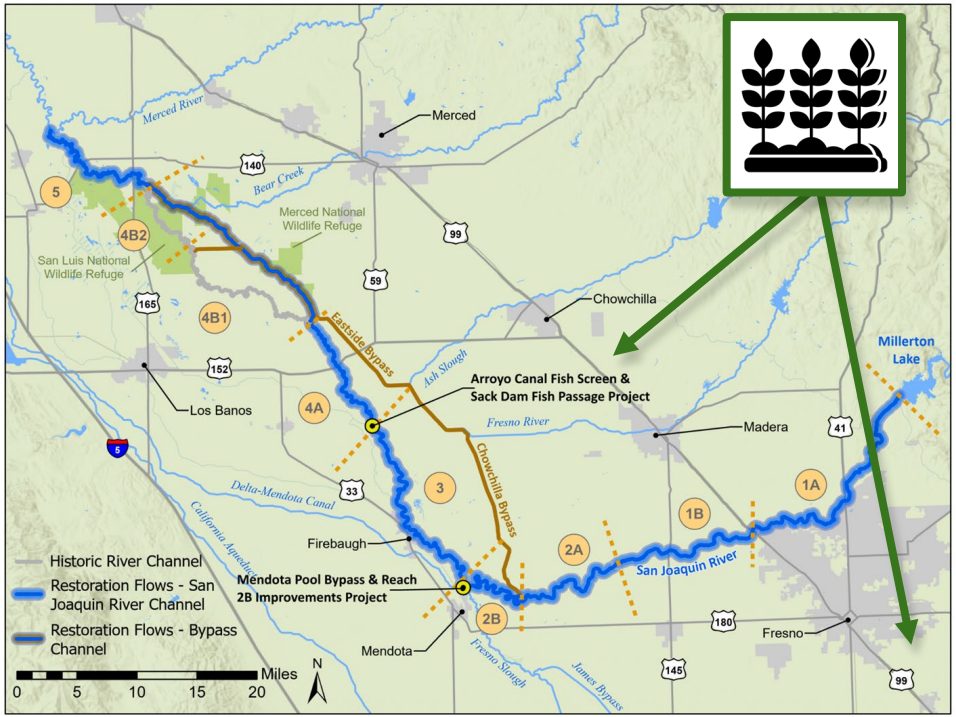
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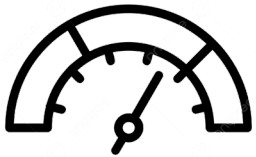
Reduce water supply impacts to water users through water recapture and other programs



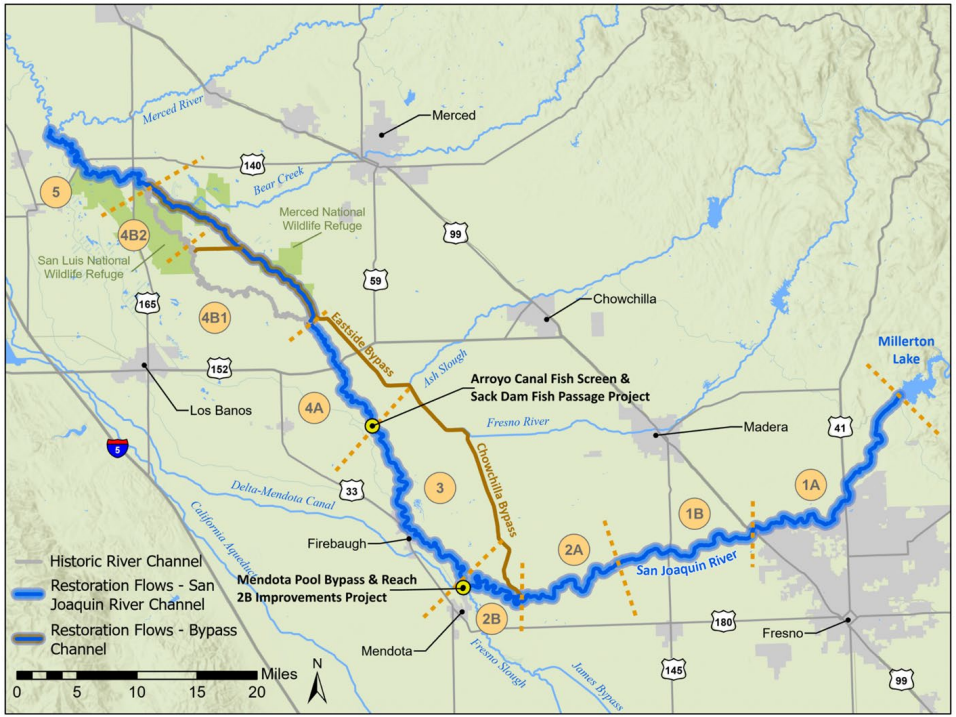
San Joaquin River Restoration Program

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Modification of water rights and rigorous tracking of flows dedicated for in -stream use



How to quantify, verify, and communicate these “Restoration Flows”?



San Joaquin River Restoration Program

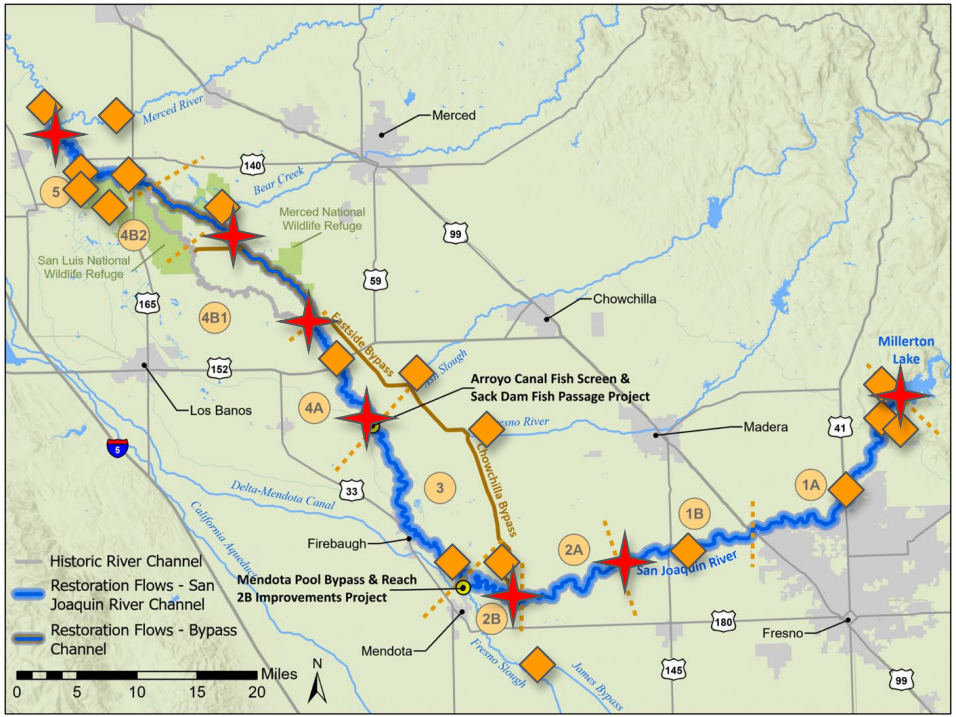
Key Concept

Restoration Flows must be released from Friant Dam, not incorporate tributary inflows, and be accounted for throughout the Restoration Area

Accounting = Protection

Calculation of Restoration Flows

Input to Calculation



Ideal Solution for SJ RRP

- Promote situational awareness of river flows
- Not just river flows, but separate out Restoration Flows for protection and downstream recapture
- Integrate data from CDEC as well as SJ RRP local water accounting spreadsheets
- Program transparency — how is water allocation being deployed, how are in-stream flows protected, and recapture
- Integration into existing platform — dependable, traffic, flexible

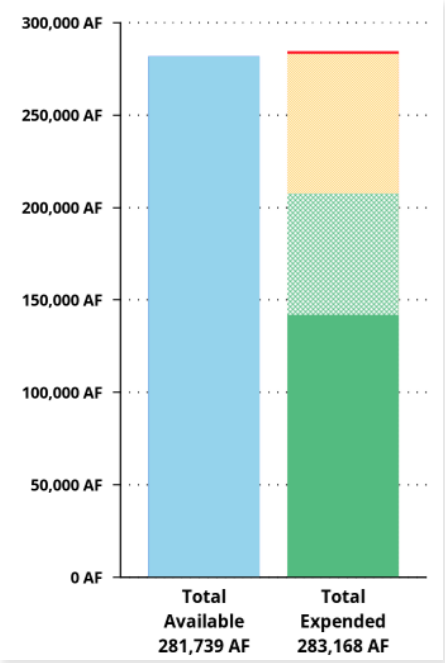
SacPAS
CENTRAL VALLEY PREDICTION AND ASSESSMENT OF SALMON

Two Examples from SacPAS

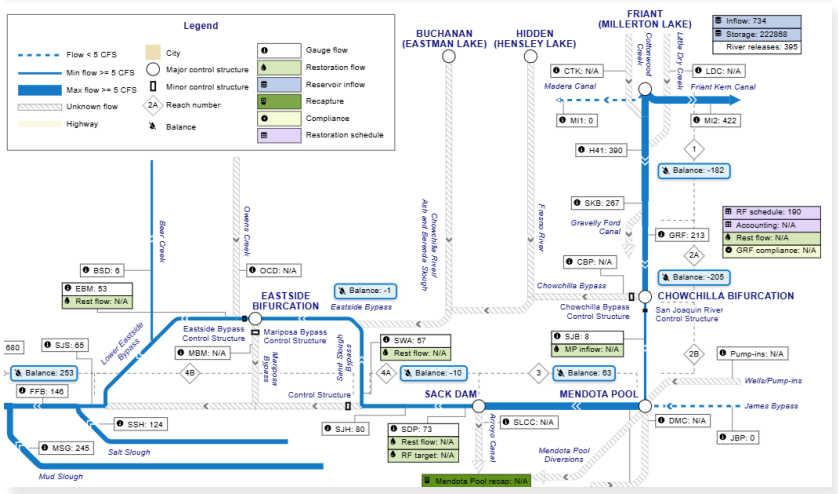
Demonstration of:

- Collaborative Process
- Design Thinking
- Data Visualizations

1) Restoration Allocation Inventory



2) Flow Rates "Subway" Diagram

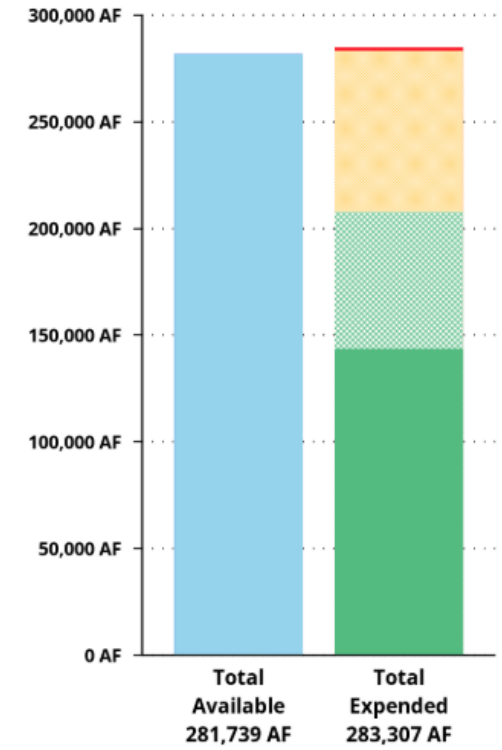


Restoration Allocation Inventory

- Allocation of restoration water volume tied to runoff forecast
- Forecasts change, therefore Restoration Allocation changes with each issuance January – June
- Release schedule must remain within a changing water budget and adapt to deviations from planned flow passing control point at Gravelly Ford
- As Restoration Allocation goes up and down, CVP water allocations respond accordingly
- Settlement sets limits upon how much flow volume can be shifted from idealized release schedule

Restoration Allocation Inventory

Water Volume Inventory



SJRRP Restoration Year 2026 Flow Volumes
Restoration Allocation Inventory

Water Year Type: Normal-Dry

Available

- Restoration Allocation: 281,739 AF
  - Allocation Date: 2026-05-15
- Acquired water added to Allocation: 0 AF
- Buffer Flows added to Allocation: 0 AF

Expended

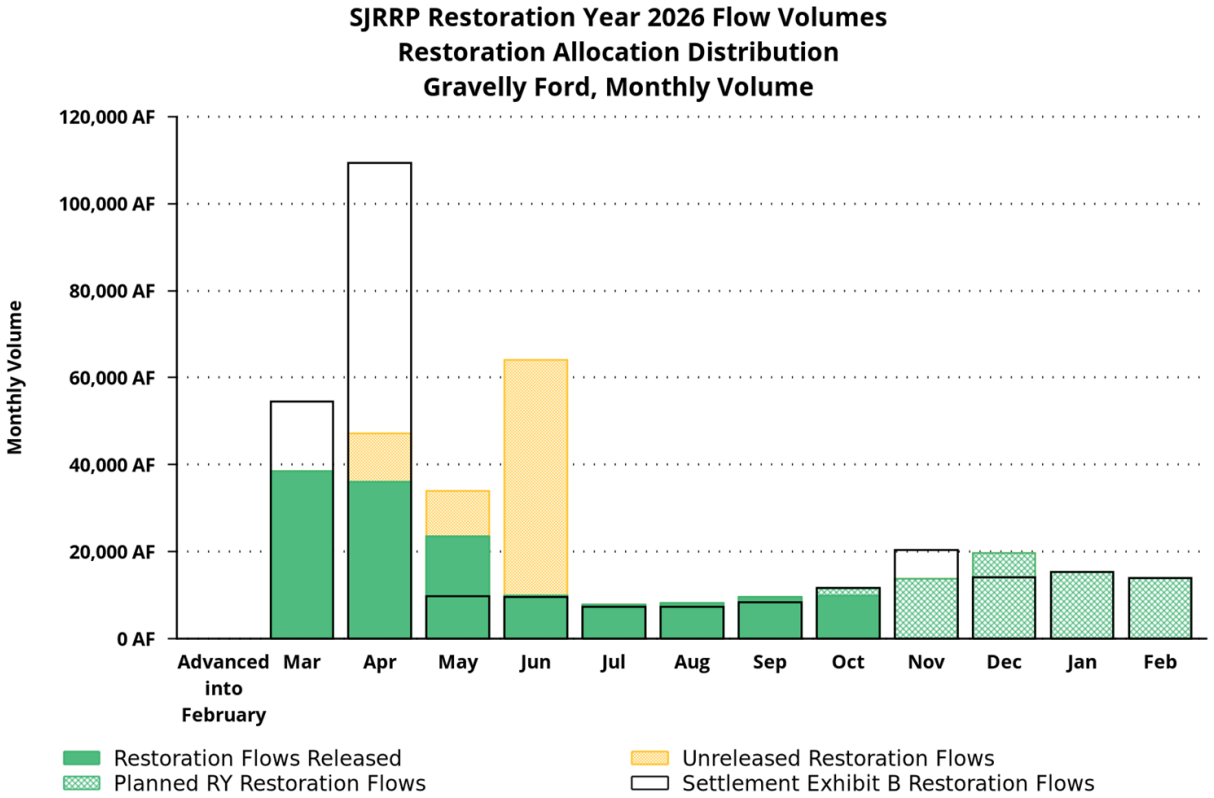
- Unreleased Restoration Flows removed from Allocation: 75,558 AF
  - As of: 2026-10-27
- Restoration Flows released from Friant Dam passing Gravelly Ford: 143,623 AF
  - As of: 2026-10-27
- Restoration Flows planned to be released from Friant Dam passing Gravelly Ford: 64,126 AF
  - On or before: 2027-02-28
- Expected Net Balance end of February: -1,568 AF

Restoration Year is from March 1 through end of February the following year.
Data extracted from SJRRP Operations spreadsheet provided by USBR.
Spreadsheet Date: 2026-10-27.

Restoration Allocation Inventory

Monthly Volume Distribution

- Note deviation from black outline bars (Settlement idealized release pattern)

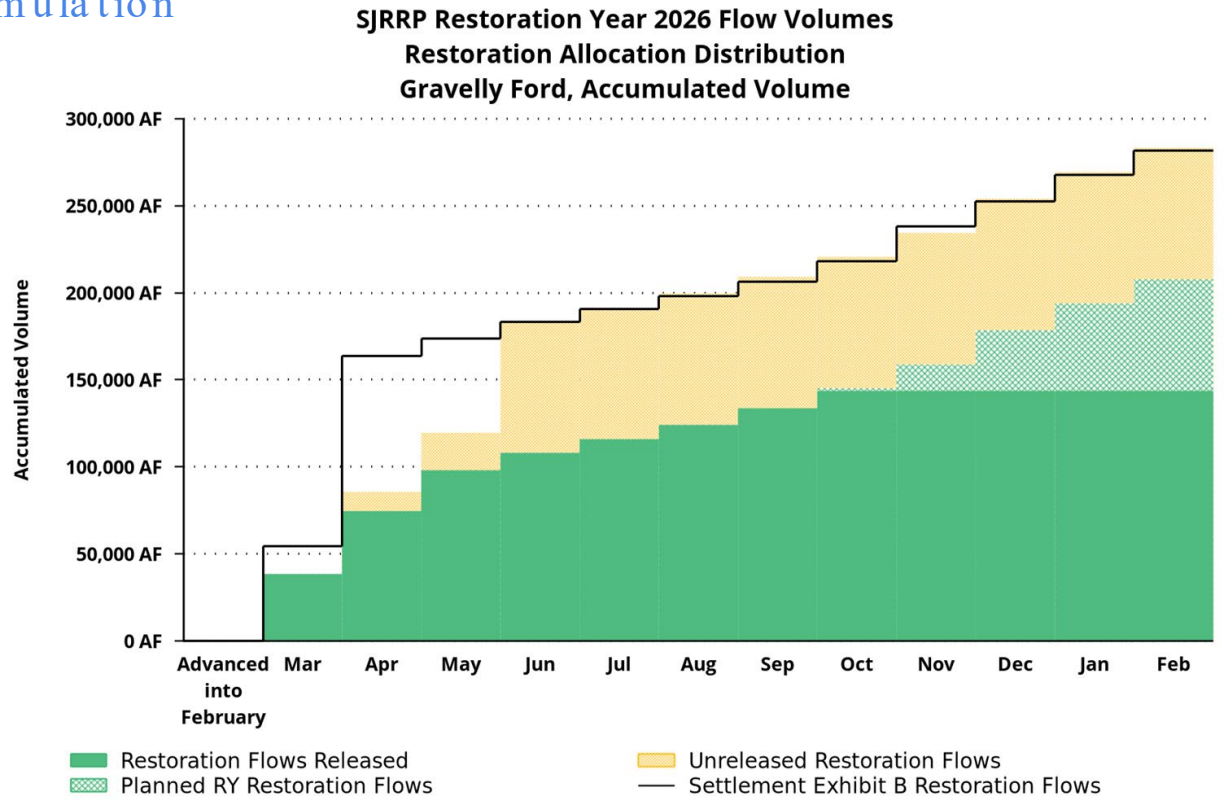


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Restoration Allocation Inventory

Monthly Volume Accumulation

- Note deviation from black stairsteps (Settlement idealized release pattern)



Restoration Year is from March 1 through end of February the following year.
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Restoration Allocation Inventory

Simple display, but dynamic data handling:

- Allocation volume available is updated monthly
- Expenditure of Allocation:
  - Initially based on CDEC of Gravelly Ford gauge flows
  - Updated with QA/QC flow data via spreadsheet integration
  - Updated with sales and exchanges of URF water
- Planned flow schedule (Allocation expenditure) is updated at regular and irregular intervals via spreadsheet

➔ Isolated spreadsheet tabs that are parsed by SacPAS

➔ Logic is incorporated at SacPAS end to handle these asynchronous updates to provide a real-time inventory

Flow Rates "Subway" Diagram

Things a river operator asks every day of the year:

- ❑ Are flows meeting the target schedule?
- ❑ Are gauges working and accurate?
- ❑ Are river losses unusual?
- ❑ Are there tributary flows into the San Joaquin River?
- ❑ Are there flood flows?
- ❑ What flows are available for recapture?

An experienced operator knows the arrangement of flow gauges by heart, what are typical losses and diversions, how pulses attenuate downstream, and which gauges are unreliable. Can we produce a visual representation of flow data which captures what's inside the head of an operator, is easily understood by the public, provides high density of information, and promotes a situational awareness in the viewer?

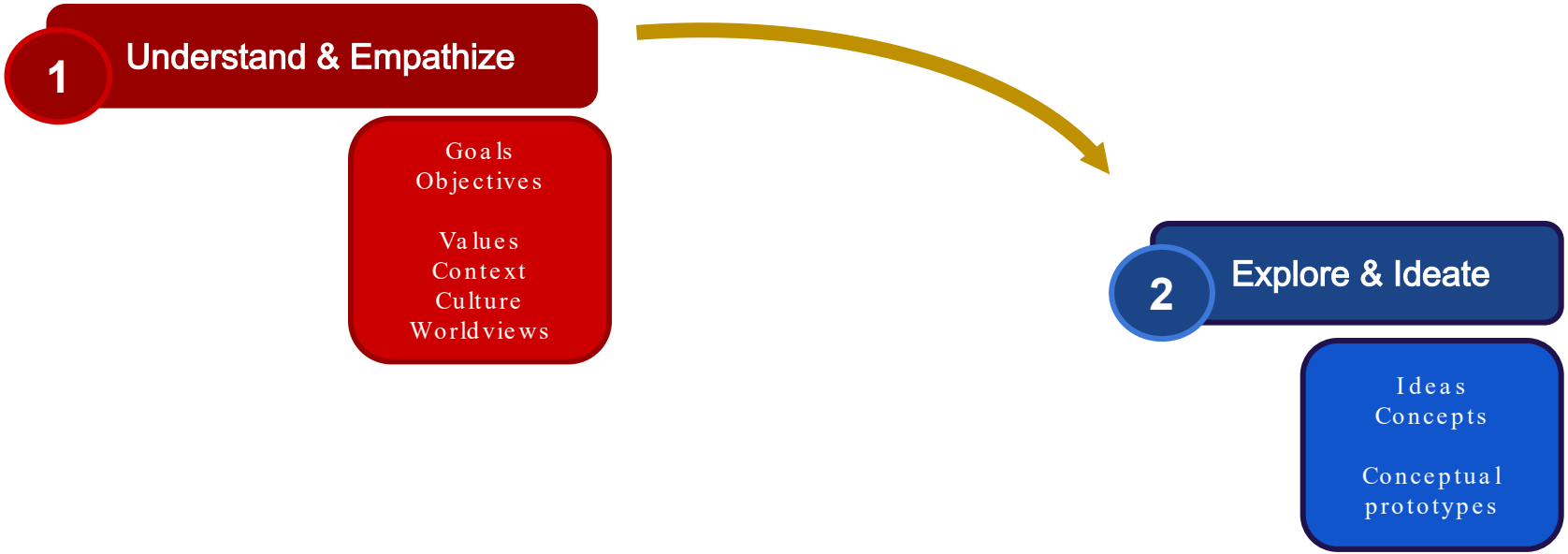
Design Thinking & Human-Centered Design



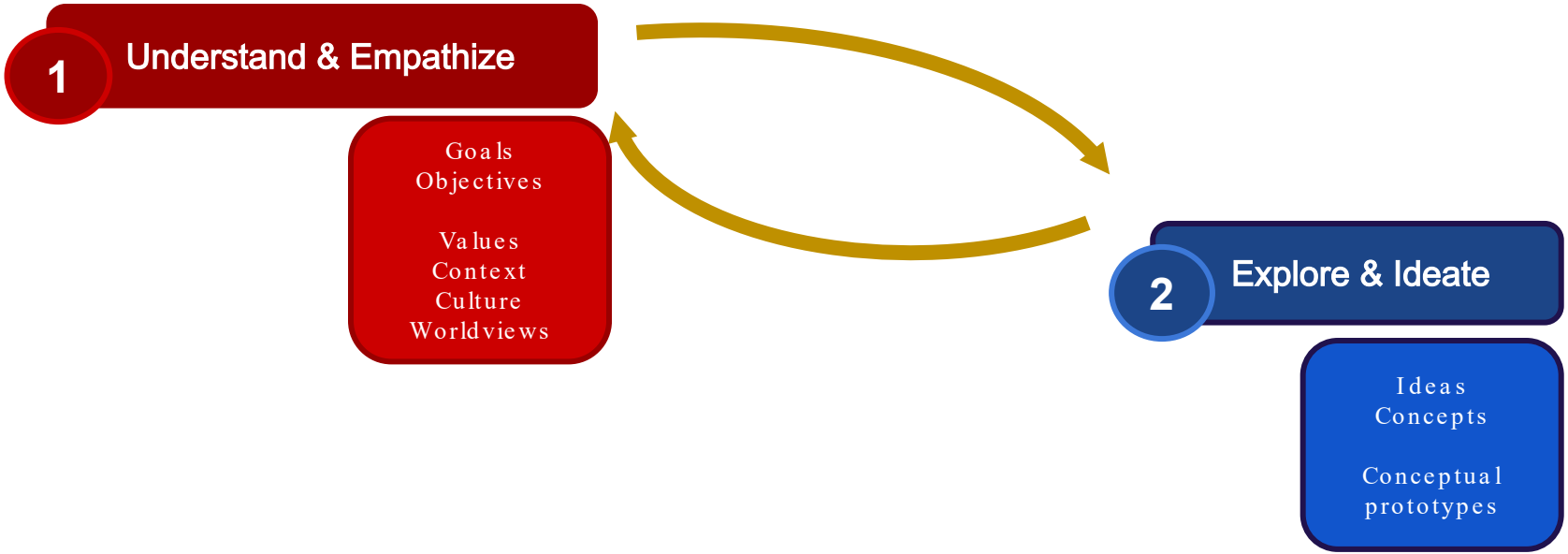
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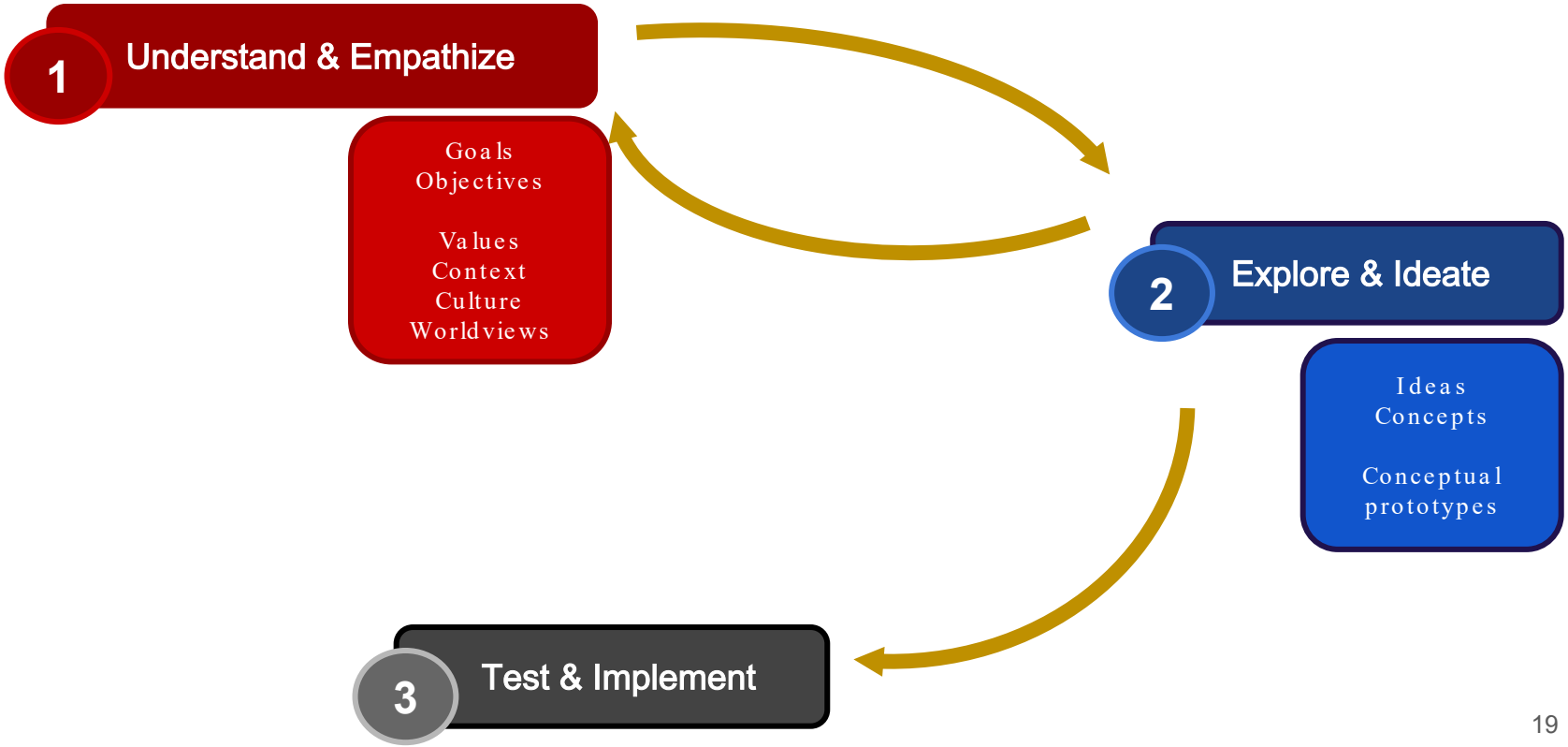
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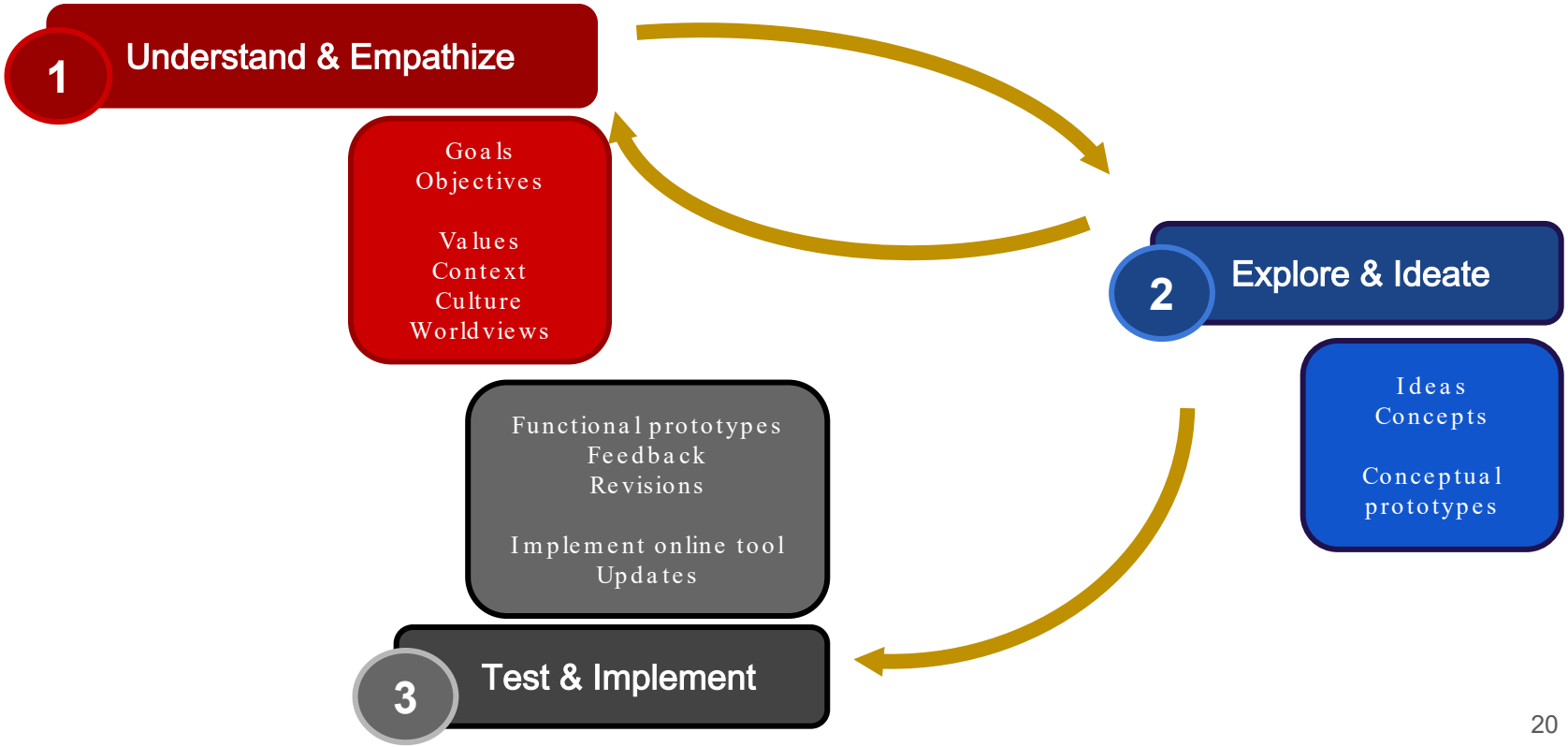
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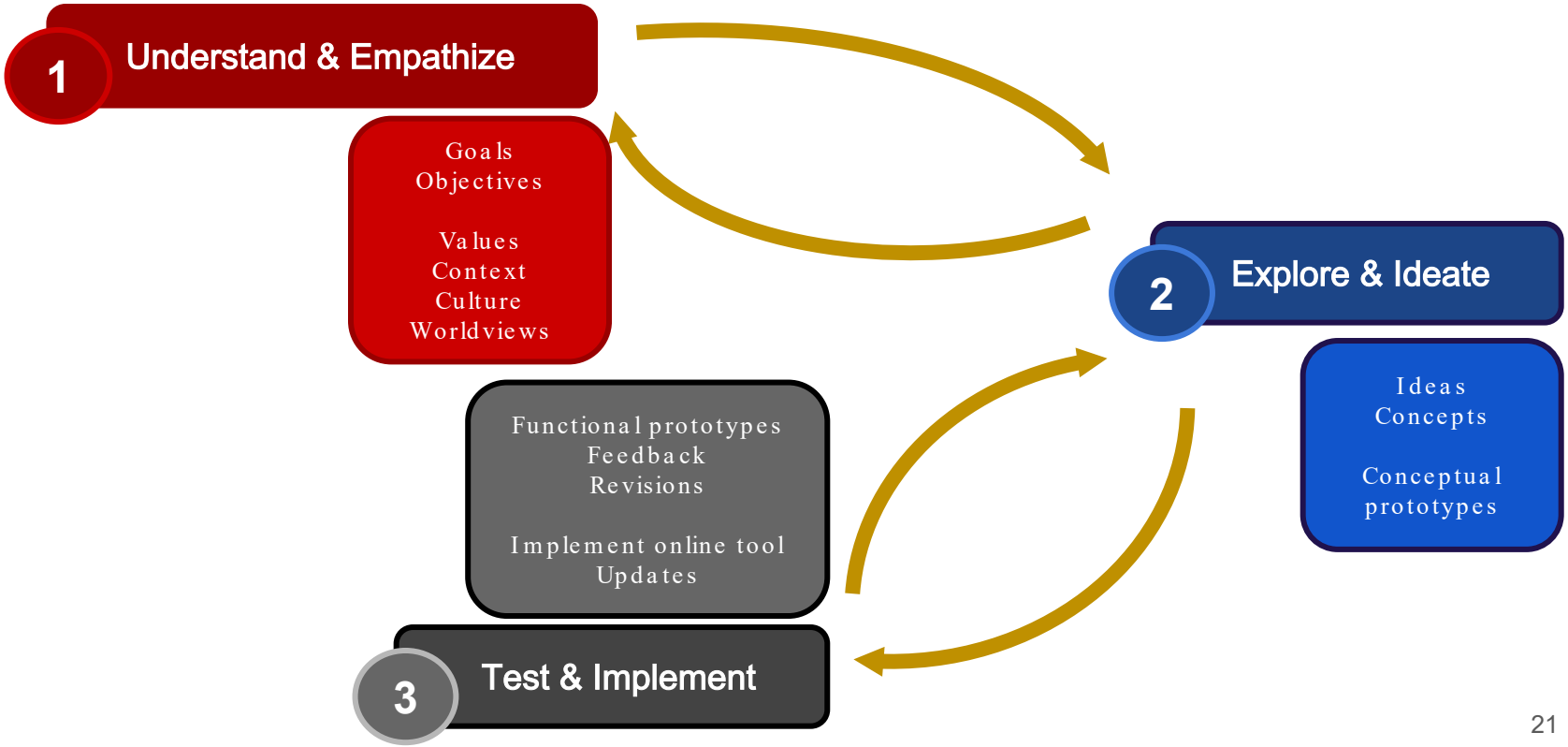
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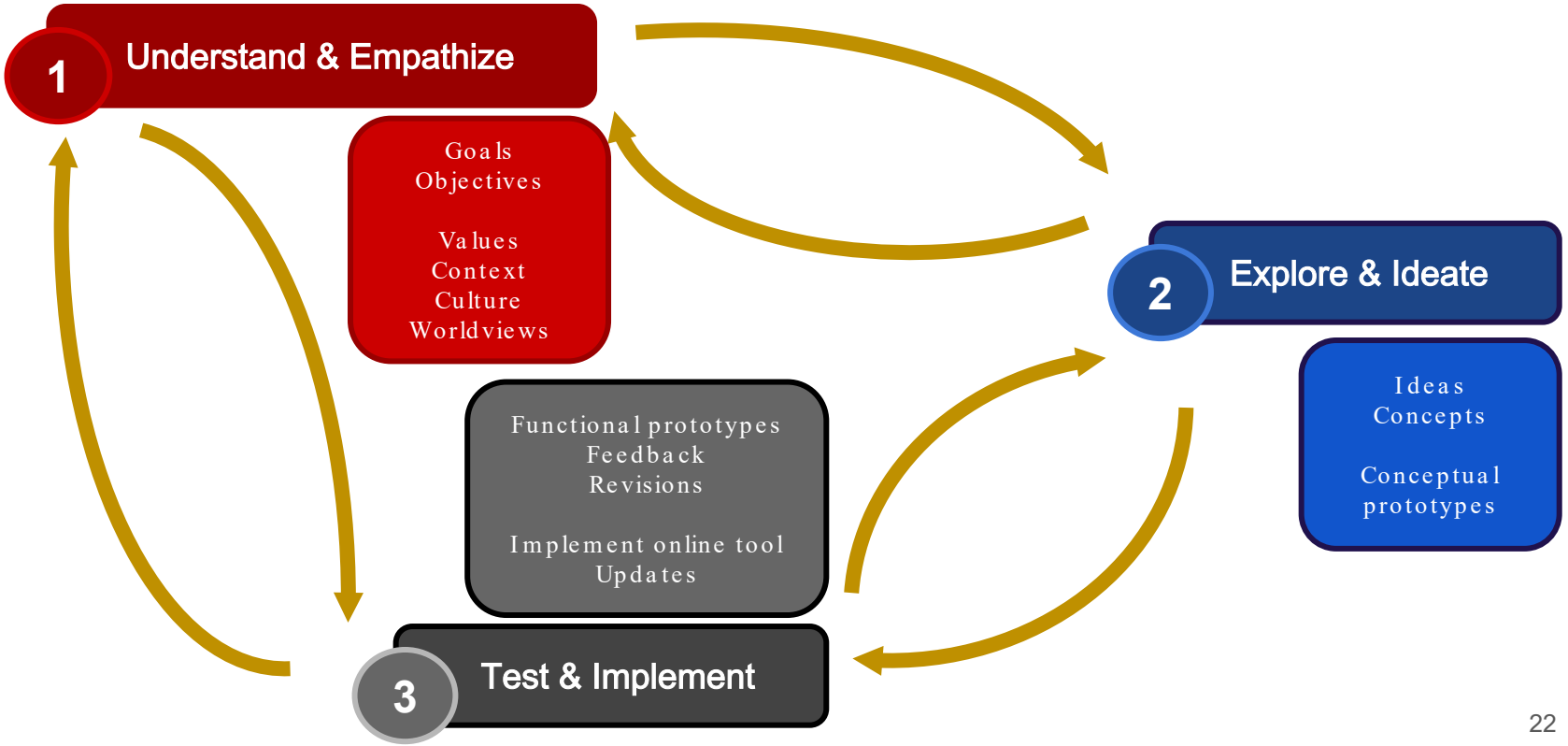
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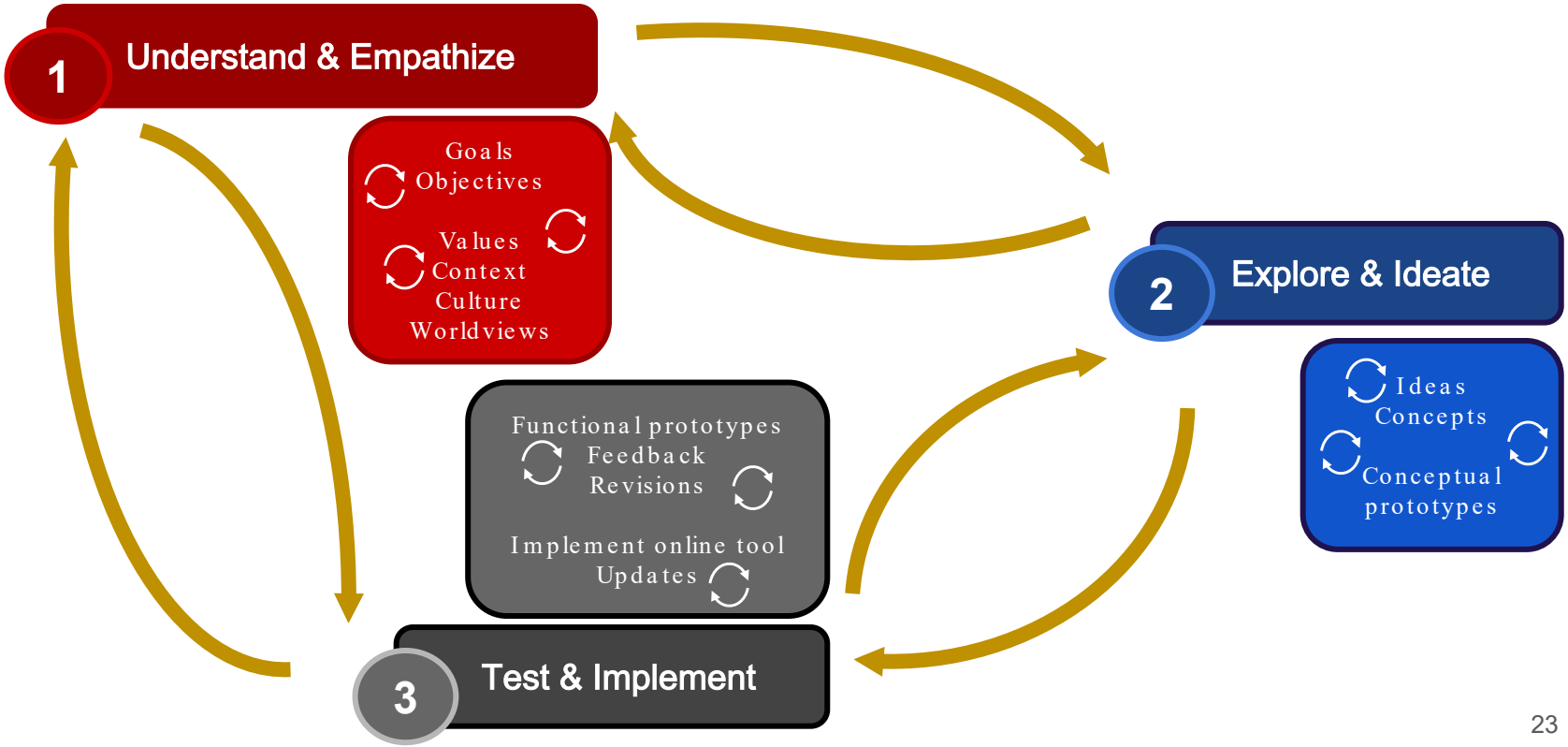
Design Thinking & Human-Centered Design



Design Thinking & Human-Centered Design



Design Thinking & Human-Centered Design



1 Understand & Empathize

Objective : Help others organize and visualize the data as a water manager does.

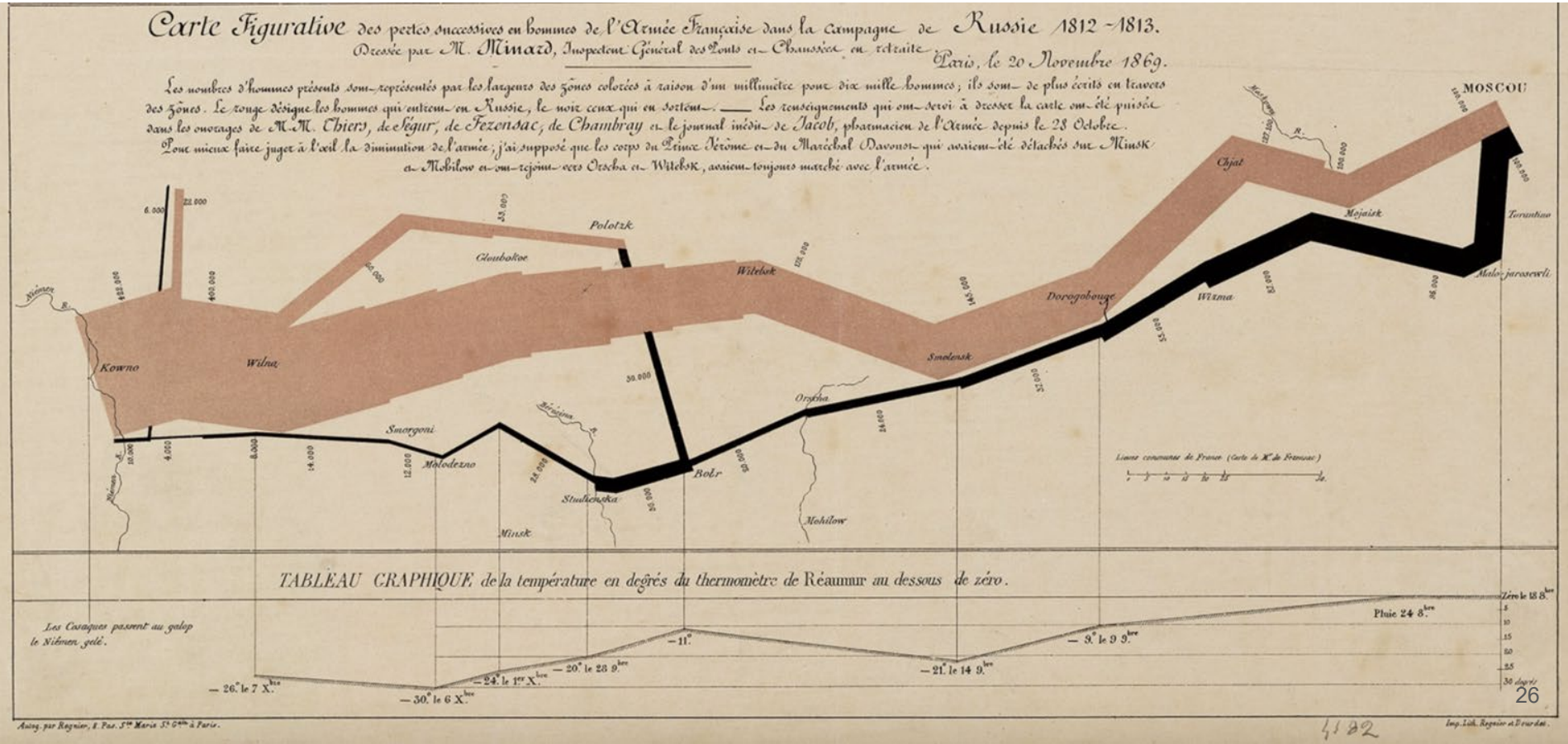


2 Explore & Ideate

Subway diagrams (geographic context)

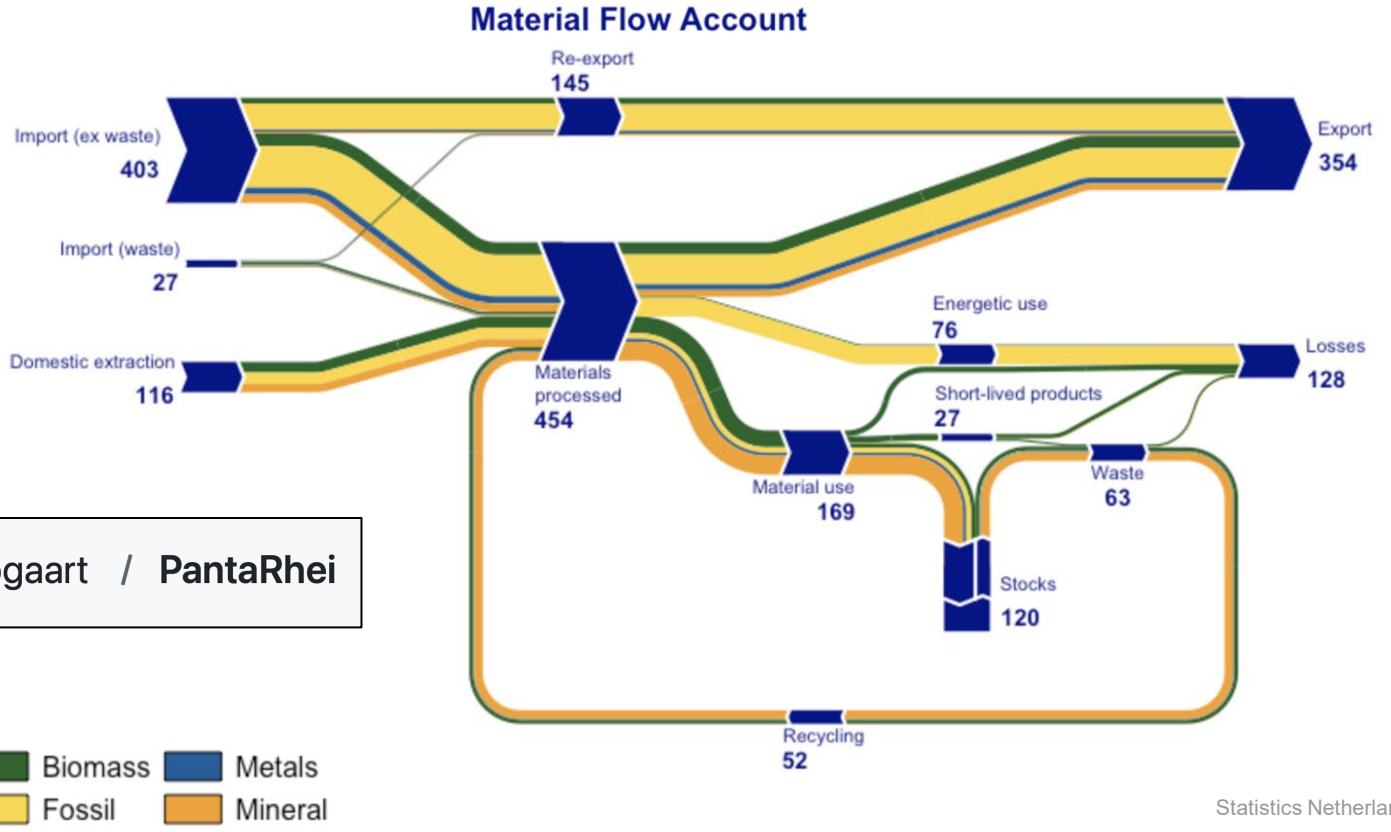


Flow diagrams (changing width)



2 Explore & Ideate

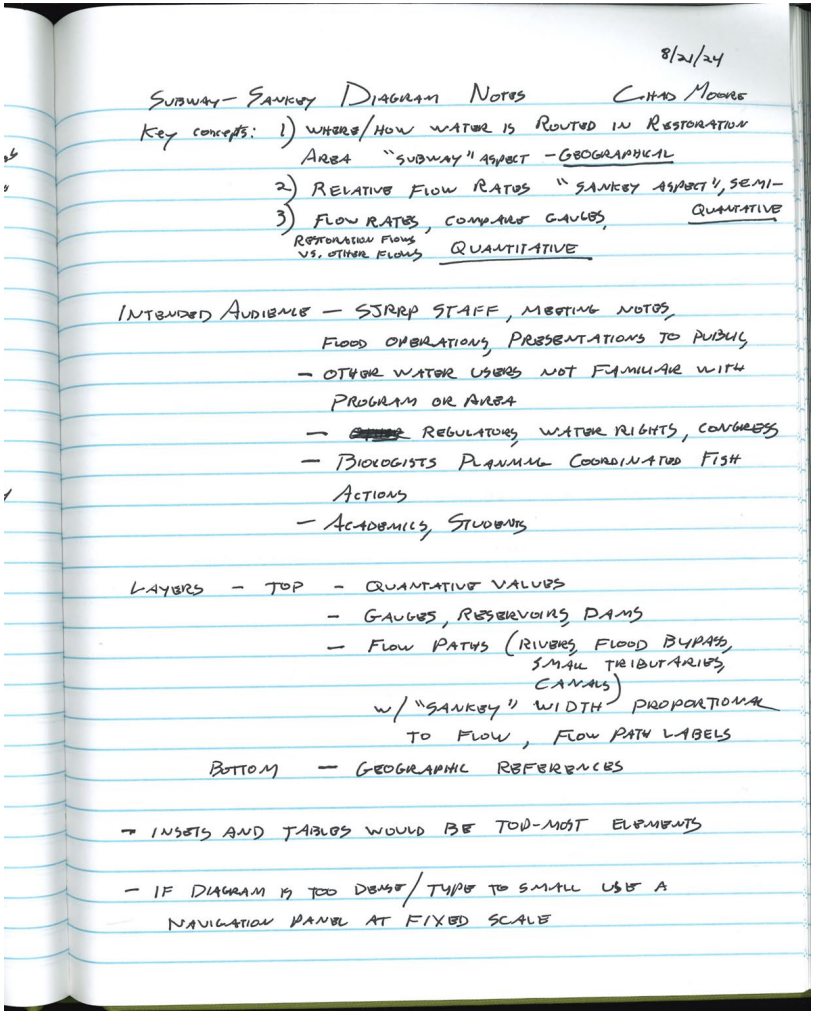
Sankey diagrams
(flow direction, numeric data)



pwbogaart / **PantaRhei**

1 Understand & Empathize

2 Explore & Ideate



8/21/24

Subway – Sankey Diagram Notes Chad Moore

Key concepts: 1) where/how water is routed in Restoration Area "subway" aspect – geographical
2) Relative flow rates "Sankey aspect", semi-quantative
3) Flow rates, compare gauges, Restoration flows vs. other flows quantitative

Intended Audience – SJRRP staff, meeting notes, flood operations, presentations to public,
– other water users not familiar with program or area
– ~~Other~~ Regulators, water rights, congress
– Biologists planning coordinated fish actions
– Academics, students

Layers – Top – Quantative values
– Gauges, reservoirs, dams
– Flow paths (rivers, flood bypass, small tributaries, canals) w/ "Sankey" width proportional to flow, flow path labels
Bottom – geographic references

→ insets and tables would be top-most elements

– If diagram is too dense/type too small use a navigation panel at fixed scale

1 Understand & Empathize

2 Explore & Ideate

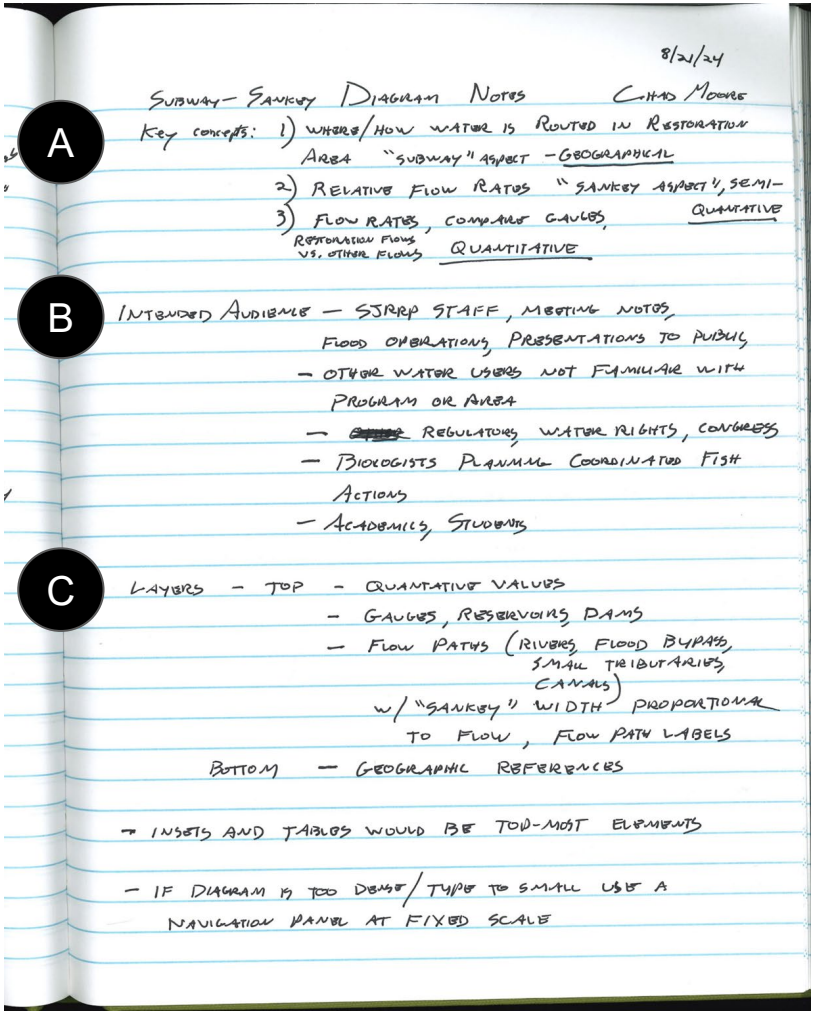
SJRRP Subway Diagram



A Key Concepts

B Intended Audience

C Specific Ideas



8/21/24

Subway – Sankey Diagram Notes — Chad Moore

A

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1 Understand & Empathize

2 Explore & Ideate

SJRRP Subway Diagram



A Key Concepts

B Intended Audience

C Specific Ideas

C

MAP CONVENTIONS – WATER BODIES IN ITALIC TYPEFACE, ALL OTHER ELEMENTS IN ROMAN

– GAUGES ARE OUTLINED IN BLACK ON TOP, AND EMPHASIZED

GAUGE

– DAMS AND DIVERSIONS ARE SHOWN AS A WHITE LINE BREAKING A FLOW PATH AND DE EMPHASIZED, LABELED SUBTLY

"CONTROL STRUCTURES" TOO → DAM

– LOSSES COULD BE SHOWN WITH SYMBOL & VALUE

17

– LESS IMPORTANT FEATURES LIKE CANALS WHICH DIVERT WATER AWAY FROM RIVER CAN BE TERMINATED QUICKLY

* or like a canal

SACK DAM

* UNLIKE TRUE SANKEY DIAGRAM, FLOW LINES SHOULD NOT CROSS

CANAL

– CONFLUENCES ARE SHOWN JOINING IN THE DIRECTION THEY FLOW

– REACH #S CAN BE IDENTIFIED BY A CONTRASTING SYMBOL "REACH 2B"

2B

NEED TO FIGURE OUT HOW TO DENOTE REACH TRANSITIONS

– SEPARATING RESTORATION FLOWS. THESE ARE A SUBSET OF RIVER FLOWS. USE A STRONGER COLOR FOR RESTORATION FLOWS, A LIGHT NEUTRAL COLOR FOR TOTAL FLOWS

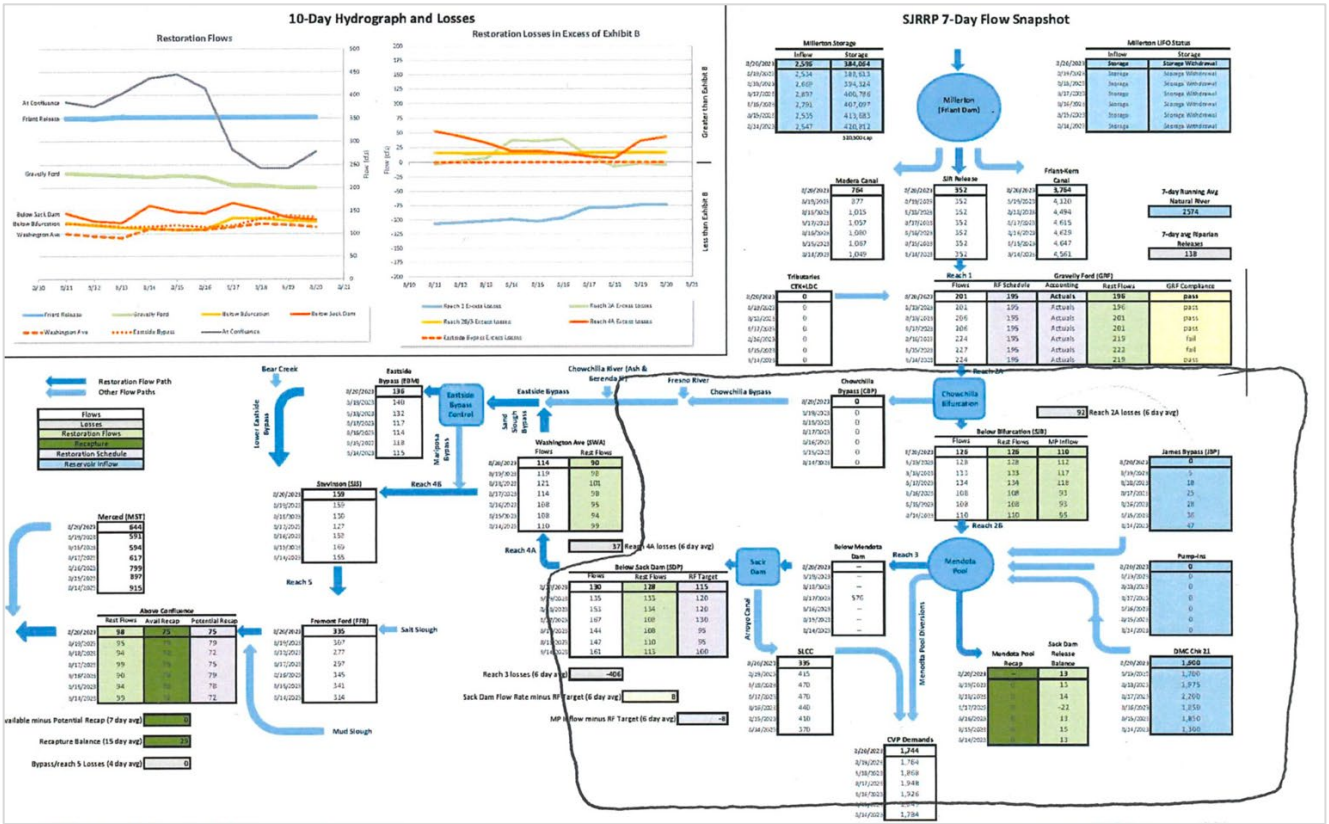
VERN FLOWS

REST. FLOWS

1 Understand & Empathize

2 Explore & Ideate

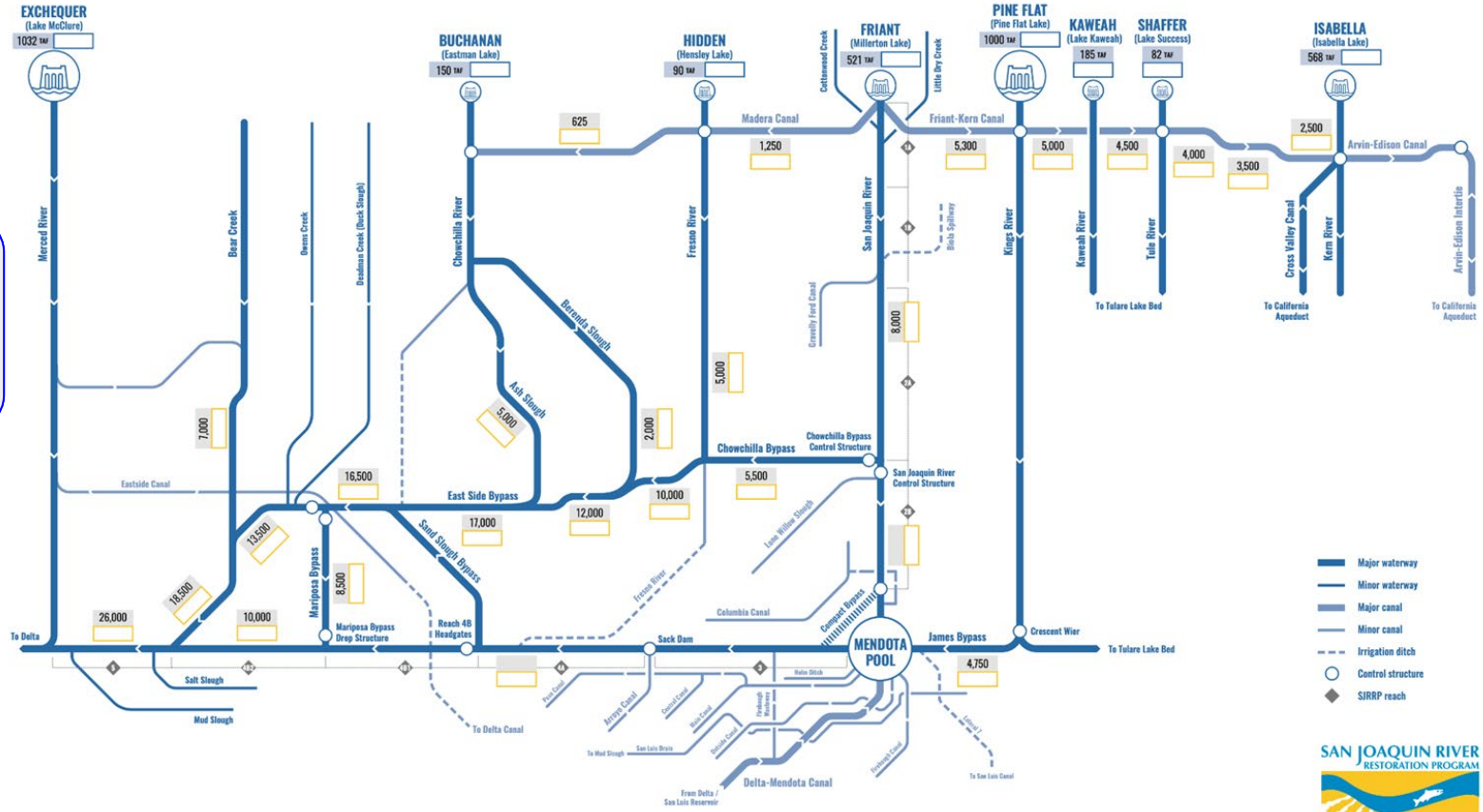
Excel
spreadsheet with
real data
in context of
directional flow



1 Understand & Empathize

2 Explore & Ideate

Existing diagrams from SJRRP



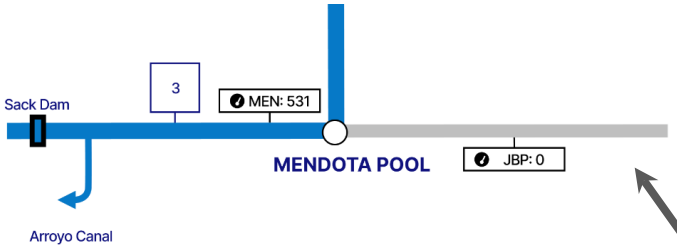
SAN JOAQUIN RIVER RESTORATION PROGRAM

1 Understand & Empathize

2 Explore & Ideate

Conceptual prototypes in Figma

Representing zero flow variations:



Zero flow

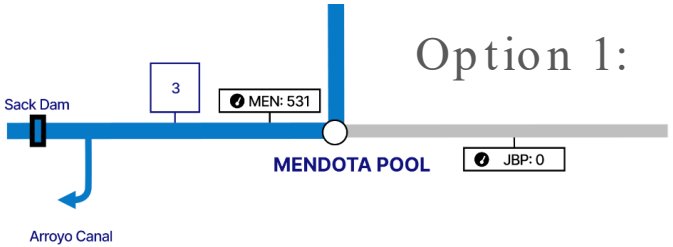
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2 Explore & Ideate

Conceptual prototypes in Figma

Representing zero flow variations:

Option 1:



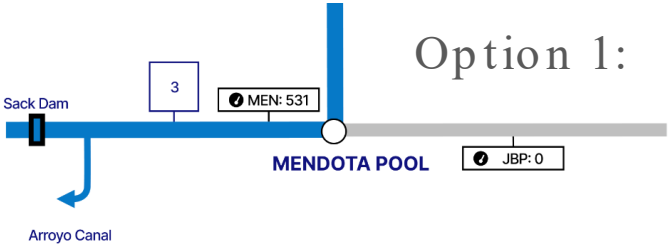
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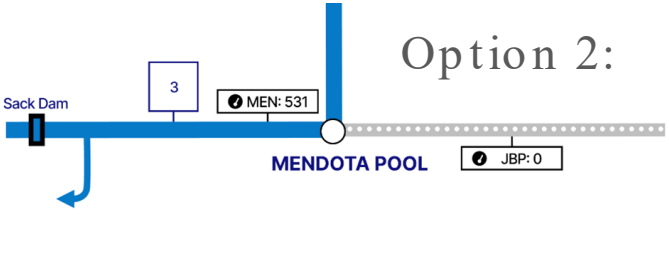
Conceptual prototypes in Figma

Representing zero flow variations:

Option 1:



Option 2:



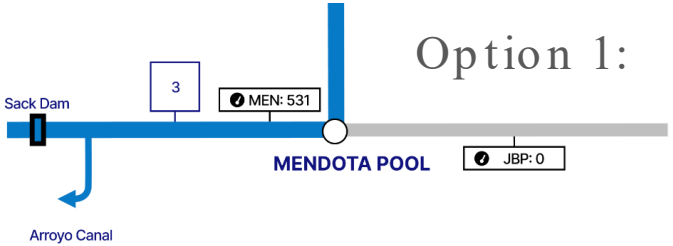
1 Understand & Empathize

2 Explore & Ideate

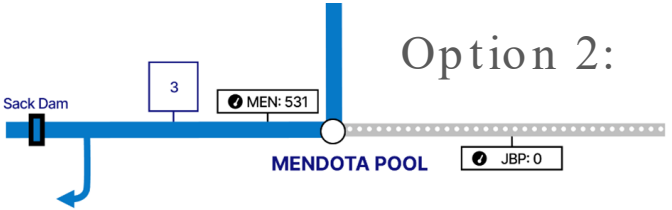
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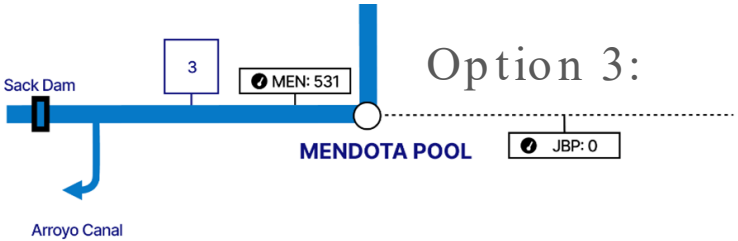
Option 1:



Option 2:



Option 3:



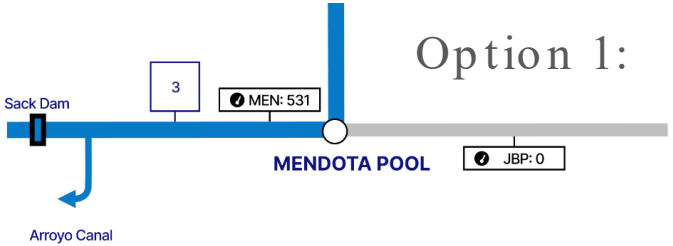
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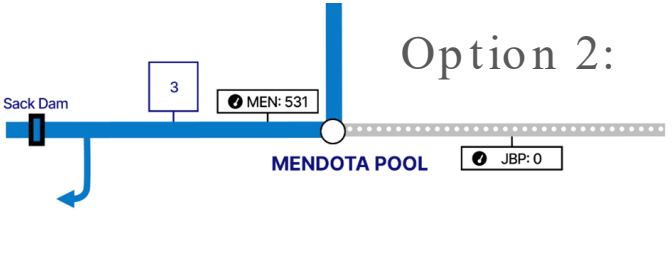
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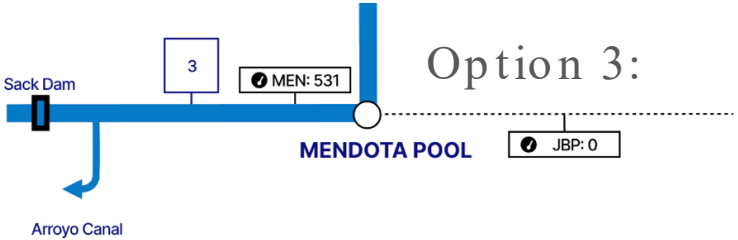
Option 1:



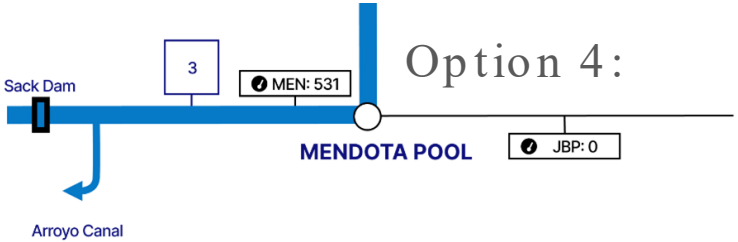
Option 2:



Option 3:

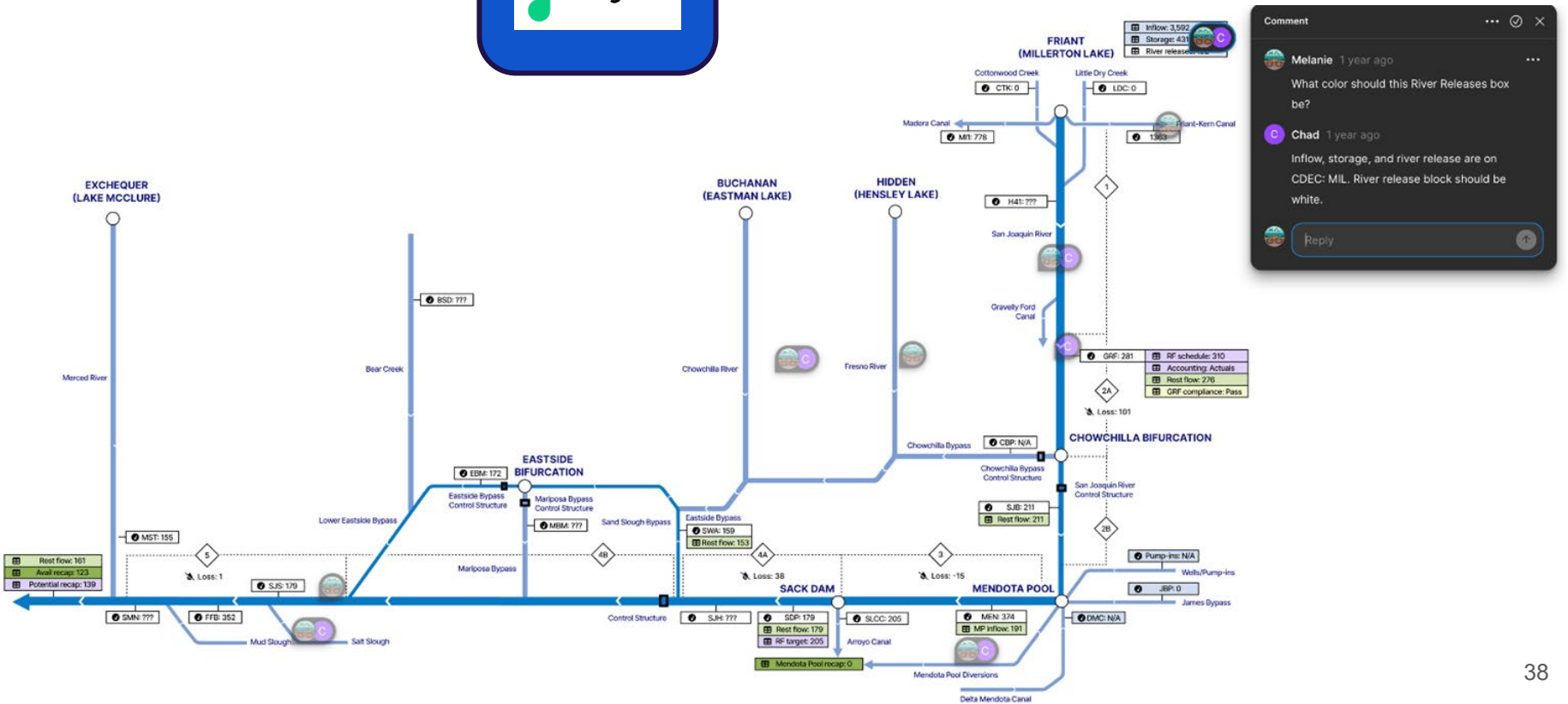


Option 4:



2 Explore & Ideate

Conceptual prototypes in Figma

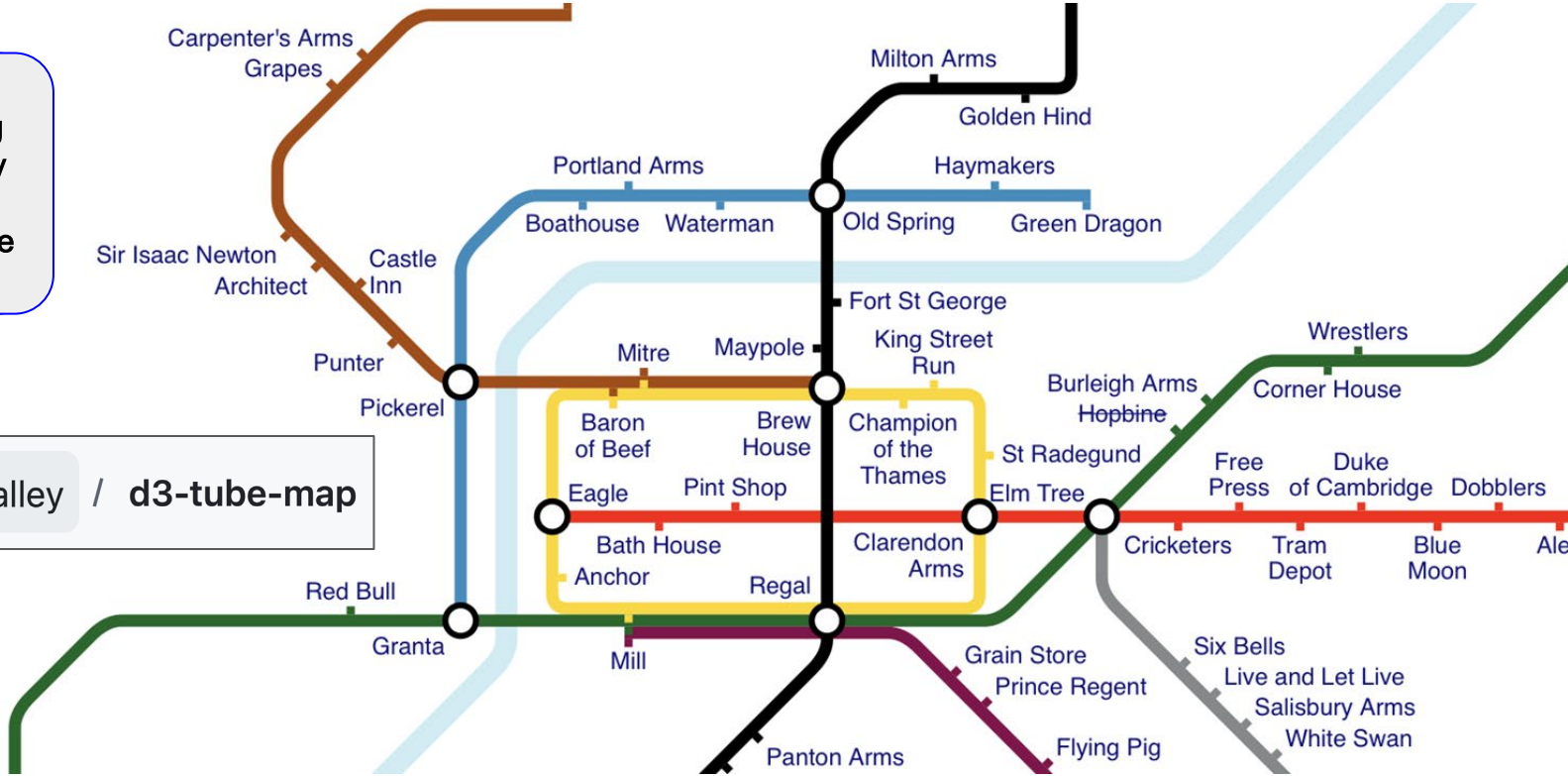


2 Explore & Ideate

3 Test & Implement

Existing subway diagram code

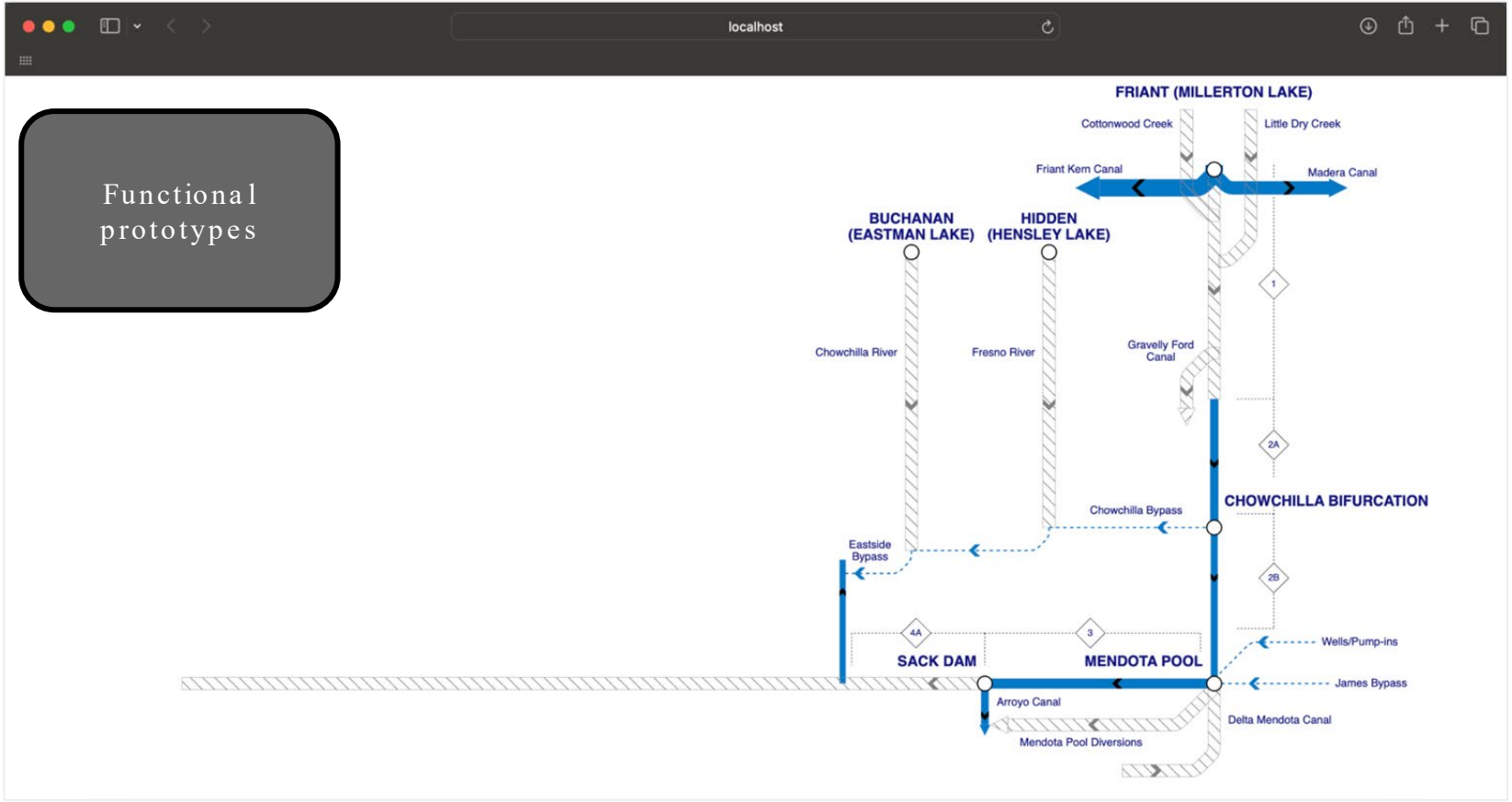
johnwalley / d3-tube-map



2 Explore & Ideate

3 Test & Implement

Functional prototypes

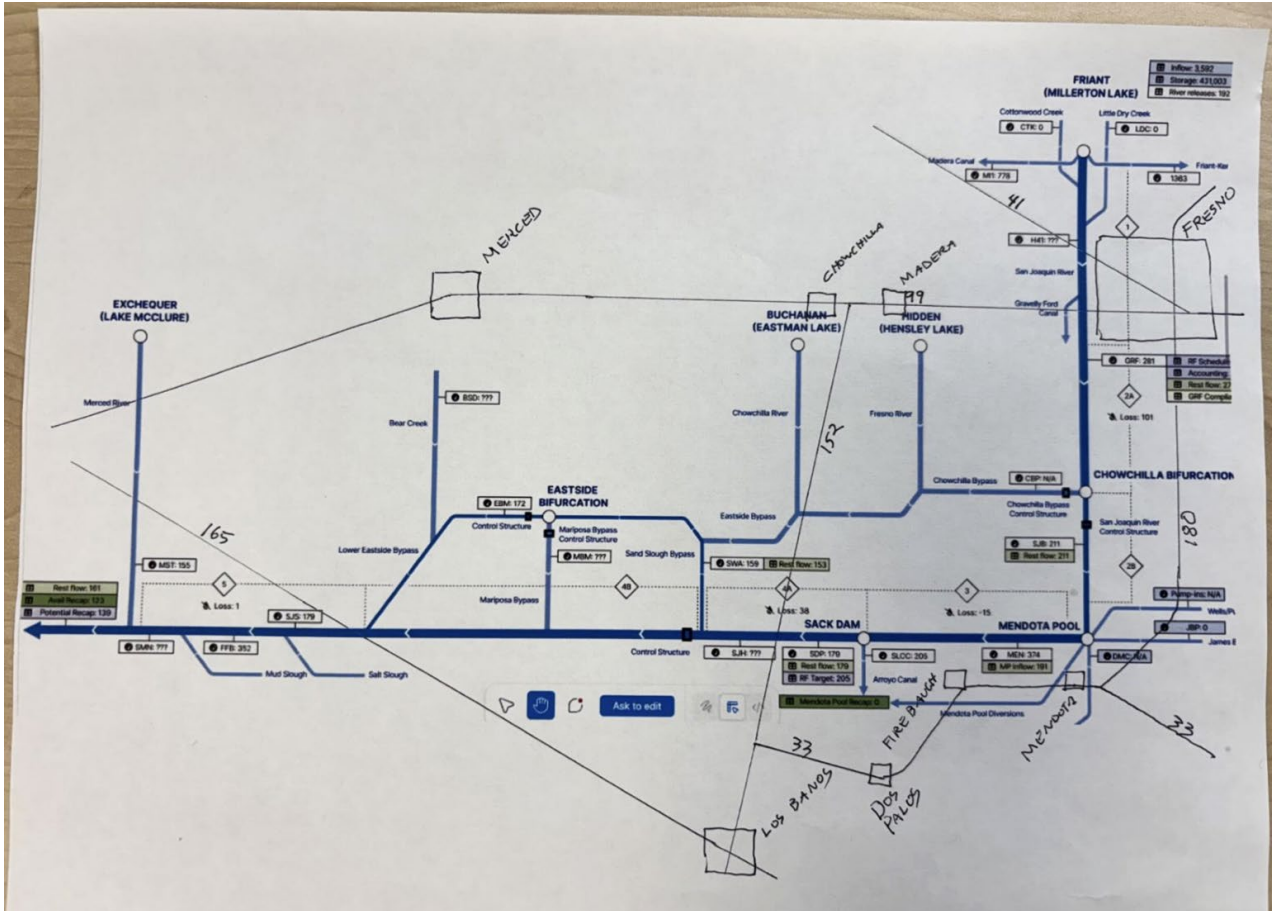


3 Test & Implement

Feedback

Revisions

Adding geographic context



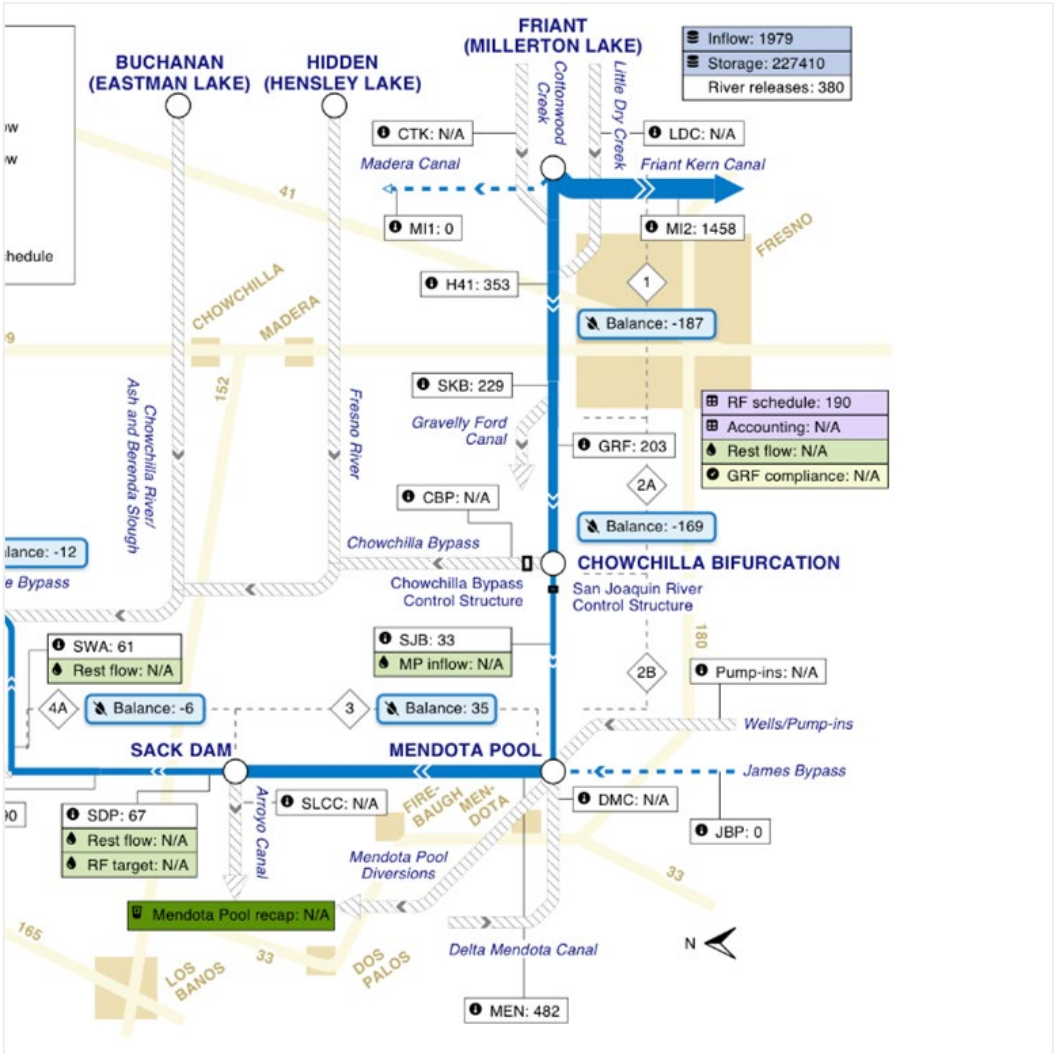
3 Test & Implement

Functional prototypes

Feedback

Revisions

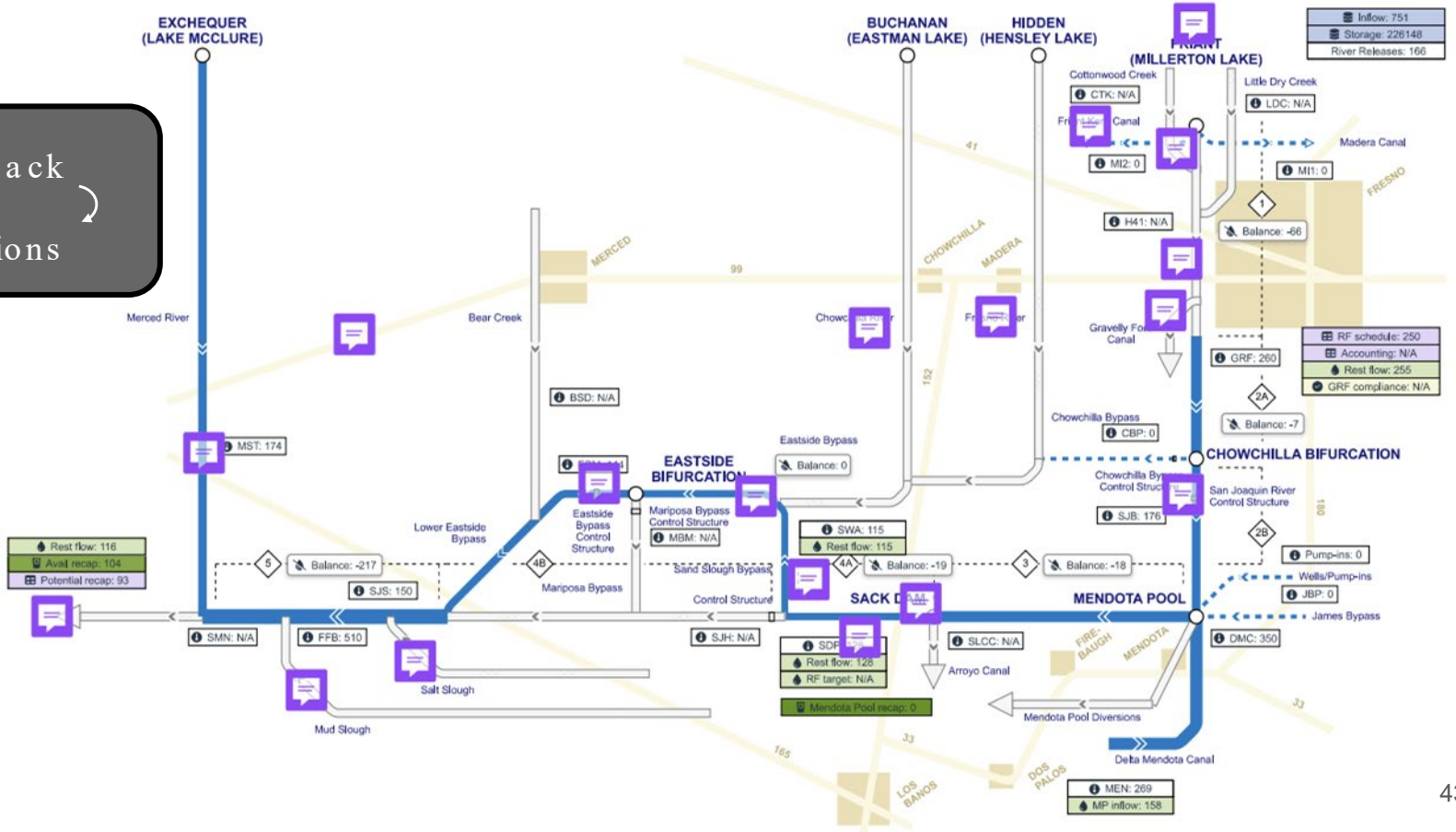
Adding geographic context



3 Test & Implement

Feedback

Revisions

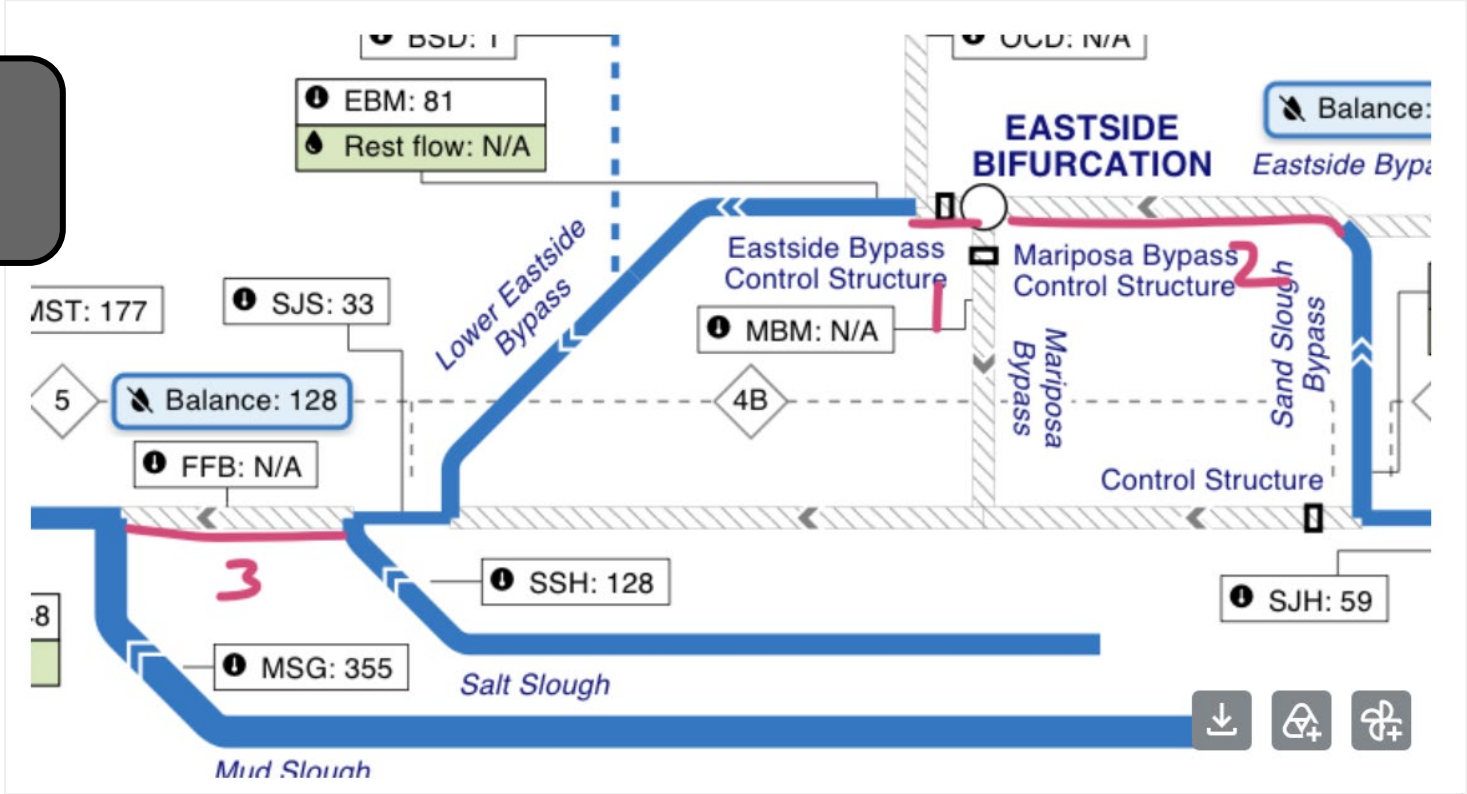


3 Test & Implement

Feedback

Revisions

Hand-drawn communication for effective iteration



3 Test & Implement

San Joaquin River Restoration Program (SJRRP) Flow Rates "Subway" Diagram

SJRRP Team Portal on SacPAS

Subway Diagram is a real-time tool of flow data in the SJRRP Restoration Area.

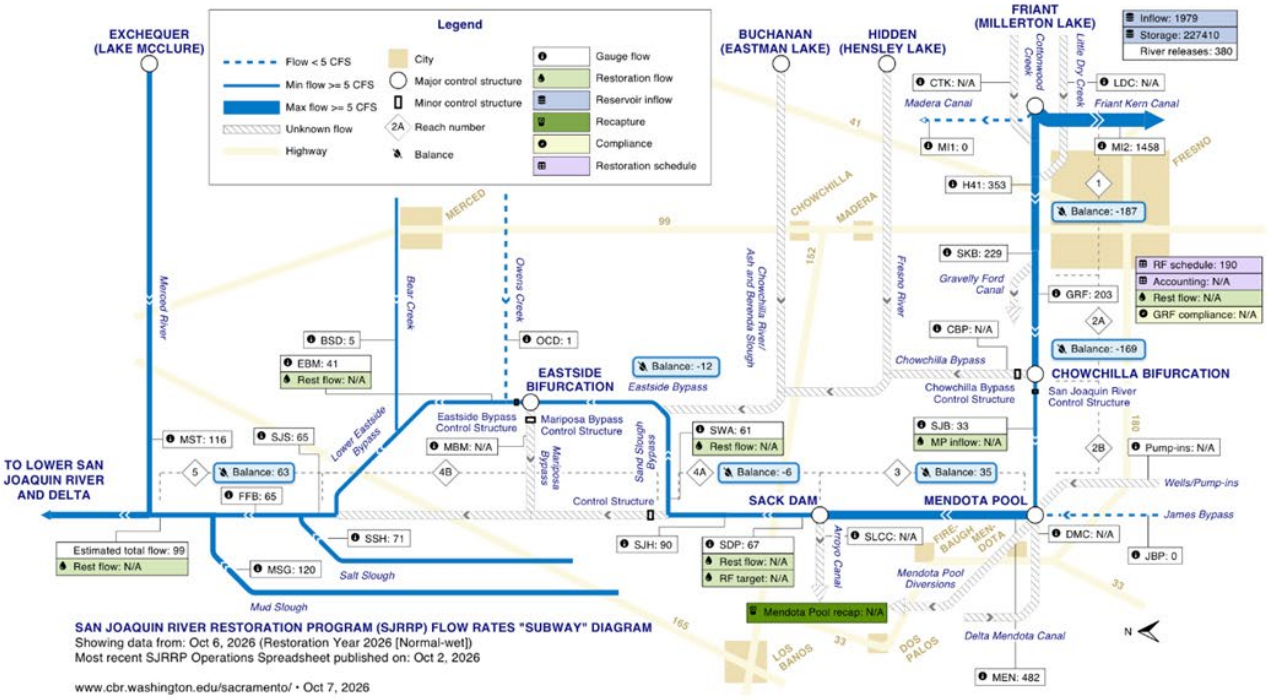
Select End Date
10/06/2026

Time Period
7 DAYS | 14 DAYS | 30 DAYS

Display Type
DIAGRAM | GRAPHS | TABLE

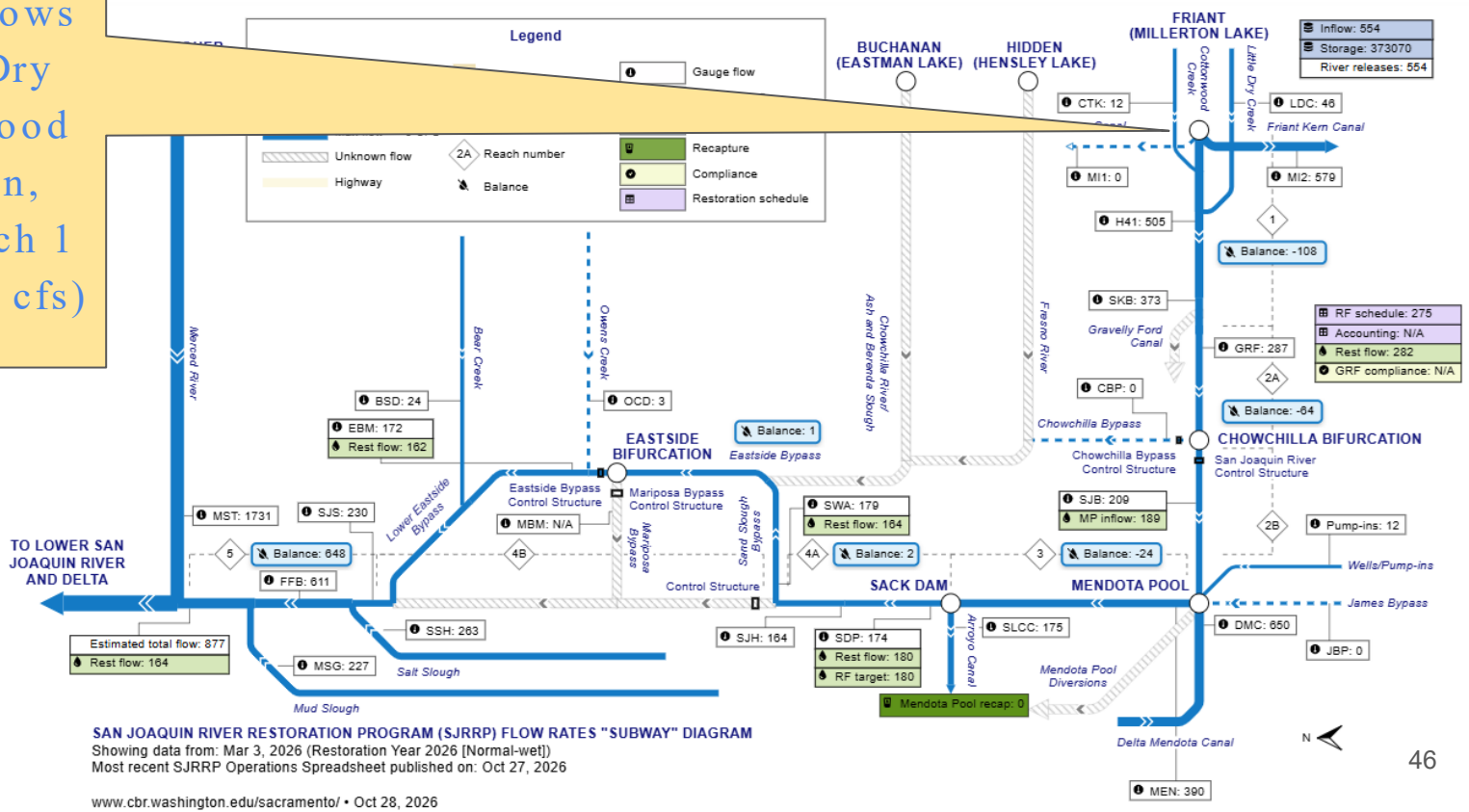
Show background map

DOWNLOAD DIAGRAM



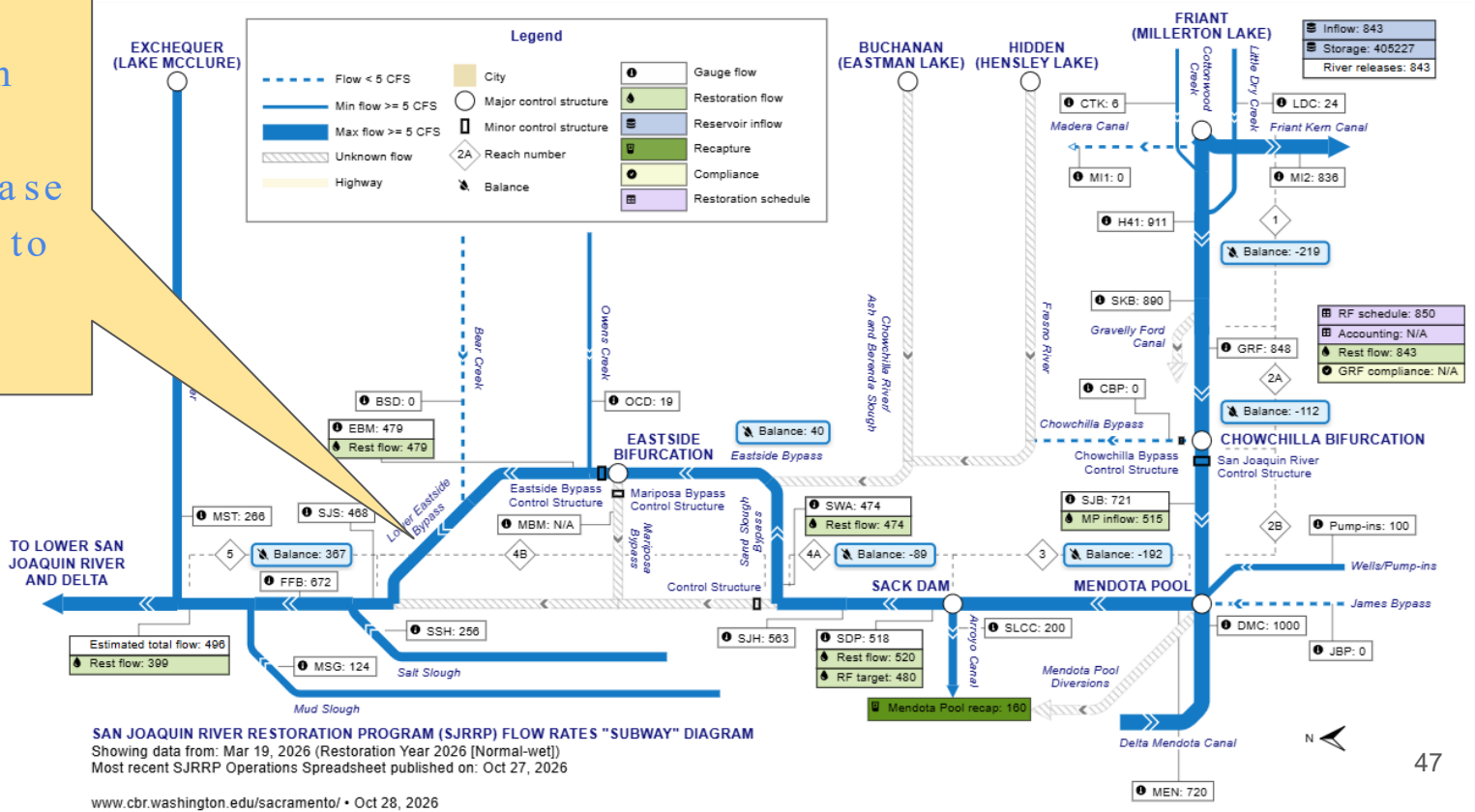
Subway Example — March 3, 2026

Tributary inflows from Little Dry and Cottonwood Creek began, reduced Reach 1 balance (-108 cfs)



Subway Example — March 19, 2026

Maximum Restoration Flows, line weights increase proportional to flow

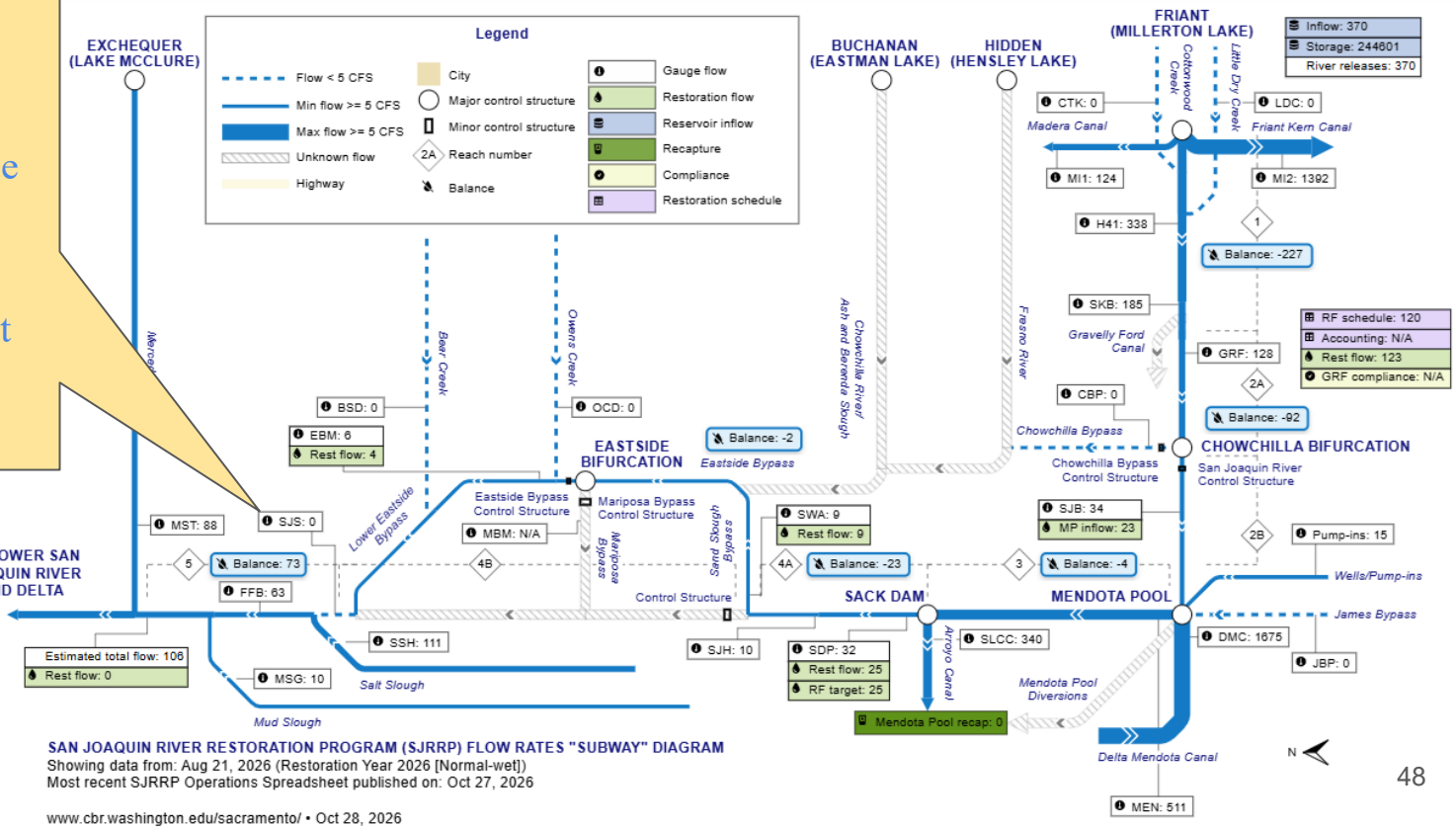


SAN JOAQUIN RIVER RESTORATION PROGRAM (SJRRP) FLOW RATES "SUBWAY" DIAGRAM
Showing data from: Mar 19, 2026 (Restoration Year 2026 [Normal-wet])
Most recent SJRRP Operations Spreadsheet published on: Oct 27, 2026

www.cbr.washington.edu/sacramento/ • Oct 28, 2026

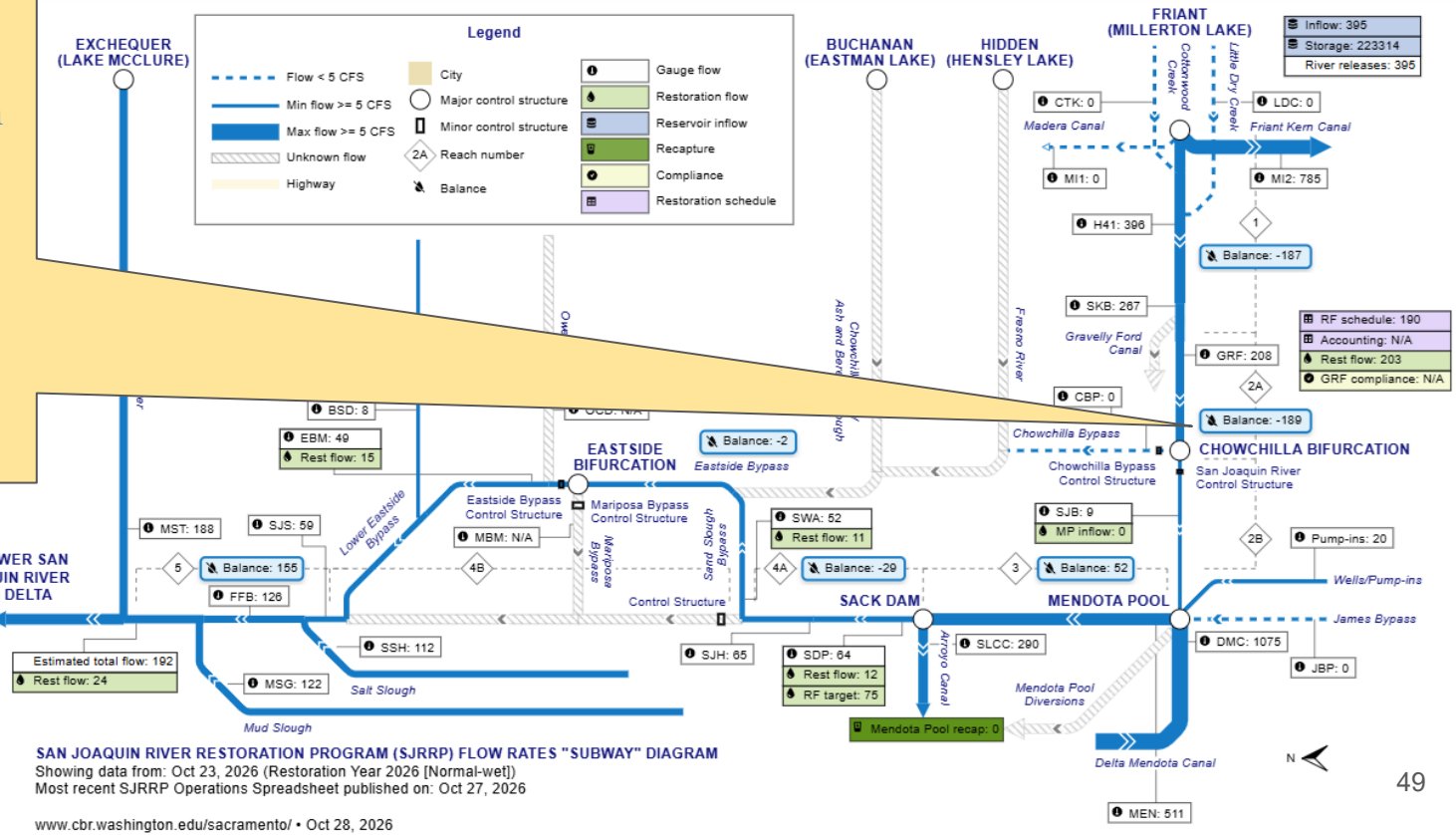
Subway Example — August 21, 2026

Minimum Restoration Flows, line weights decrease proportional to flow, disconnection at SJS

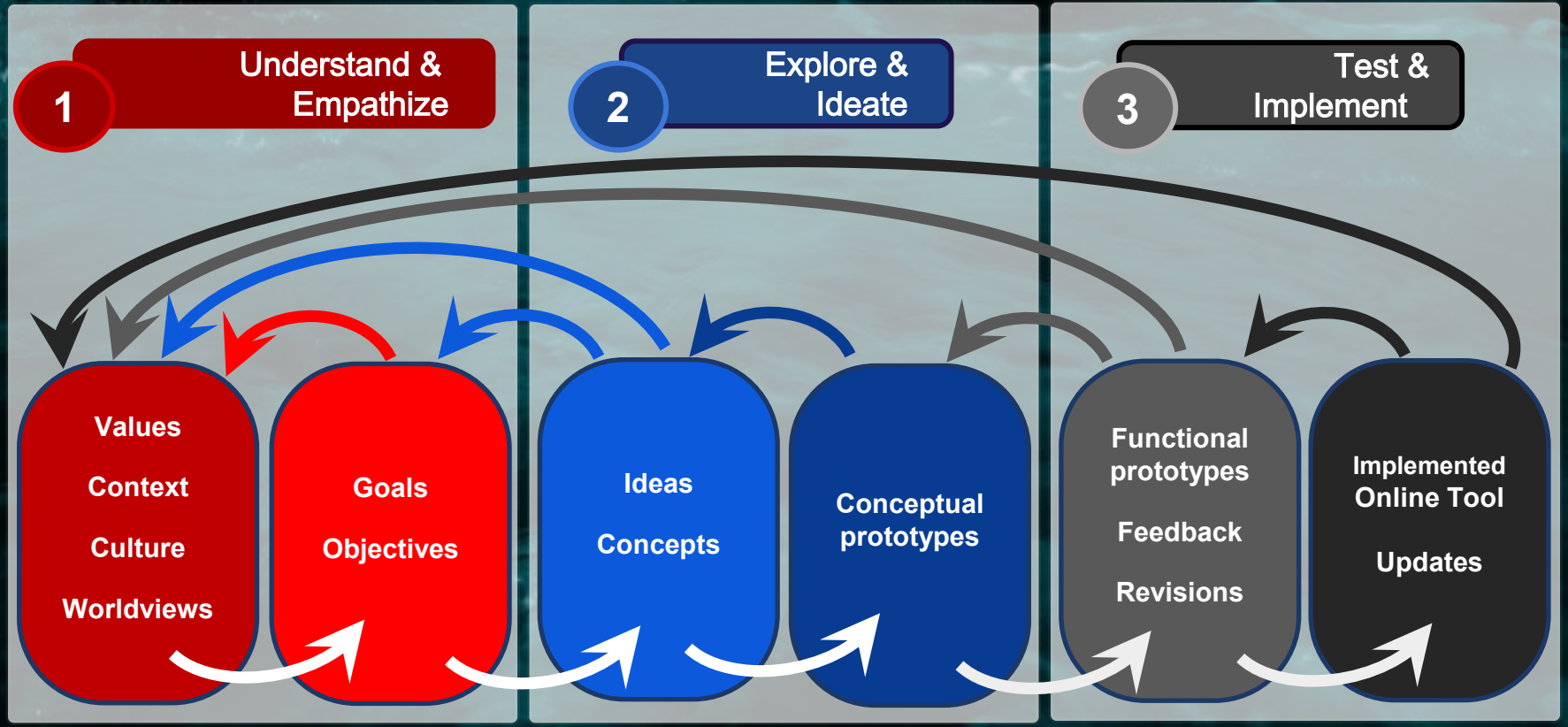


Subway Example — October 23, 2026

Reach 2A balance is abnormally high (-189 cfs), indicating likely gauge mis-calibration at SJB



Design Thinking



1 Understand & Empathize

2 Explore & Ideate

3 Test & Implement

Values

Context

Culture

Worldviews

Goals

Objectives



1 Understand & Empathize

2 Explore & Ideate

3 Test & Implement

Values

Context

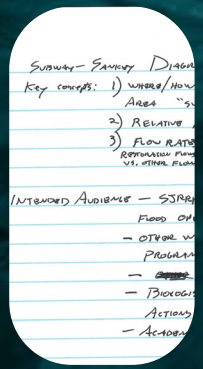
Culture

Worldviews

Goals

Objectives





1 Understand & Empathize

2 Explore & Ideate

3 Test & Implement

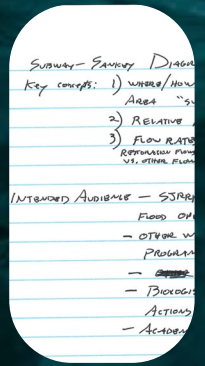
Values
Context
Culture
Worldviews

Goals
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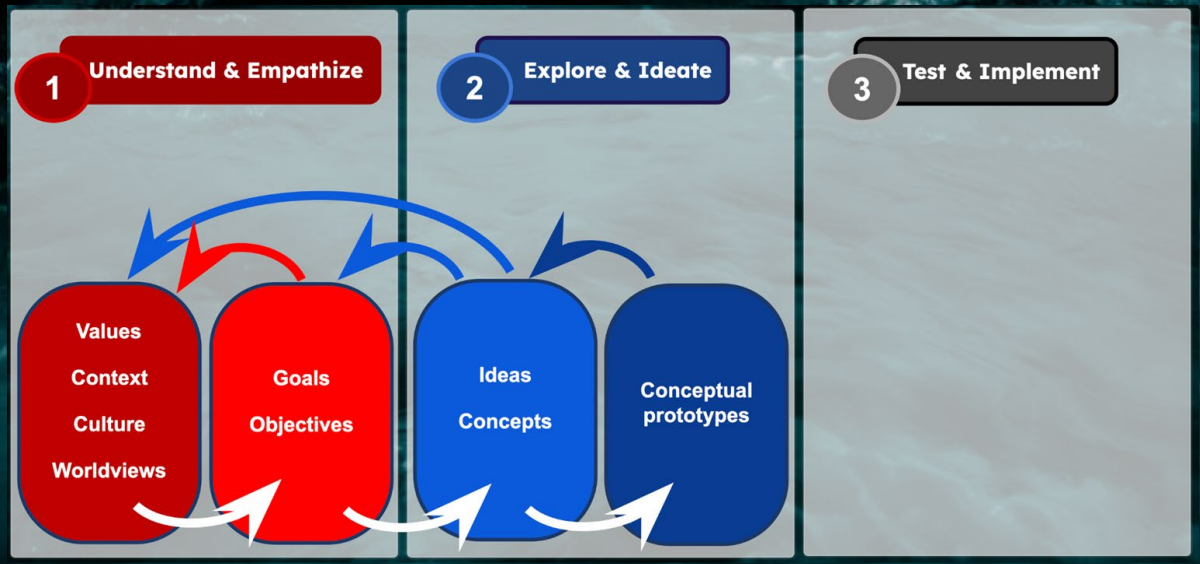
Ideas
Concepts



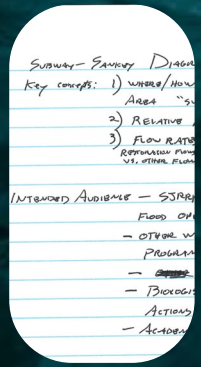




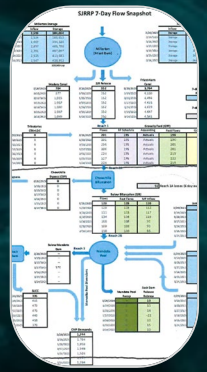


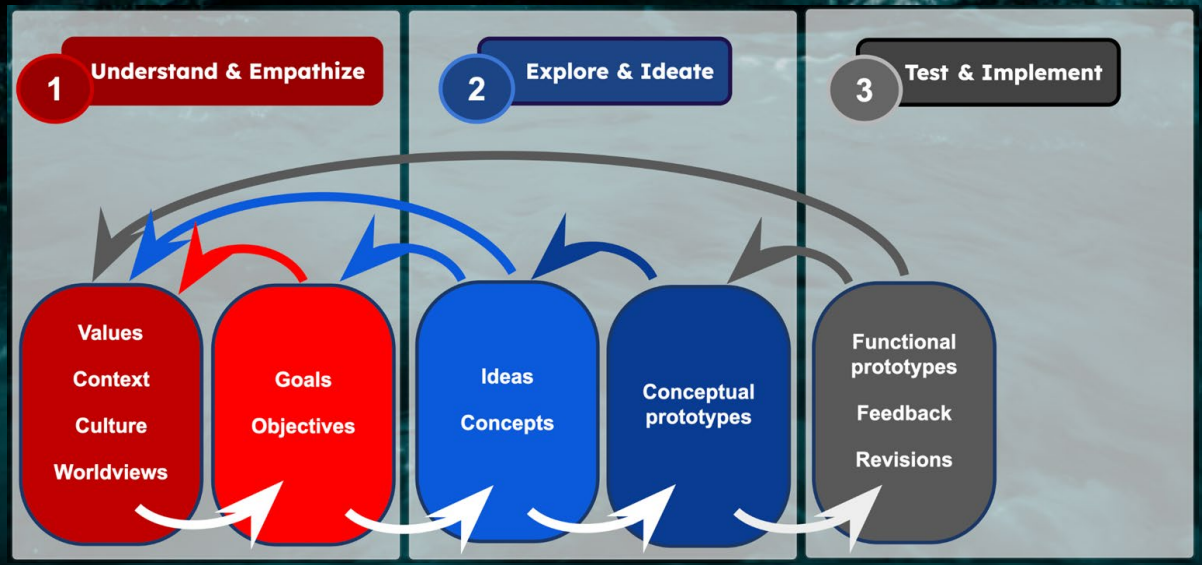

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Culture
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Goals
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Concepts
Conceptual prototypes



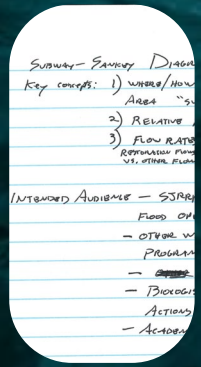



UNDERGROUND

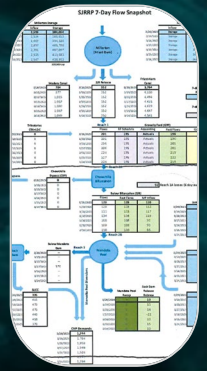


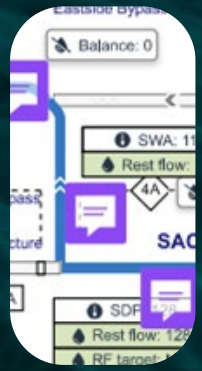

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2
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3
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Context
Culture
Worldviews
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Conceptual prototypes
Functional prototypes
Feedback
Revisions

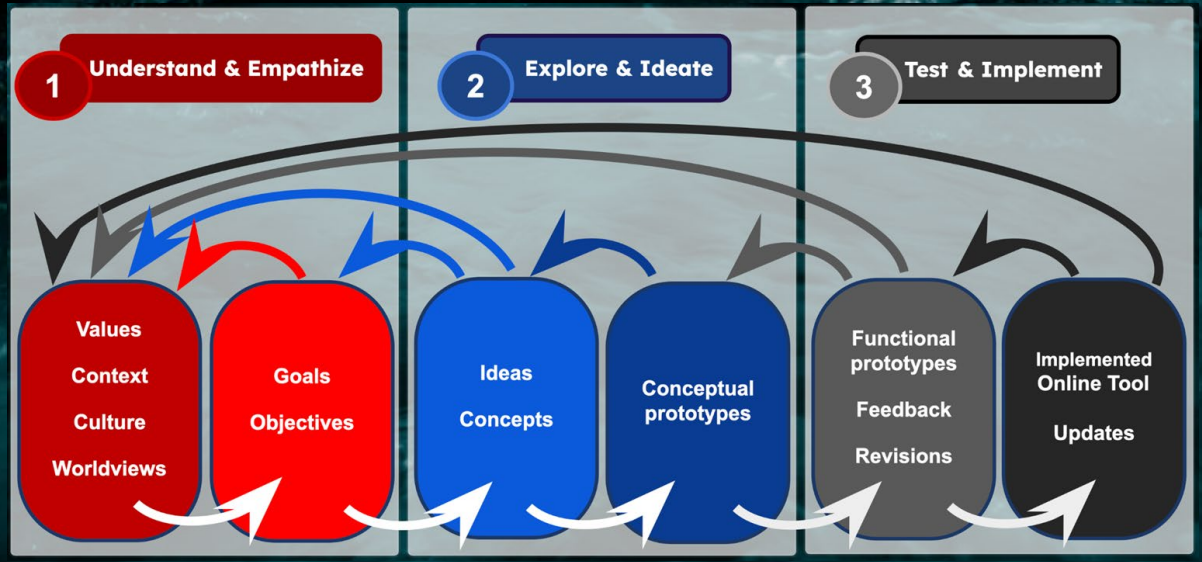




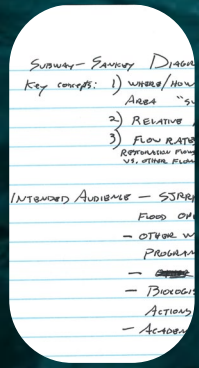

UNDERGROUND



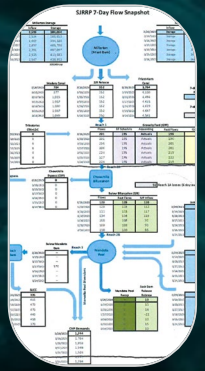

Balance: 0
SWA:
Rest flow:
4A
SAC
Rest flow:

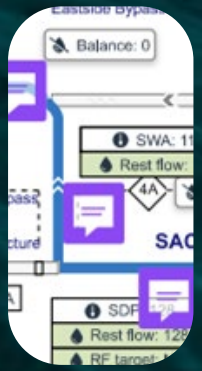

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2
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3
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Culture
Worldviews
Goals
Objectives
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Implemented Online Tool
Updates



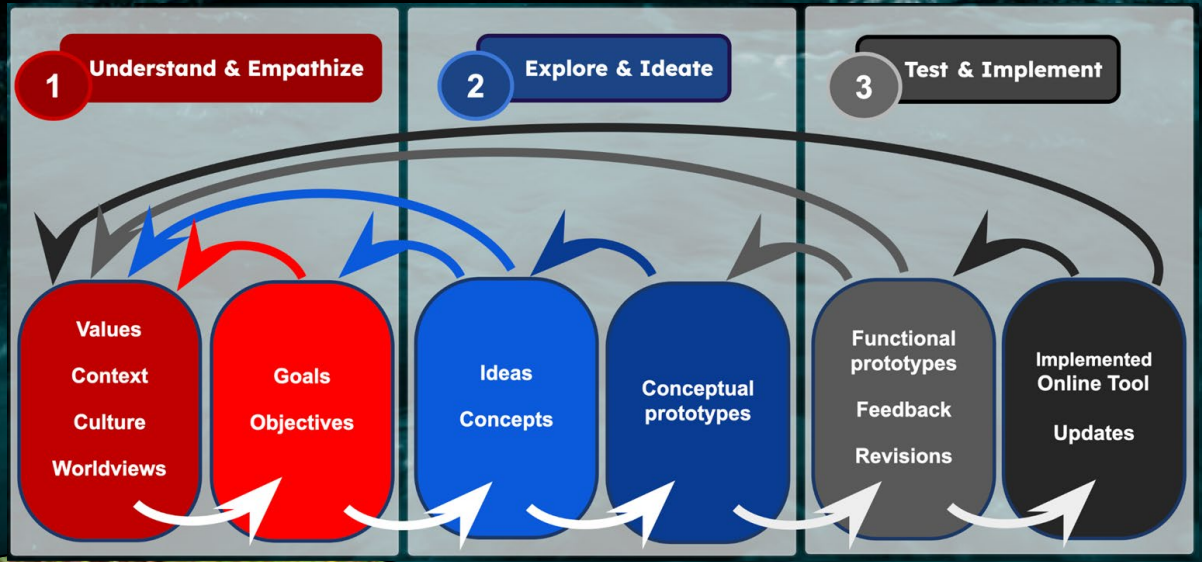



UNDERGROUND



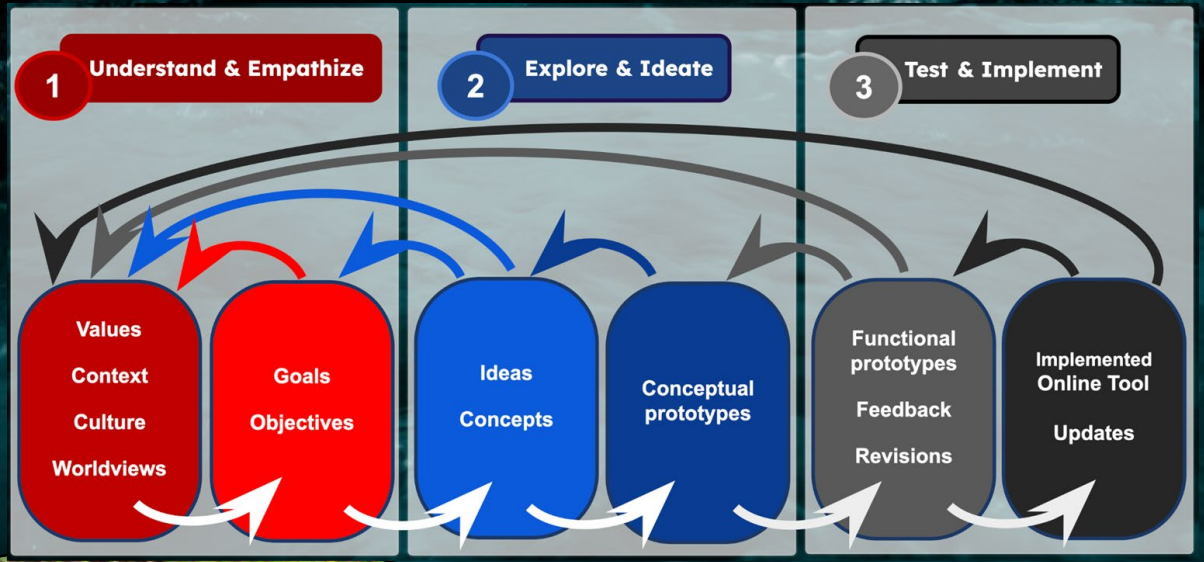

Balance: 0
SWA:
Rest flow:
4A


SacPAS


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Objectives
Ideas
Concepts
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Decision Support Tool

Acknowledgments

We are grateful for Reclamation funding our SacPAS work, and in particular Lisa Elliott (GOTR) and Josh Israel.

BUREAU OF RECLAMATION