Drought Mitigation Planning in the Colorado River Basin in Utah

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California Water & Environmental Modeling Forum

September 23rd, 2024

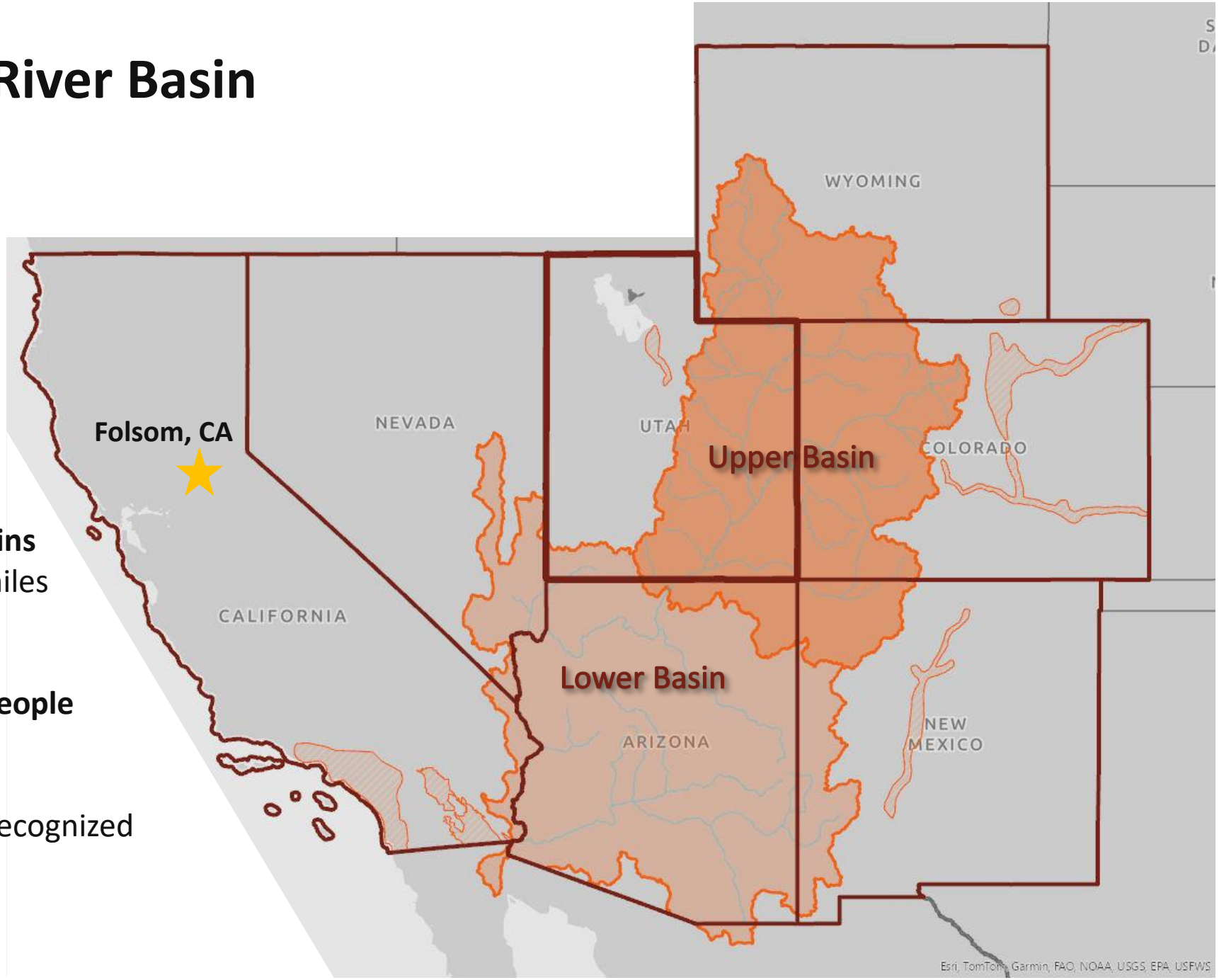
Colorado River Basin

Upper and Lower Basins

- 250 square miles

Supports 40 million people

- 7 states
- 2 countries
- 30 federally recognized tribes



It's Complicated…

Law of the River / "Interstate"

- The Colorado River Compact (1922)
- Boulder Canyon Project Act (1928)
- California Seven Party Agreement (1931)
- Mexican Water Treaty (1944)
- Upper Colorado River Basin Compact (1948)
- Colorado River Storage Project Act (1956)
- Arizona v. California (1964)
- Colorado River Basin Project Act (1968)
- Criteria for the Coordinated LROC (1970)
- Minute 242 of the U.S. Mexican IB and Water Commission (1973)
- Colorado River Basin Salinity Control Act (1974)
- Upper Colorado River Endangered Fish Recovery Program (1987) & San Juan Basin Recovery Program
- Grand Canyon Protection Act (1992)
- Interim Guidelines for Shortage and Coordinated Ops (2007)
- Minutes to the U.S. Mexican Treaty
- Minute 323 (2017) and Drought Contingency Plans (2019)
- …..

Utah Water Law / "Intrastate"

Index Utah Code

Title 73 Water and Irrigation

Chapter 1	General Provisions
Chapter 2	State Engineer - Divis on of Water Rights
Chapter 3	Appropriation
Chapter 3a	Water Exports
Chapter 3b	Groundwater Recharg and Recovery Act
Chapter 3c	Wastewater Reuse Act
Chapter 3d	Water Preferences During Emergencies
Chapter 4	Determination of Water Rights
Chapter 5	Administration and Distribution
Chapter 5a	Dam Safety
Chapter 6	Withdrawal of Unappropriated Waters
Chapter 10	Board of Water Resources - Division of Water Res urces
Chapter 10c	Water Development Coordinating Council
Chapter 10d	Utah Privatization Act
Chapter 10e	Water Development and Flood Mitigation Reserve ccount
Chapter 10f	Bear River Development
Chapter 10g	Water Infrastructure and Long-term Planning
Chapter 11	Consolidation of Water Companies and Conservati n Districts
Chapter 12a	Colorado River Compact
Chapter 13	Upper Colorado River Basin Compact
Chapter 15	Modification of Weather
Chapter 16	Amended Bear River Compact
Chapter 18	State Boating Act

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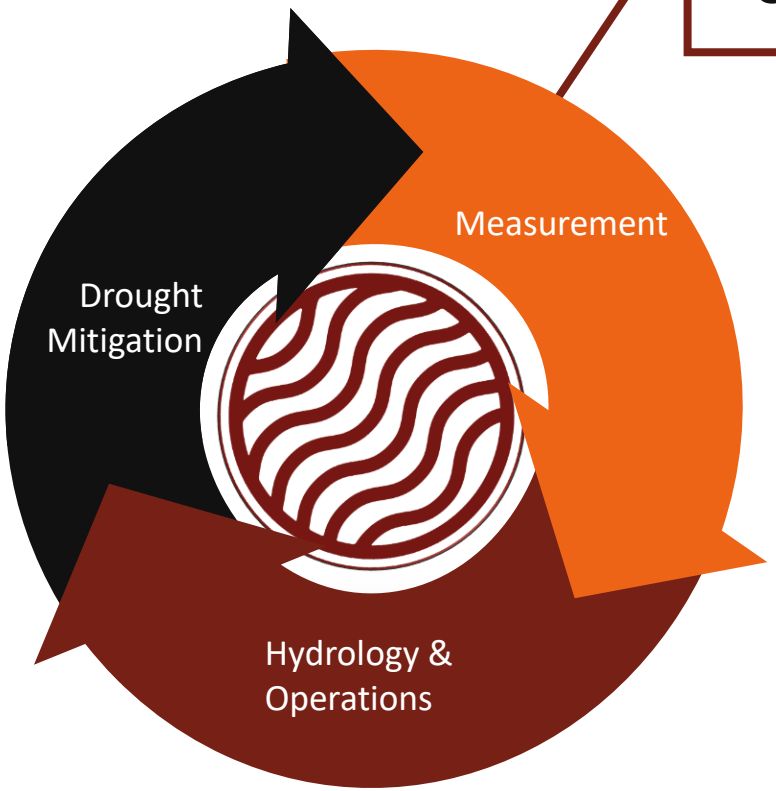
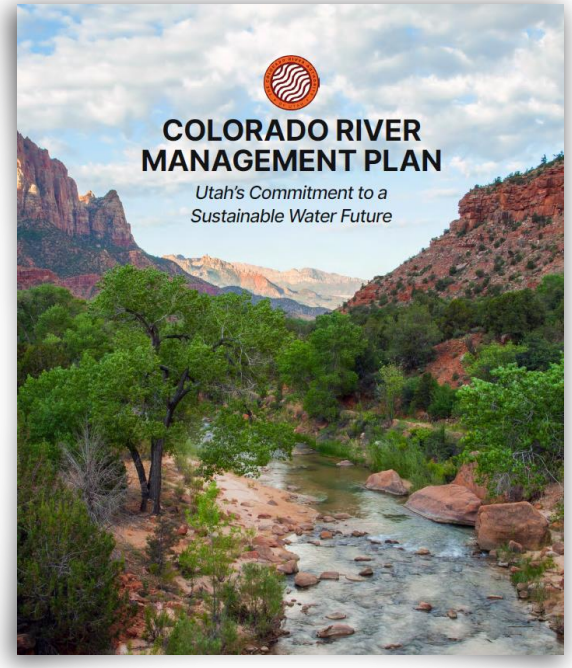
Colorado River Authority of Utah

"The mission of the Authority is to **protect, conserve, use, and develop** Utah's waters of the Colorado River system"

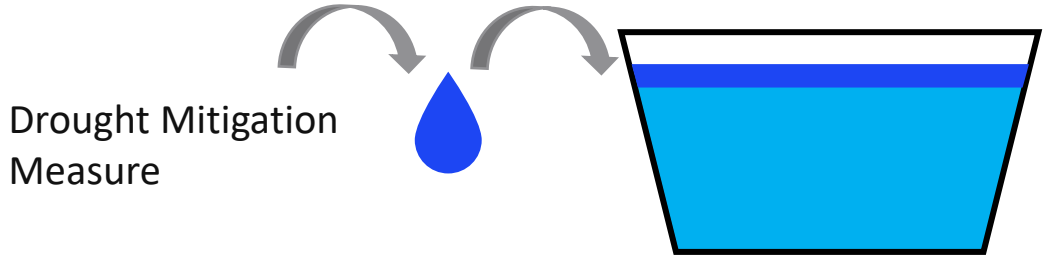


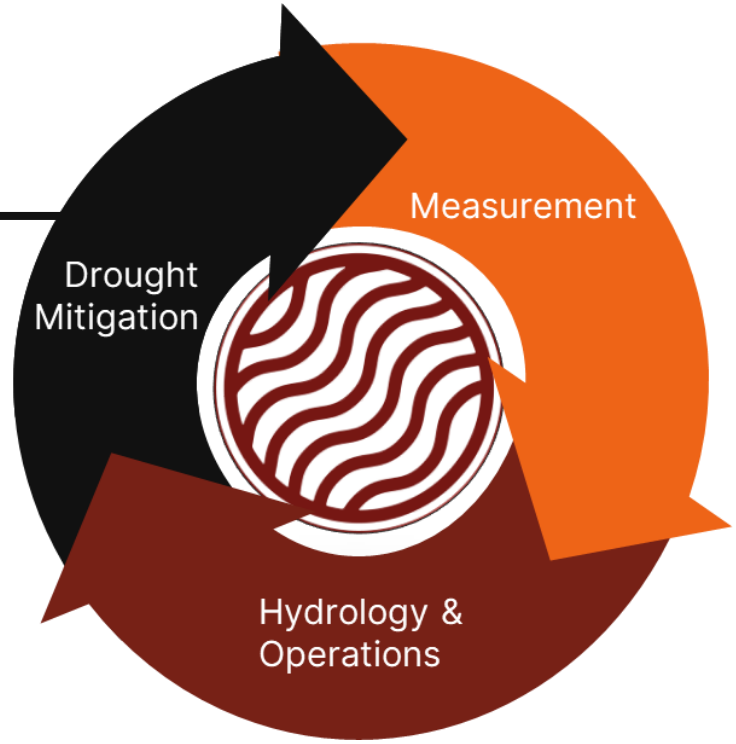


Agricultural Water Use in Utah

Drought Mitigation

Develop solutions to support water use and demand under stressed conditions





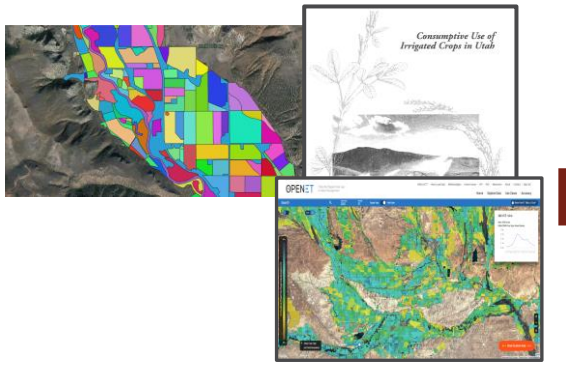
- How much conserved water do drought mitigation measures produce?
- What are the most effective measures for producing conserved water?
- In what conditions will programs be successful?
- What are the unanticipated consequences?

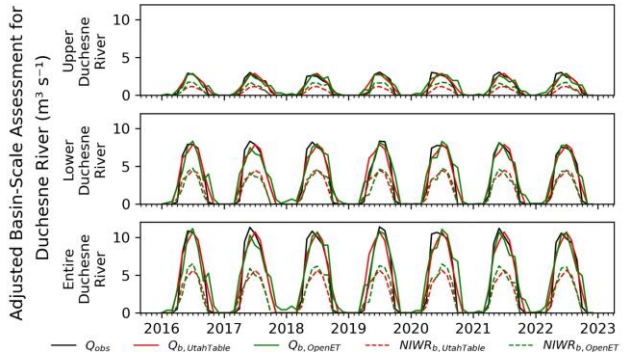
Utah Colorado River Accounting and Forecasting (UCRAF)

UCRAF was proposed as a **planning tool** for the Colorado River Basin in Utah

- Characterize the **water budget** (supply, consumptive use, losses) and **water rights**
- Understand the impact of **drought mitigation measures**
  - Identify potential programs and **quantify depletion savings**

Diversion-Runoff Calculator (DRC)





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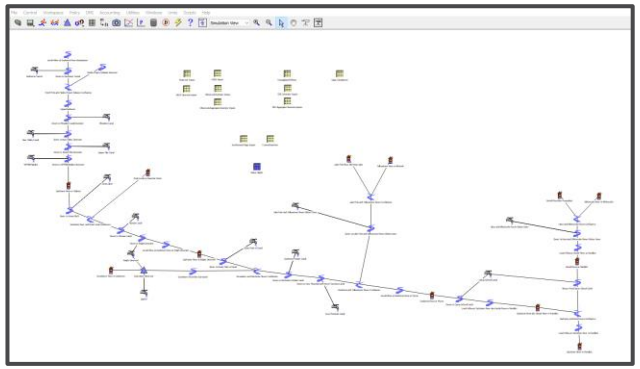
RiverWare©



P W R E

PRECISION
WATER RESOURCES ENGINEERING

Diversion Runoff Calculator

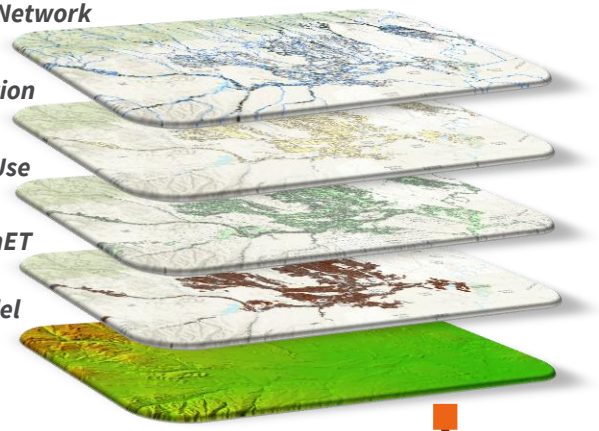
Water Distribution Network

Place of Use Irrigation

Water Related Land Use

OpenET

Digital Elevation Model



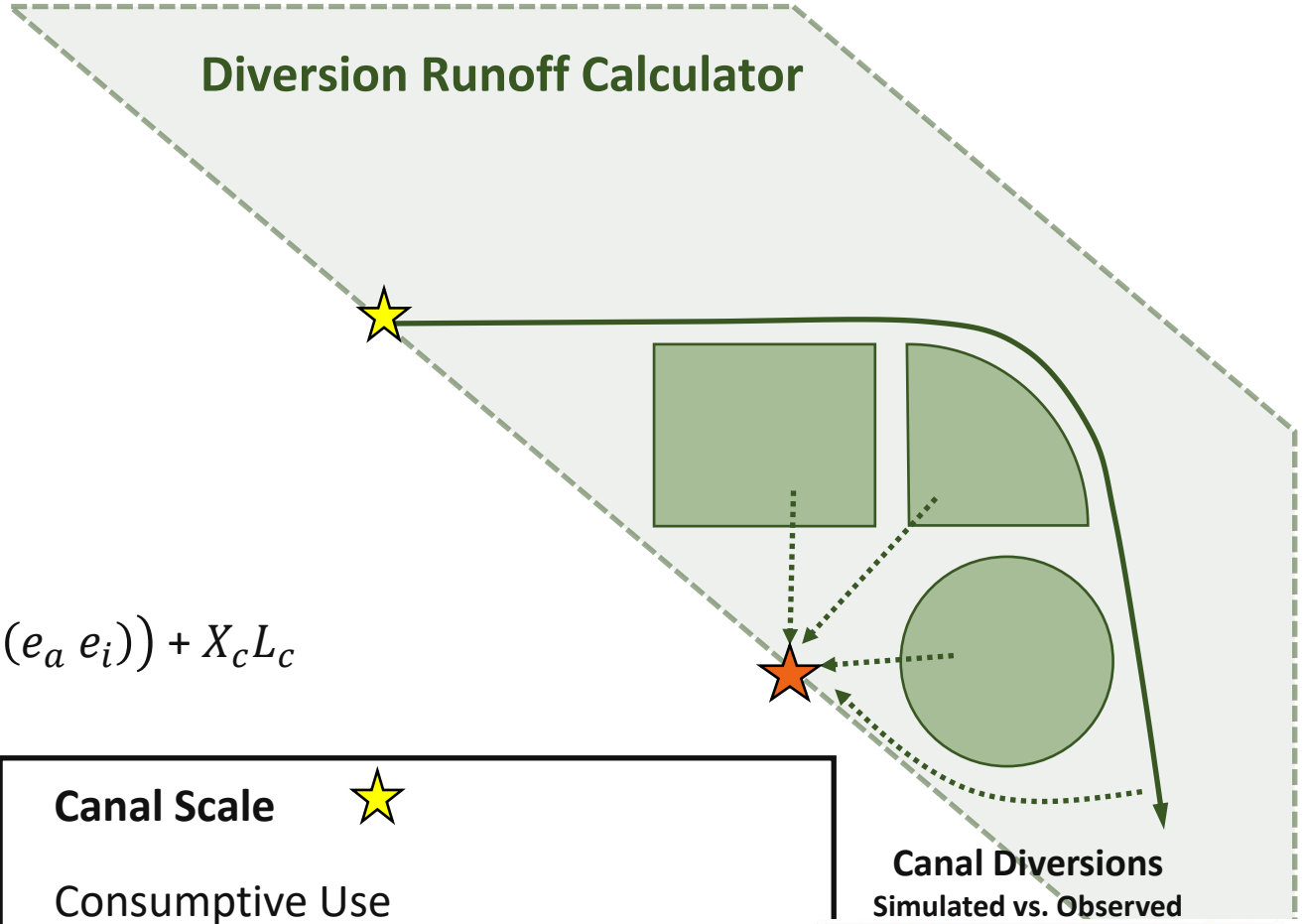
Python

```
(SimFlowUTTable, SimFlowOpenET, SimFlowCanalLoss) = CombineFlowValuesForCanal(CanalName, FlowLineName_Single_List, MonthlyDepletionBase
(SimNIWR_UTTable, SimNIWR_OpenET, SimNIWRCanalLoss) = CombineFlowValuesForCanal(CanalName, FlowLineName_Single_List, MonthlyNIWR_BasedO
print(' ObsFlowTable=' + str(MonthlyObsFlow[30]))
print(' SimFlowTable=' + str(SimFlowUTTable[30]))
print(' SimFlowOpenET=' + str(SimFlowOpenET[30]))
print(' SimFlowCanalloss=' + str(SimFlowCanalLoss[30]))

ax.plot(DatesUse, MonthlyObsFlow, label='Obs', linewidth=1.0, color='k')
ax.plot(DatesUse, SimFlowUTTable, label='Calc Tables', linewidth=1.0, color='r')
ax.plot(DatesUse, SimFlowOpenET, label='Calc OpenET', linewidth=1.0, color='g')
if LegendYes == 1:
    ax.legend(loc='upper center', bbox_to_anchor=(0.3, 1.325), ncol=3, fancybox=False, shadow=False, framealpha=0.0)
# Update the ylabel with the modified CanalName
YName = re.sub(r'([a-z])([A-Z])([a-z])', r'\1 ', CanalName_abrv)
YName = YName.replace('Whiterocksand', 'Whiterocks and\n')
YName = YName.replace('Uintah Independent', 'Uintah\nIndependent\n')
YName = YName.replace('United States Lake Fork Canal', 'United States\nLake Fork\nCanal')
YName = YName.replace('Numbers', 'Number1 ')
YName = YName.replace('West Rock Creek aka George Wright', 'West Rock Creek')
YName = YName.replace('Orchard Mesa Canal/Knight Diversion', 'Orchard Mesa Canal/Knight Div.')
YName = YName.replace('Whiterocks and Ouray Valley Canal', 'Whiterocks and \nOuray Valley Canal')
YName = YName.replace('Big Sand Wash Feeder Pipeline', 'Big Sand Wash \nFeeder Pipeline')
YName = YName.replace('Strawberry Aqueduct - Upper Stillwater Tunnel', 'Strawberry Aqueduct - \nUpper Stillwater Tunnel')
if len(YName) > 12 and len(YName.split(' ')) > 2:
    YName = YName.replace(' Canal', '\nCanal')
    YName = YName.replace(' Pipeline', '\nPipeline')
    YName = YName.replace(' Conduit', '\nConduit')
    YName = YName.replace(' Ditch', '\nDitch')
    YName = YName.replace(' Lateral', '\nLateral')
ax.set(ylabel=YName)
ax.set_ylim(bottom=0.0)
```

Water Rights Records

Diversion Runoff Calculator

- Fields
- Canals
- Diversions
- Return Flows



Calculating Diversions $Q_c = \sum(CU_f\ A_f/(e_a\ e_i)) + X_c L_c$

Field Scale

Consumptive Use

OPENET

Aggregate →

Canal Scale

Consumptive Use

↓ *Account for Efficiencies*

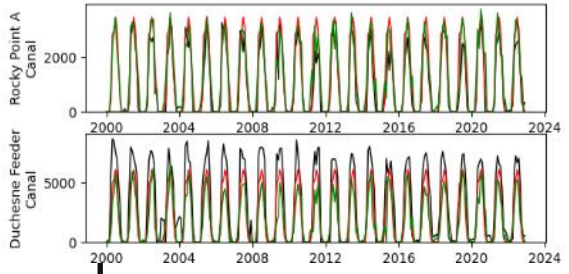
Diversion Requirement (modeled)

vs.

Observed Canal Data

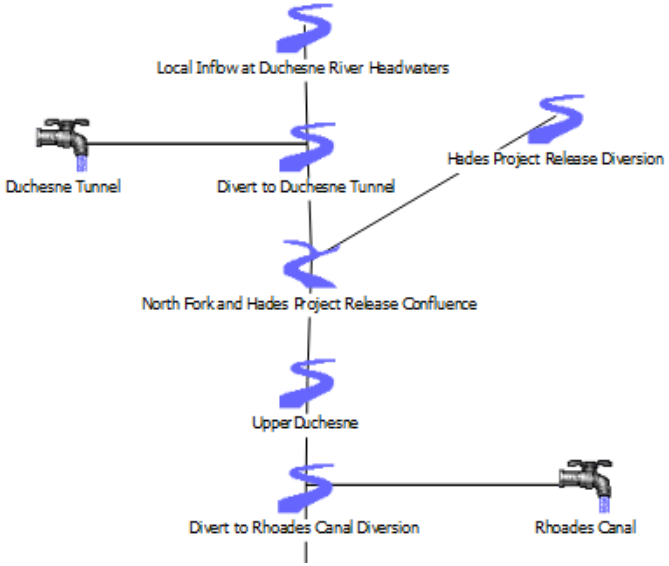
Canal Diversions

Simulated vs. Observed

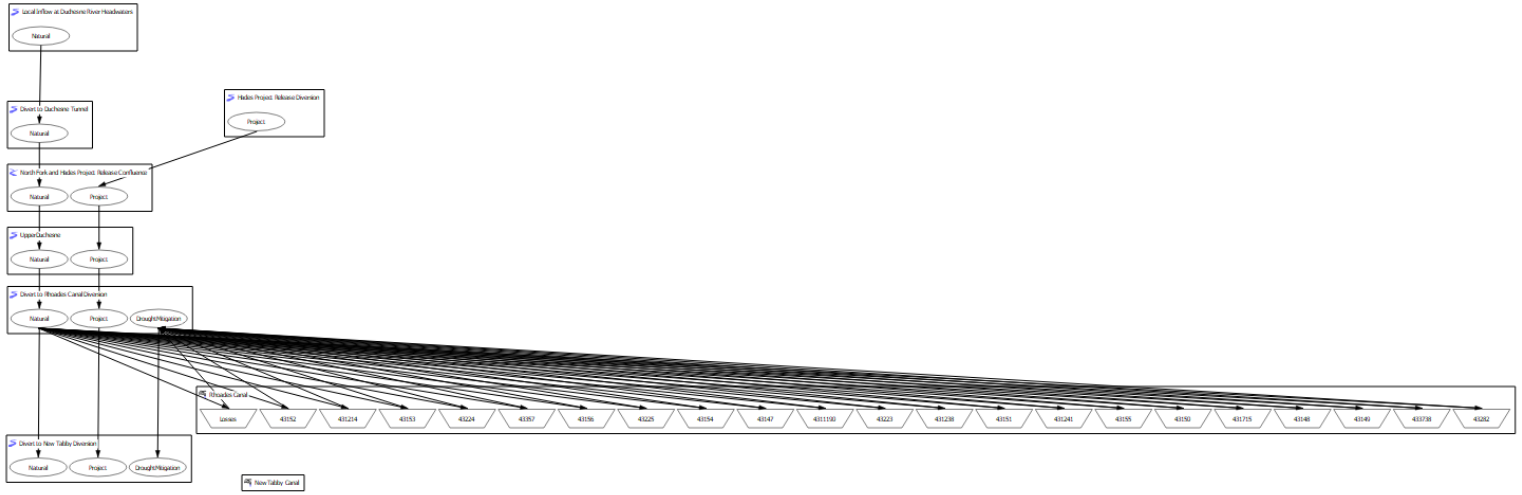


RiverWare Model

Physical Representation



Accounting Representation

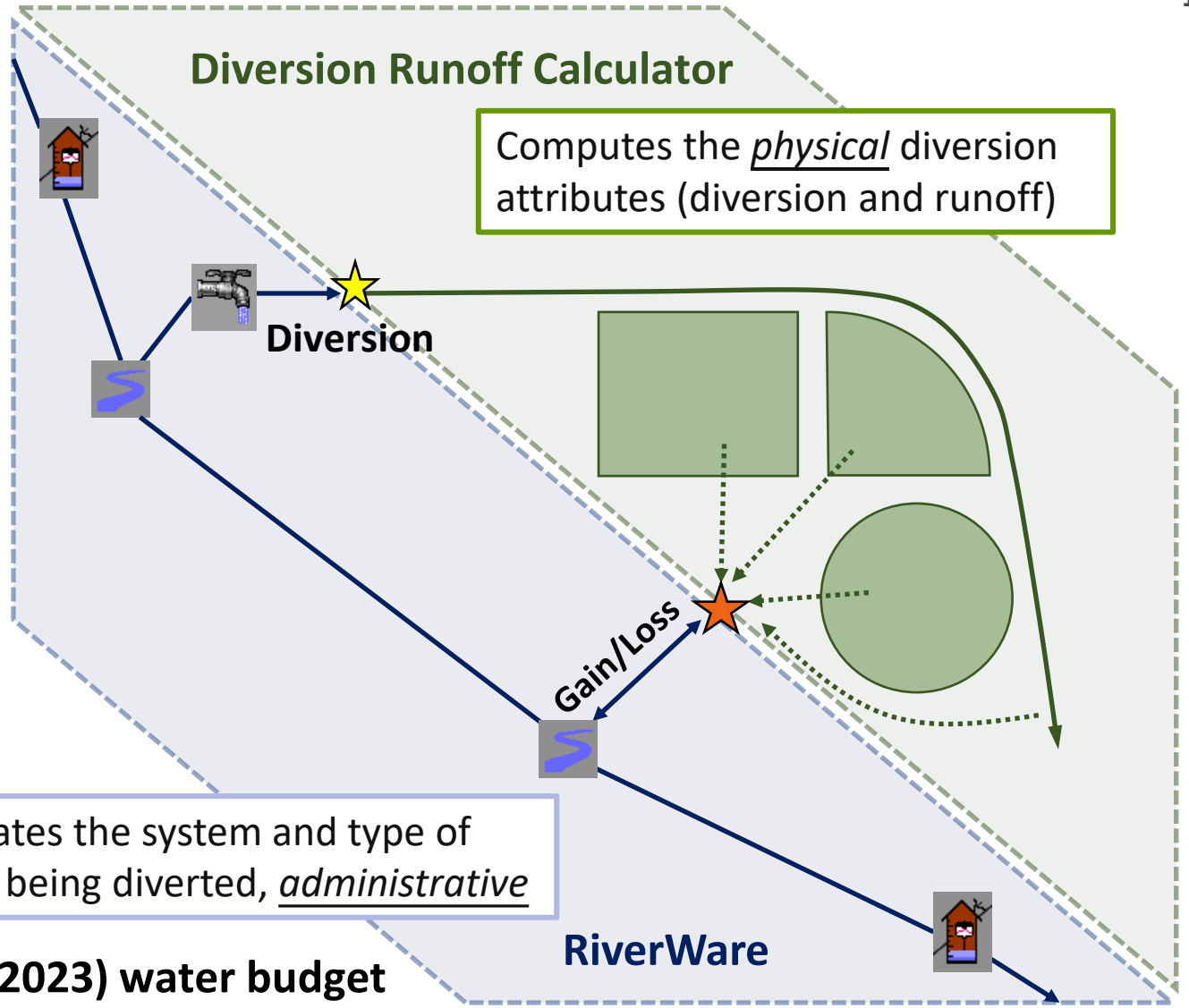


- Computes basin-wide mass balance
- Accounting framework enables distribution via accounts
- Water rights solver allocates water in priority

DRC/ RiverWare Interaction

Linkages

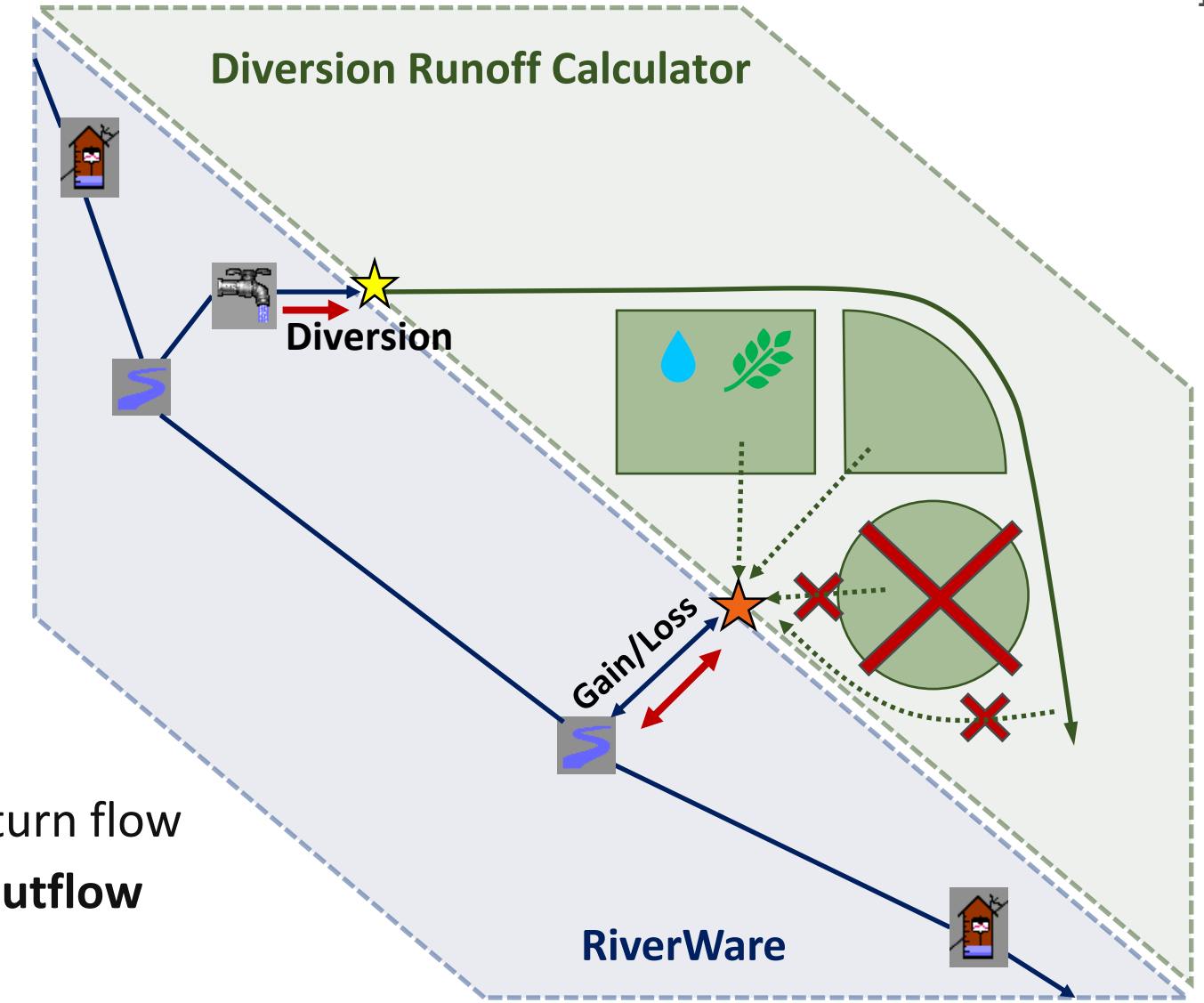
- RW Diversion – Canal Linkage
- RW Gain/Loss – Return Flow Linkage



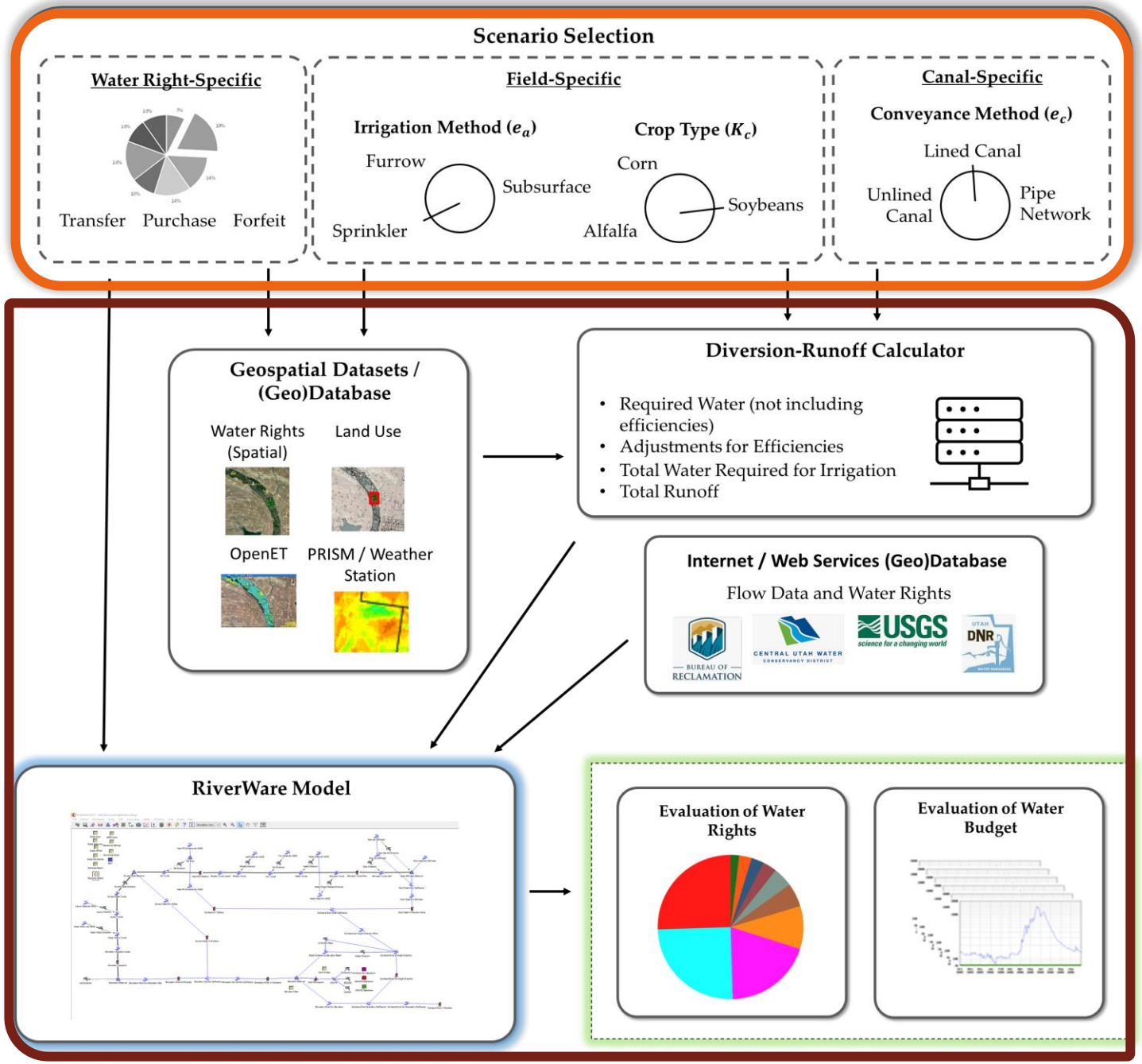
- **Characterize the historical (1991-2023) water budget and water rights within the basin**

UCRAF Application

- **Planning tool to assess the impact of drought mitigation measures**
  - Line canals
  - Fallow fields
  - Change irrigation methods
  - Change crop type
  - Change in diversion and return flow
  - **Estimate change in basin outflow**



UCRAF Overview



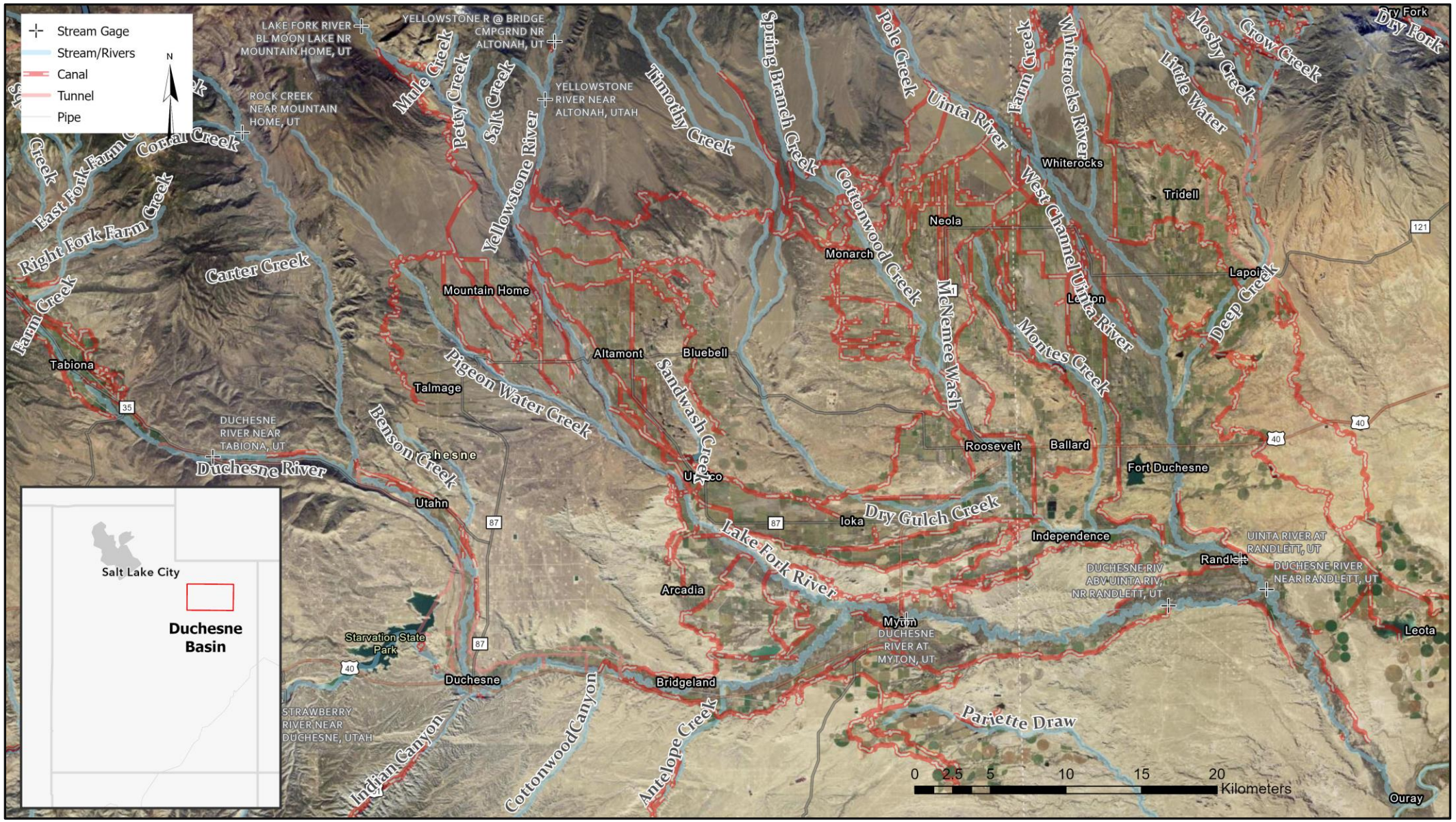
Decision Support

"Change Case"

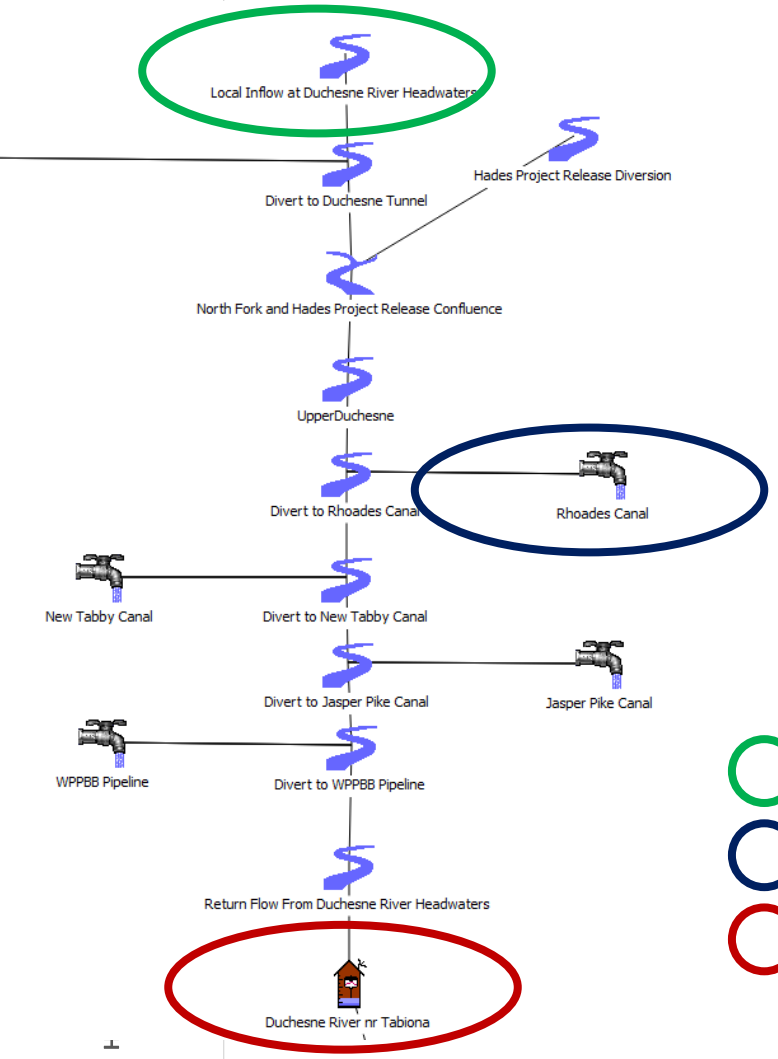
UCRAF Model

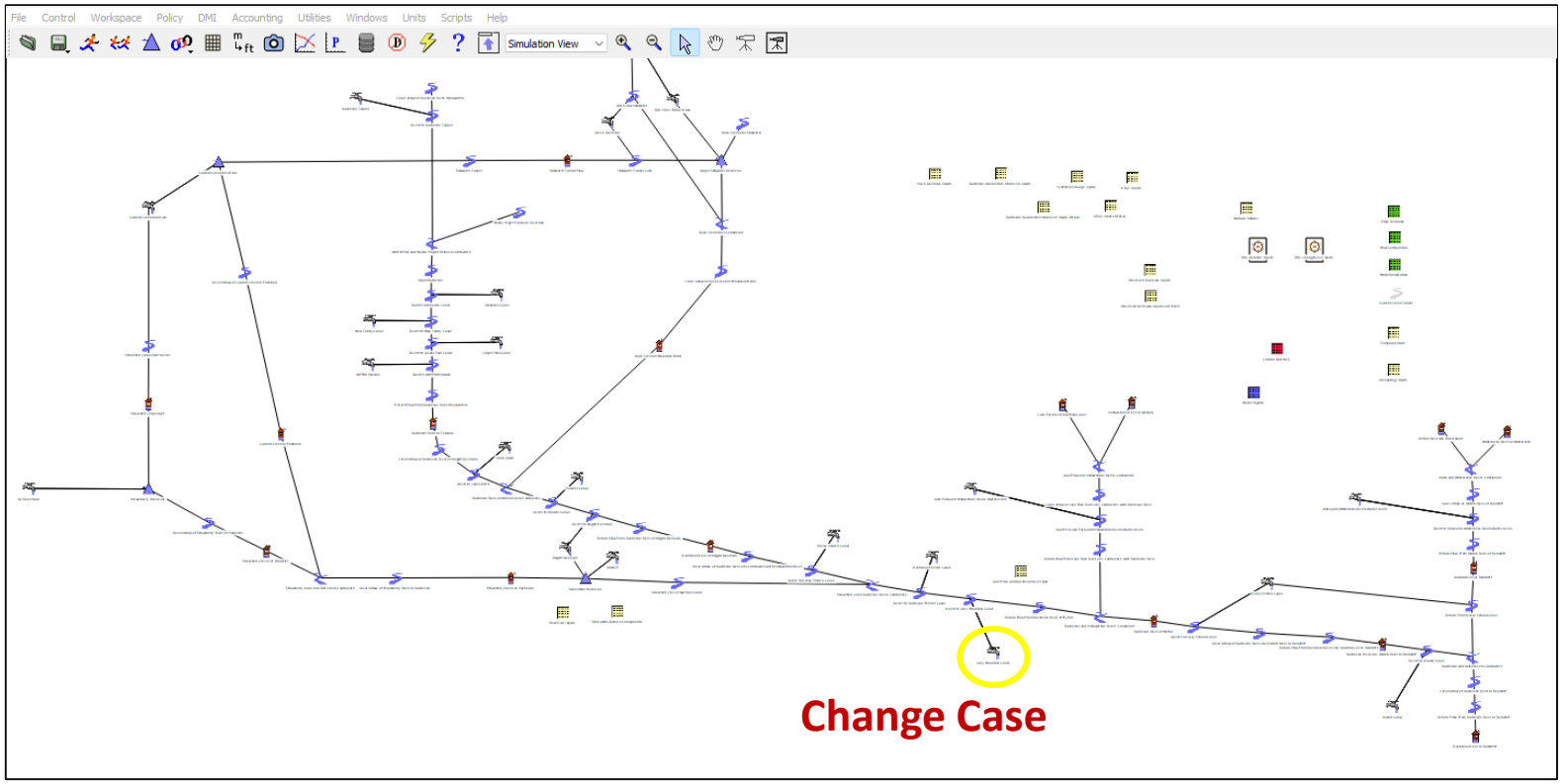
"Baseline"

Duchesne Basin Pilot



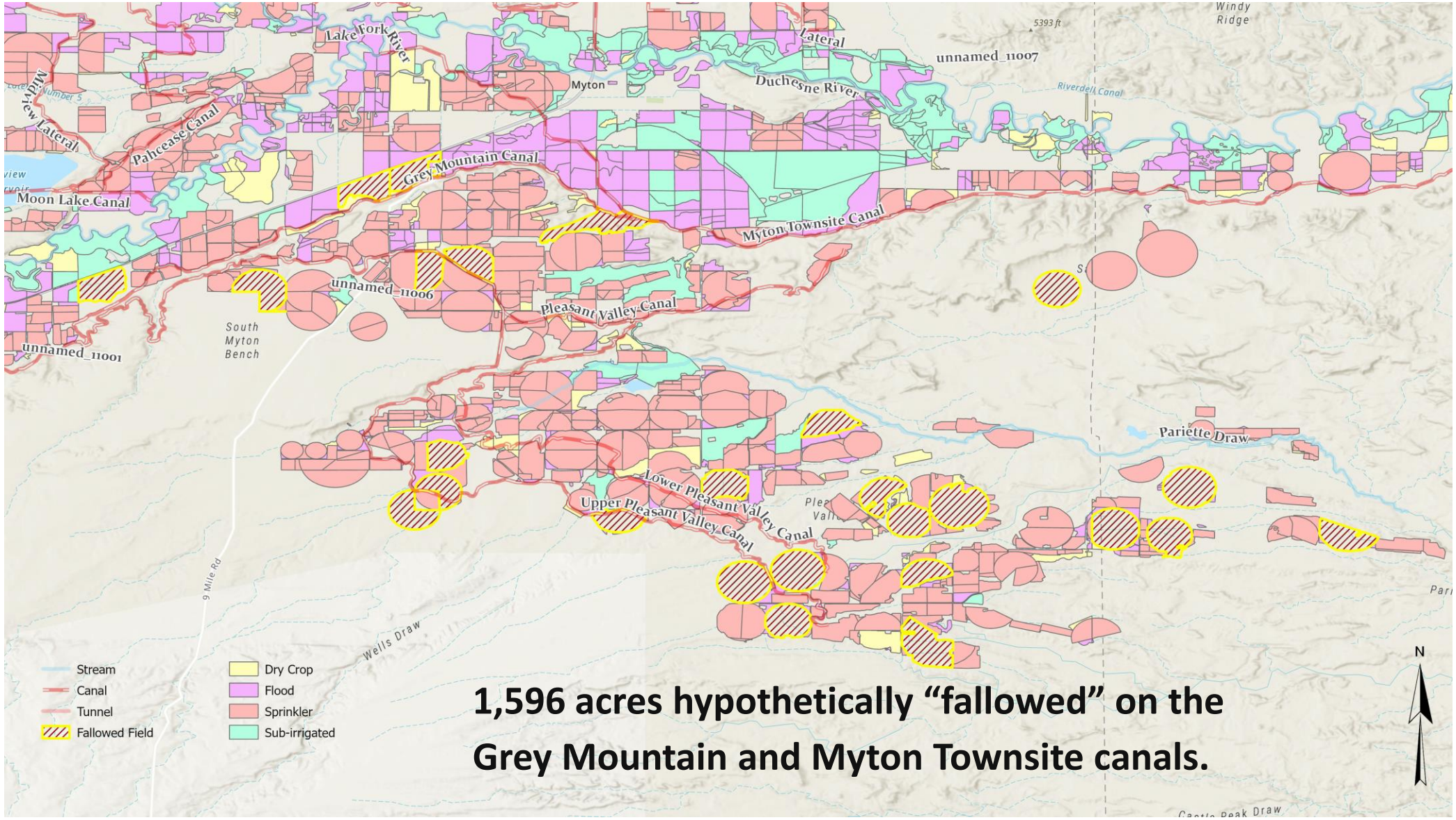
Duchesne Basin RiverWare Model





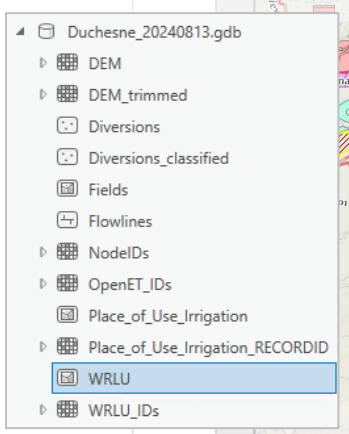
- Inflows are Determined using Observed Data
- Demands on water users are computed from the DRC
- Flows are verified using Gage Data

Duchesne Change Case Example



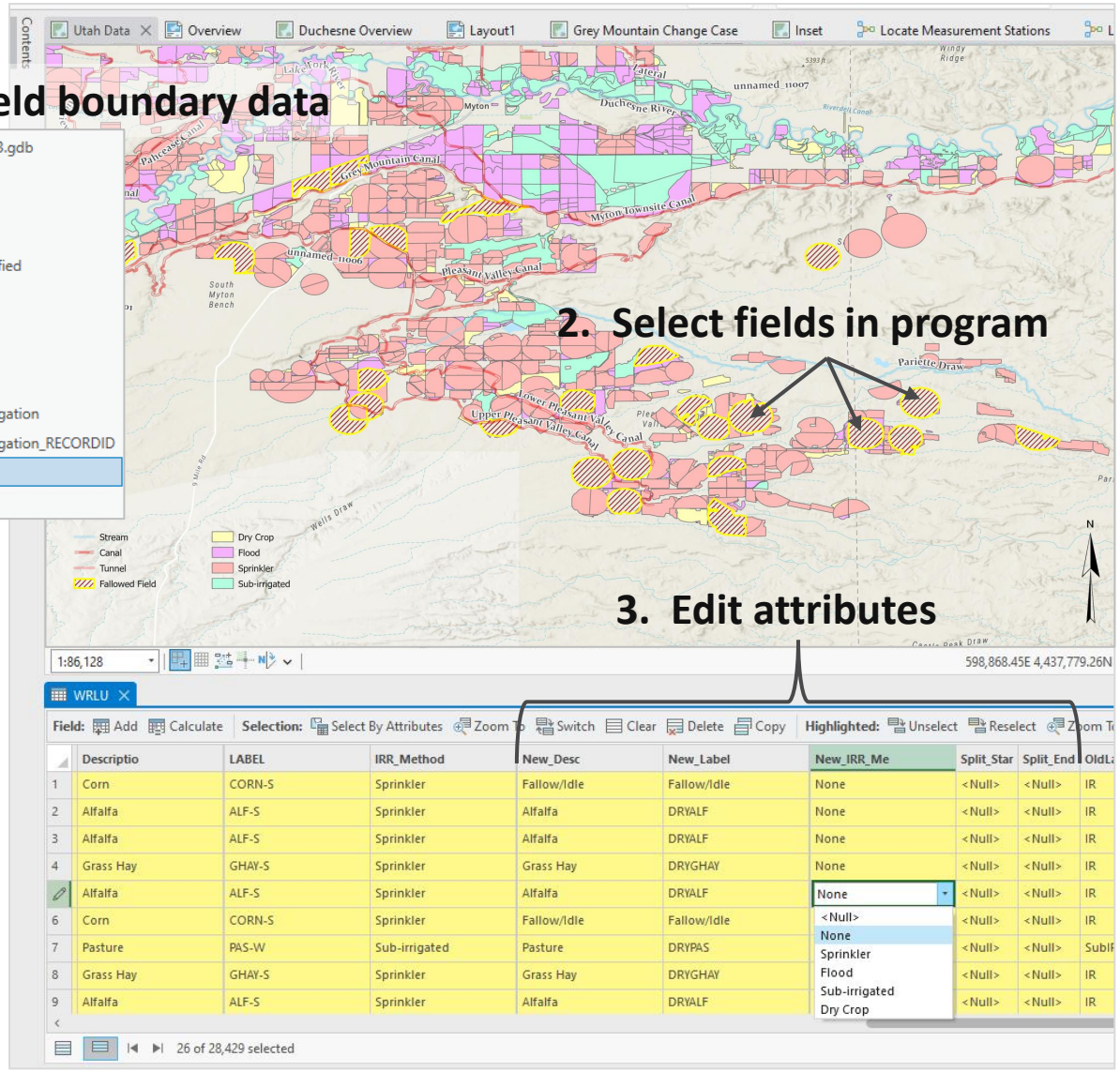
Change Case – Diversion Runoff Calculator

1. Load field boundary data



2. Select fields in program

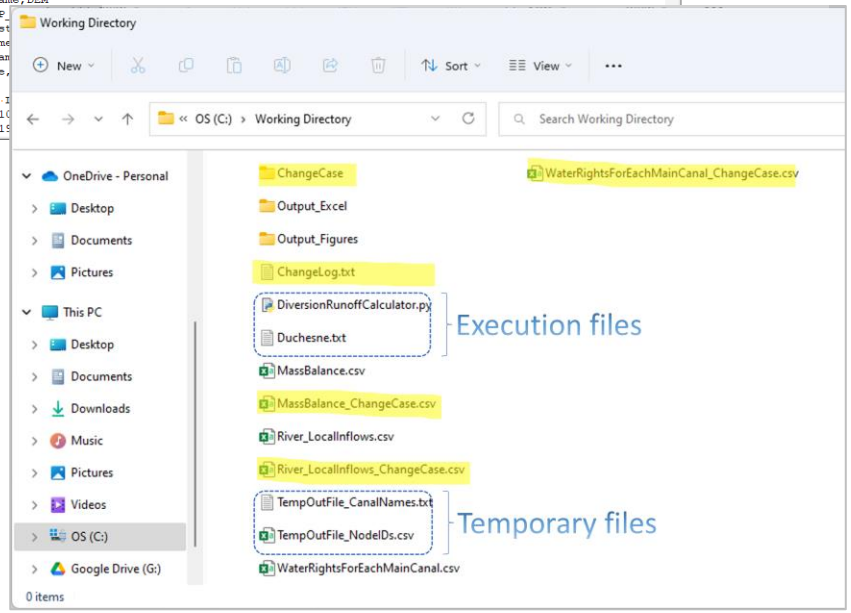
3. Edit attributes



4. Set "Modified Scenario"

```
Start Year: 2000
End Year: 2022

Use Shapefile (True/False): False

Use Utah Tables (0) or OpenET (1): 1

For Utah Tables use closest by distance (0) or nearest elevation (1): 0

Use Base Scenario (0) or Modified Scenario (1): 1

Aggregate canals for RiverWare (True/False): True

File List:
Utah_GDB,DUCH_20240513.gdb,C:/UCRAF/Duchesne/GIS
NetPathlinesTable,NetPathlines Table.xlsx,C:/UCRAF/GIS/Utah Water Right Distribution Network/20240513
NetPathPointsTable,PathPoints Table.xlsx,C:/UCRAF/GIS/Utah Water Right Distribution Network/20240513
NetPathsTable,NetPaths Table.xlsx,C:/UCRAF/GIS/Utah Water Right Distribution Network/20240513
UT_Table_Folder, ,C:/UCRAF/ET_Tables
UT_Table_File,UT_Table_ConsumptiveUse.xlsx,C:/UCRAF/ET_Tables
OpenET_InputCSV_Name,OpenET_Data_Duchesne.csv,C:/UCRAF/Duchesne/OpenET
CanalToFieldsTXT,DUCH_OutFile_CanalToFields.txt,C:/UCRAF/Duchesne/DRC/Terrain_20240513
CanalToRiverTXT,DUCH_OutFile_CanalToRiver.txt,C:/UCRAF/Duchesne/DRC/Terrain_20240513
FieldsToFieldsTXT,DUCH_OutFile_Fields.txt,C:/UCRAF/Duchesne/DRC/Terrain_20240513
FieldsToCanalTXT,DUCH_OutFile_RiversCanals.txt,C:/UCRAF/Duchesne/DRC/Terrain_20240513
ObsFlowFolder,,C:/UCRAF/Duchesne/CanalFlow_DWRi/data
WaterRightFolder_Name,,C:/UCRAF/Duchesne/WaterRightData
WaterRightExcelFileName,000_WaterRights_CompiledData.xlsx,C:/UCRAF/Duchesne/WaterRightData
OutputFigureFolder,,Output_Figures
OutputExcelFolder,,Output_Excel
ObservedFlowData,Observed_List.csv,C:/UCRAF/Duchesne/CanalFlow_DWRi/data

Shapefile List:

GeoDatabase Feature Layers:
NetFieldsRAST,NodeIDs
NetFlowlinesSHP,Flowlines
DiversionsSHP,Diversions_classified
DEM_RAST_Name,DEM
Utah_WR_SHP
Utah_WR_Rast
WRLU_ID_Name
WRLU_SHP_Nam
OPENET_Name,
Main Canal
unnamed_2010
unnamed_2019
```

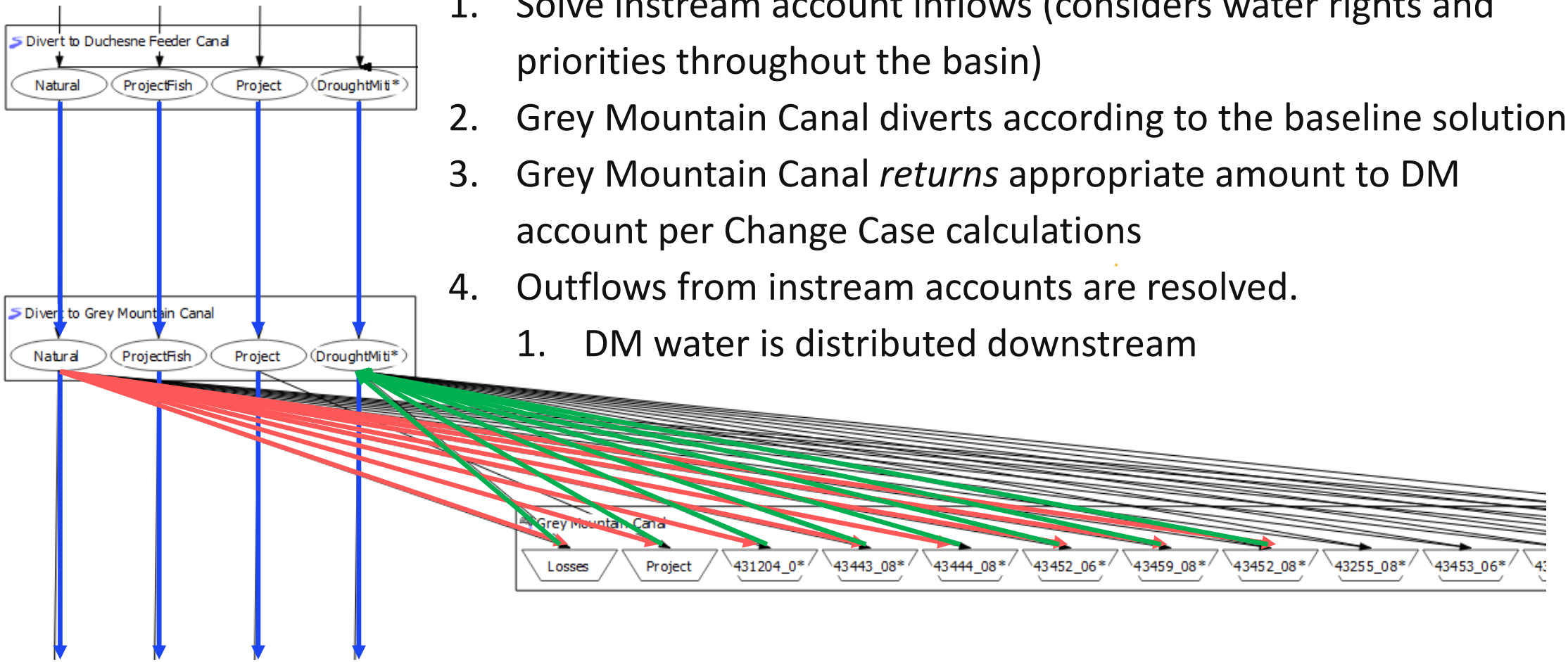
5. Run DRC and compare output



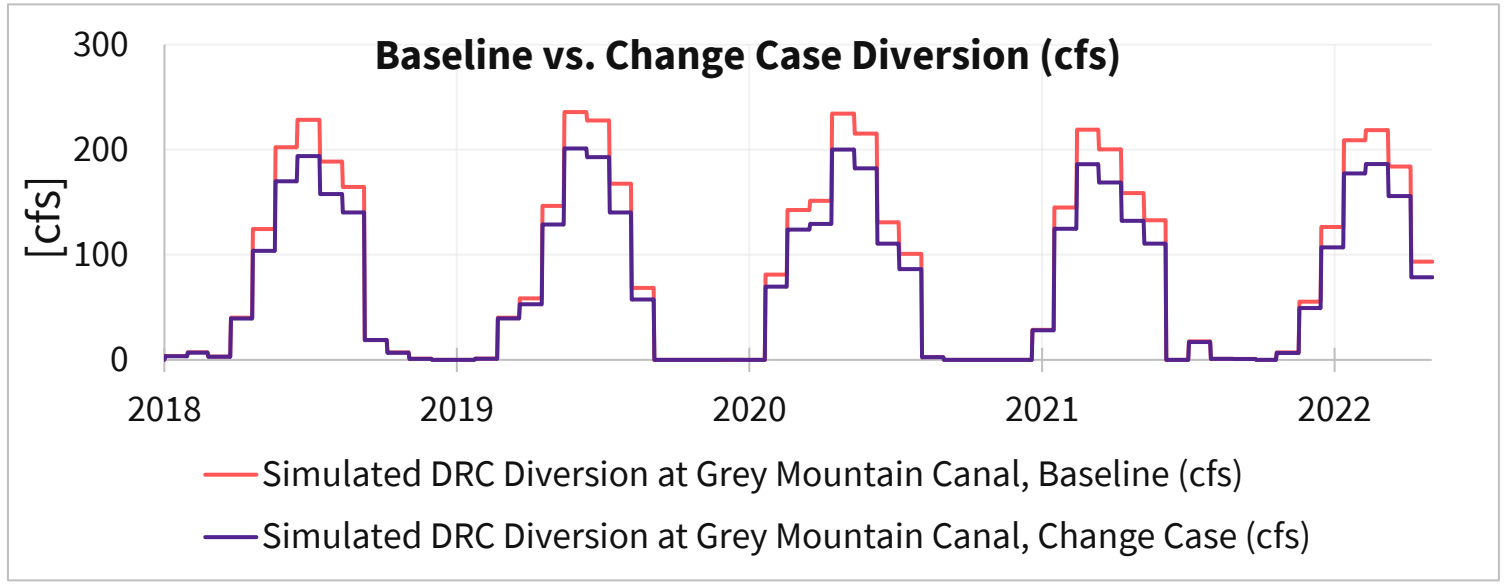
Change Case – Water Rights Accounting in RiverWare

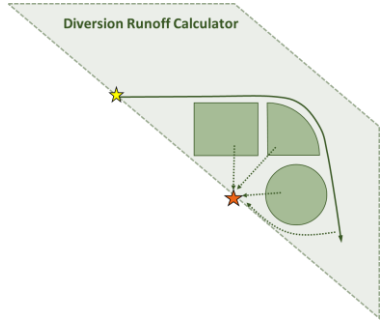
Solution logic:

1. Solve instream account inflows (considers water rights and priorities throughout the basin)
2. Grey Mountain Canal diverts according to the baseline solution
3. Grey Mountain Canal *returns* appropriate amount to DM account per Change Case calculations
4. Outflows from instream accounts are resolved.
    1. DM water is distributed downstream



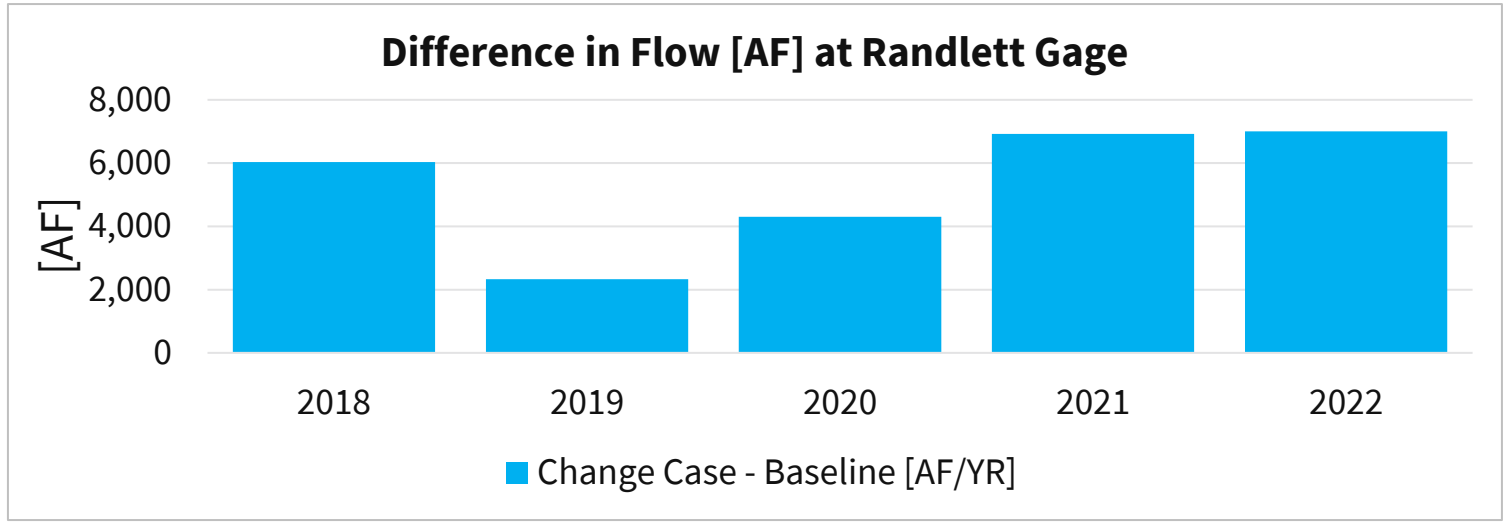
Change Case Results

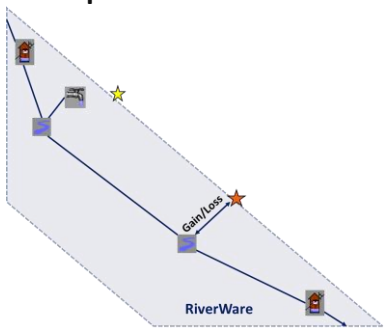




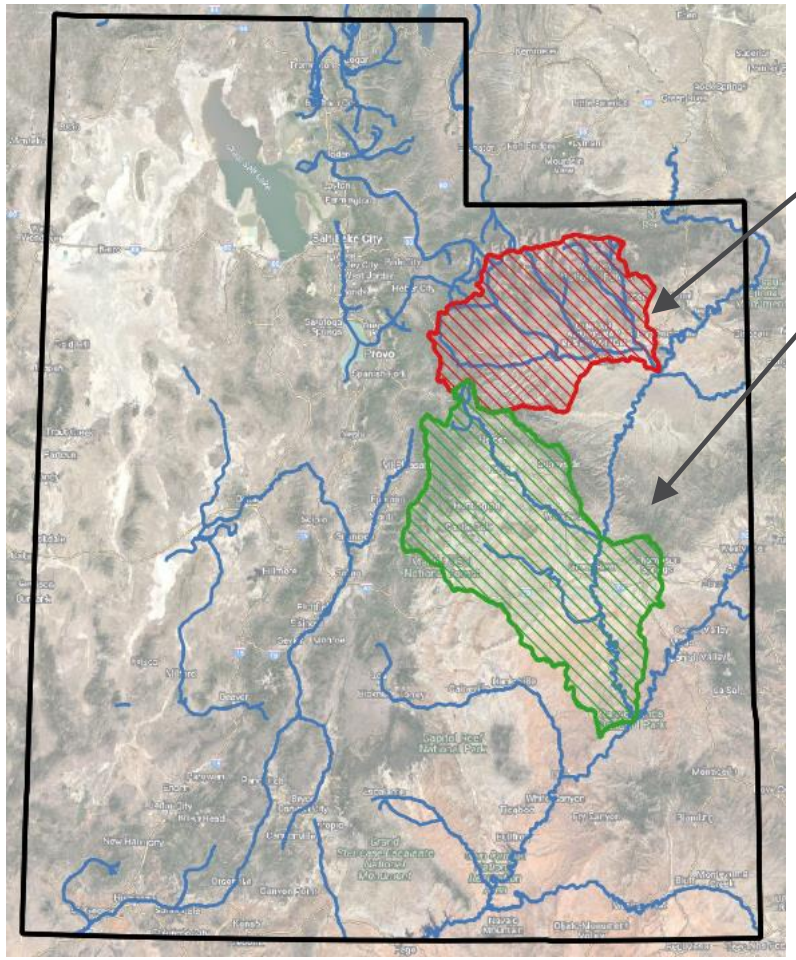
~5,900 AF

Average conserved volume at Randlett gage across 23 yr run period





Next Steps



Model Development

- Duchesne Basin
- Price / San Rafael Basin
- Expand to other basins

Change Case Scenarios

- Planning
- Program Development

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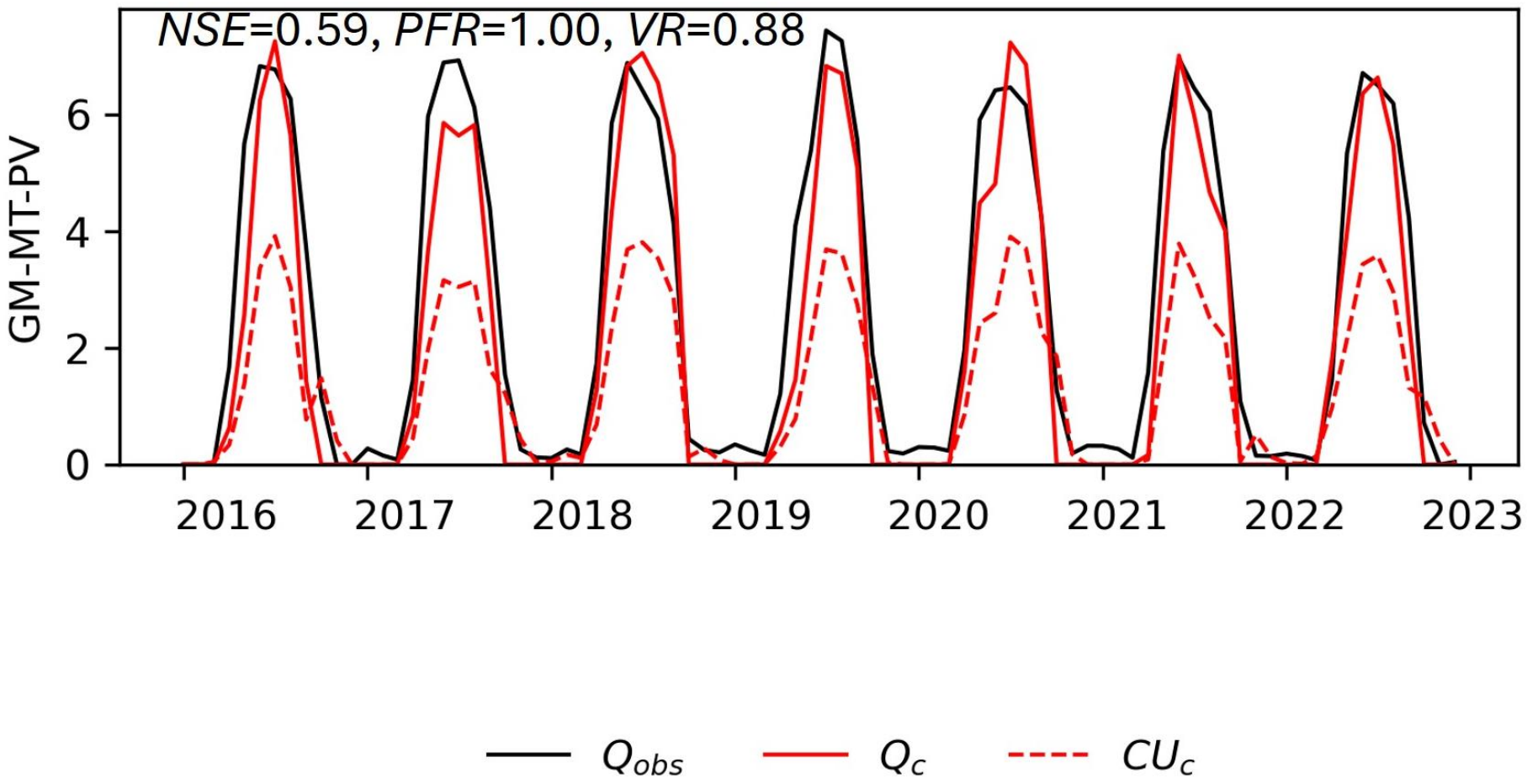
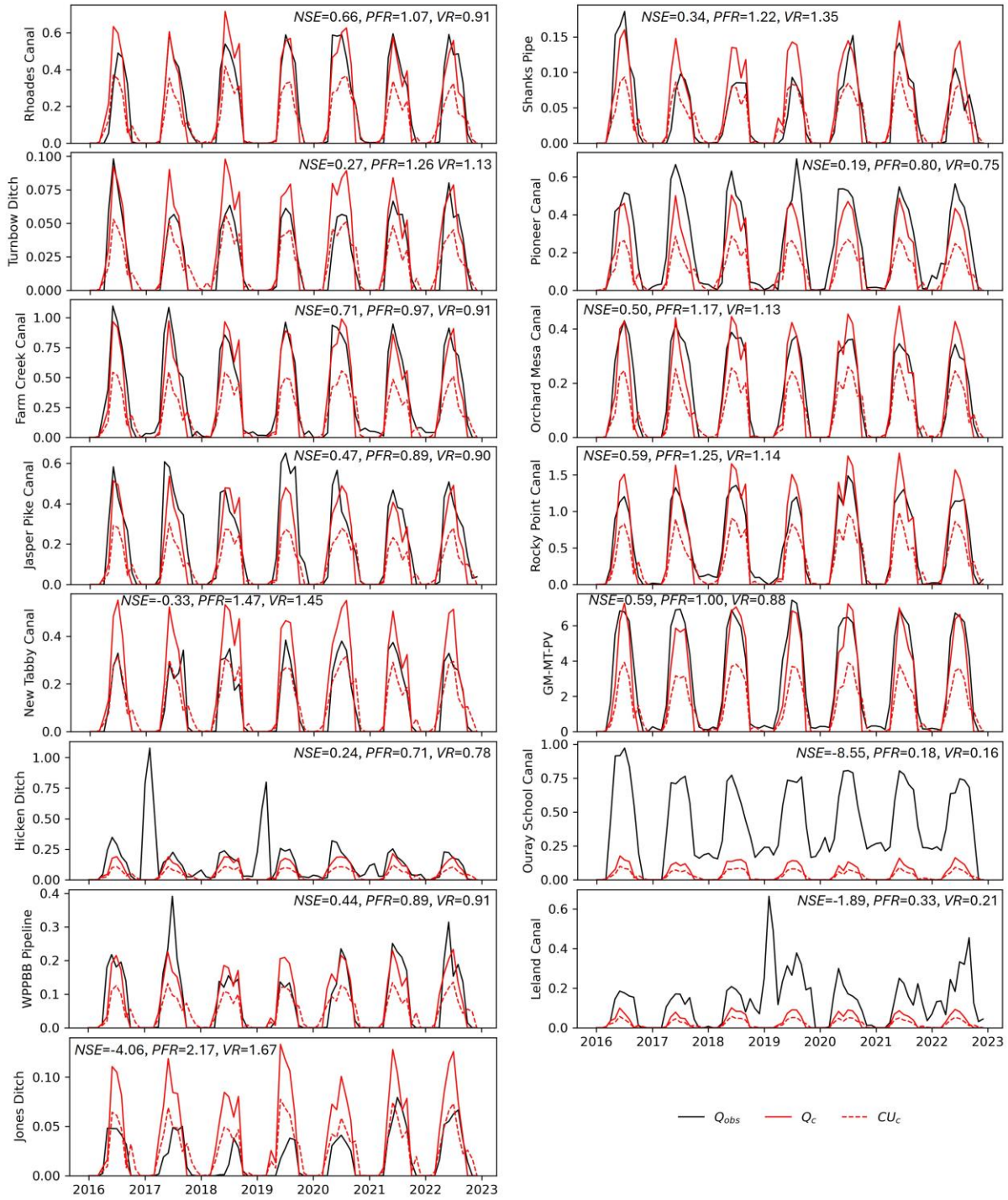
@AmyHaasColoRivr

Supplemental Material



Supplemental Material



Supplemental Material