TECHNICAL BASIS FOR
FLATHEAD INDIAN IRRIGATION PROJECT
WATER USE AGREEMENT
SEPTEMBER 4, 2012 - POLSON

Approach to Quantifying Existing Water Use

- Water Accounting Models are used to track all of the individual elements that comprise the Reservation-wide water budget
  - Accounts for monthly flow for every measurable stream, monthly diversion for every Project and Private Ditch, ditch losses, crop consumption, reservoir storage, stream seepage losses and gains, etc…
  - All of these elements of the water budget have been independently checked by peer reviewers and technical representatives from all 4 negotiating teams
  - An Independent Study sponsored by the Montana RWRCC and completed by Dr. Richard Allen of the University of Idaho (the METRIC study) provided a cross-check of the crop water use results determined through Water Accounting

Basis of Water Allocation

1. Provide Adequate Water Supply to Match Existing Crop Irrigation Consumption

2. Identify Potential Water Conservation Improvements to Project Water Distribution Operations

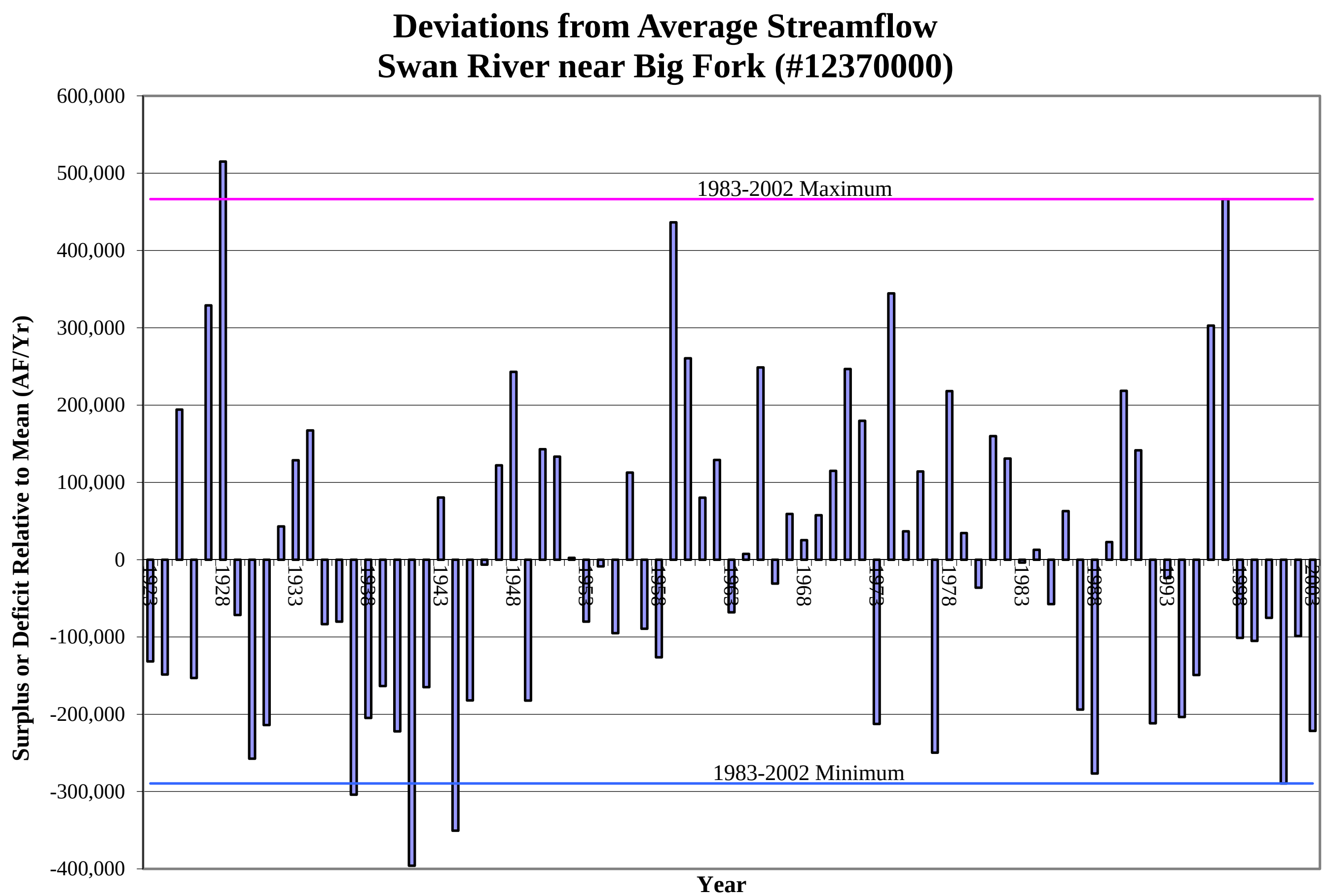
3. Determine the remaining streamflow available for Minimum Instream Flows (MEFs) and Target Instream Flows (TIFs) after implementing Project Improvements

Water Accounting Models

- 1983 – 2002 Study Period (240 months of data)
- Model Structure
- Key Model Inputs
  - Natural Flows
  - Irrigated Lands Mapping
  - FIIP Irrigation System Configuration
    - Canal Capacities
    - Canal Losses
    - Irrigation Service Areas
  - Crop Water Requirements
- Results of Water Accounting Model
- Calibration and Other Reasonableness Checks
- Water Available through FIIP Operational Improvements

Water Accounting Models

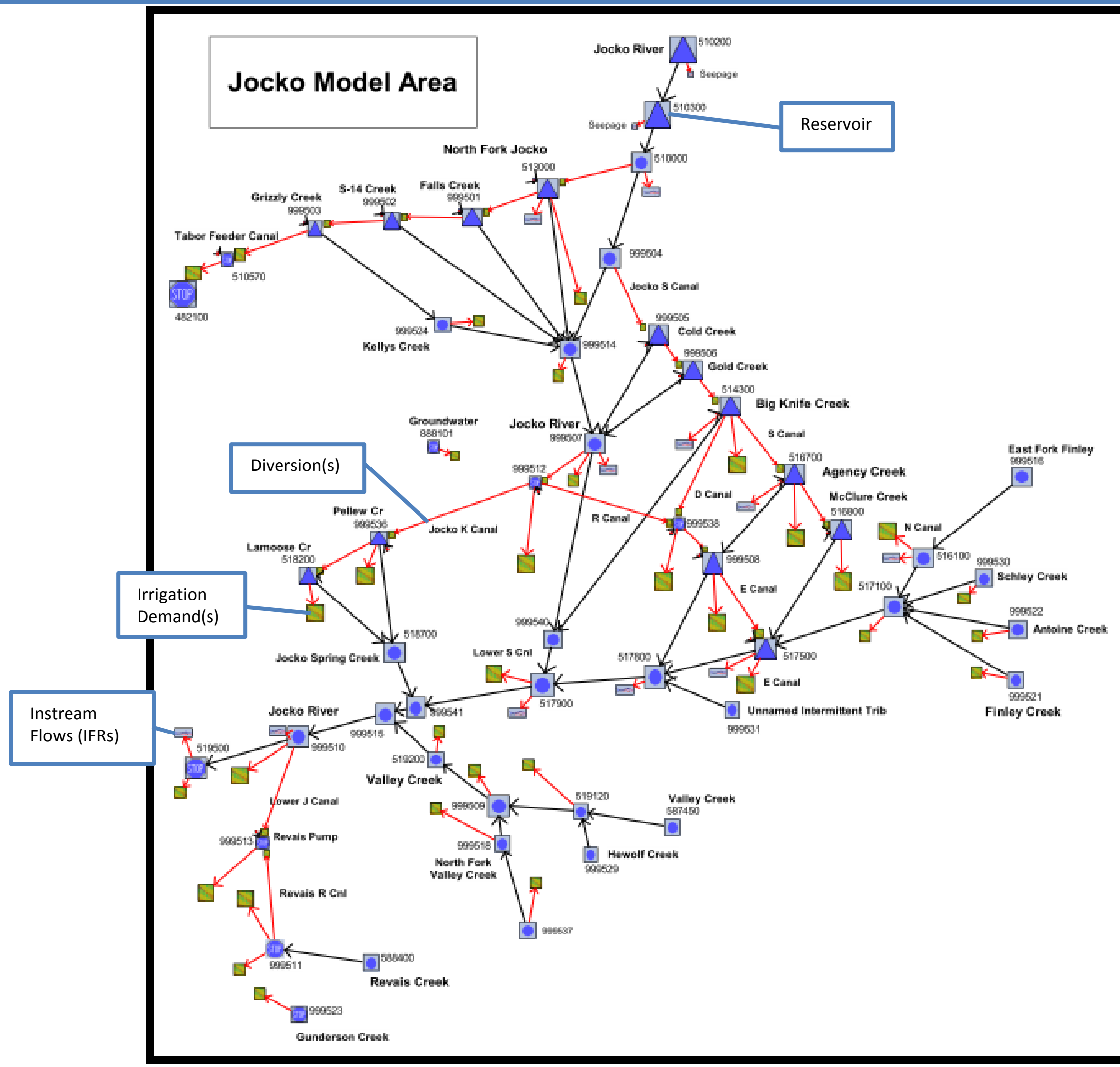
1983 – 2002
Study Period
(240 months)



Water Accounting Models

Model Structure

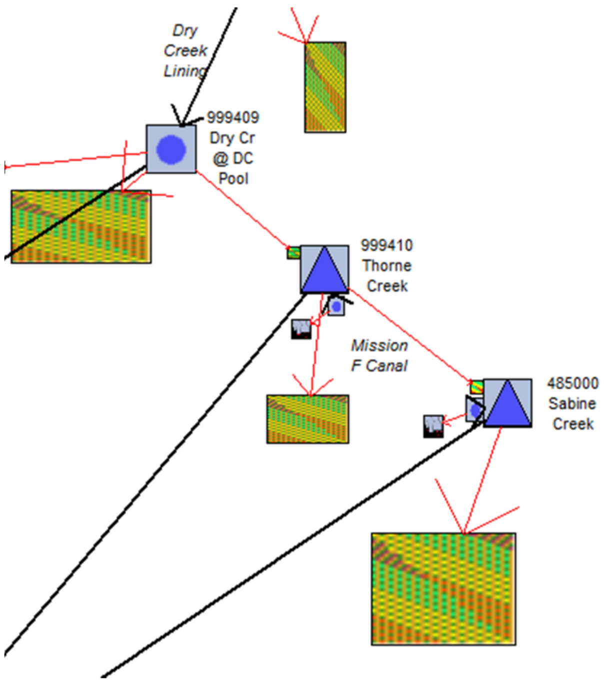
Jocko Model Schematic

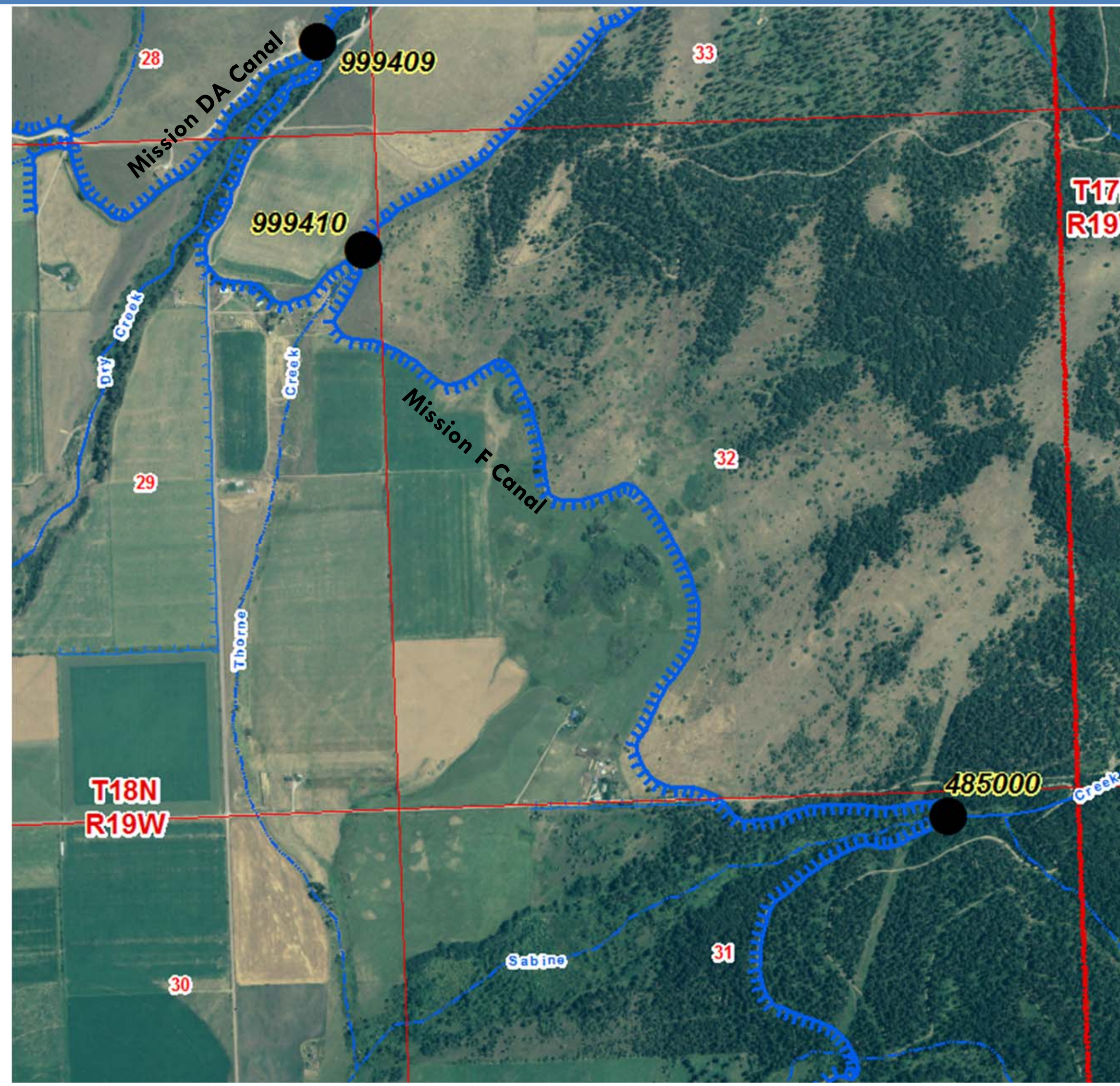


Water Accounting Models

Model Structure – Mission Model

Schematic Diagram

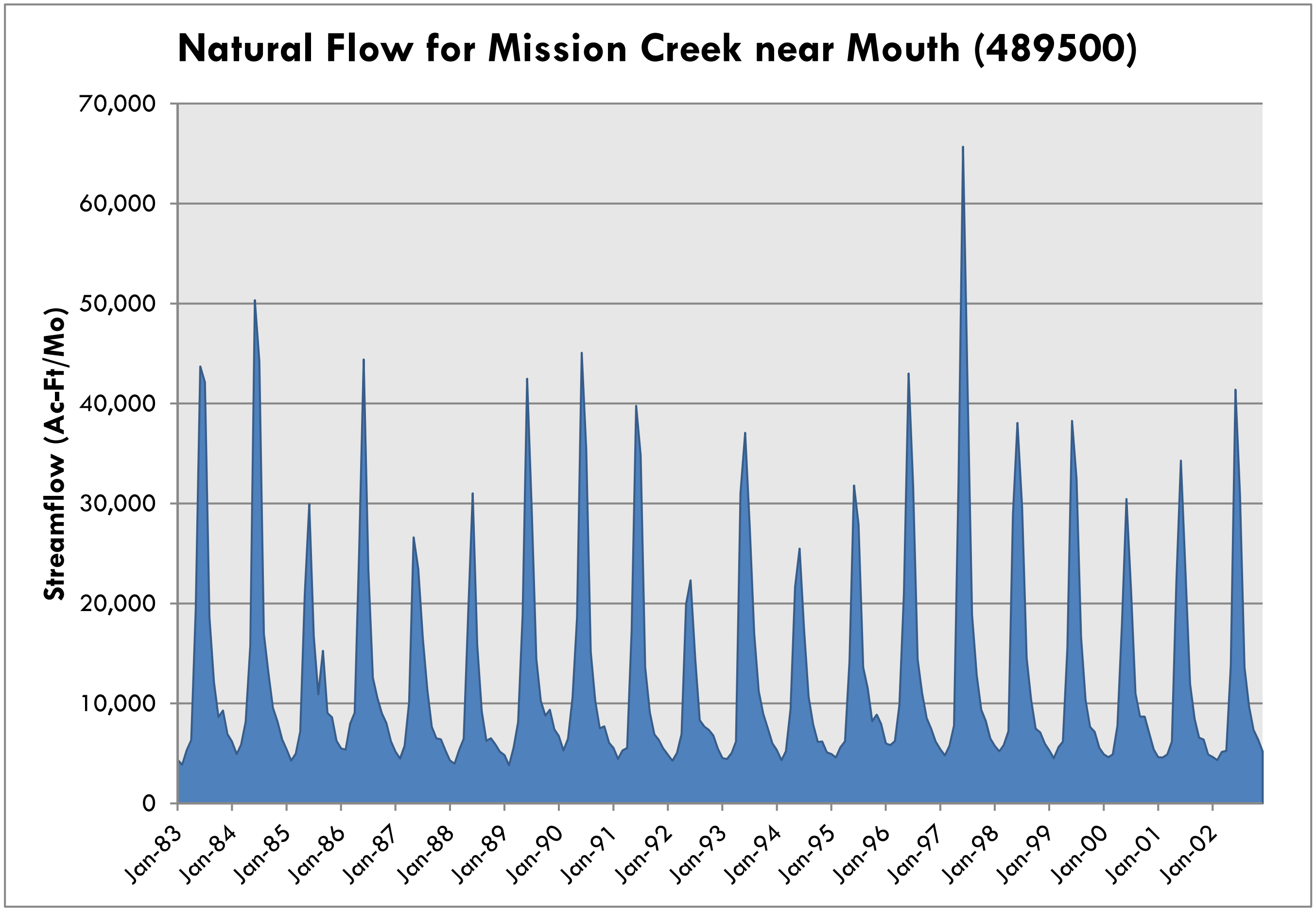




Water Accounting Models

Key Model Inputs

- Natural Flows (120 Nodes)
- Irrigated Lands Mapping
- FIIP Irrigation System Configuration
- Crop Water Requirements

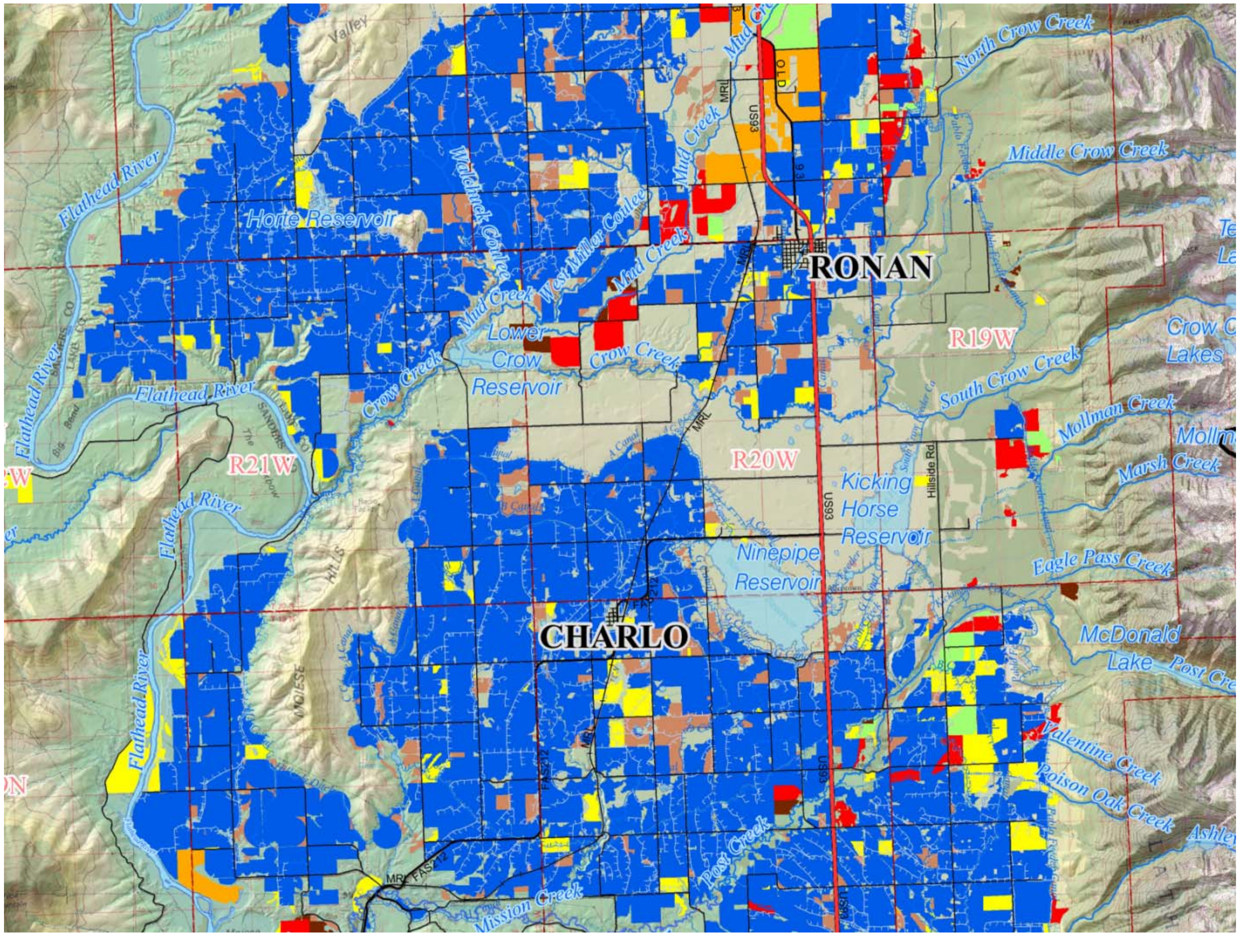


Water Accounting Models

Key Model Inputs

- Natural Flows
- Irrigated Lands Mapping
- FIIP Irrigation System Configuration
- Crop Water Requirements

Mapping of Current Irrigation

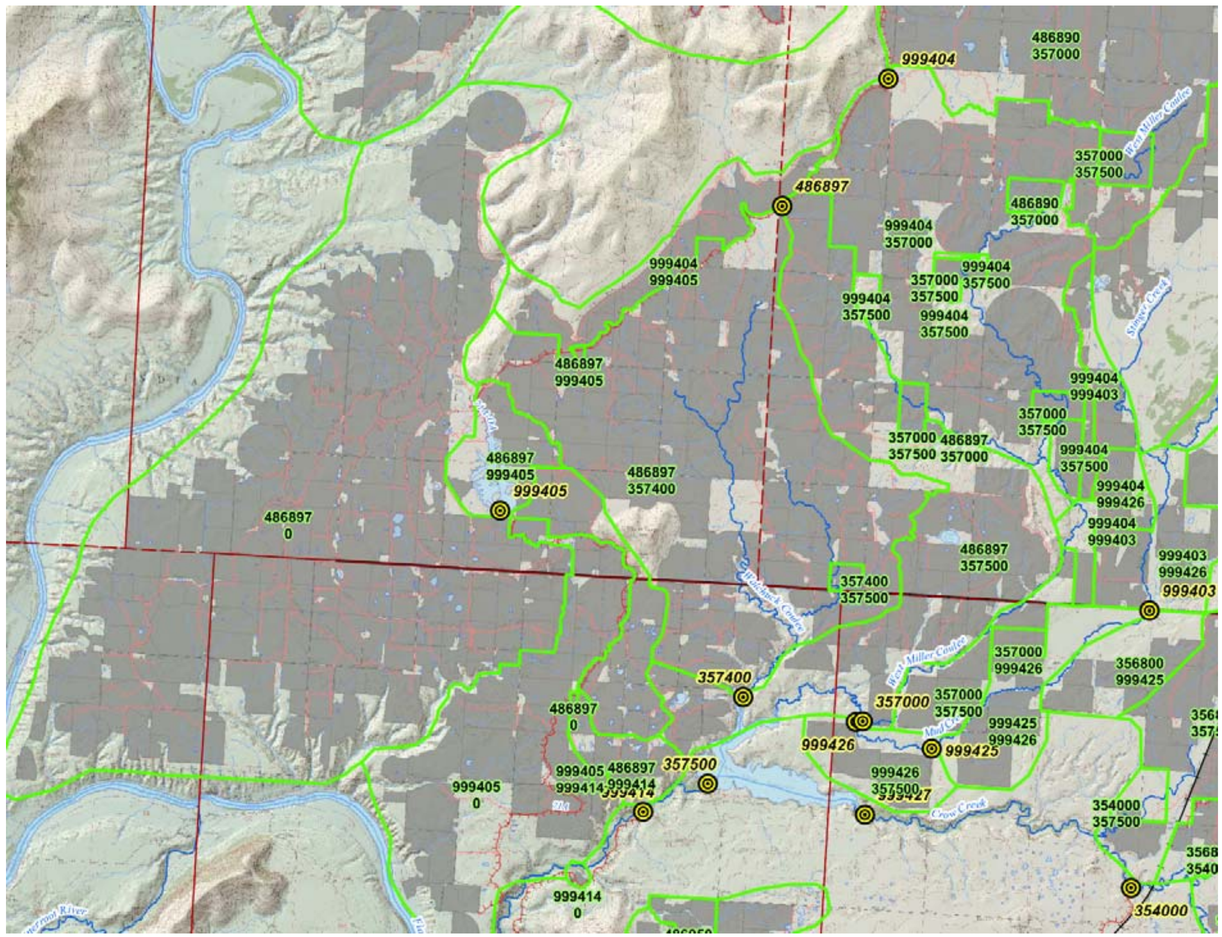


Water Accounting Models

Key Model Inputs

- Natural Flows
- Irrigated Lands Mapping
- FIIP Irrigation System Configuration
  - Canal Capacities (from Canal Diversion Records)
  - Canal Losses (from DNRC Canal Seepage Study)
  - Irrigation Service Areas
- Crop Water Requirements

Irrigation Service Areas



Water Accounting Models

Crop Water Requirements

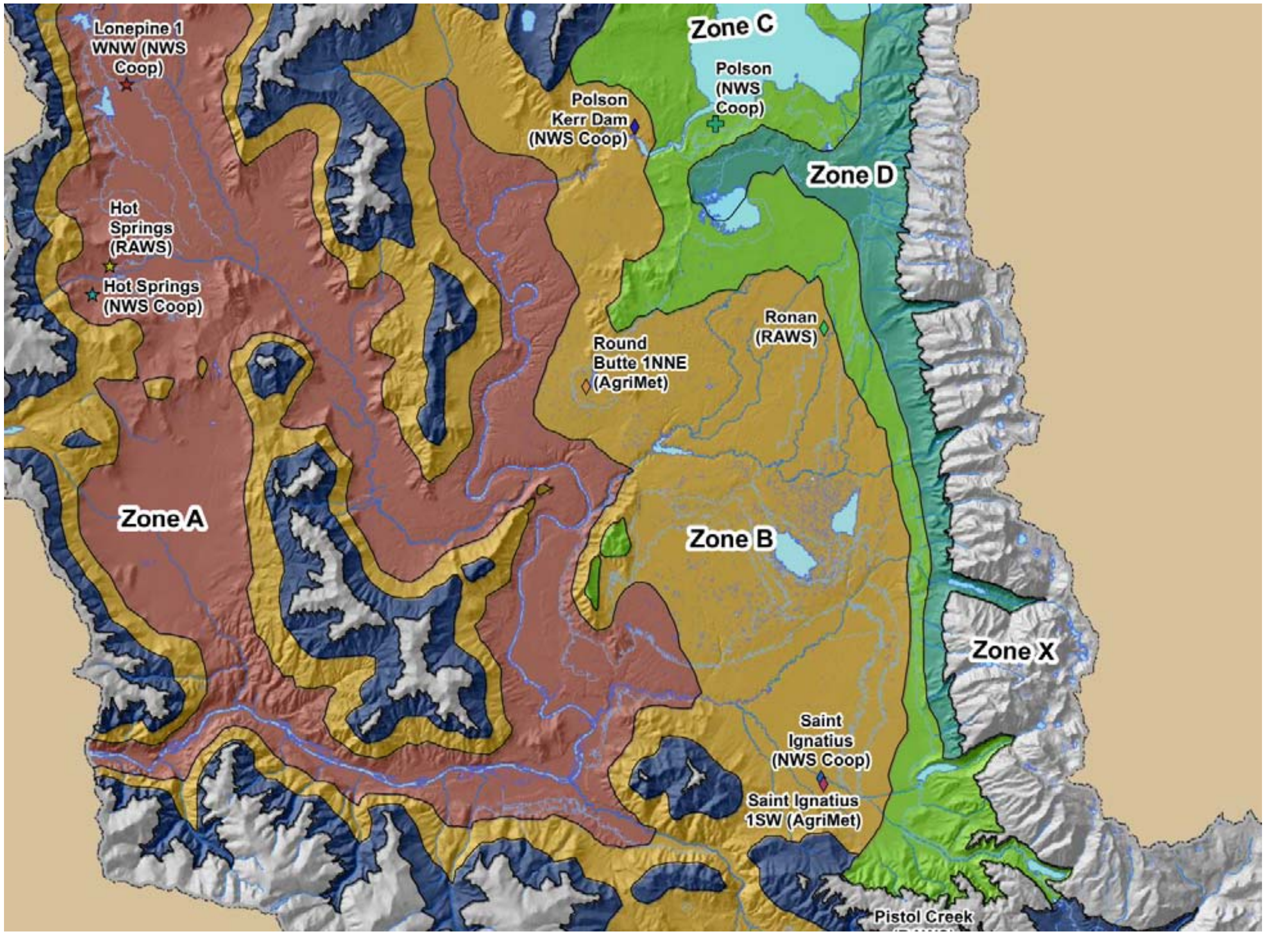
Climatic Data

- Regional NWS Stations: Missoula/Kalispell
- USBR AgriMET Stations: St. Ignatius/Round Butte
- BLM/USFS RAWS Stations: Jette/Hot Springs/Ronan/ Pistol Creek/Point 6/Plains
- NWS Coop Stations: Bigfork 13S/Polson/Polson Kerr Dam/St. Ignatius/Lonepipe/Hot Springs

Climatic Zones

- Utilized Oregon State University climate work as tool in delineating zones
- Average monthly max and min temperature and precipitation normals (1971-2000) for each 800x800-meter grid cell across the Reservation
- Assigned local climatic stations to represent each zone

Climatic Zones



Crop Water Requirements
Definitions

- **Potential Evapotranspiration (ET)**
  - Consists of three components:
    - Water evaporated from the soil surface,
    - Water intercepted by the plants, and
    - Water transpired by the plants
  - Assumes full water supply and ideal water management
- **Effective Precipitation (Pe)**
  - Precipitation used to offset crop water requirements
- **Net Irrigation Requirement (NIR)**
  - Irrigation water required to fully meet the maximum potential crop consumption (ET – Pe)
- **Crop Irrigation Consumption (CIC)**
  - Irrigation water consumed by the crop
  - Typically less than NIR due to less than perfect water management and less than full water supply

Crop Evapotranspiration (ET) in inches (1983 – 2002, April – October)

Crop	Zone A	Zone B	Zone C	Zone D	Zone E
Alfalfa Hay	23.71	23.24	23.58	22.71	24.59
Timothy Grass Hay	23.82	23.21	23.28	22.08	24.17
Pasture Grass	22.12	21.37	21.21	19.88	21.99
Winter Wheat	21.78	20.62	20.06	18.49	20.66
Spring Grains	17.47	16.55	17.05	14.82	16.54
Corn (Grain)	24.04	22.83	22.09	20.33	22.83
Corn (Silage)	23.66	22.47	21.74	19.99	22.47
Potatoes	25.06	23.79	22.98	21.19	23.79
Fruit Orchards	30.03	29.38	29.65	27.65	30.77

Comparison of Alfalfa ET Estimates

Weather Station	DNRC Flood/ Wheeline/ Handline ET (inches)	DNRC Center Pivot ET (inches)	DOWL HKM ET (inches)
Bigfork	17.37	20.61	22.71
Polson	20.46	23.23	23.58
Polson Kerr Dam	21.37	24.08	24.23
St. Ignatius (NWS)	19.53	22.33	22.96
St. Ignatius			23.90
Round Butte			22.44
Hot Springs			23.42

DNRC values taken from NRCS Irrigation Water Requirements (IWR) software results obtained from the Montana Rule 36.12.1902 (Change Application – Historic Use)

Optimum July Net Irrigation Requirement (NIR) for Alfalfa in inches (1983 – 2002)

Zone	Station	Elevation (Ft)	Average July Alfalfa ET	Average July Effective Precip.	Average July Alfalfa NIR
A	Hot Springs	2780	6.56	1.06	5.50
A	Hot Springs (RAWS)	2960	6.36	1.01	5.35
A	Lonepine	2880	6.16	0.58	5.58
A	Plains (RAWS)	2400	6.58	0.98	5.60
B	Ronan (RAWS)	3060	6.00	1.42	4.58
B	Round Butte (AgriMET)	3040	5.94	1.04	4.90
B	Polson Kerr Dam	2730	6.13	1.36	4.77
B	St. Ignatius	2900	6.35	1.43	4.91
B	St. Ignatius (AgriMET)	2990	6.09	1.40	4.69
C	Polson	2990	5.93	1.15	4.77
D	Bigfork	2910	5.43	1.80	3.63
E	Jette	3600	6.10	1.32	4.78

Optimum Net Irrigation Requirement (NIR) for Alfalfa in inches (1983 – 2002)

Zone	Station	Elevation (Ft)	Average Apr-Oct Alfalfa ET	Average Apr-Oct Precip.	Average Apr-Oct Effective Precip.	Average Apr-Oct Alfalfa NIR by Station	Average Apr-Oct Alfalfa NIR by Zone
A	Hot Springs	2780	23.42	8.15	7.35	16.07	16.73
A	Hot Springs (RAWS)	2960	24.54	7.56	6.97	17.58	
A	Lonepine	2880	21.43	7.24	6.20	15.23	
A	Plains (RAWS)	2400	25.46	7.72	7.40	18.05	
B	Ronan (RAWS)	3060	22.64	10.89	9.24	13.40	14.07
B	Round Butte (AgriMET)	3040	22.44	9.71	8.39	14.06	
B	Polson Kerr Dam	2730	24.23	10.61	9.48	14.75	
B	St. Ignatius	2900	22.96	11.62	9.13	13.83	
B	St. Ignatius (AgriMET)	2990	23.90	10.82	9.61	14.30	
C	Polson	2990	23.58	10.68	9.49	14.08	14.08
D	Bigfork	2910	22.71	14.57	12.01	10.70	10.70
E	Jette	3600	24.59	11.82	10.40	14.19	14.19

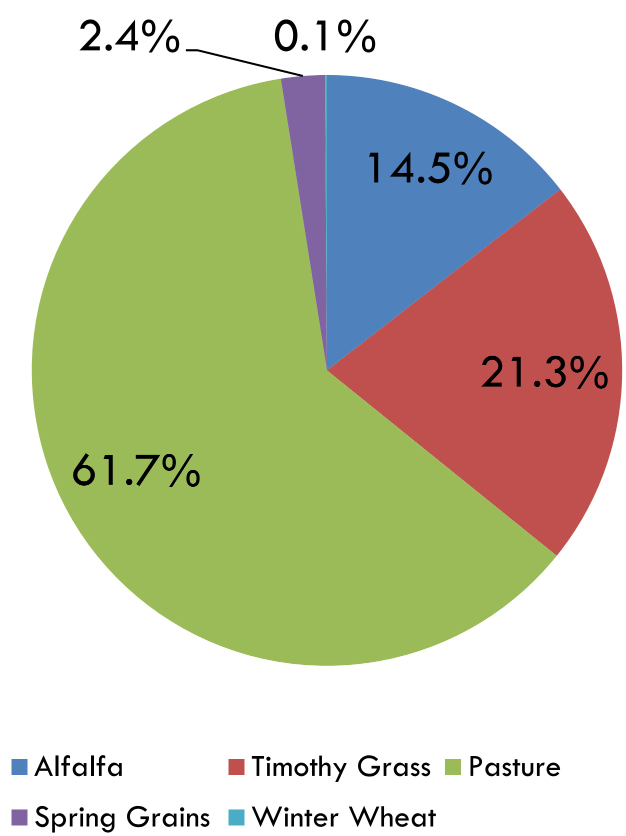
Optimum Apr – Oct Net Irrigation Requirement (NIR) in inches by Crop and Climatic Zone (1983 – 2002)

Crop	Zone A	Zone B	Zone C	Zone D	Zone E
Alfalfa Hay	16.73	14.07	14.08	10.70	14.19
Timothy Grass Hay	16.53	13.65	13.57	10.01	13.61
Pasture Grass	14.80	11.58	11.34	7.86	11.28
Winter Wheat	16.32	13.01	12.62	8.71	12.51
Spring Grains	12.11	9.75	9.53	6.87	9.45
Corn (Grain)	18.10	15.25	14.61	11.31	14.77
Corn (Silage)	18.08	15.21	14.57	11.29	14.74
Potatoes	18.76	15.45	14.79	11.31	14.97
Fruit Orchards	22.69	19.43	19.50	14.95	19.63

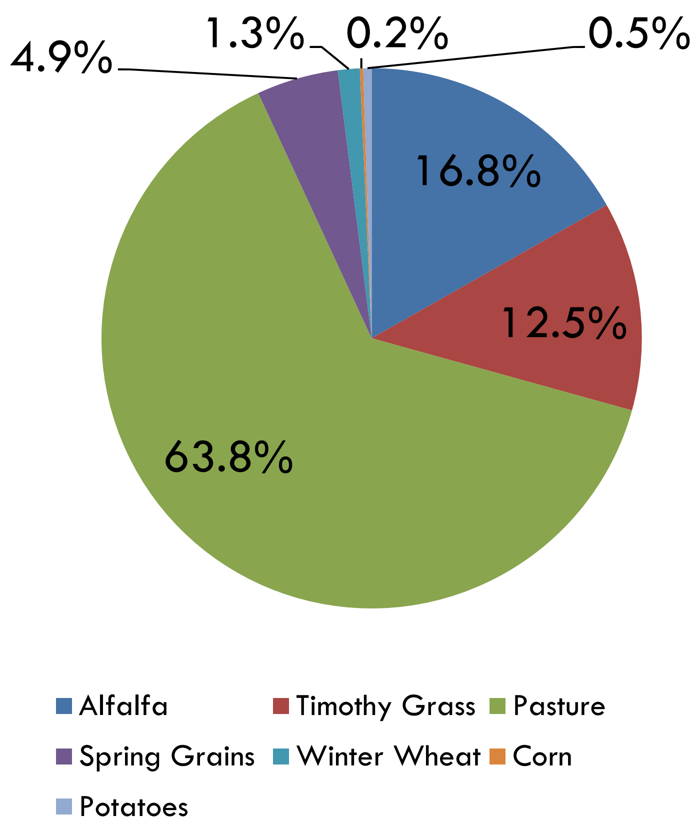
Water Accounting Models

Crop Water Requirements

Jocko Cropping Pattern



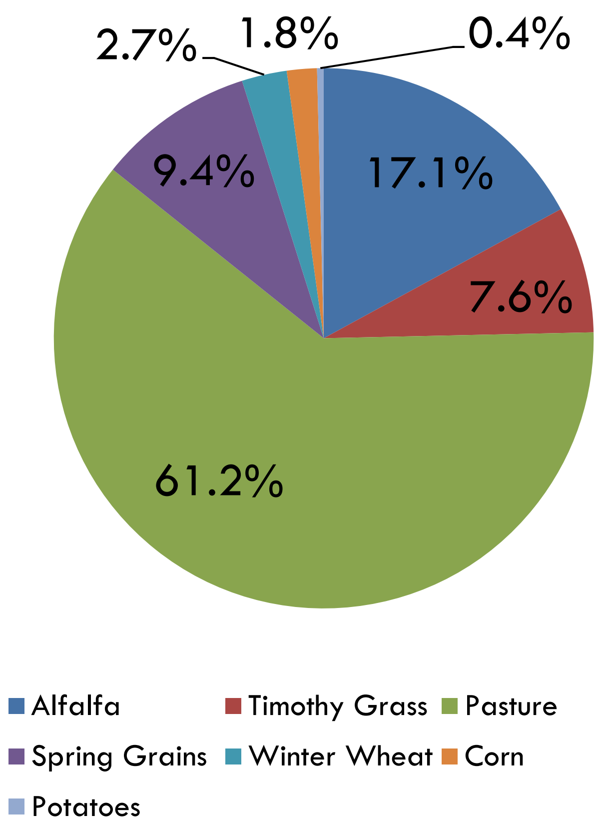
Mission Cropping Pattern



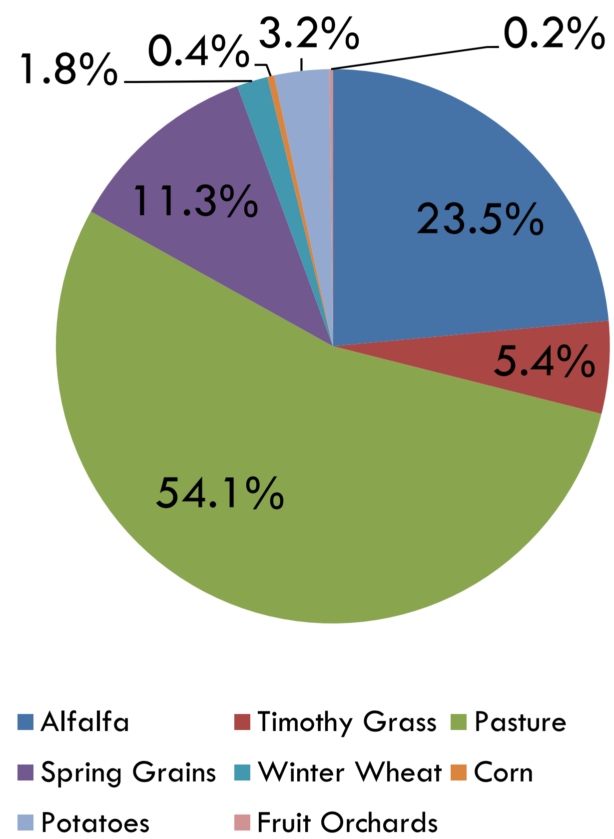
Water Accounting Models

Crop Water Requirements

Post Division Cropping Pattern



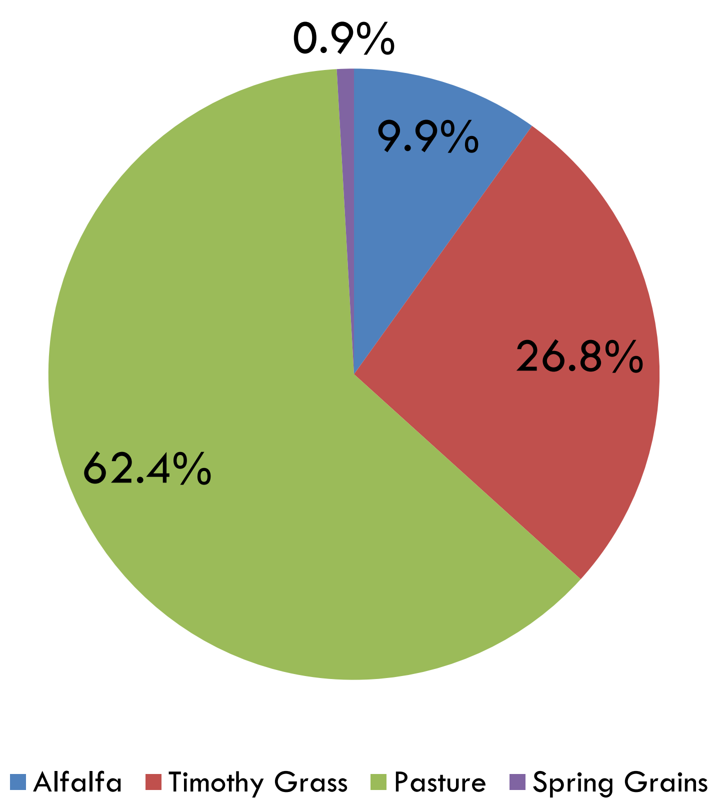
Pablo Division Cropping Pattern



Water Accounting Models

Crop Water Requirements

Little Bitterroot Cropping Pattern



Crop Water Requirements
by Model Area and Climatic Zone

Irrigated Acreage

Model Area	Zone A	Zone B	Zone C	Zone D	Zone E	Total
Jocko	2,529	14,750	0	0	100	**17,379**
Little Bitterroot	23,295	103	0	0	0	**23,397**
Mission: Mission	570	20,877	4,417	4	0	**25,869**
Mission: Pablo	6,720	37,753	14,215	3,670	0	**62,358**
Mission: Post	11,673	24,695	469	6	0	**36,843**
Unmodeled	5,328	902	1,585	369	66	**8,248**
Total	**50,115**	**99,079**	**20,686**	**4,047**	**166**	**174,094**

Optimum Net Irrigation Requirement (1983 – 2002, April – October)

Model Area	Zone A	Zone B	Zone C	Zone D	Zone E	Area Wtd. Avg.
Jocko	15.38	12.34	12.18	8.71	12.16	**12.78**
Little Bitterroot	15.43	12.37	12.20	8.71	12.18	**15.42**
Mission: Mission	15.25	12.21	12.03	8.59	12.01	**12.25**
Mission: Pablo	15.22	12.25	12.07	8.69	12.05	**12.32**
Mission: Post	15.12	12.11	11.91	8.51	11.89	**13.06**

Note: includes active and idle and Project and Private irrigation

Water Accounting Models

Overall Water Budget

Average
Annual Volume
(Acre-Feet)

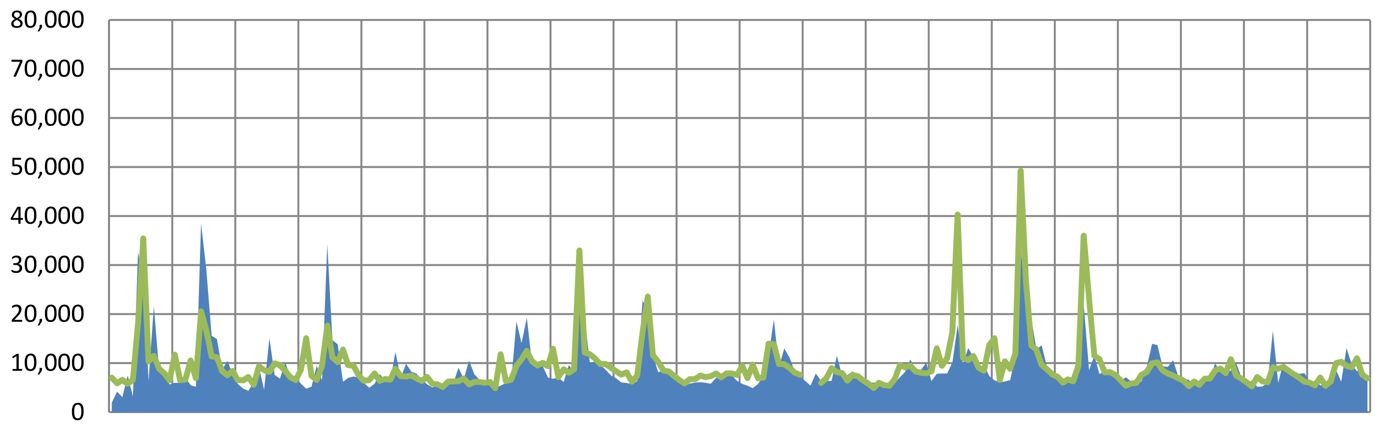
1983 – 2002

Parameter	**Jocko**	**Mission**	**Little Bitterroot**
Inflows (Runoff)	198,250	215,184	39,124
Inflows (Natural GW/Snowmelt)	22,502 (Natural GW)	34,619 (Natural GW)	6,669 (Valley Floor Snowmelt Runoff)
Imports	6,055 (Placid Canal)	53,192 (Tabor Feeder & Flathead Pump)	3,038 (Alder & McGinnis)
Depletions	14,970	131,711	18,066
Crop Consumption	8,997	78,393	11,797
Diversion Losses to Basin	5,630	35,676	628
Reach Losses to Basin	223	12,185	114
Evaporation	121	5,458	5,526
Exports	27,701 (Tabor Feeder)	0	0
Change in Storage	36	-480	-540
Outflow	184,100	171,764	31,306
Water Balance	**0 (0.0%)**	**0 (0.0%)**	**0 (0.0%)**

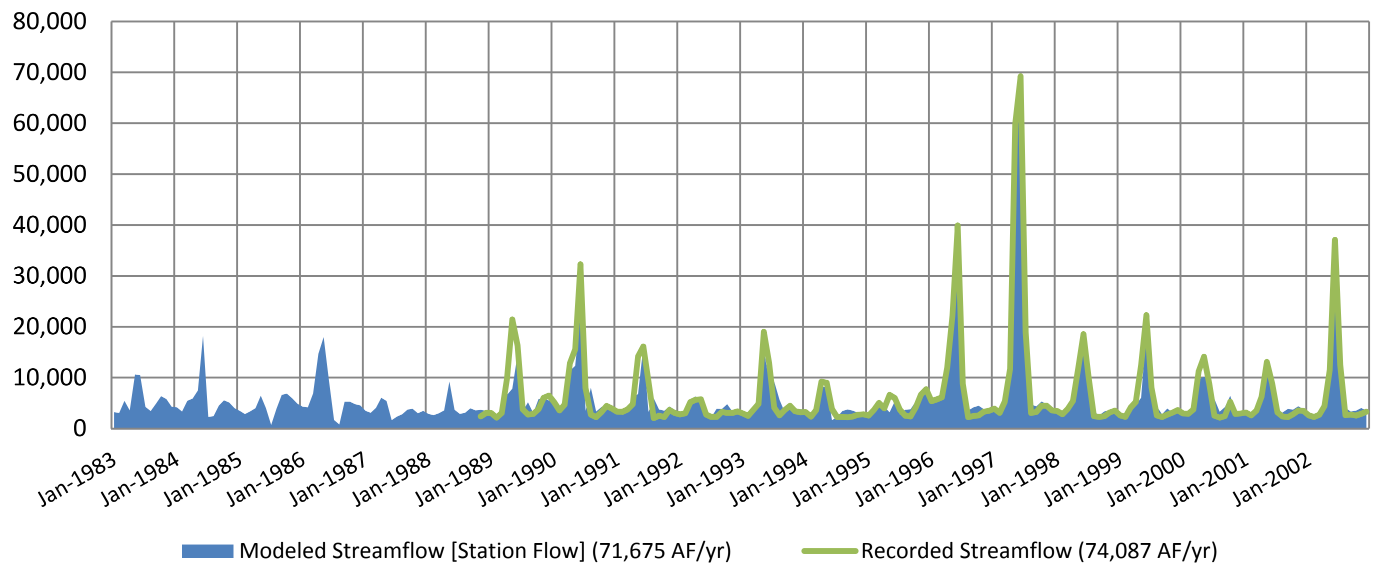
Calibration and Other Reasonableness Checks

Streamflow (36 sites) [Acre-Feet/Month]

Mission Creek at Bison Range at Moiese (Gage #4895.00 / Model Node #999412)



Jocko River below Jocko K Canal (Gage #5169.00 / Model Node #999507)

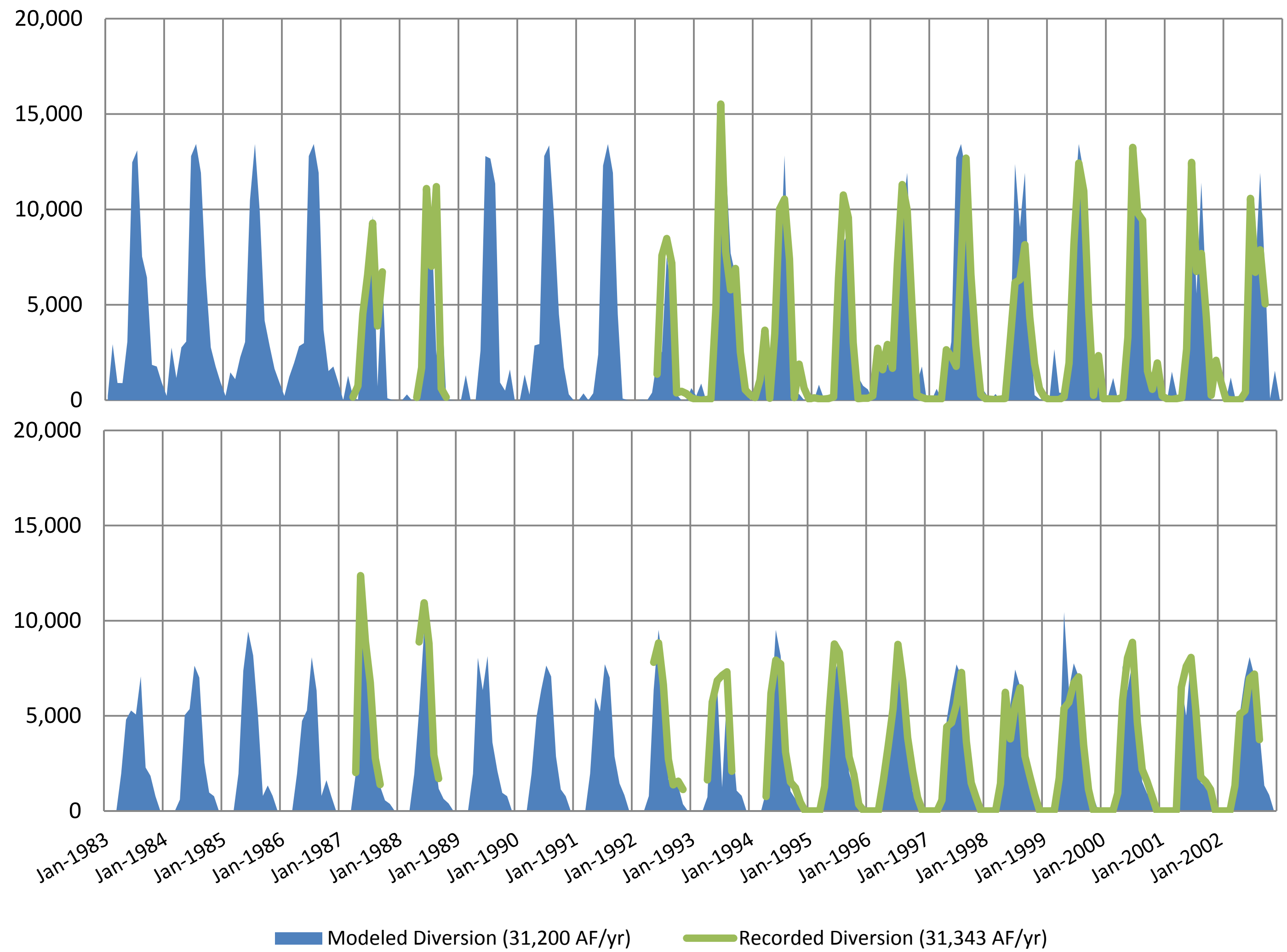


Calibration and Other Reasonableness Checks

Diversions (47 sites) & Tailwater (5 sites) [Ac-Ft/Mo]

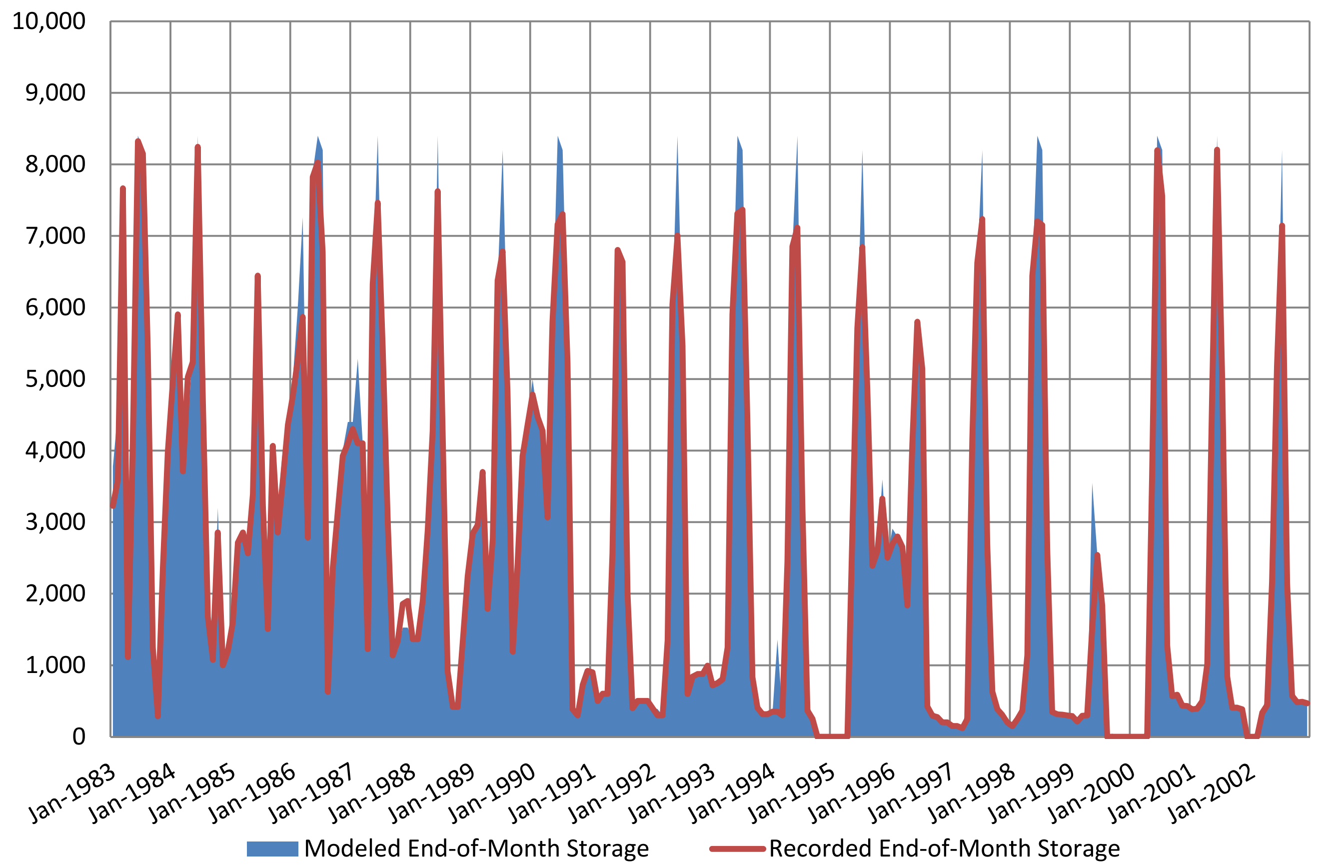
Mission A Canal below Headworks (Gage #4814.10 / Model Mode #481500)

Jocko K Canal below Headworks (Gage #5140.00 / Model Node #999507)



Calibration and Other Reasonableness Checks
Reservoir End-of-Month Storage (14 sites) [Ac-Ft/Mo]

McDonald Reservoir (Gage #McDonald/ Model Node #486300)



Water Accounting Models

Calibration and Other Reasonableness Checks

- Canal seepage study from DNRC
- Stream seepage runs from CSKT
- S.S. Papadopulos & Associates (SSPA) Ground Water Modeling Work
  - Surface Water Budget is also balanced with Groundwater Budget
- METRIC study of actual Crop Water Use in 2006-2008

Independent Reviews by Others

- All elements of this work have been reviewed by Peer Reviewers and technical representatives from the 4 Negotiating Parties
  - Keller-Bliesner Engineering performed a Peer Review
  - US agricultural engineer, Stetson Engineers
  - Montana RWRCC agricultural engineer, Bill Greiman
  - FJBC consultant hydrologist, Larry Cawlfield
  - This is in addition to the cross-checks provided through Rick Allen's METRIC work and the groundwater modeling work (S.S. Papadopulos & Associates)

Crop Irrigation Consumption (CIC)

- FIIP is not a full water supply project and irrigation water management is generally less than perfect, as is typical for many irrigation projects
  - "Using the data thus obtained for average flows and applying the needs of the better quality lands on the basis of the duty of water as determined in this investigation, it was found that existing supplies will provide only enough water to irrigate 120,000 acres, assuming good management by the project and optimum use of water by farm operators." (Walker Report, 1946)
  - "Most local irrigators do not have sufficient irrigation water available to satisfy crop water needs and are therefore practicing deficit irrigation." (Land and Water Consulting, 1994)
    - Table 2 of that reports indicates that existing crop consumption is roughly 70% of optimum
- This fact is reinforced by canal diversion records

Recorded Diversions (1983 – 2002)

Diversion	Avg. Ann. Vol.	1990's Acres	Ac-Ft/Acre
Camas A Canal near Niarada (3111.00)	16,931	13,069	1.30
Camas B Canal @ Headworks above Lower Dry Fork Reservoir (3176.10)	7,936	6,449	1.23
Camas C Canal @ Headworks below Lower Dry Fork Reservoir (3177.10)	6,096	5,734	1.06
Mission F Canal @ Headworks (4829.00)	3,992	1,980	2.02
Mission B Canal near Headworks (4827.10)	3,674	3,214	1.14
Mission C Canal (4829.10) + Mission 6C Canal (4831.50) near Headworks	9,256	7,540	1.23
Post F Canal near Headworks (4875.10)	4,265	4,362	0.98
Post G Canal @ Headworks below Kicking Horse Reservoir (4869.30)	3,771	2,289	1.65

Recorded Diversions (1983 – 2002)

Diversion	Avg. Ann. Vol.	1990's Acres	Ac-Ft/Acre
Post C Canal @ Headworks below Ninepipe Reservoir (4869.60)	12,401	10,053	1.23
Post D Canal @ Headworks below Ninepipe Reservoir (4869.70)	7,210	5,243	1.38
Mission H Canal @ Headworks below Mission Creek (4892.50)	2,079	402	5.17
Ronan A Canal @ Headworks (4868.35)	2,206	1,581	1.40
Ronan B Canal @ Headworks (3567.10)	2,939	3,331	0.88
Pablo A Canal below Pablo Reservoir (4868.91)	50,807	37,741	1.35
Valley View Inflow from Pablo Reservoir (4868.95)	12,976	9,150	1.42
Pablo A Canal @ Round Butte Weir (4868.97)	28,410	19,273	1.47
Moiese A Canal @ Headworks (3585.00)	15,078	6,482	2.33
Twin Feeder Canal below Centipede Creek (66.00)	1,588	1,182	1.34
Polson D Canal @ Headworks below Twin Reservoir (78.10)	1,320	935	1.41

Crop Irrigation Consumption (CIC)

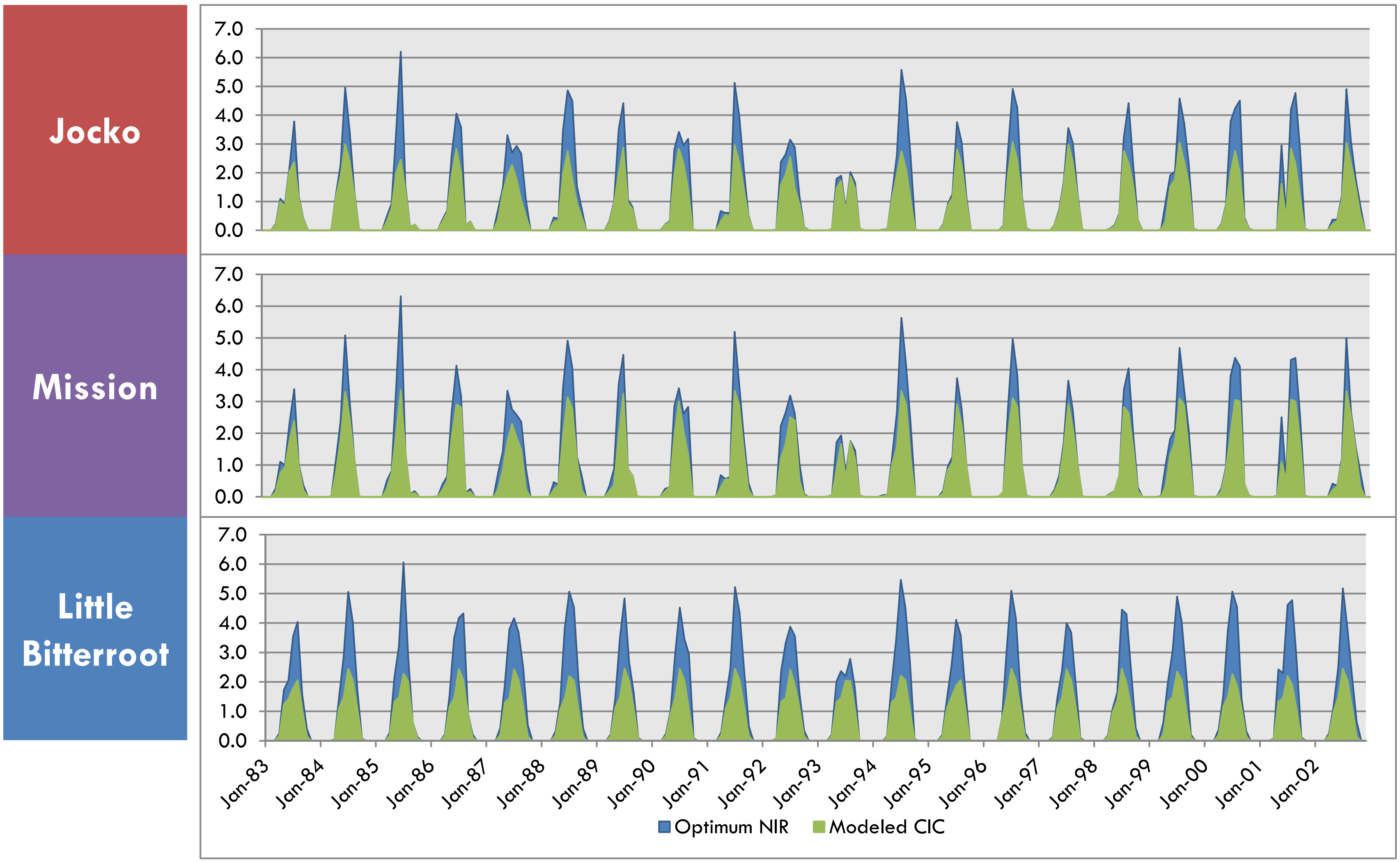
- The Montana DNRC in their Water Right rules administered throughout the State similarly recognize that actual crop irrigation consumption is typically less than the potential maximum (Rule: 36.12.1902)

- The **County Management Factor (CMF)** provides an estimate of the proportion of historical crop irrigation use to potential ET

County	Lake	Sanders
CMF 1964-1973	55.0%	58.8%
CMF 1997-2006	68.7%	62.8%

County Management Factor (CMF) obtained from the Montana Rule 36.12.1902 (Change Application – Historic Use)
1997-2006 values are provisional and are currently under review

Optimum NIR vs. Crop Irrigation Consumption (Inches per Acre per Month)



Water Accounting Models

Water Available through FIIP Operational Improvements

- Objectives
  - Improve FIIP water distribution operations
    - Operate FIIP based on crop demands, with allowance for existing on-farm, lateral and canal inefficiencies and reasonable levels of operational waste
    - Maintain existing levels of FIIP Crop Irrigation Consumption (CIC)
    - Distribute water gained through operational improvements to enhance instream flows, as guided by Fishery objectives

Water Accounting Models

Water Available through FIIP Operational Improvements

- Assumptions
  - Reduce or eliminate non-crop-based diversions
  - Reduce Tabor Feeder exports to Mission by 15% to enhance North Fork Jocko instream flows
  - Maintain the same levels of FIIP farm turnout deliveries as current in dry, normal, and wet years, respectively

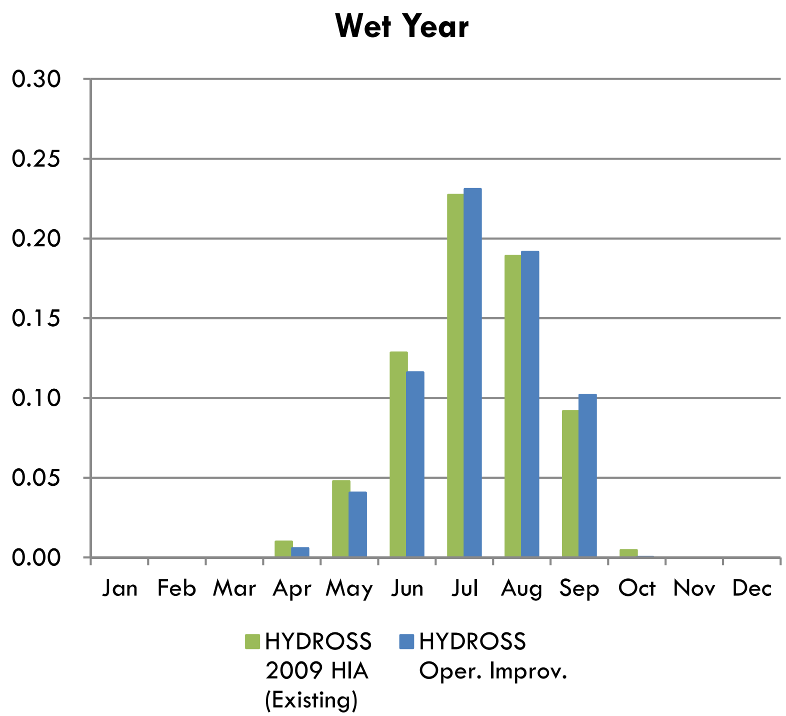
Water Accounting Models

Water Available through FIIP Operational Improvements

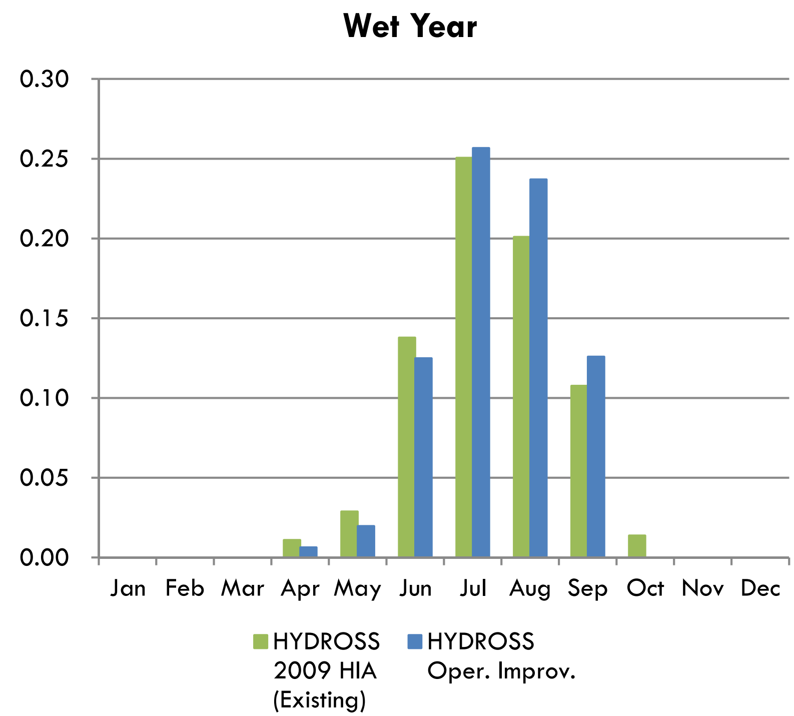
- Assumptions (cont.)
  - Establish Wet, Dry, and Normal years based on April through July natural streamflow, consistent with the anticipated spring/summer forecast period
  - Settlement funding will provide for installation of comprehensive water measurement network, water accounting system, and rehabilitation of key distribution structures to facilitate operational improvements

Total FIIP Crop Irrigation Consumption
(Acre-Feet/Acre)

Mission
(67% Sprinkler/33% Flood)



Jocko
(58% Sprinkler/42% Flood)



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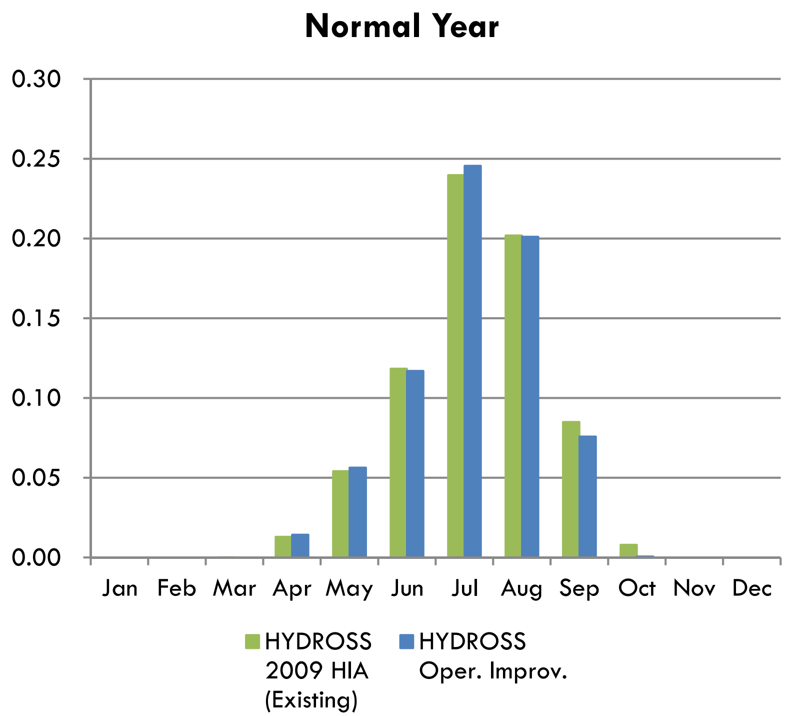

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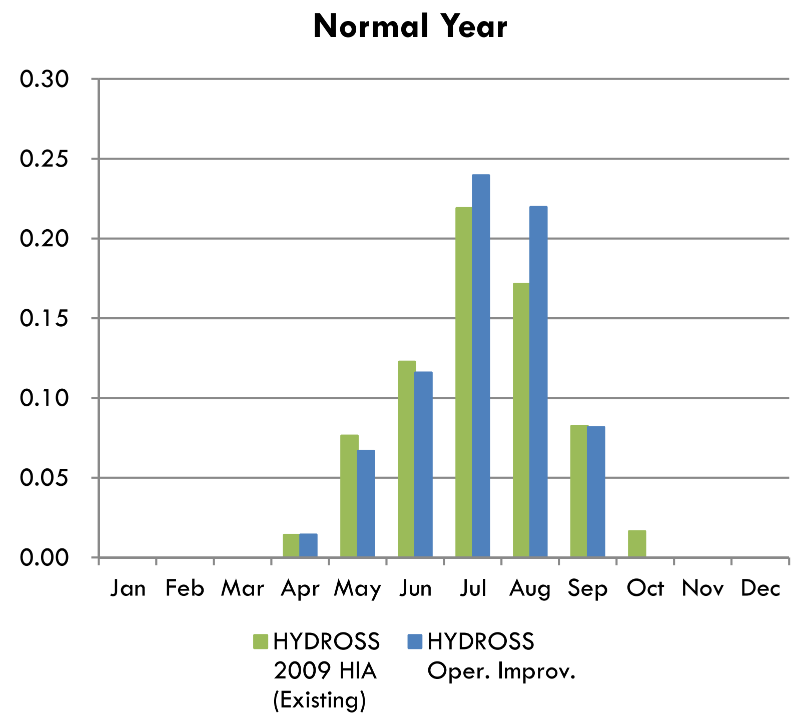

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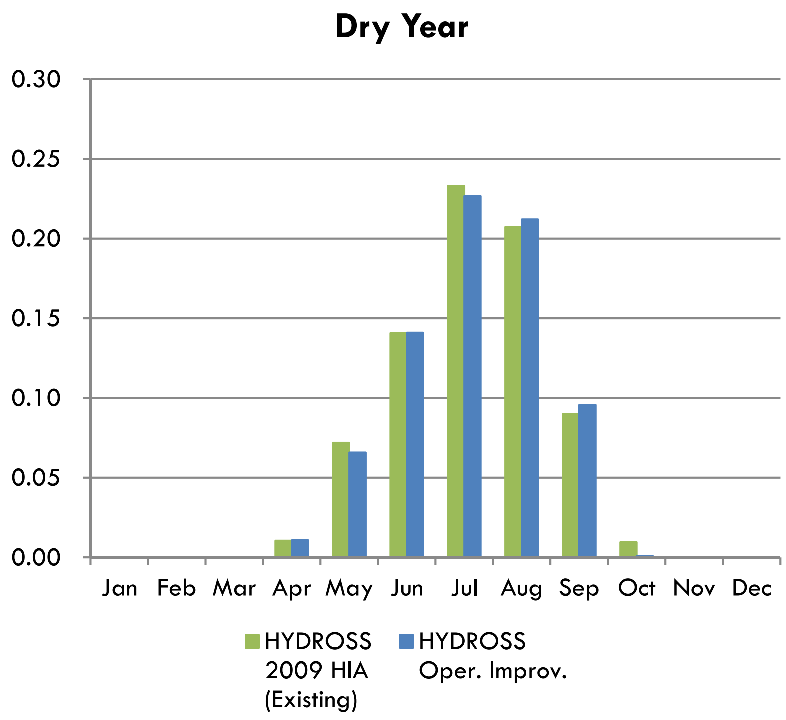

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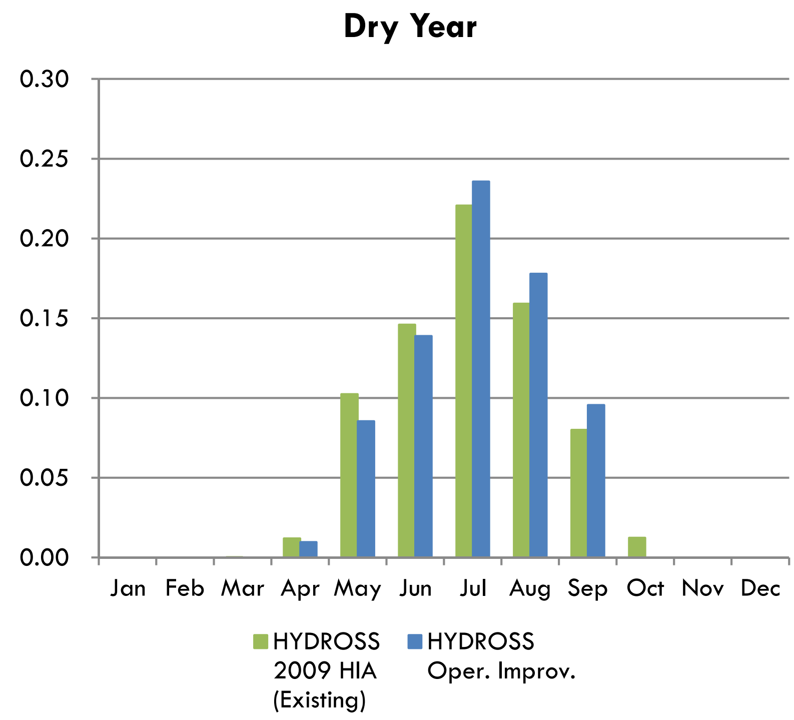
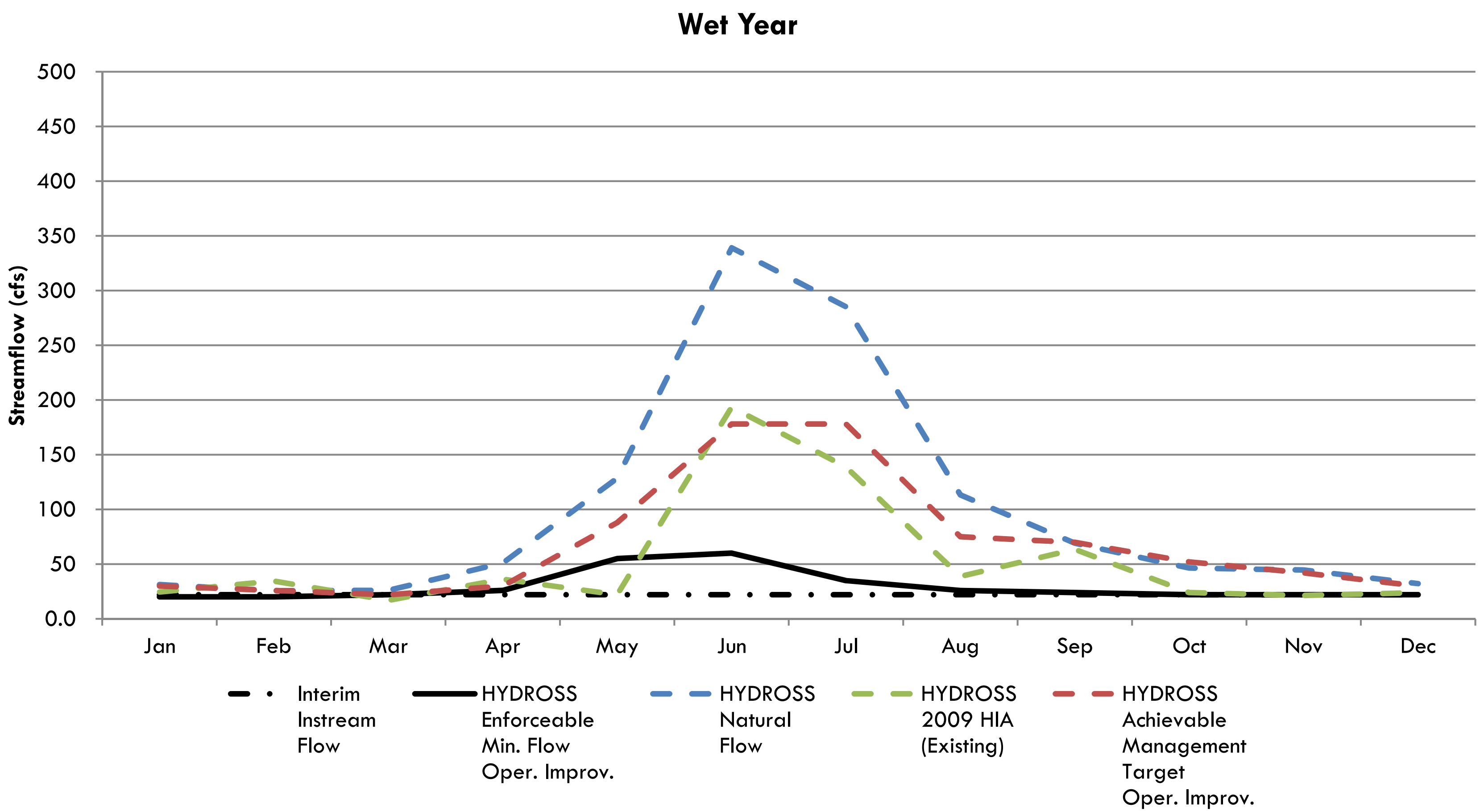


Post Creek below Post F Canal



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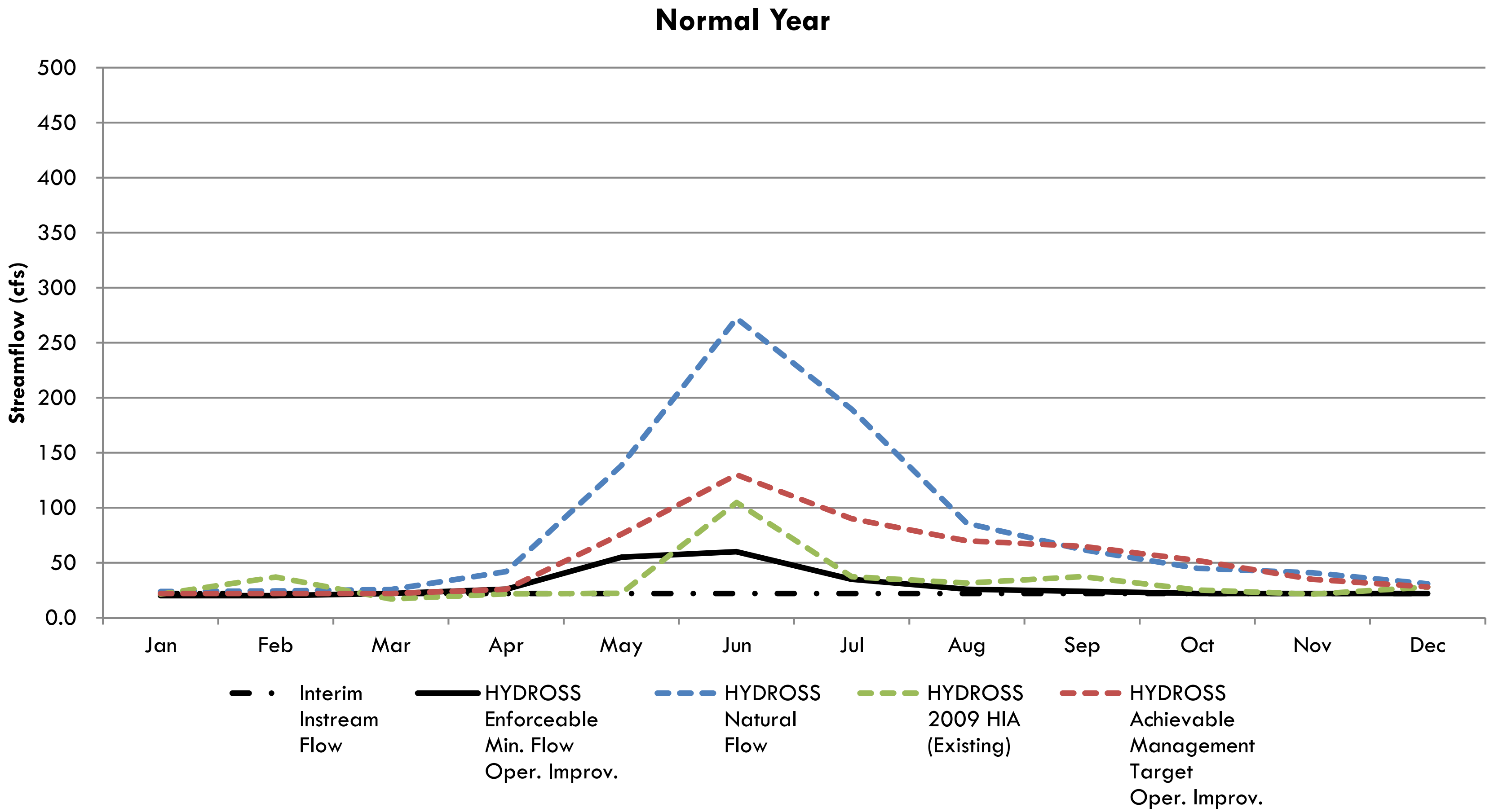
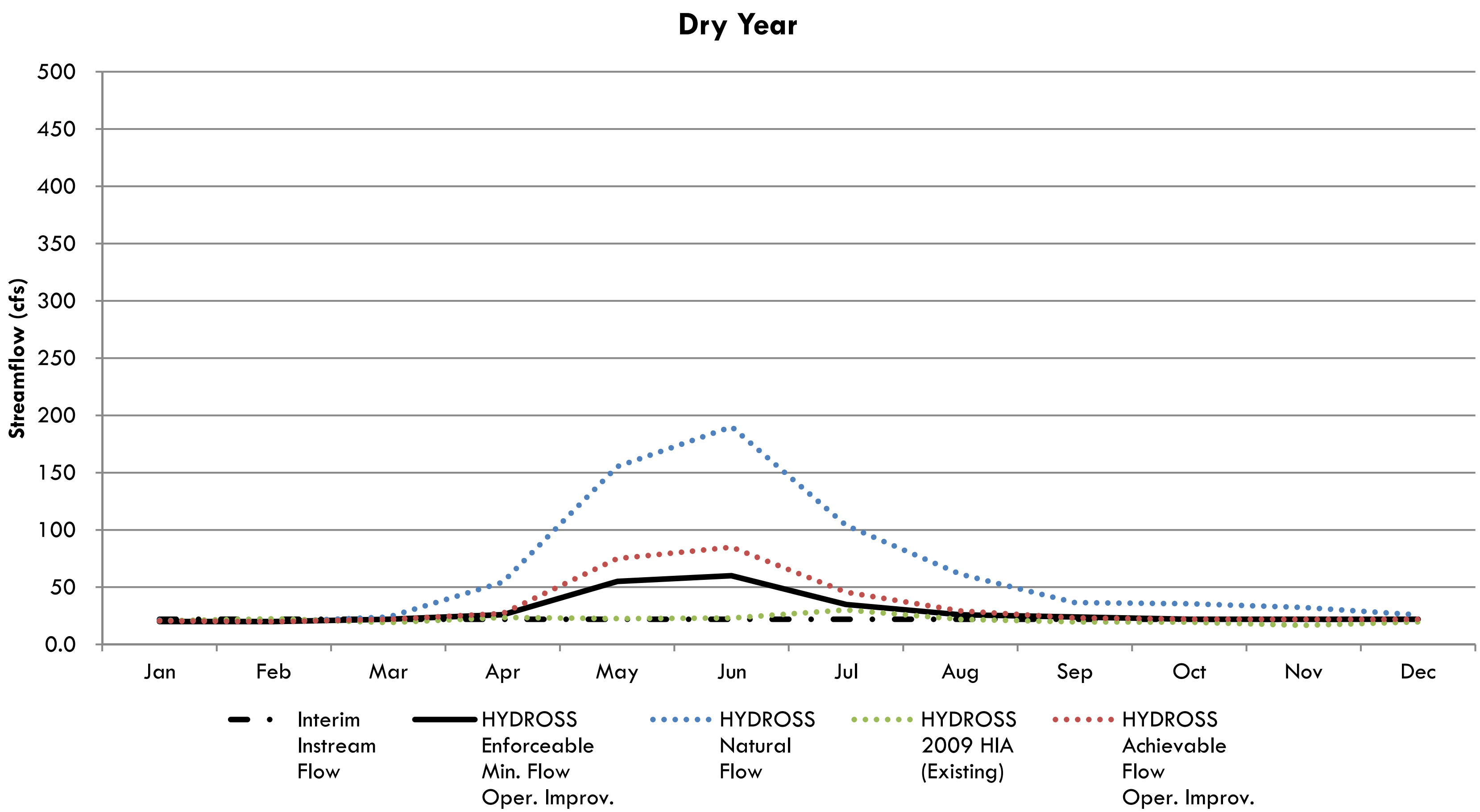


Post Creek below Post F Canal



Basis of Water Allocation

1. Provide Adequate Water Supply to Match Existing Crop Irrigation Consumption
2. Identify Potential Water Conservation Improvements to Project Water Distribution Operations
3. Determine the remaining streamflow available for Minimum Instream Flows (MEFs) and Target Instream Flows (TIFs) after implementing Project Improvements