Physically Based Modeling of DICU
- Fabian Tract case study

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UCDAVIS
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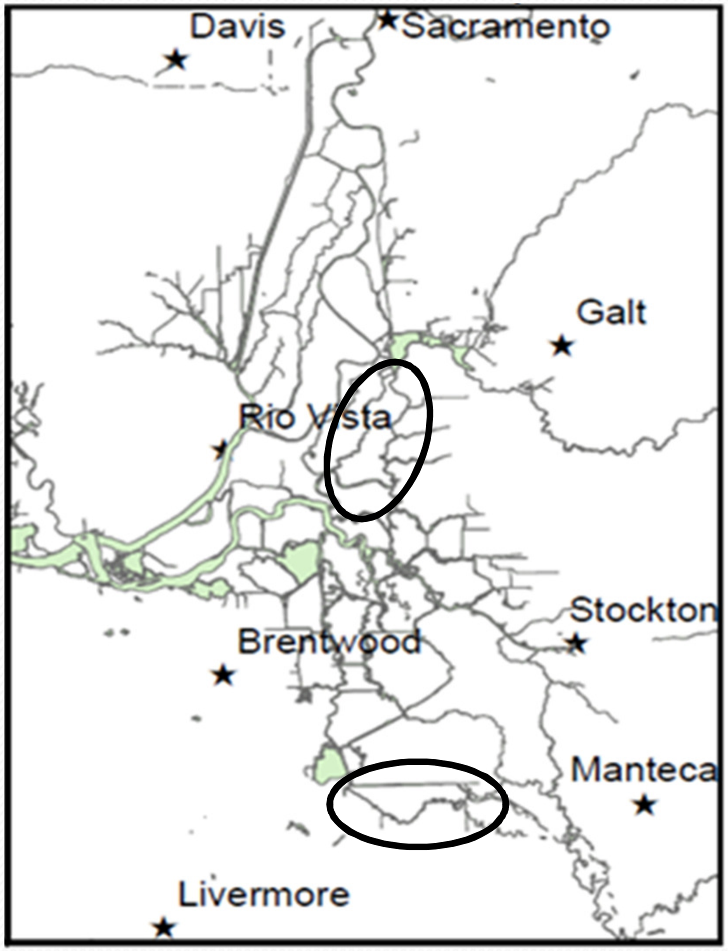
DICU affects Delta model results.

Objectives:

- Reduce uncertainty in DICU locations
- Improve DICU and water quality estimates
- Compare current and more contemporary physically-based DICU estimates
- Produce a model that accepts better data when available
- Estimate how further data collection and modeling improves water quality modeling estimates

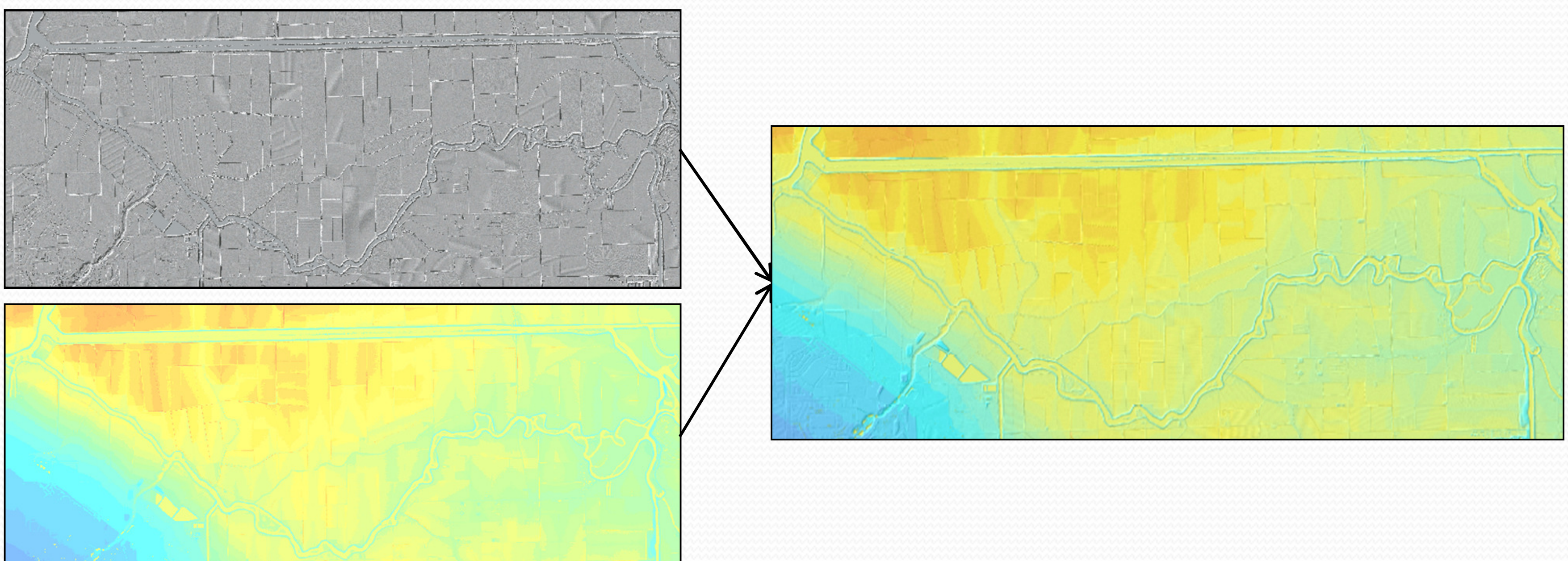
Project Steps

1. Identify Diversion and Return Locations using LIDAR and GIS
   - Supplemented with water rights, place of use, and Google Earth data
2. Ground-Truth Diversion and Return Locations
3. Model Integration
   - Model Selection
   - GIS Analysis
   - Comparison of Results
4. Water Quality Correlation



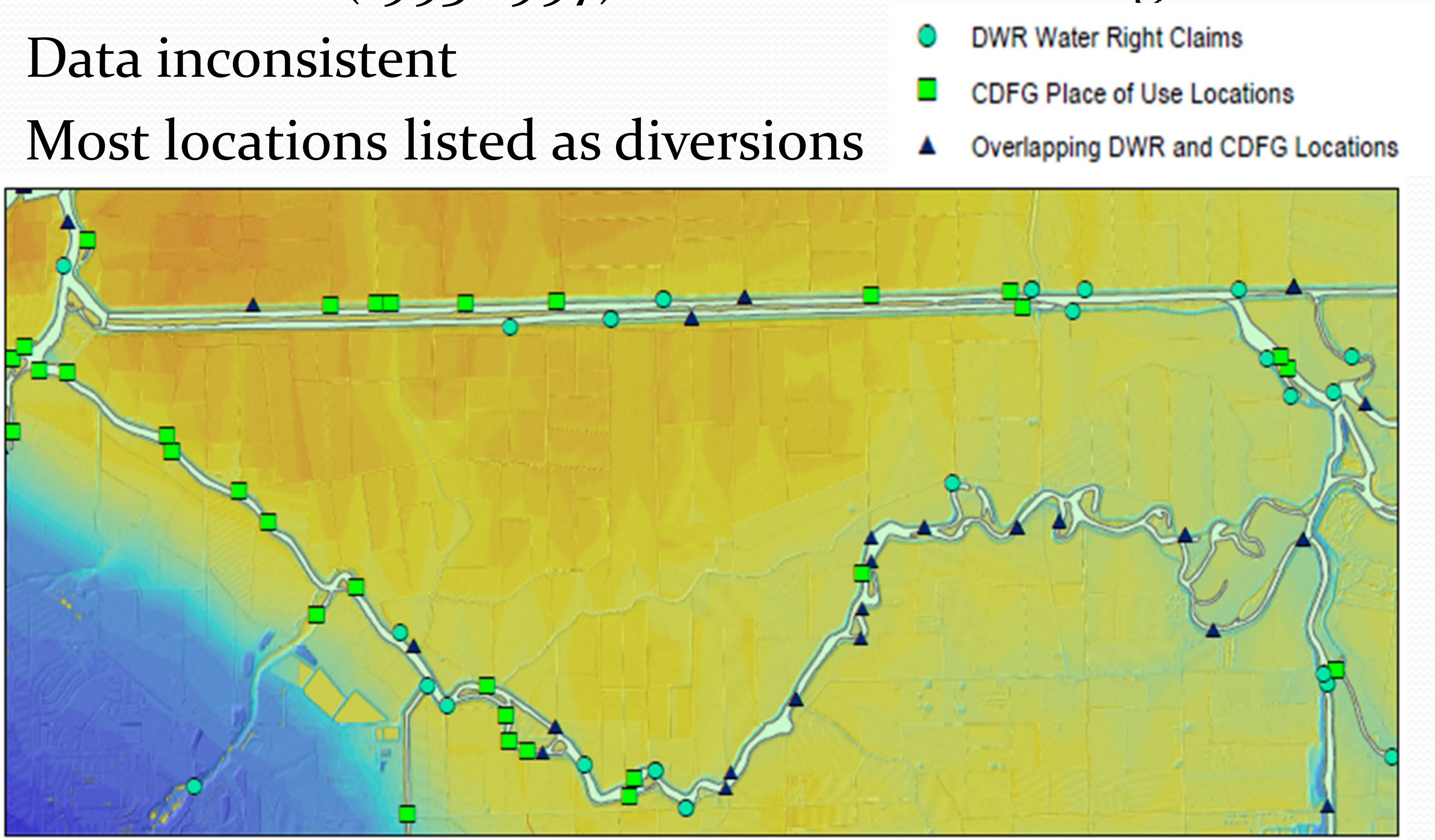
Step 1. Data Acquisition: LIDAR

- Digital Elevation Model data, Center for Spatial Technologies and Remote Sensing, UC Davis
  - 1 x 1 meter grid resolution, 6 inch elevation resolution
- ArcGIS hillshade overlayed by classified elevations
  - Combined use gives better picture



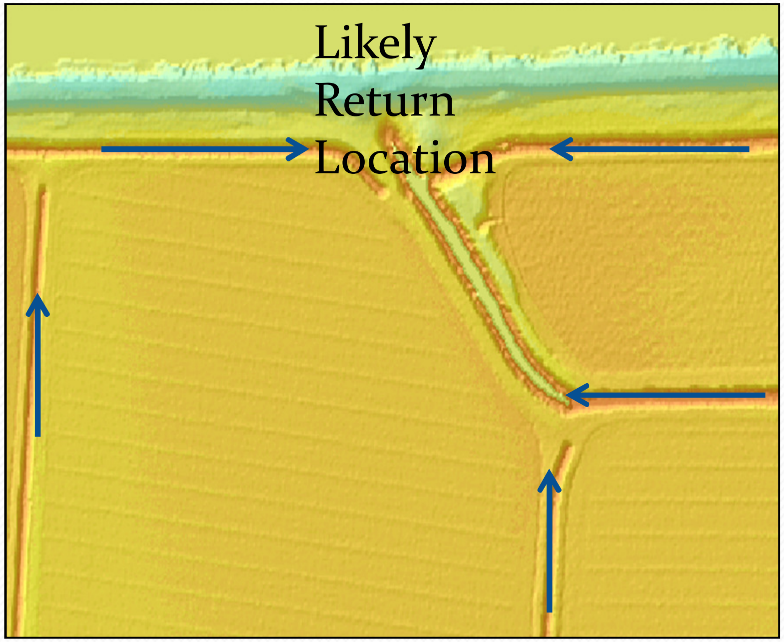
Data Acquisition: DFG and SWRCB

- DFG studies (1993-1997) and SWRCB water rights
- Data inconsistent
- Most locations listed as diversions



Data Interpolation: LIDAR and Google Earth

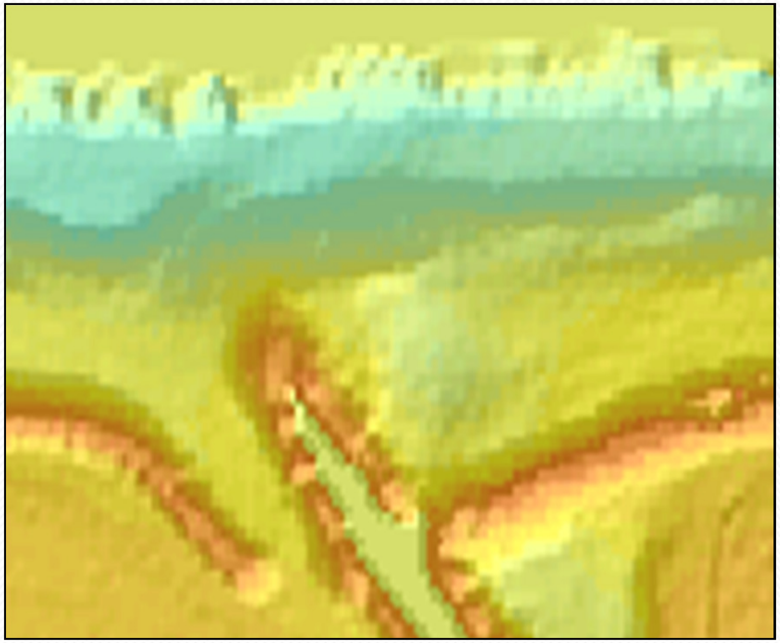
- LIDAR in GIS used to determine diversion and return flow patterns and sources
- Google Earth used to verify these locations



Data Interpolation: LIDAR and Google Earth

- Zooming in…

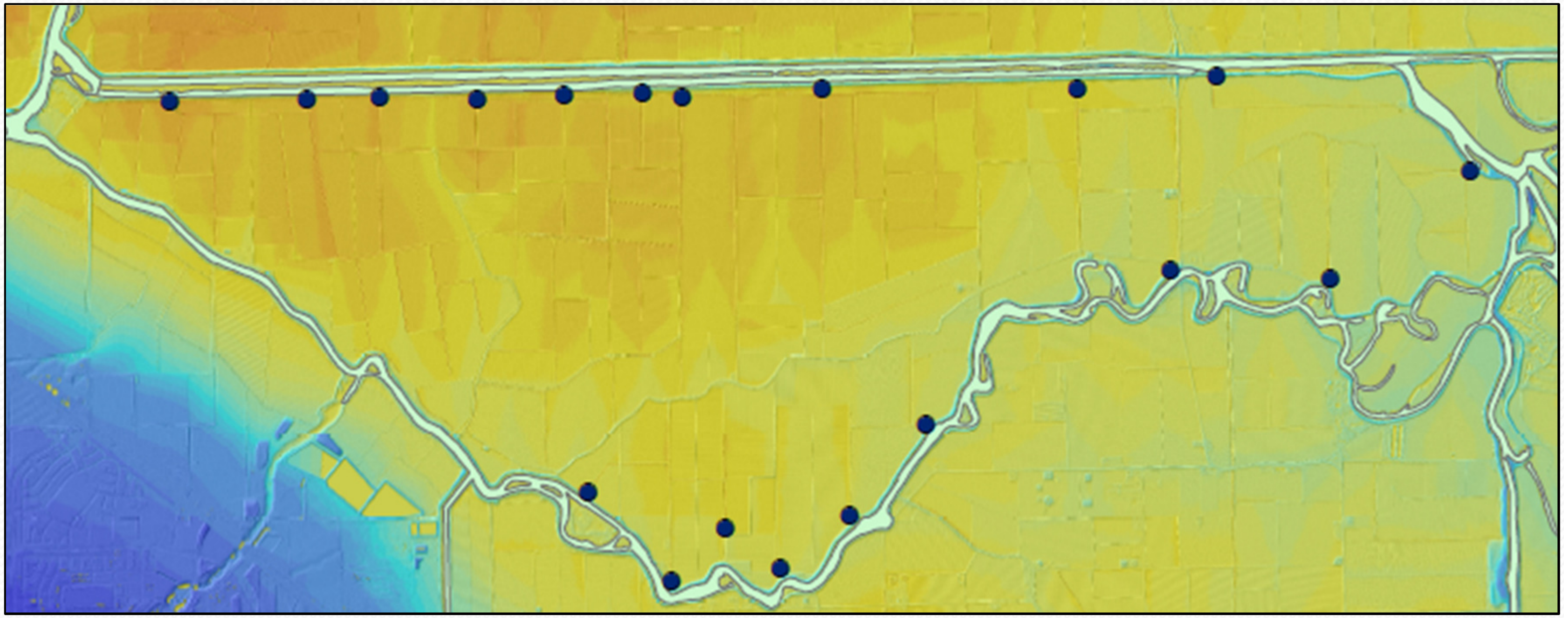
LIDAR



Google Earth

Data Interpolation: LIDAR and GIS

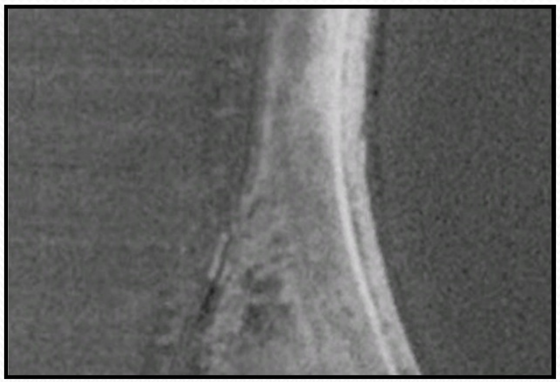
- Predicted Return Locations from GIS analysis



Data Interpolation: LIDAR and Google Earth

- Google Earth also provides insight into historical changes

Staten Island, 1993



2002

2005

2007

2011

Challenges Determining Locations

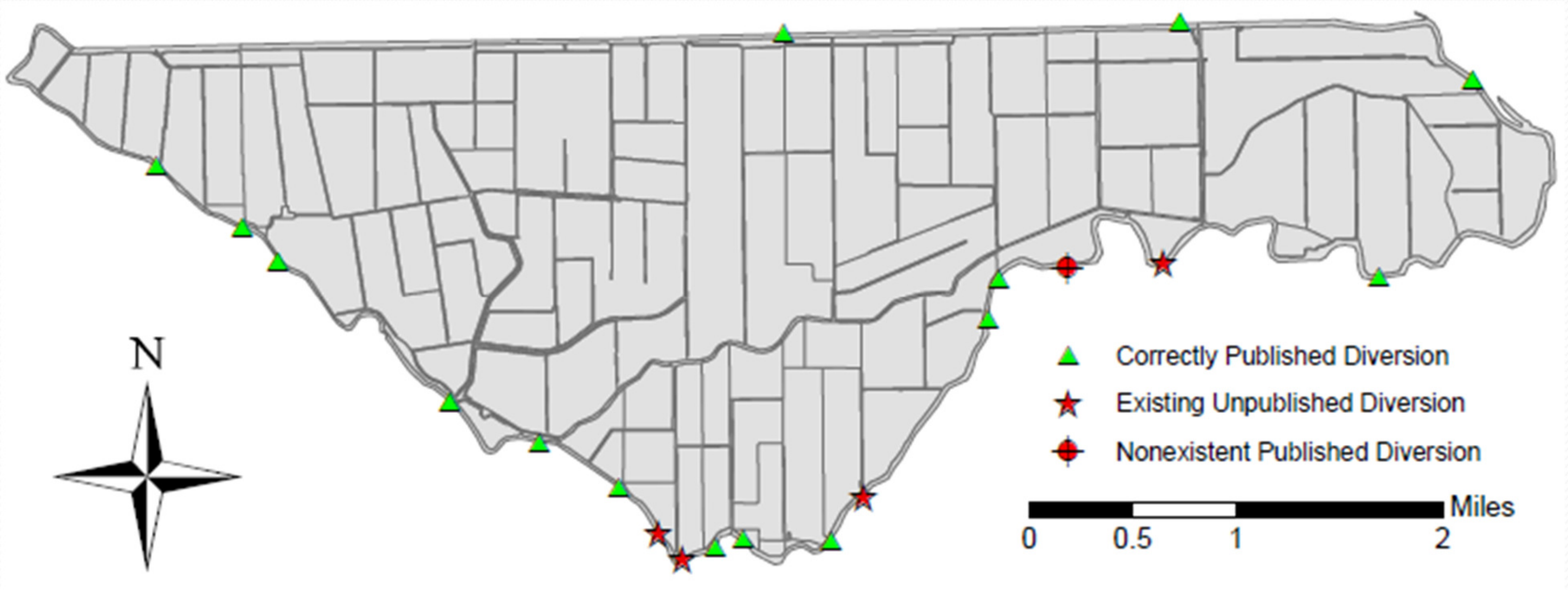
- Data Acquisition
  - Inconsistent data
  - Most locations listed as diversions
  - Location status as active or inactive unclear
- Data Interpolation
  - Labor intensive
  - Vegetation, low gradient slopes, and inconsistent imagery sometimes makes locations difficult to determine
  - Location status as active or inactive unclear

Ground-Truthing used to add clarity

Thanks to South Delta Water Agency and John Herrick!

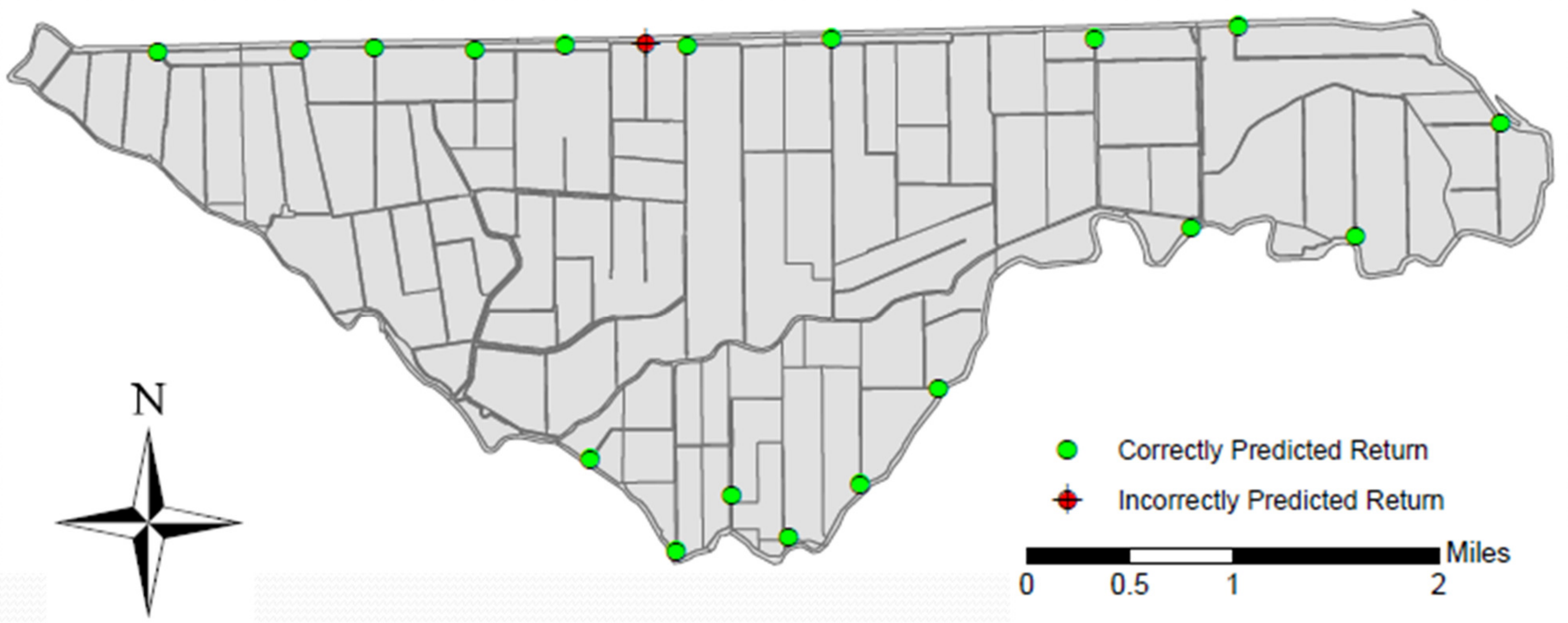
Step 2. Data Acquisition: LIDAR vs. Ground-Truthing

- Of 16 diversions in two sources, correct diversions: 15
- Nonexistent published diversions: 1
- Existing missed diversions: 4



Data Acquisition: LIDAR vs. Ground-Truthing

- Of LIDAR-data based predicted returns, correctly predicted returns: 18
- Predicted returns didn't exist: 1
- No unpredicted returns found.



Data Acquisition: Ground-Truthing

- Challenges determining status of diversion/return locations during ground-truthing
  - Active

    vs.
  - Inactive

Data Acquisition: Ground Truthing

- Challenges of ground-truthing diversions/returns

  - Permanent

    vs.

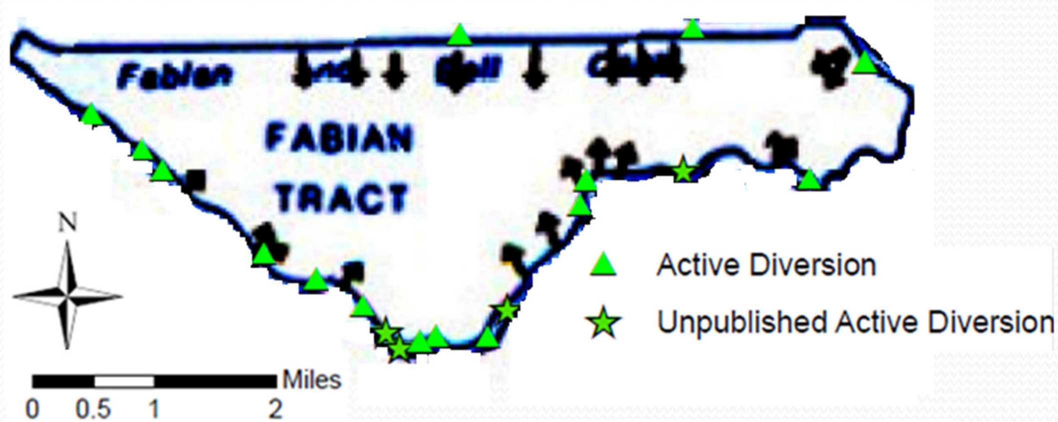
  - Temporary

Diversion and Return Comparison:

- California Water Atlas vs. Ground-Truth

	Diversions	Near-Matches
Ground-Truthed	19	8
Water Atlas	21	

	Returns	Near-Matches
Ground-Truthed	17	10
Water Atlas	13	

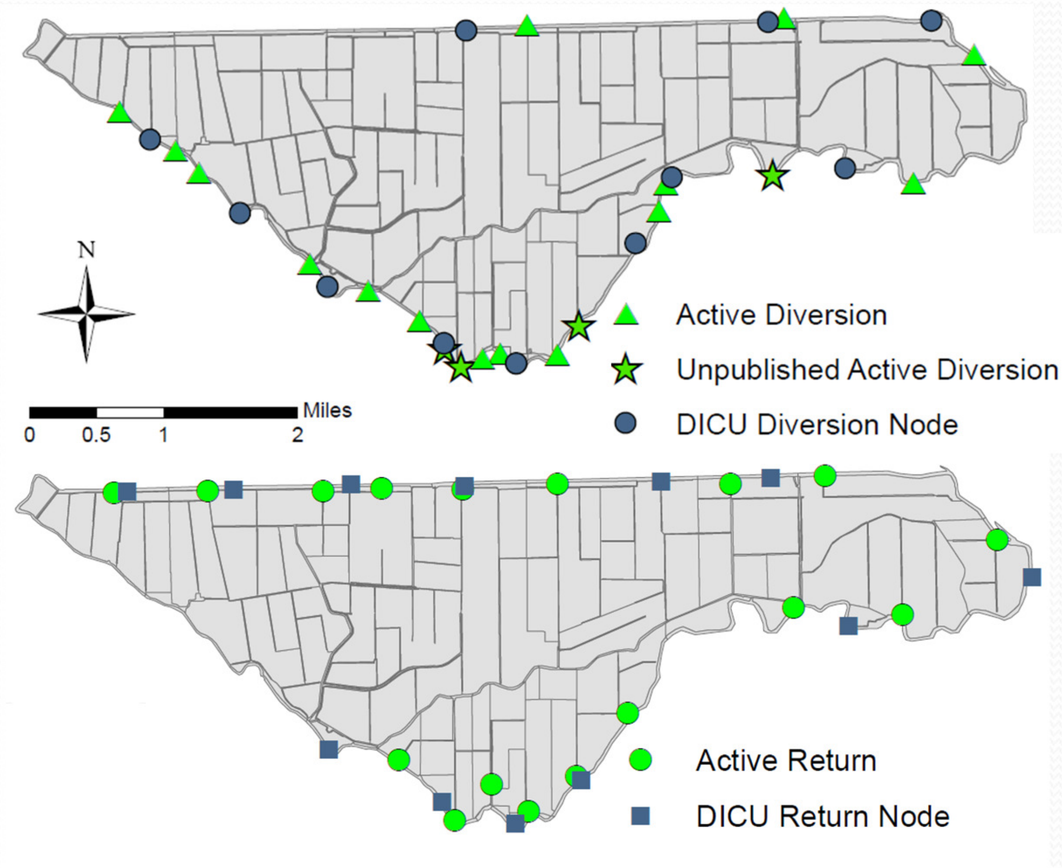


Diversion and Return Comparison :

- DICU vs. Ground-Truth

	Diversions	Near-Matching
Ground-Truthed	19	10
DICU	11	

	Returns	Near-Matching
Ground-Truthed	17	10
DICU	12	



GIS-LIDAR Analysis Benefits and Costs

- Benefits
  - Performed remotely and unobtrusively
  - Provides insight into crop and irrigation drainage patterns
  - Provides insight into diversion and return locations
  - Historical satellite images provide insight into changes in landuse and irrigation practices
- Costs
  - Labor intensive
    - ~20 person hours per island, 40 person weeks for entire Delta
  - Does not confirm diversion and return locations

Ground-Truthing Benefits and Costs

- Benefits
  - Relatively fast
    - ~5 person hours per island, 10 person weeks for entire Delta
  - Provides insight into diversion and return locations
  - Provides insight into diversion and return status
- Costs
  - Access required
  - Can be intrusive
  - Does not provide insight into crop and irrigation drainage patterns other than diversion and return locations
- Google Earth can be a partial substitute for Ground-Truthing

Step 3. Model Selection

- DETAW: Delta Evapotranspiration of Applied Water Model
- MF-MFP: MODFLOW with Farm Management Practices
- IDC: IWFM Demand Calculator
  - IDC selected based on:
    - Capabilities
    - Ease of use
    - Applicability
    - DWR recommendations

IDC Background

- Generic input-driven model developed by DWR several years ago, currently at version 4.0
- Free and documented on DWR website
- Compatible with other Central Valley hydrologic analysis
  - Used by DWR to develop the hydrology for CalSim 3
  - Used by consultants in northern and southern California
  - Compatible with DWR Central Valley groundwater model (C2VSIM)

- DWR plans an IDC workshop soon

IDC Calculations

P=Precipitation

R_p=Direct Runoff

A_w=Applied Water

R_f= Return Flow

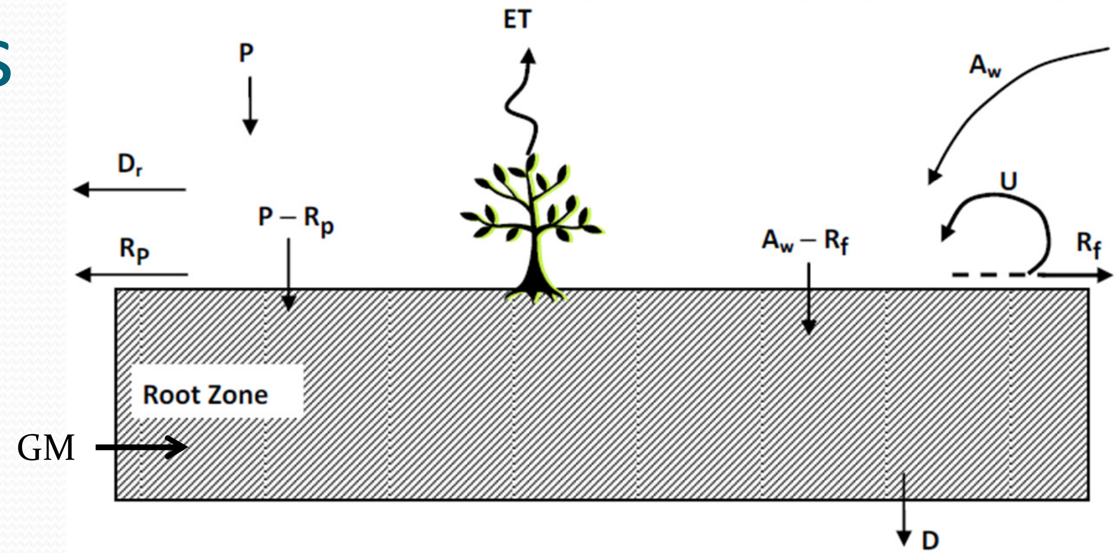
U=Re-Use Fraction

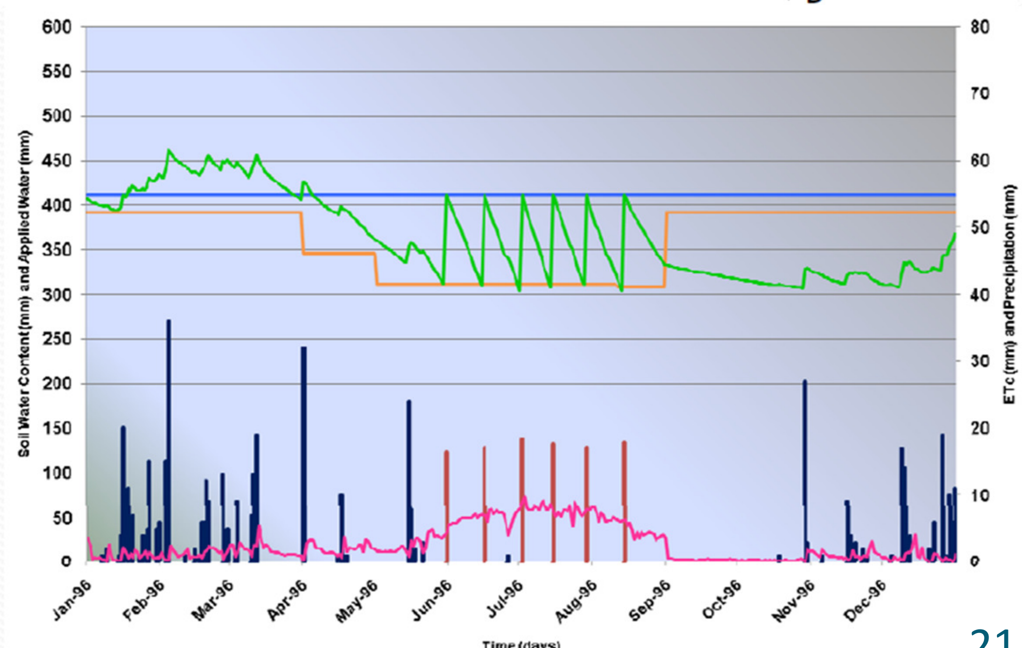
D_r=Drainage of Rice and Refuge Ponds

D=Deep Percolation

ET=Evapotranspiration

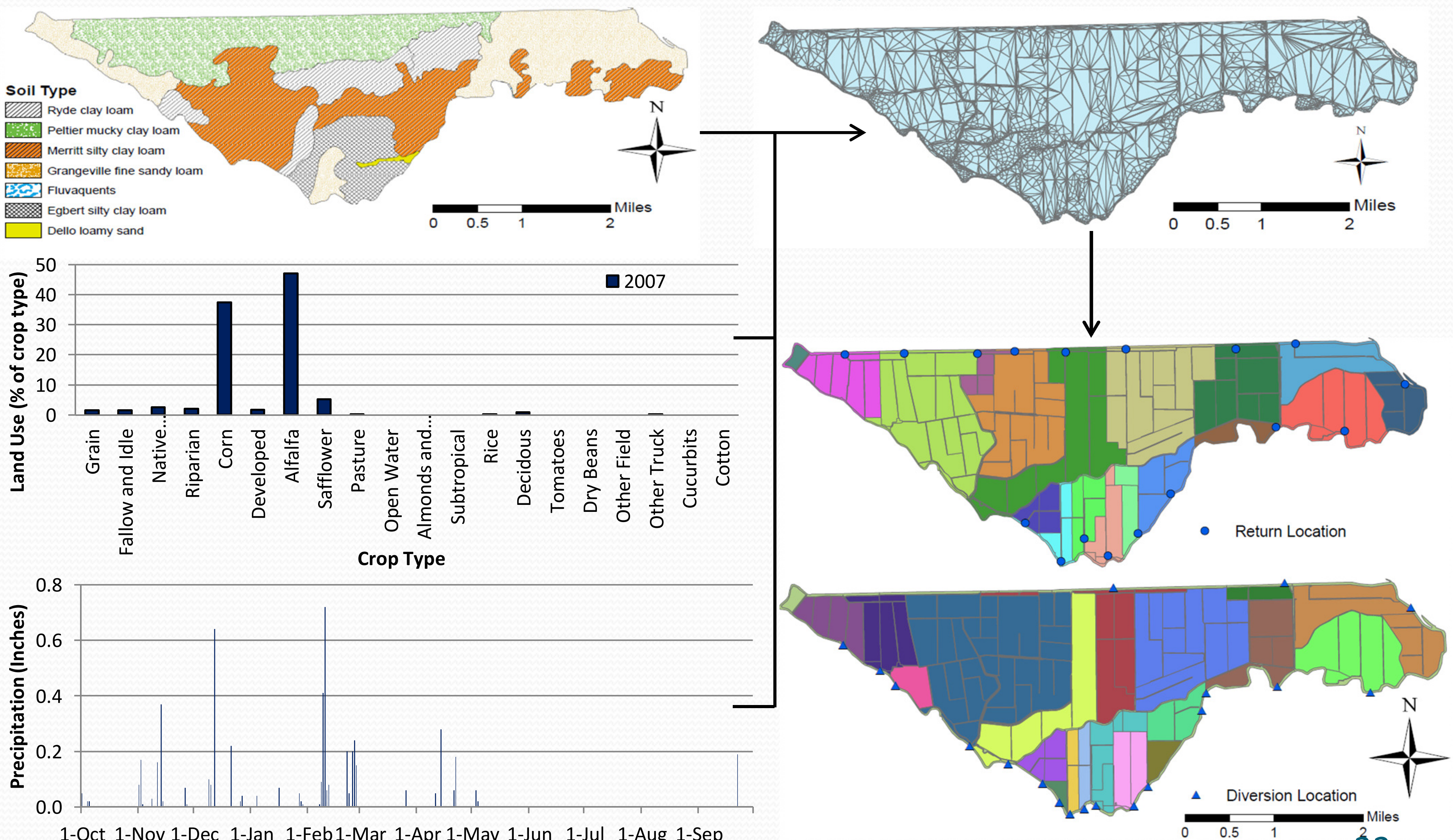
GM=Generic Moisture Source (Seepage)





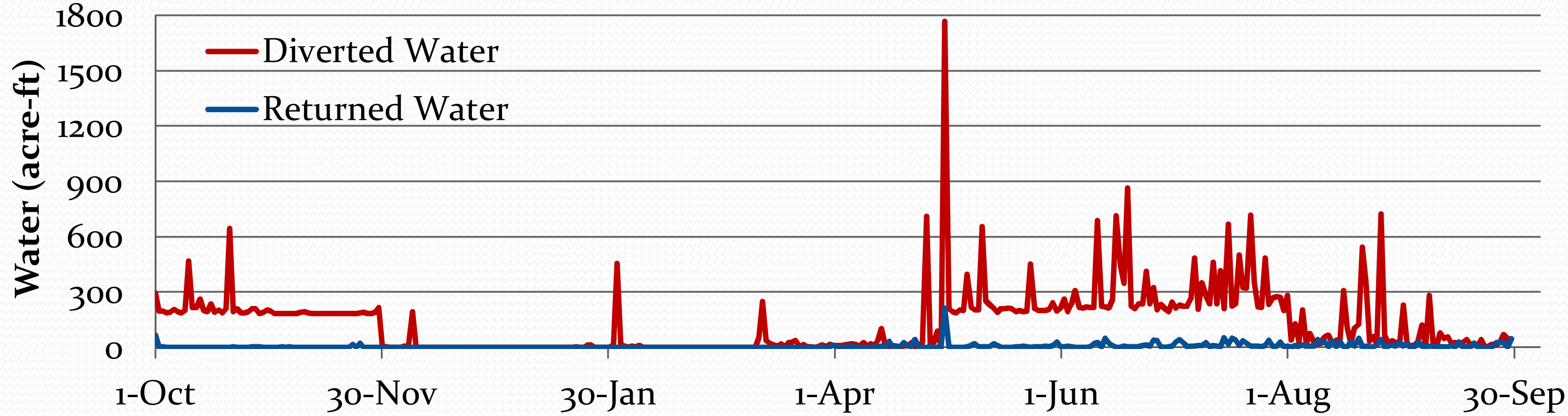
Images from:
Integrated Hydrological Models Development Unit (2011).IWFM Demand Calculator IDC v4.0 Theoretical Documentation and User's Manual, Modeling Support Branch, Bay-Delta Office.

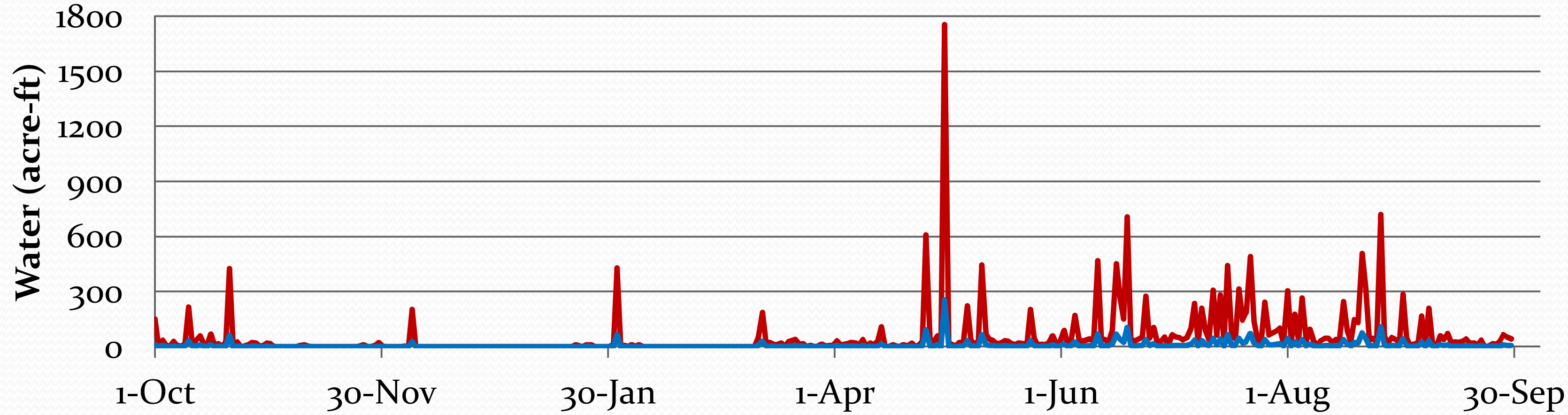
IDC Fabian Tract (IDCFT) Inputs



IDCFT Calibration and Sensitivity

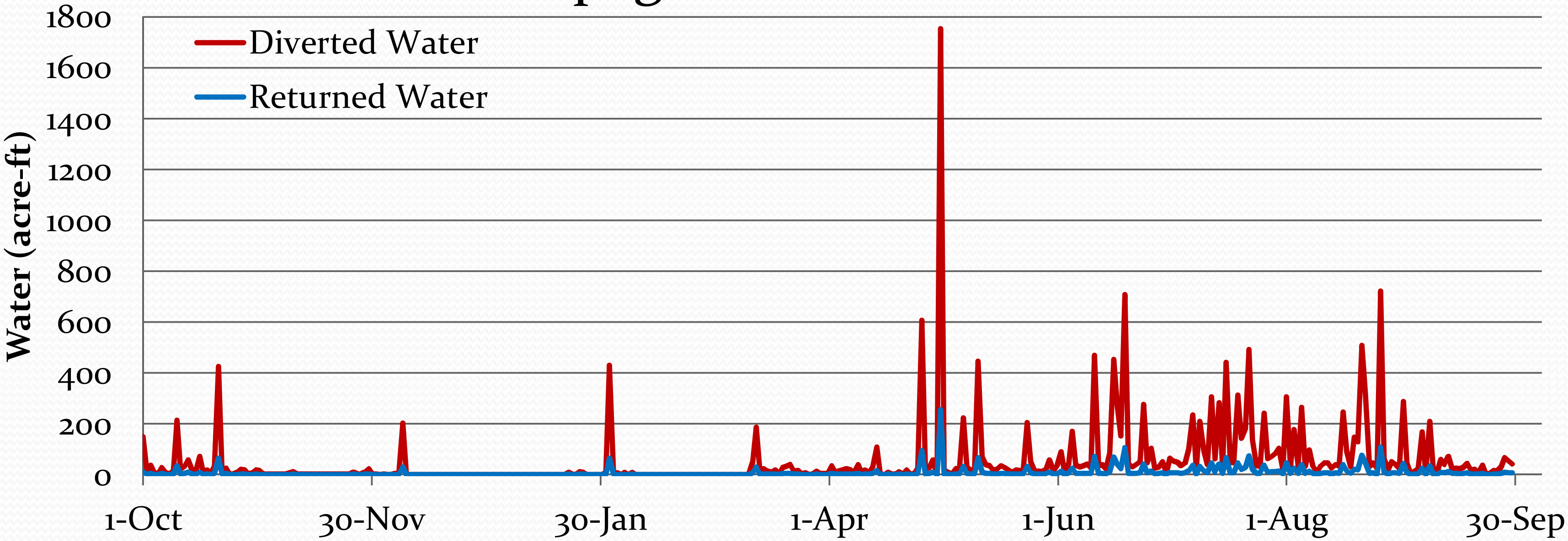
- Saturated Hydraulic Conductivity

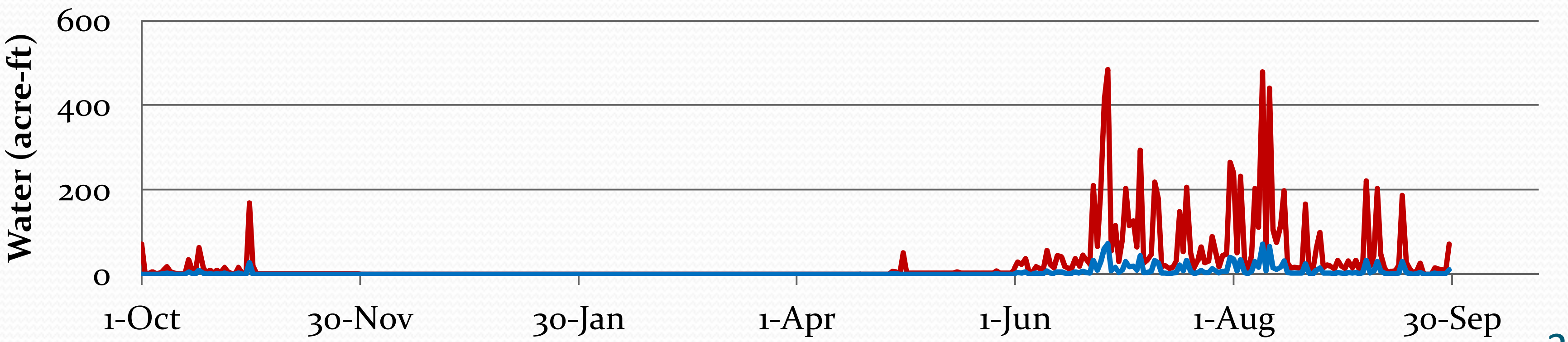




IDCFT Calibration and Sensitivity

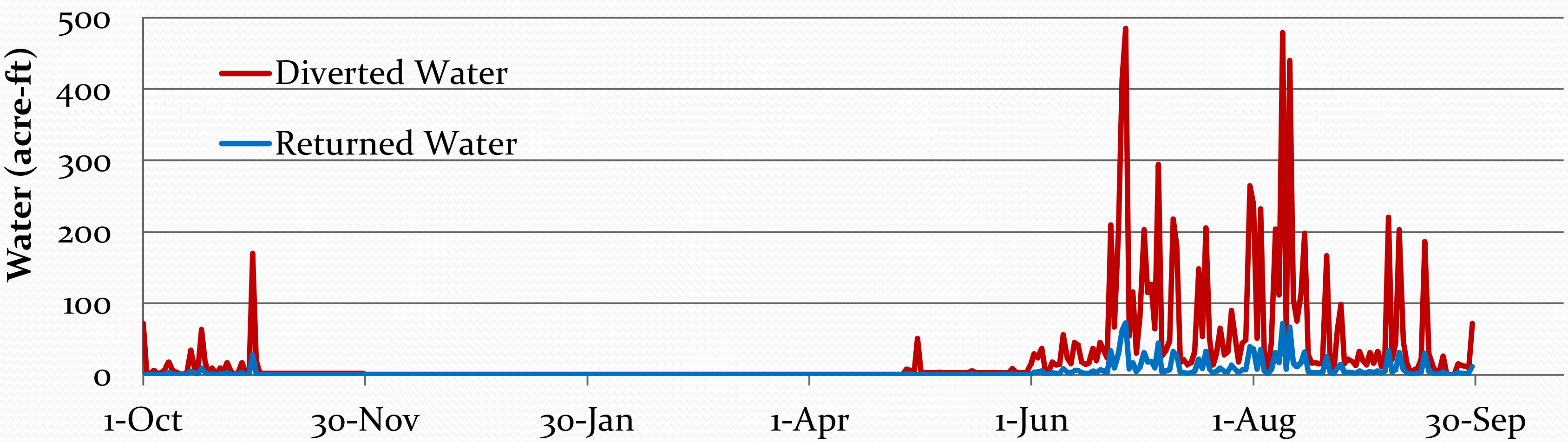
- Ground Water Seepage

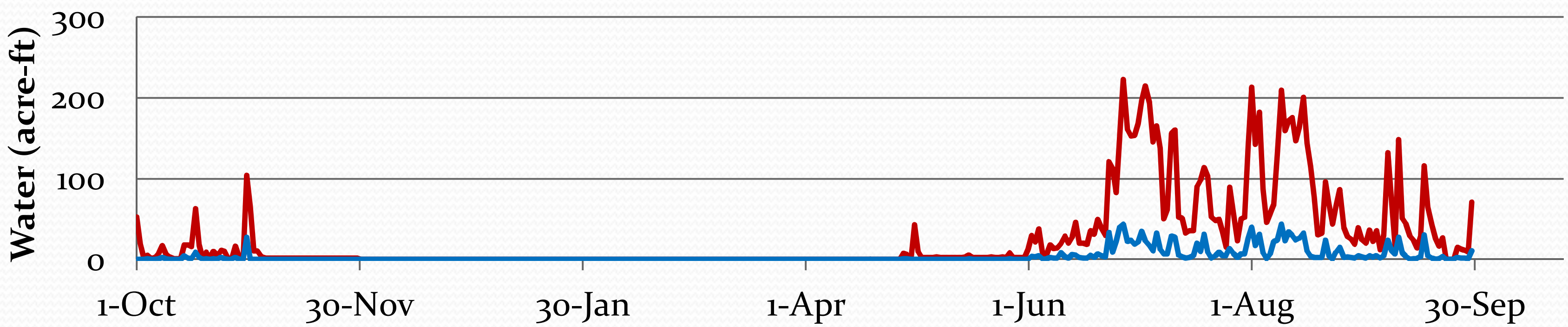




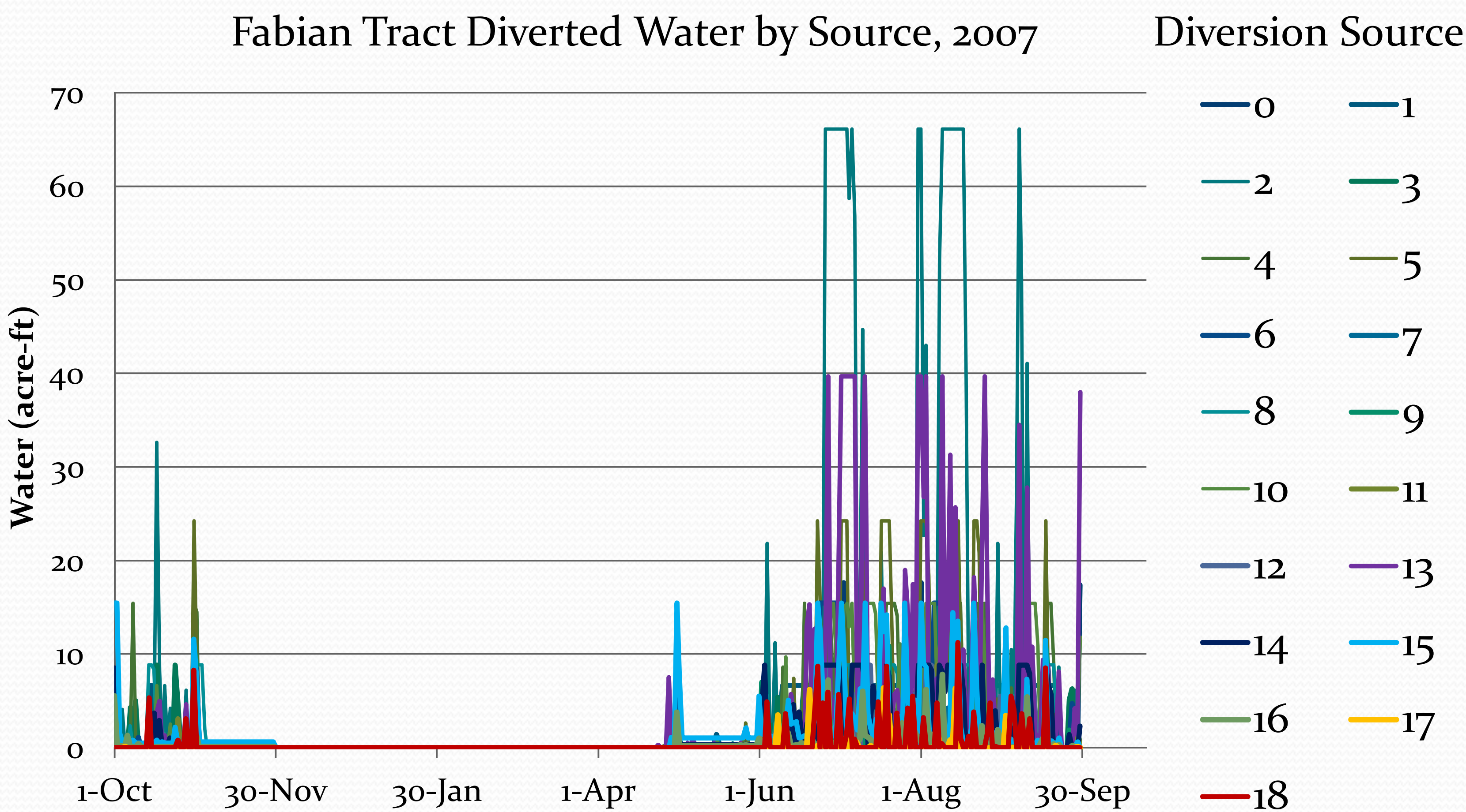
IDCFT Calibration and Sensitivity

- Pumping and Siphoning Rate Constraints

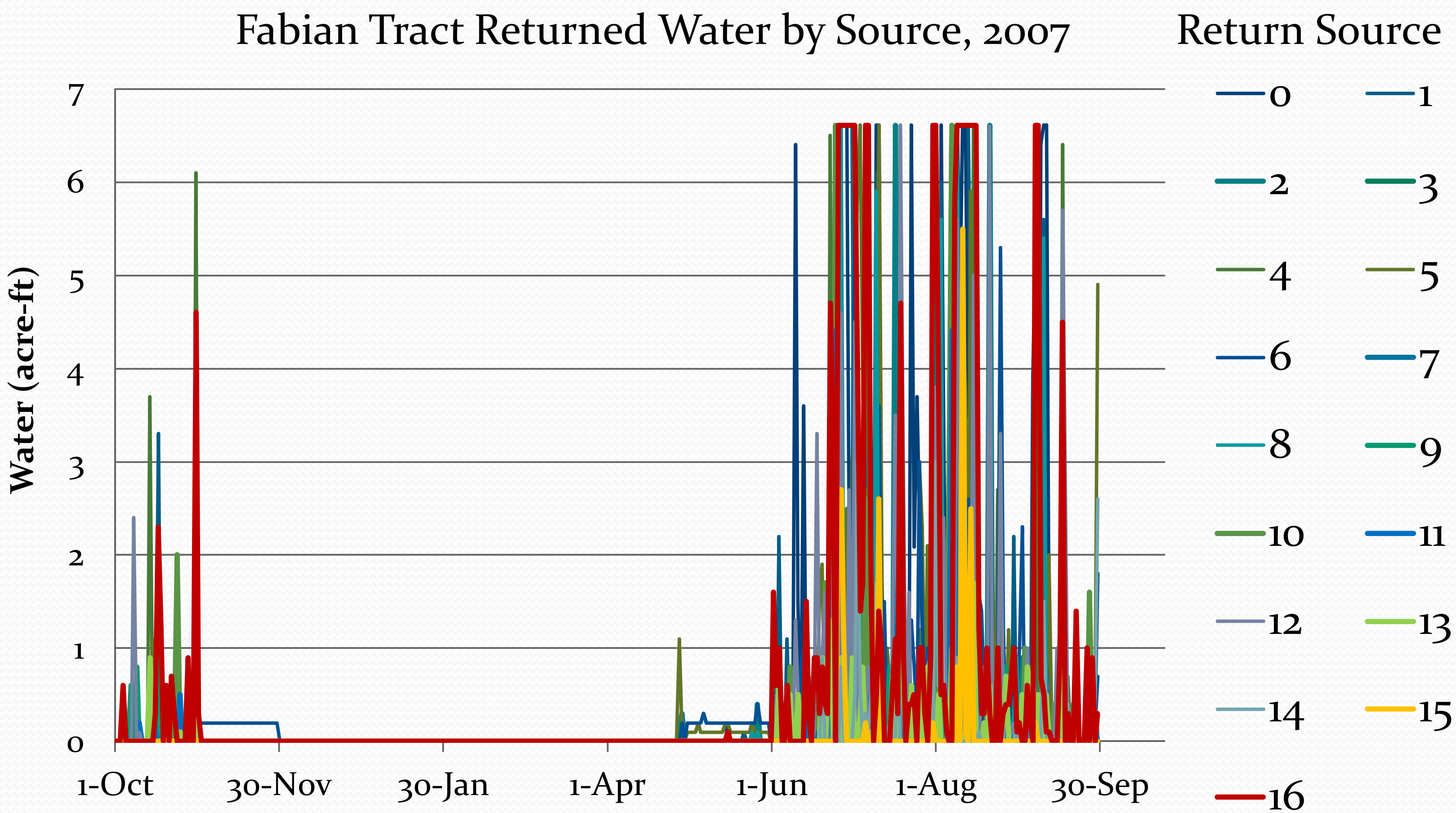




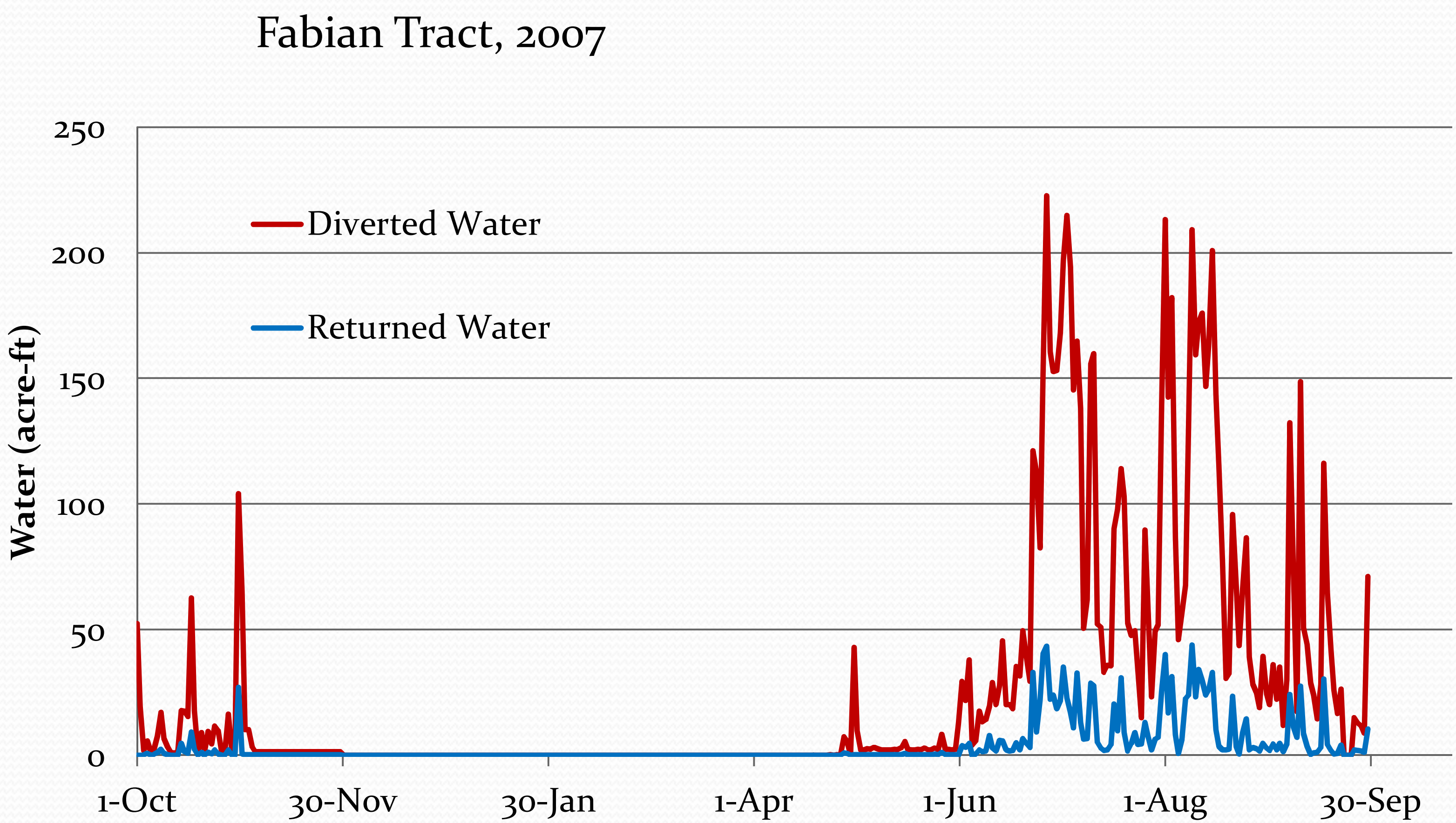
IDCFT Results: Diverted Water



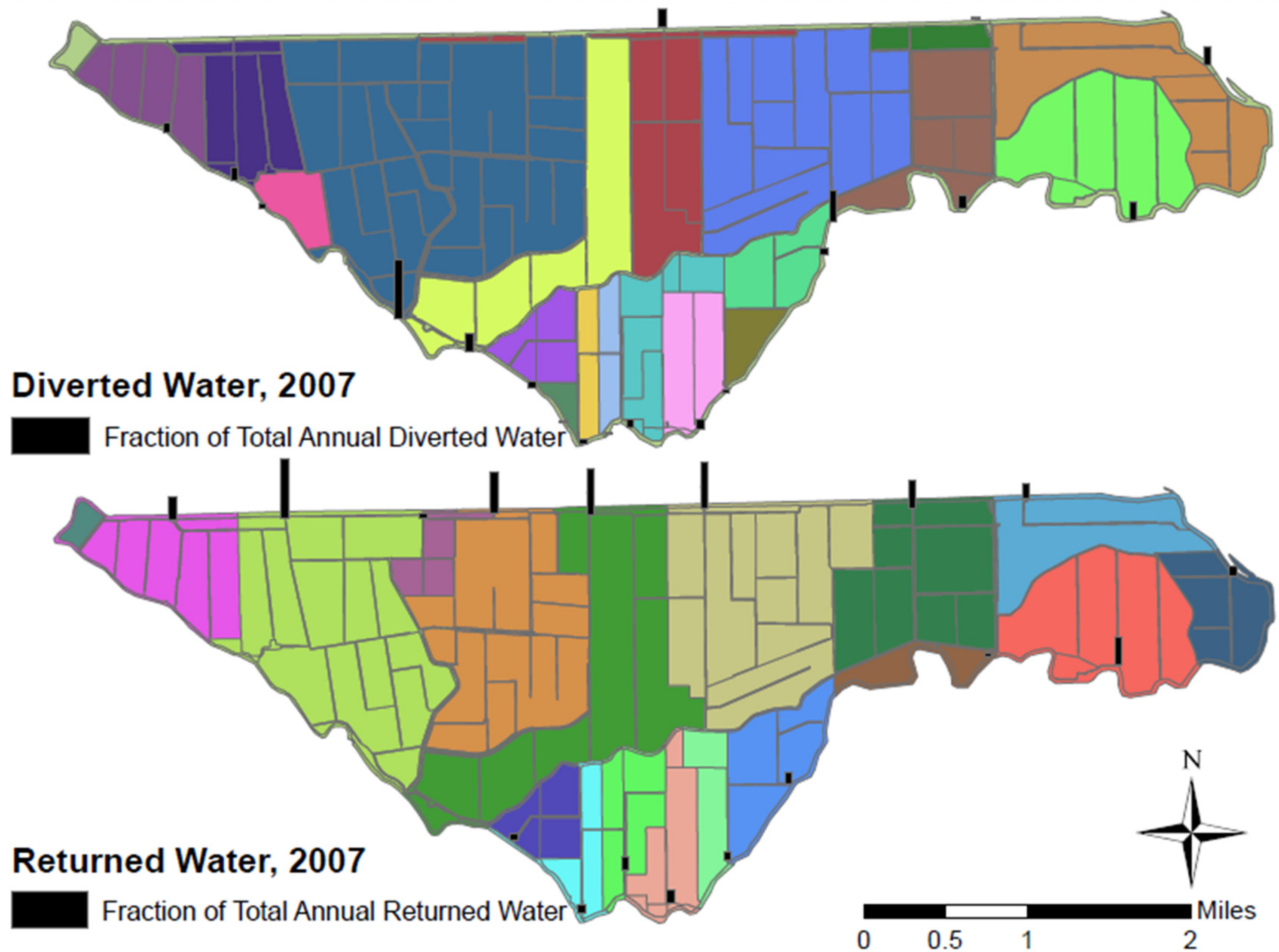
IDCFT Results: Returned Water



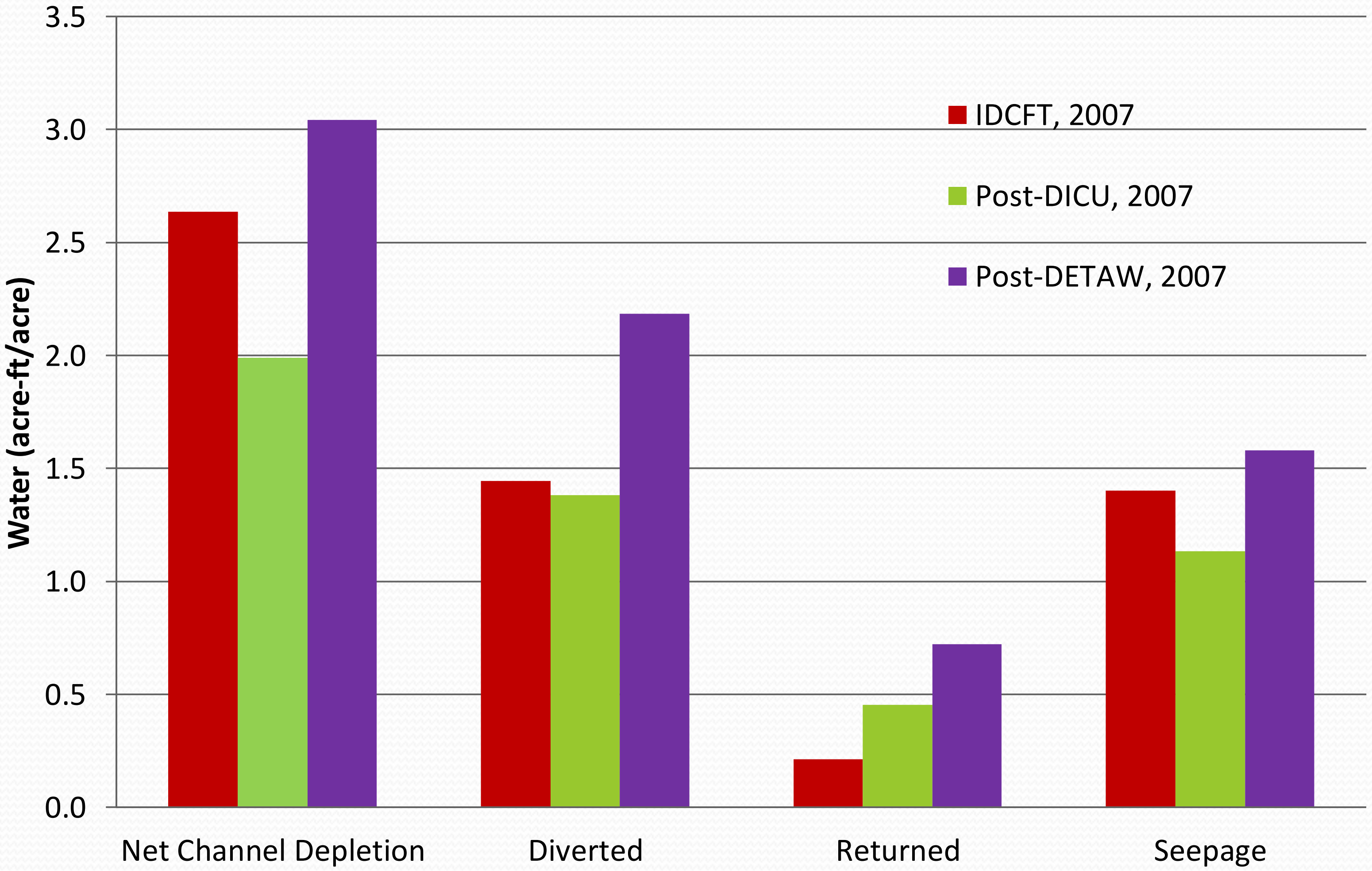
IDCFT Results: Total Returns and Diversions



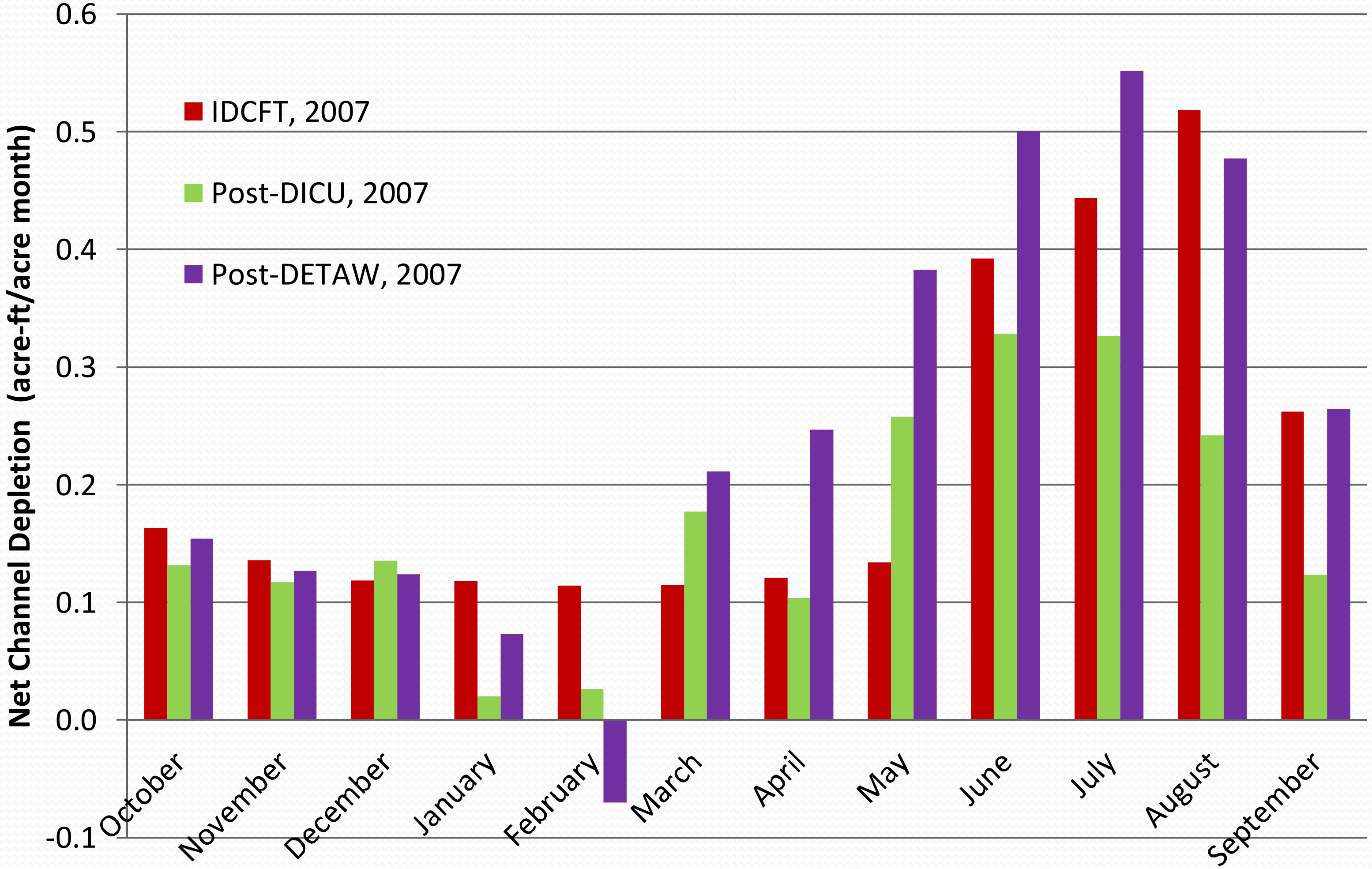
IDCFT Results: Annual Total by Watershed



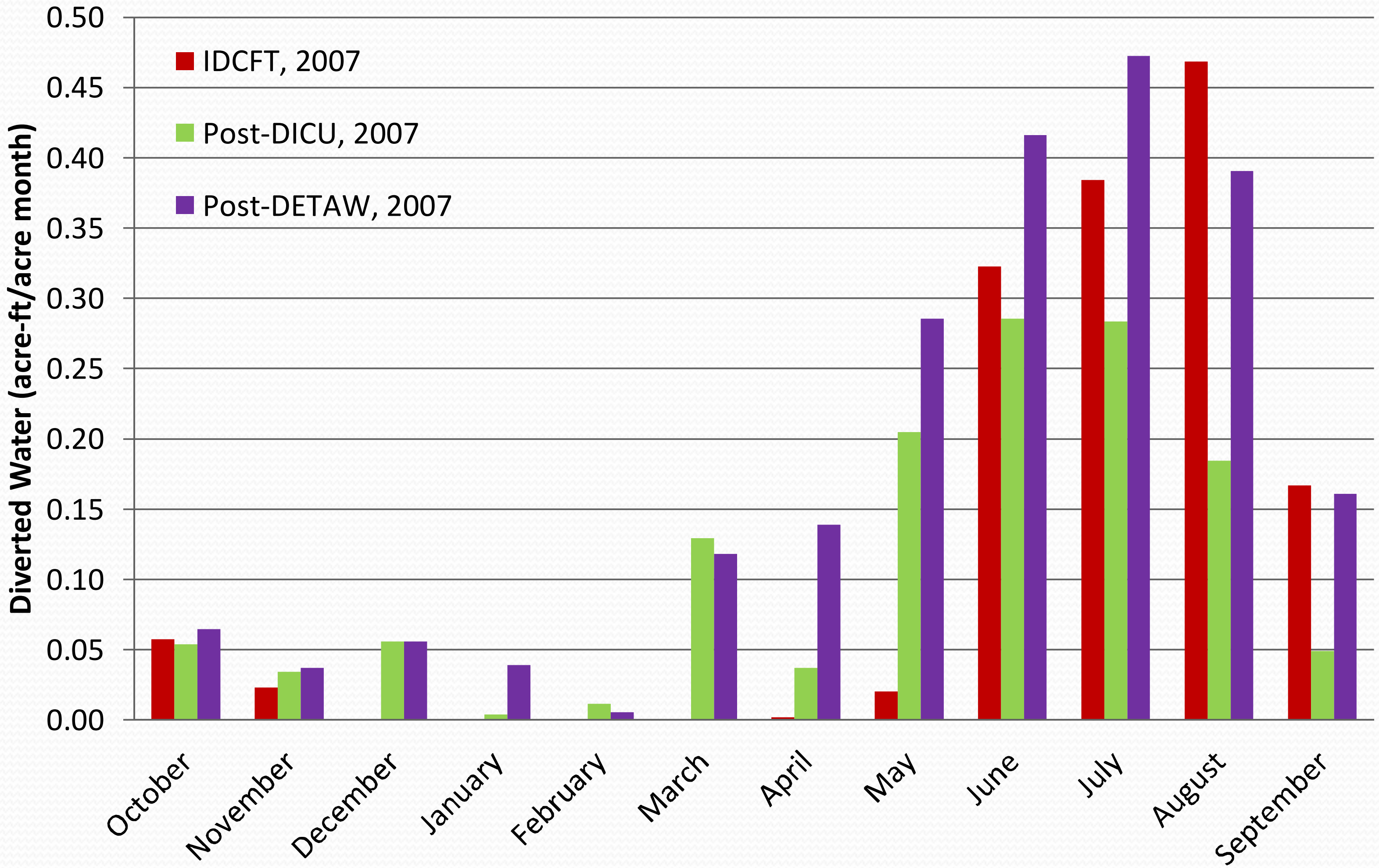
Model Comparison: Annual Total



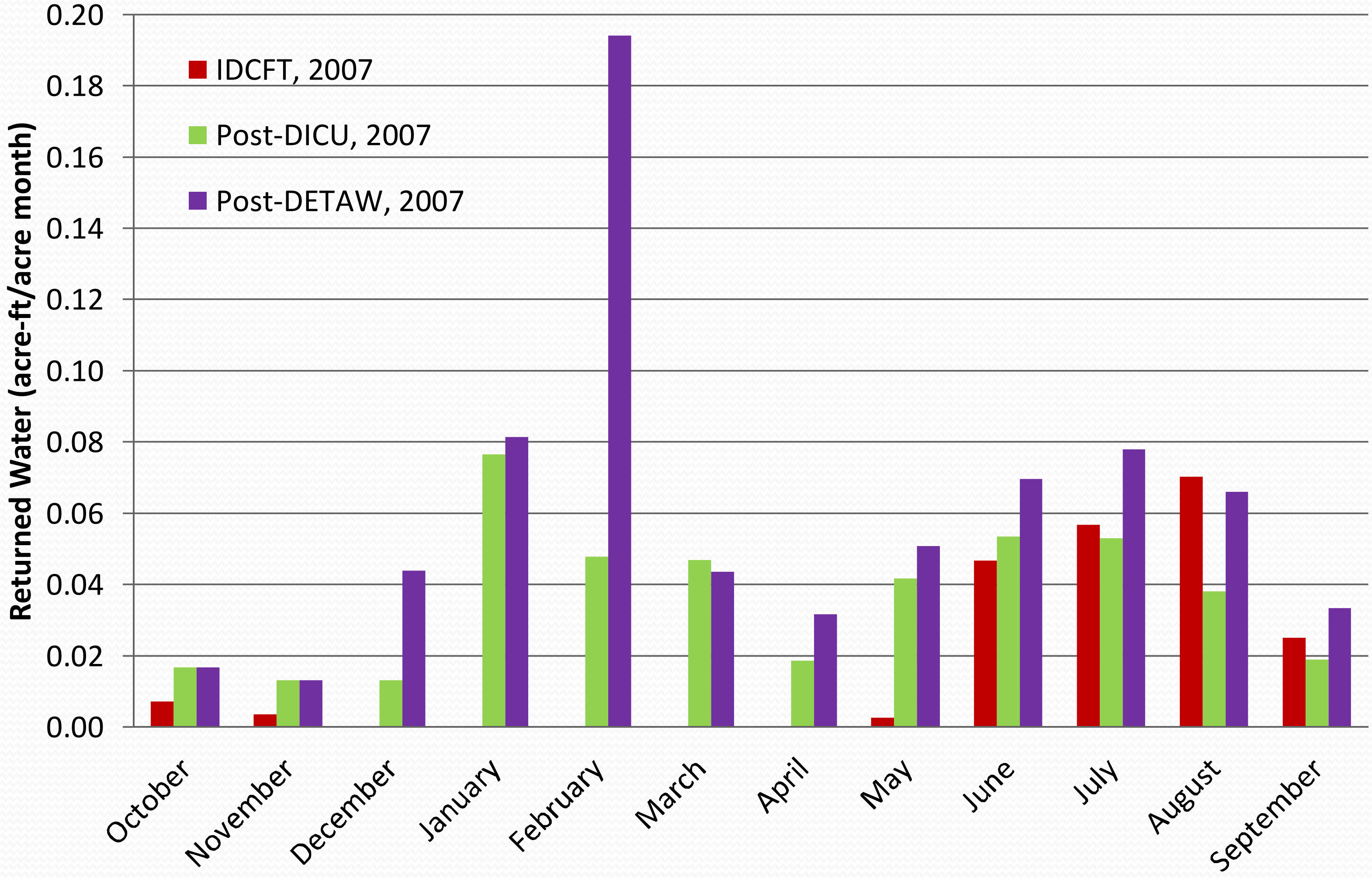
Comparison of Seasonal Net Channel Depletion



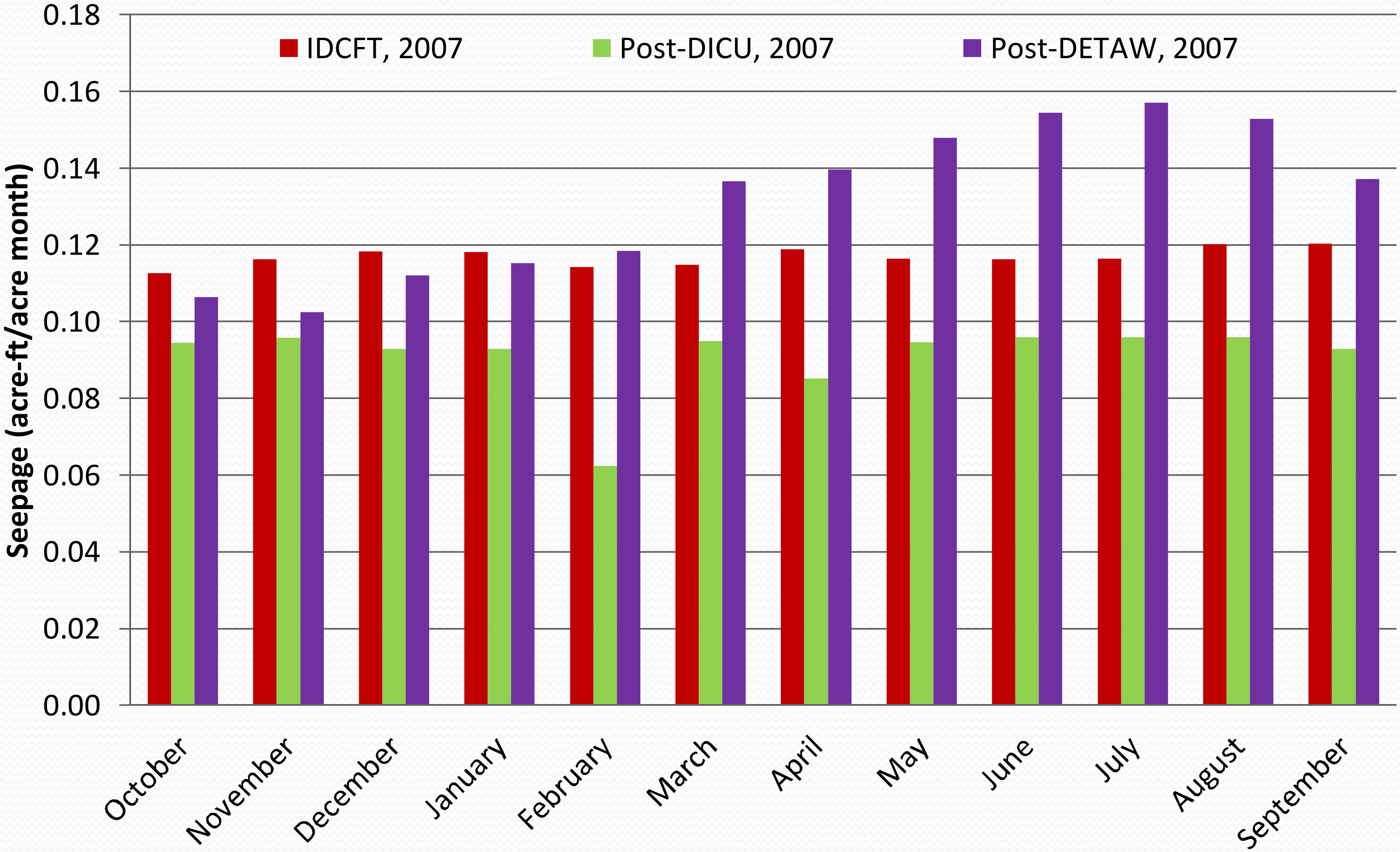
Comparison of Seasonal Diverted Water



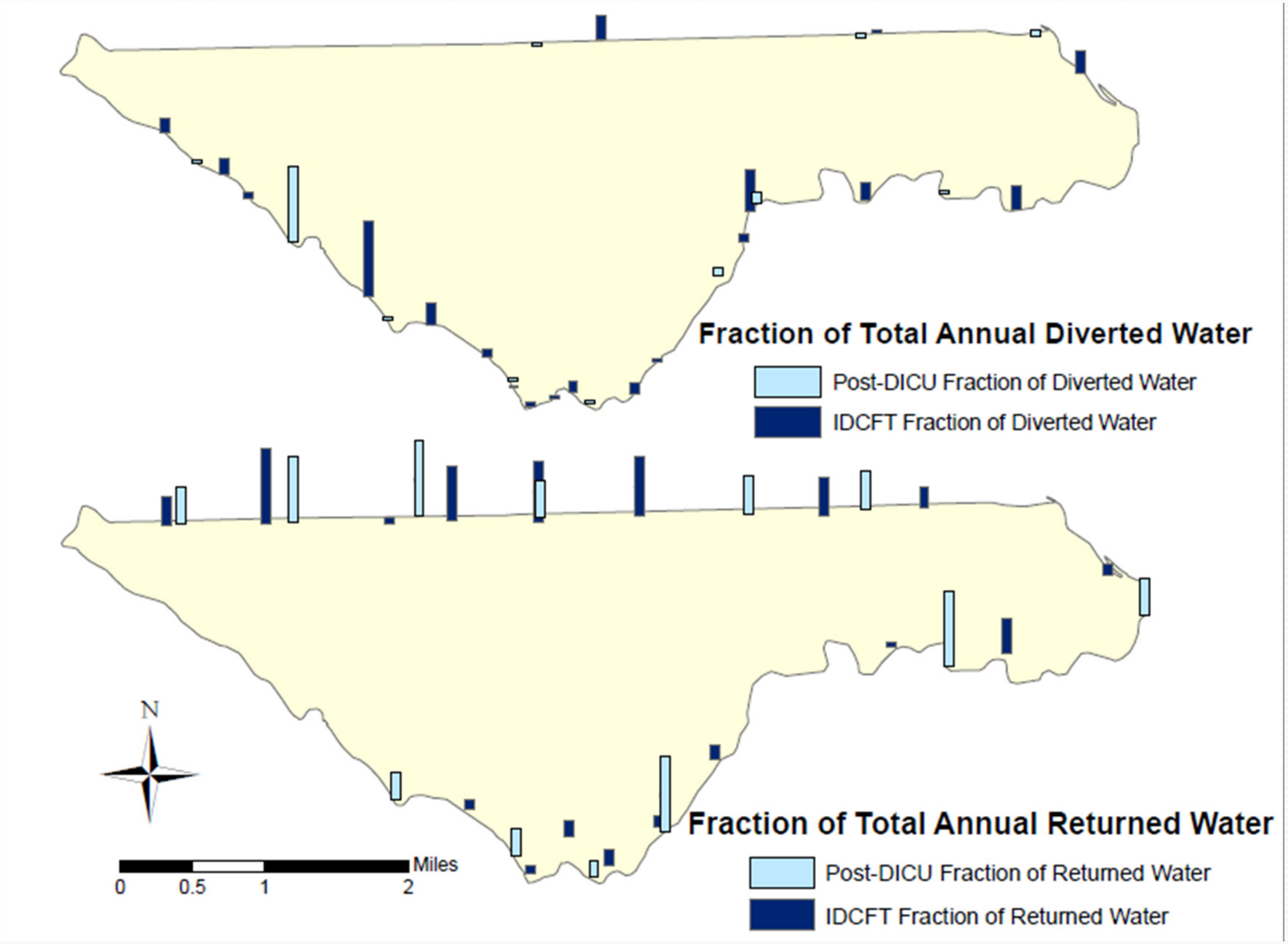
Comparison of Seasonal Returned Water



Comparison of Seasonal Seepage

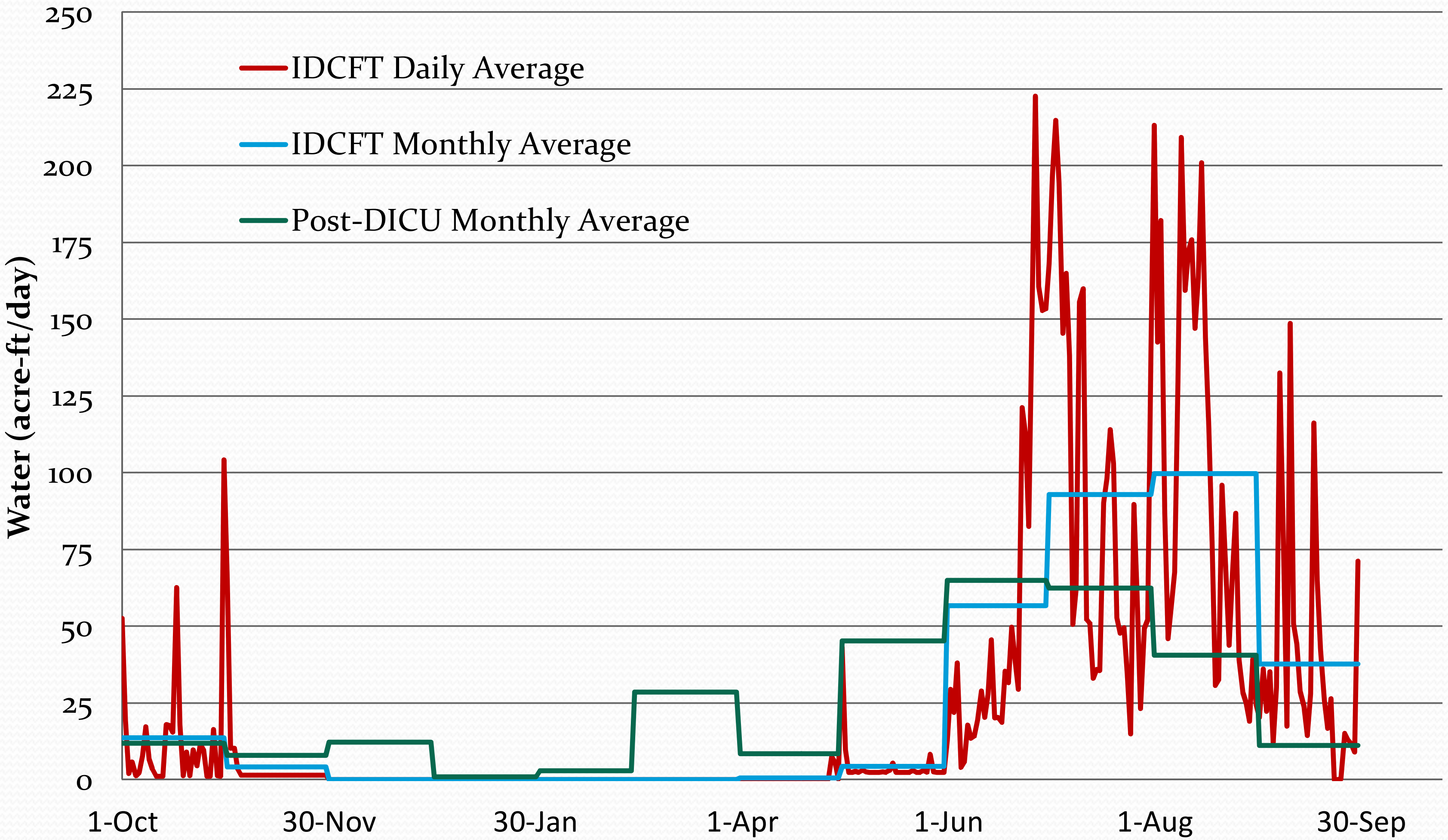


Comparison of Location Volumes



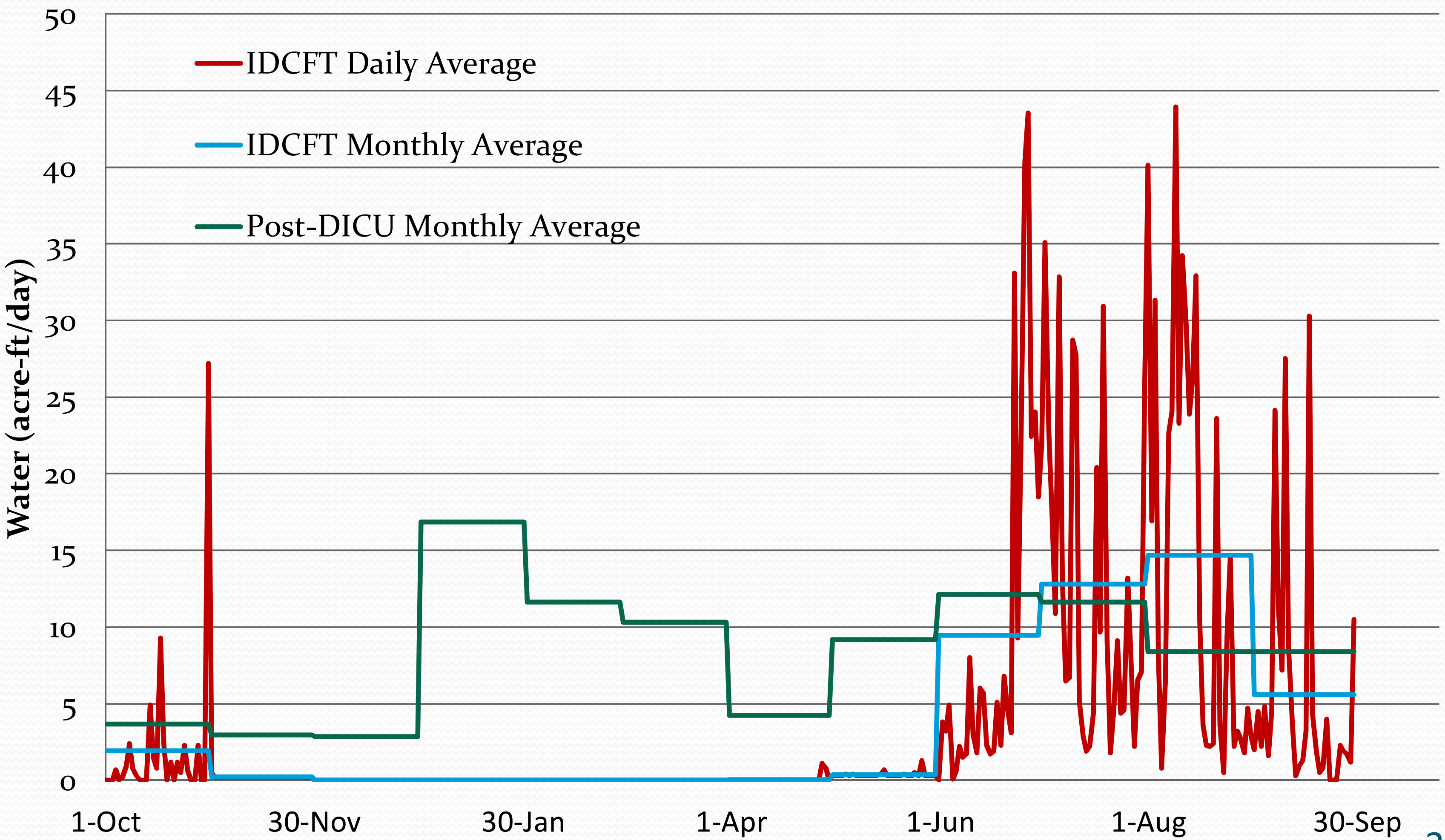
Comparison of Daily vs. Monthly Diversions

- Fabian Tract



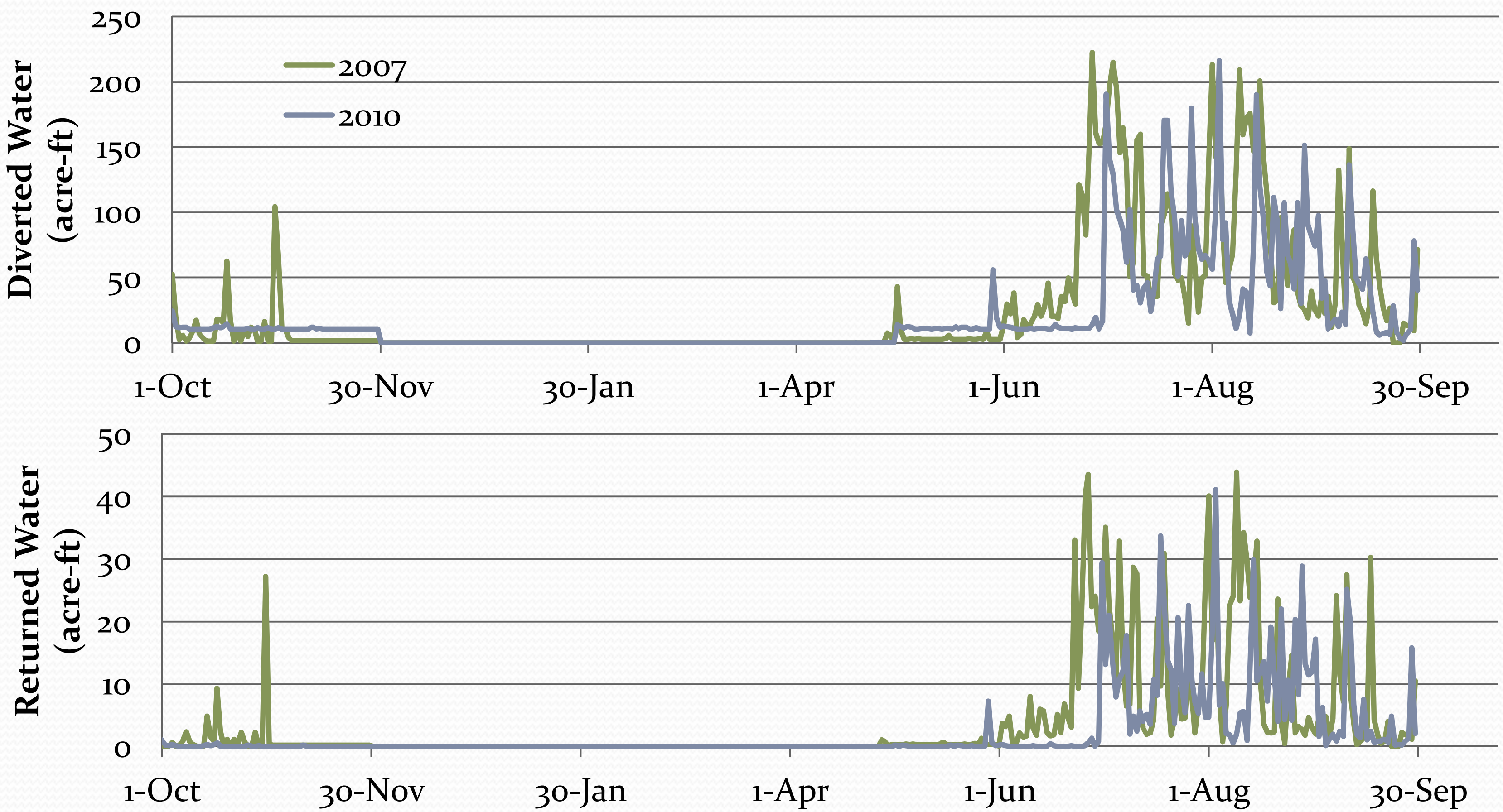
Comparison of Daily vs. Monthly Returns

- Fabian Tract



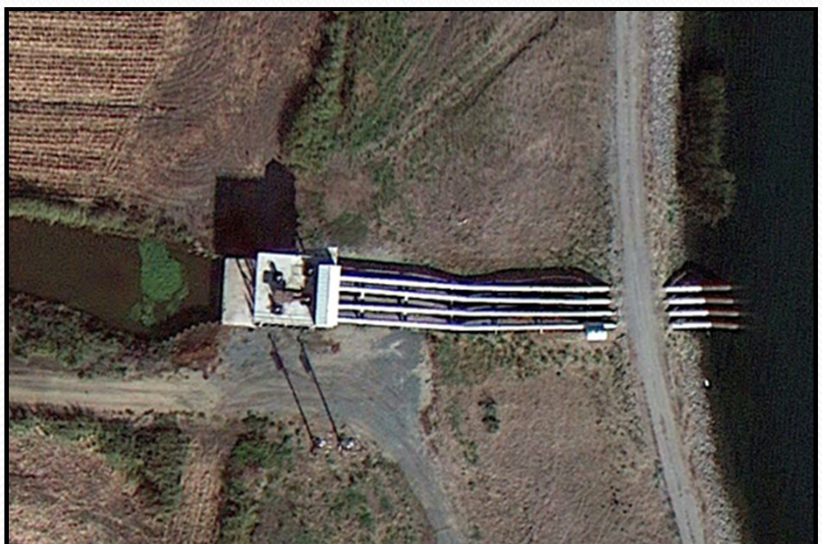
Can look at multiple years

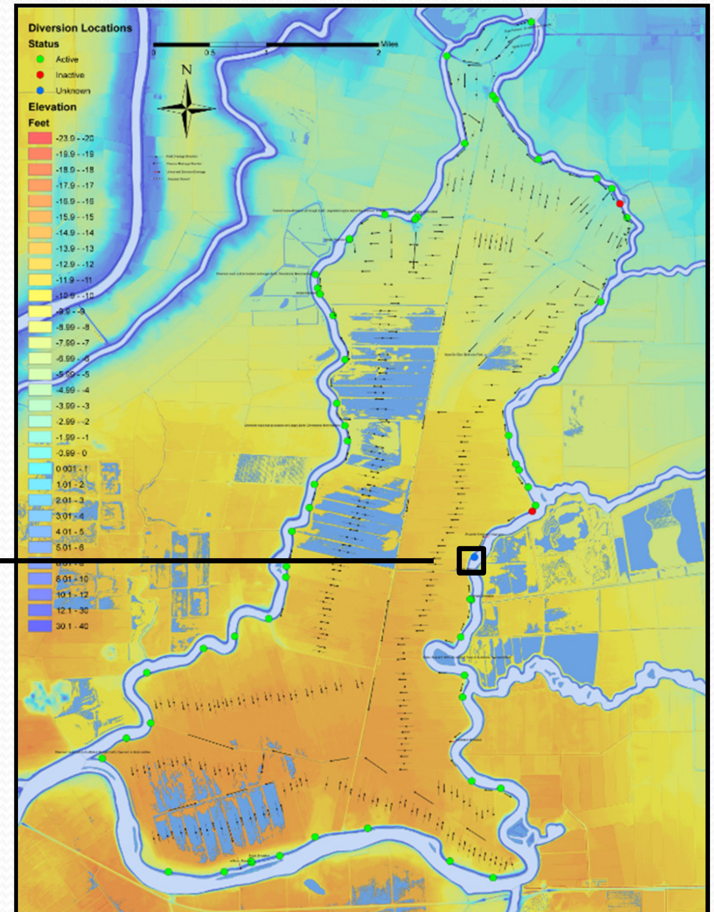
- IDCFT Model Total Results for 2007 and 2010



Now examining Staten Island

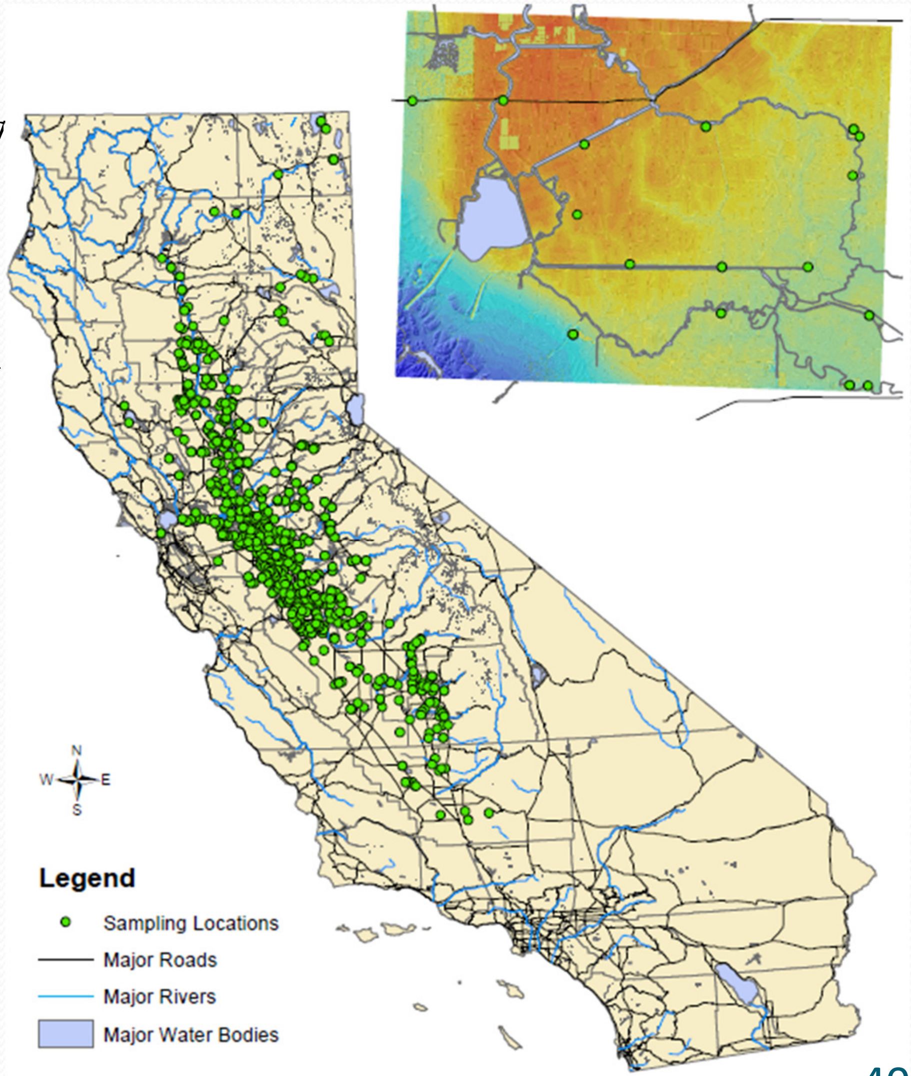
- Google Earth helps with ground-truthing
- Going faster…





Step 4. Water Quality Correlations

- Central Valley Regional Data Center Water Quality Data
- Obtained data insufficient to determine water quality correlations for current model years
- Older data available to establish EC or turbidity correlations



Water Quality Correlations

- Water quality correlations with a physically-based DICU model would likely improve water quality estimates within the Delta by:
  - Capturing daily variations
  - Having better diversion and return locations
  - Relating water quality to landuse statistics of crop type and land area per diversion or return

Cost for DICU modeling estimates for entire Delta?

Task	Rough Time Estimate
1. Identify Diversion and Return Locations using LIDAR and GIS	40 person weeks
2. Ground-Truth Diversion and Return Locations	10 person weeks
3. Model Integration	60 person weeks
Total	110 person weeks
	28 person months

Conclusions

1. Physically Based Modeling of DICU
2. Diversion and return locations and patterns found accurately using GIS and satellite imagery
3. Ground-Truthing adds clarity
   - Google Earth might substitute
4. IDC model provides physical basis for daily DICU estimates (timing, locations, routing of diversions and returns)
5. Do flow quantity differences affect water quality?
   - DSM2 results?
6. ~28 person months to model the entire Delta
7. A physically based modeling approach could improve Delta water quality estimates