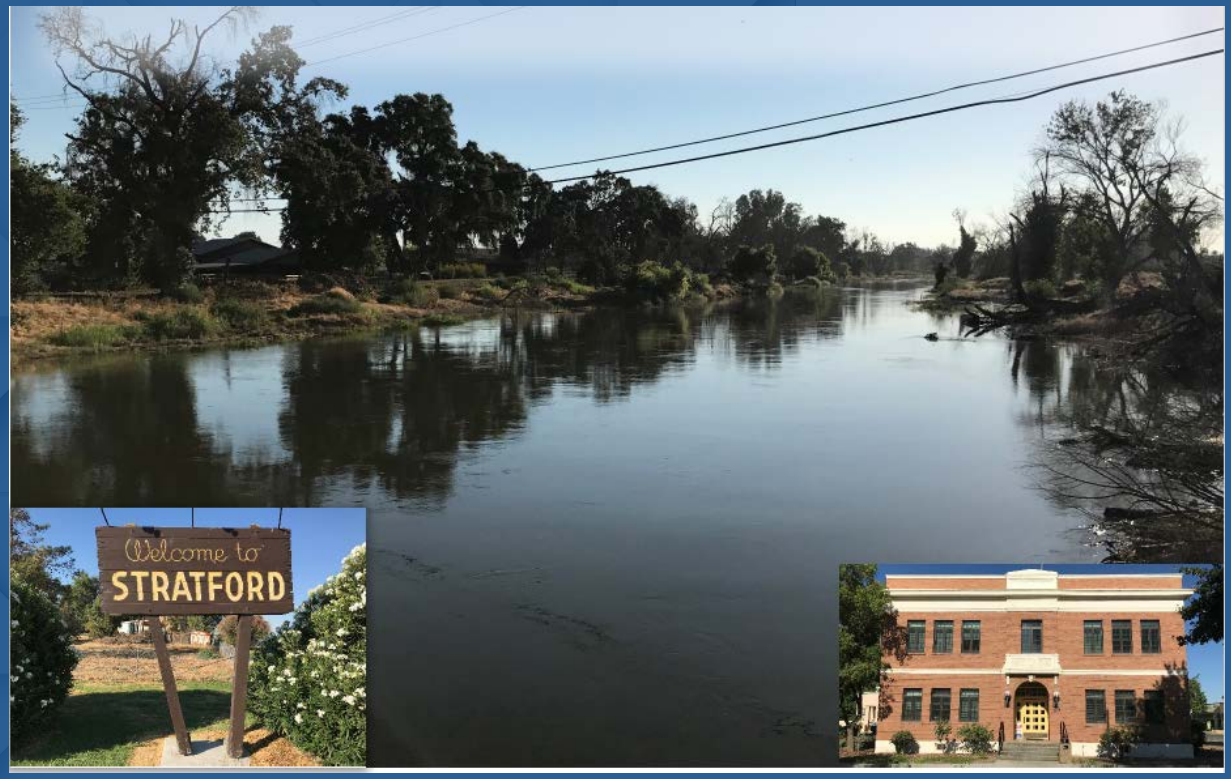
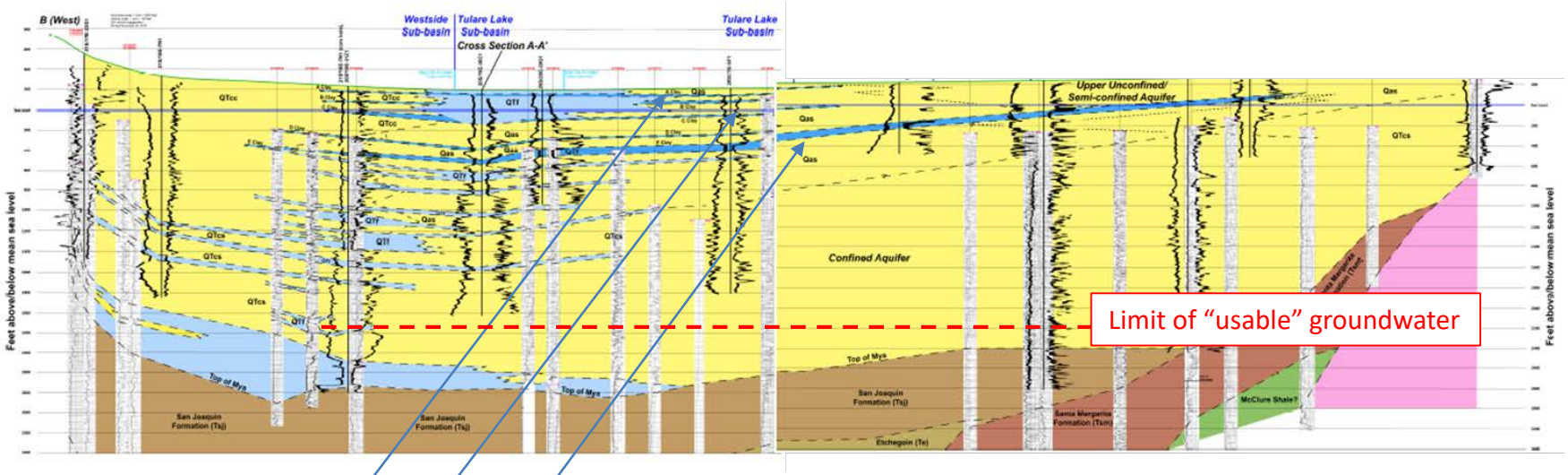


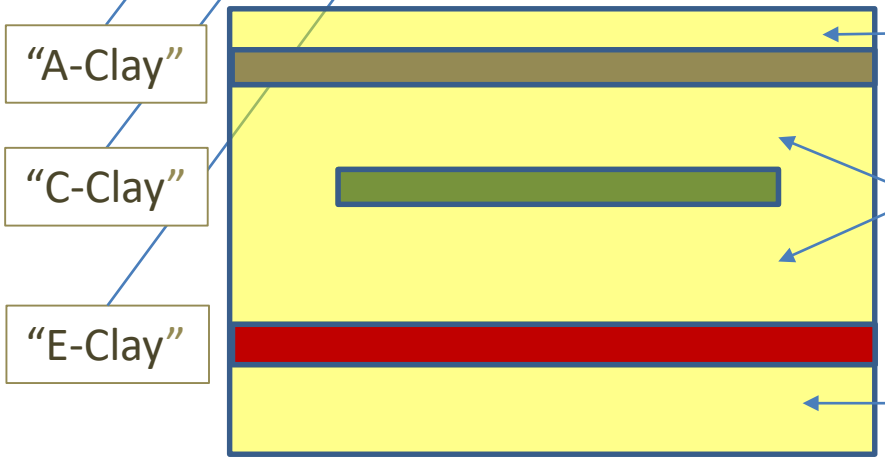
South Fork Kings GSA
GSA Board Technical Workshop
Groundwater Flow Measurement
March 21, 2019

Geosyntec consultants

Workshop Overview

- Brief hydrogeology review
  - Semi-confined aquifer
- Measurement program discussion
  - Why measure?
  - What to measure
  - How to measure it
  - Pros/cons discussion





"A-Clay"

"C-Clay"

"E-Clay"

Perched Aquifer (A-Zone)

Semi-Confined Aquifer (B-Zone)

Confined Aquifer (C-Zone)

E-Clay + C-Clay + A-Clay

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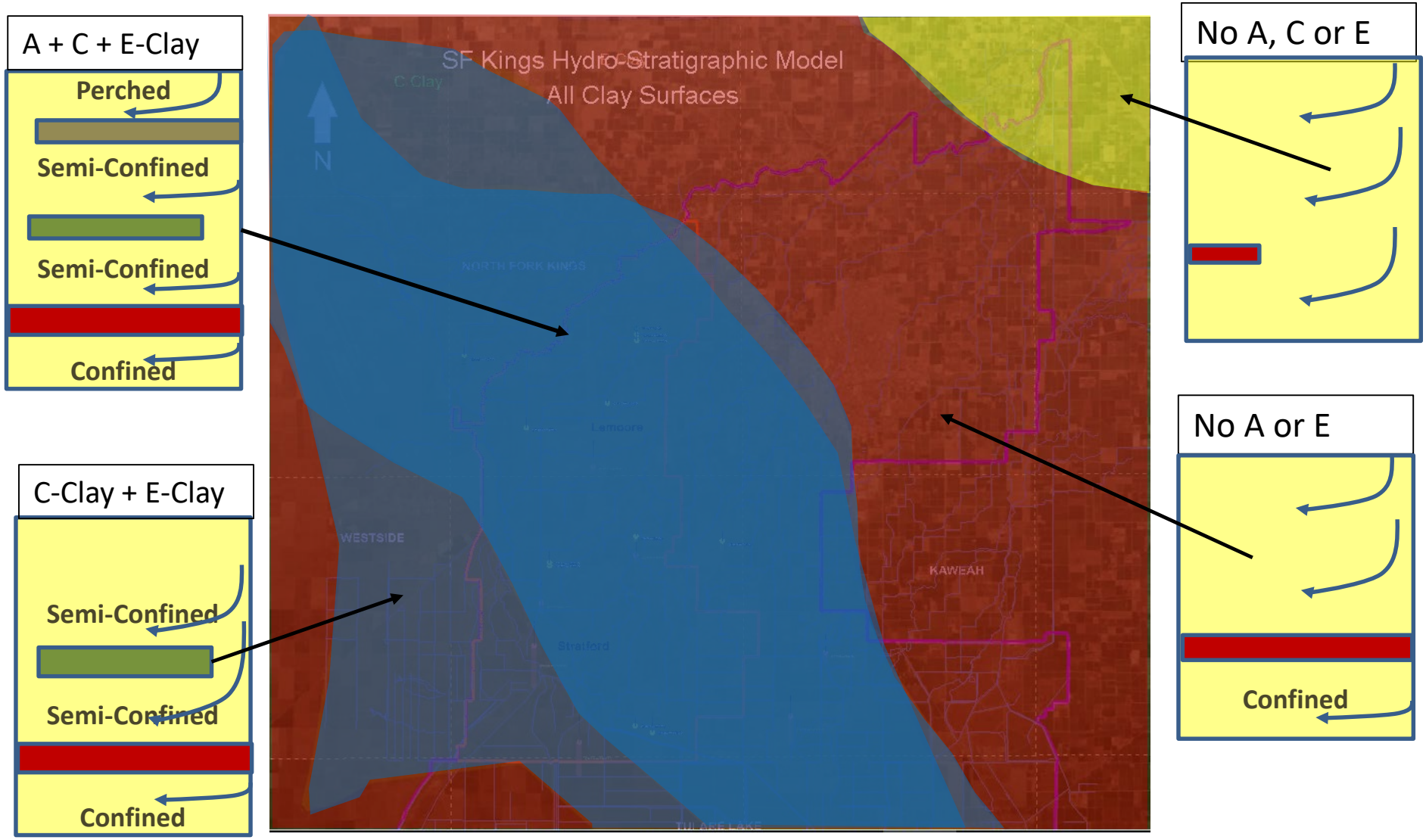

Observed Groundwater Levels

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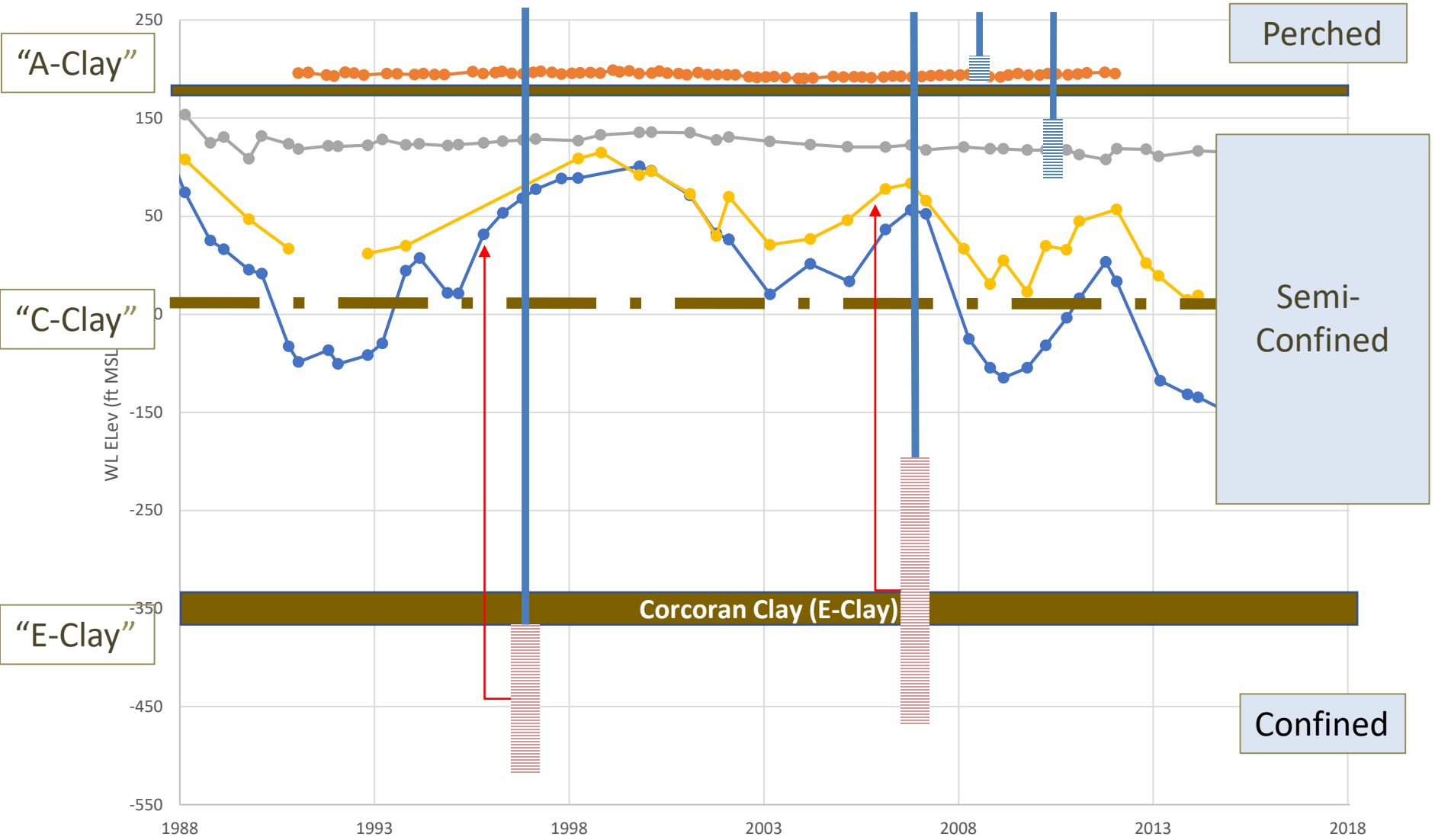

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WORKING DRAFT

South Fork Kings GSA
Pumping Measurement Evaluation

Prepared for

South Fork Kings Groundwater Sustainability Agency

Prepared by

Geosyntec Consultants, Inc.
5084 N Fruit Ave, Suite 103
Fresno, CA 93711

~~March~~, 2019

- Why Measure?
- How to Measure It?
- Pros and Cons

Why Measure Groundwater Pumping?

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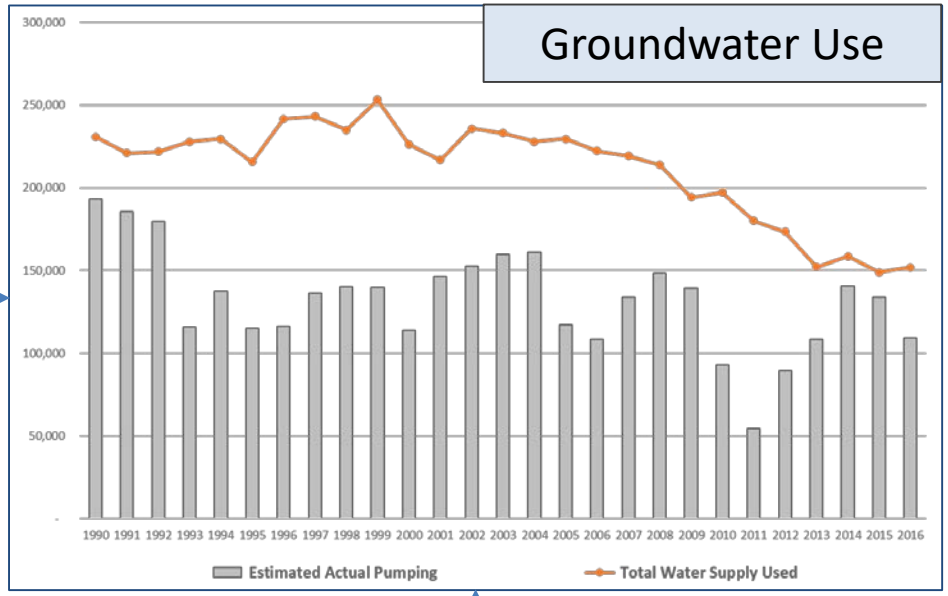
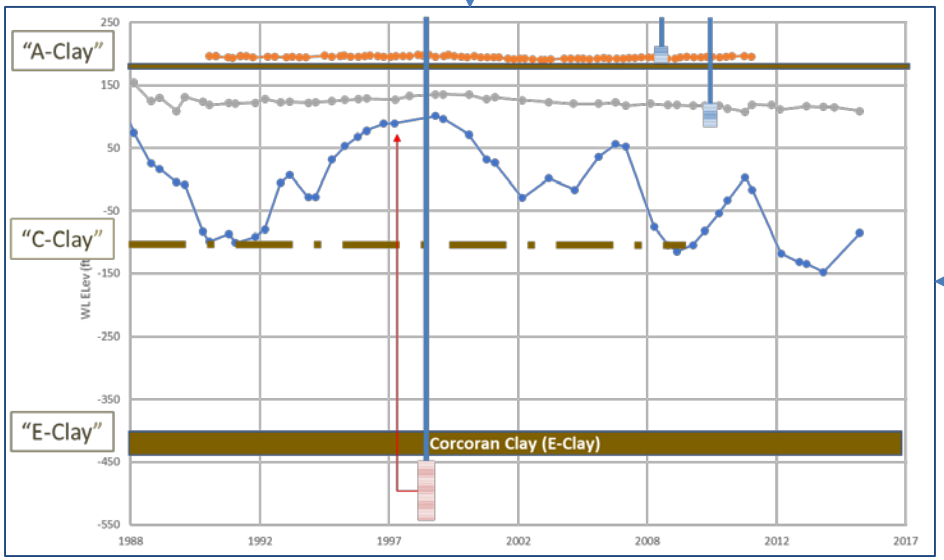
SGMA Monitoring, Projects and Management Actions



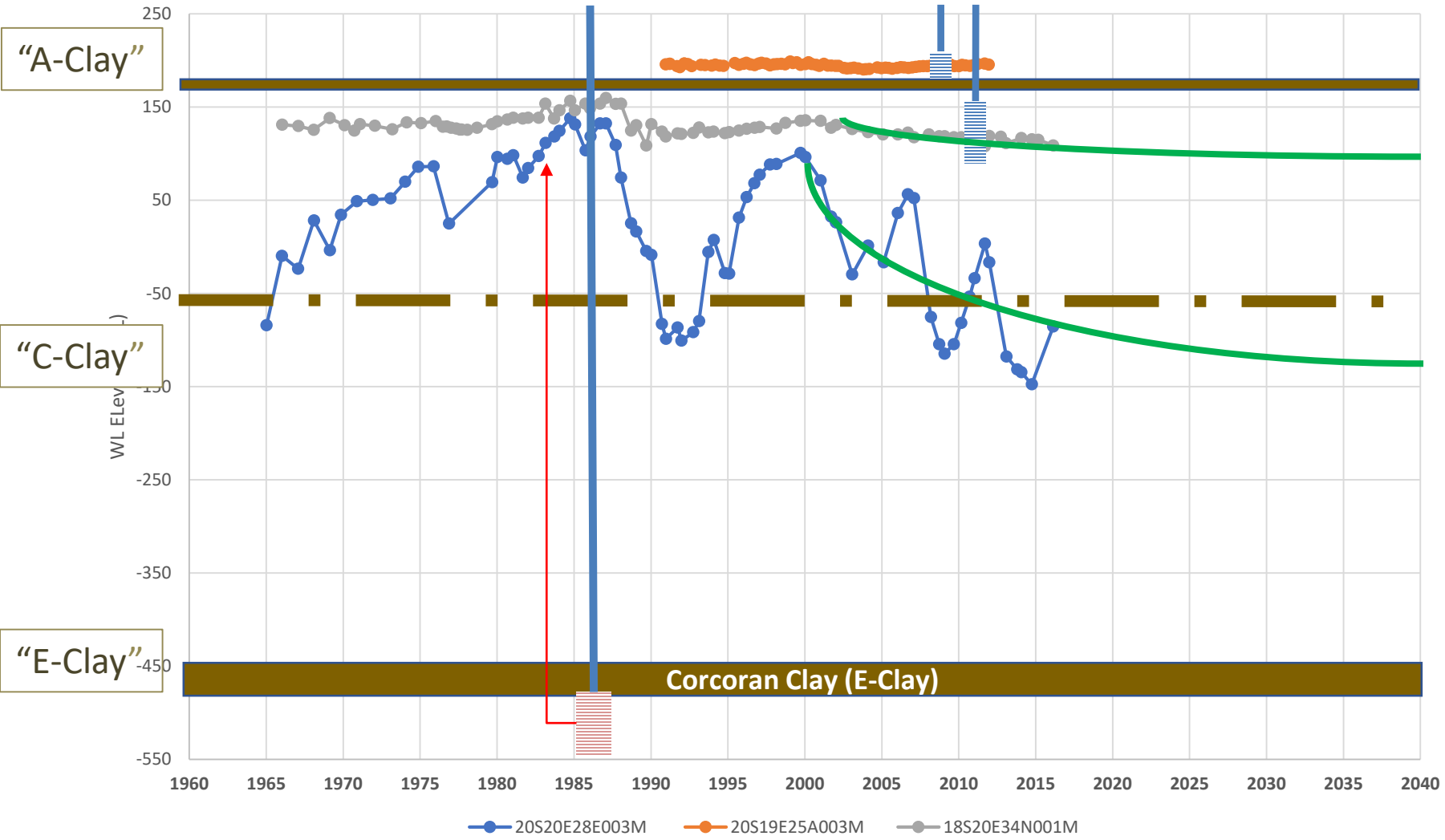


SGMA Undesirable Effects From Pumping

SGMA Compliance Water-Level

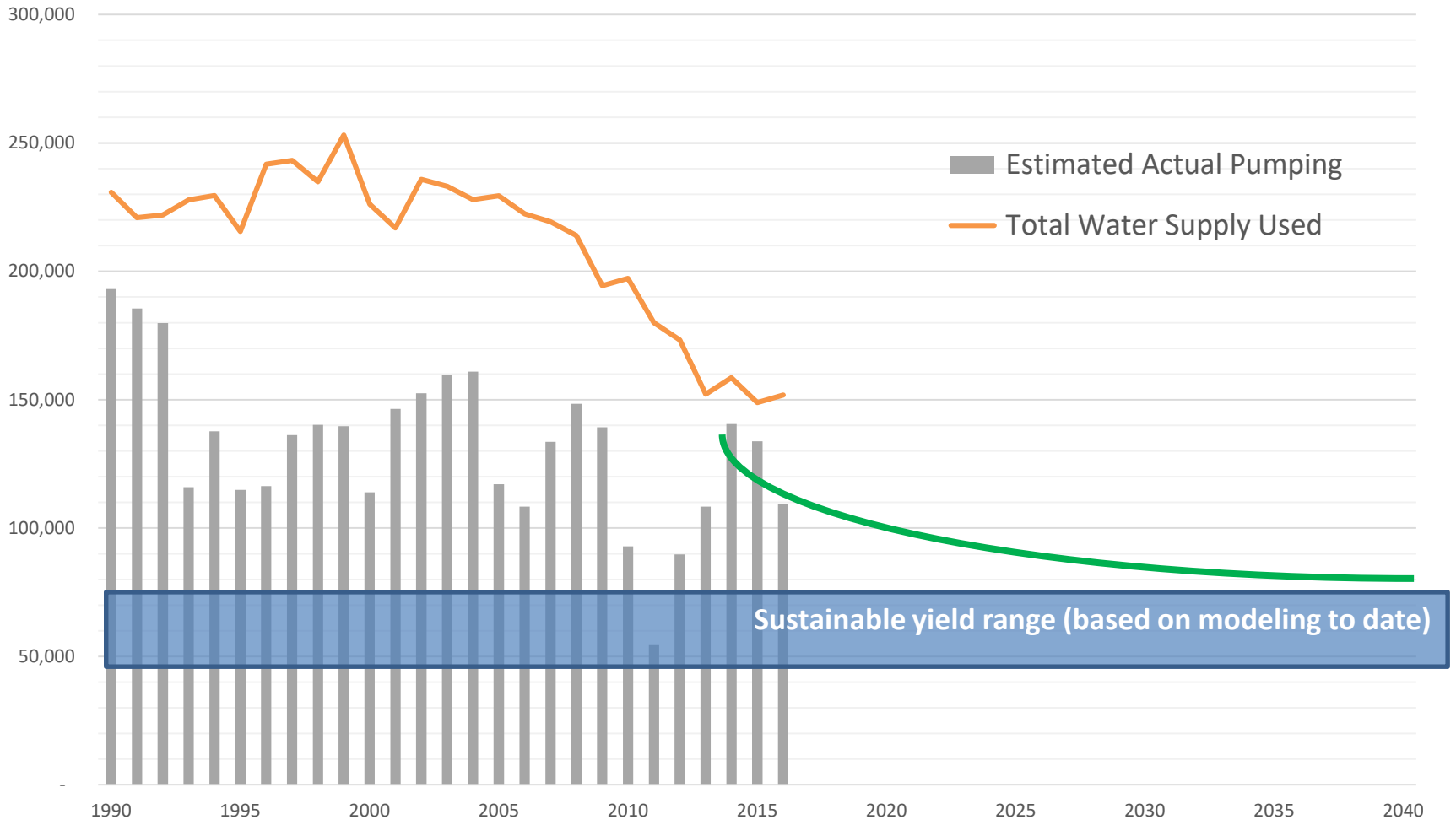
SFKGSA Sustainability Projection

Geosyntec consultants

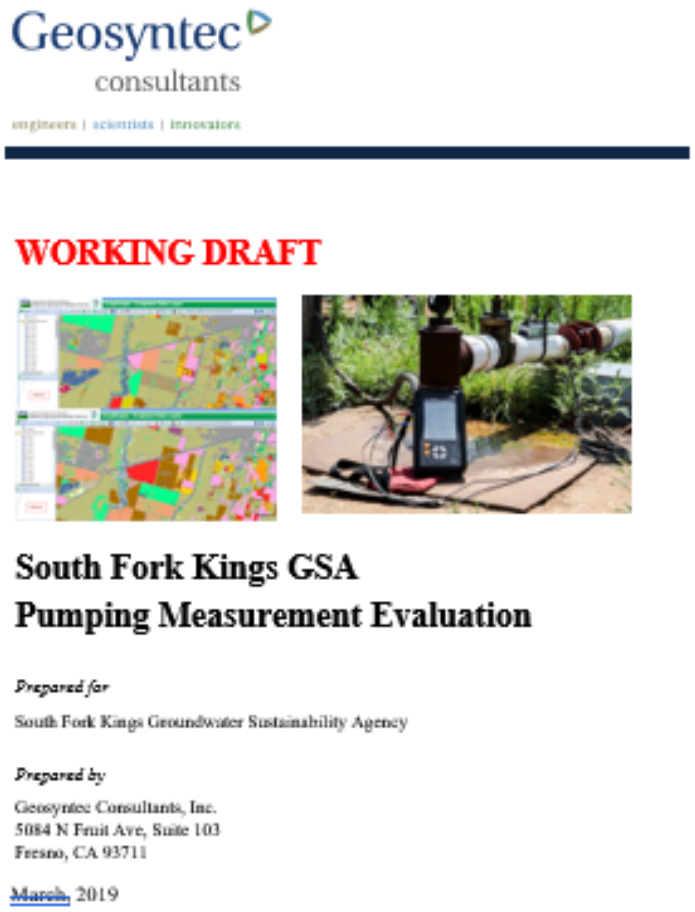


SFKGSA Sustainability Projection

Geosyntec consultants



Pumping Measurement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~~March~~, 2019

- Why Measure?
  - Groundwater levels
  - Groundwater pumping
- How to Measure It?
  - Direct
  - Indirect
- Pros and Cons

Direct vs Indirect – Summary

Direct (Flow Meter)	Indirect (Remote Sensing)
A physical measurement of flow at a wellhead or irrigation delivery	A calculation of flow based on crop imaging measurements
Measures total use, not consumptive use	Calculates consumptive use, not total use
Deep recharge, crop ET, irrigation efficiency and return flow are separate calculations	Total pumping, deep recharge, irrigation efficiency and return flow are separate calculations
Preferred data for modeling and credits/trading	Acceptable (not preferred) for modeling and credits/trading
Individual wells can combine to parcel level	Parcel-based only (cannot distinguish individual wells)

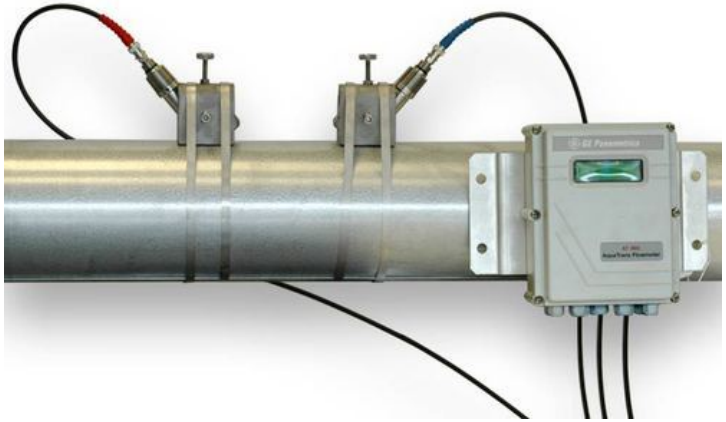
SFKGSA Parcel Summary

Geosyntec consultants

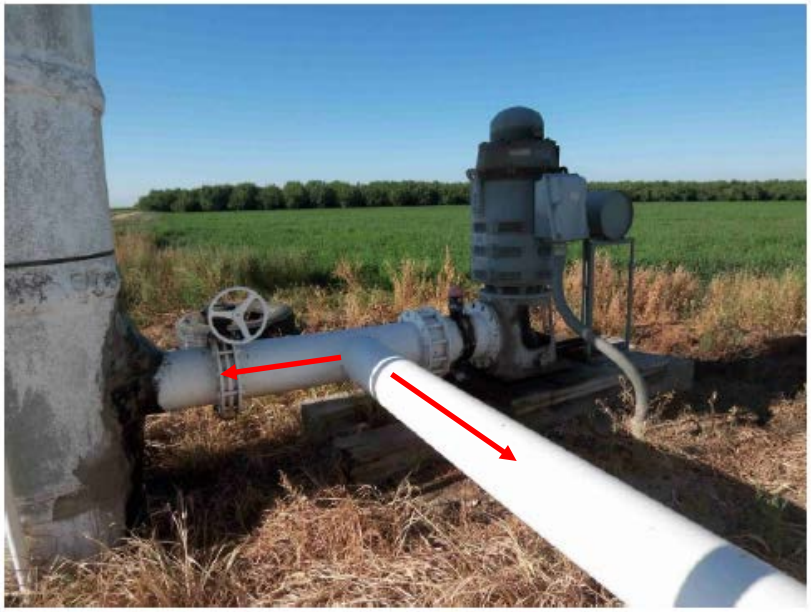
Parcel size	# of parcels	Total Acreage	Cumulative Parcels	Cumulative Acres	Cumulative % of Parcels	Cumulative % of Acres
>640 acres	4	2626	4	2,626	0%	3%
320-640 acre	28	12,135	32	14,761	0%	19%
160-320 acre	80	18,245	112	33,006	1%	41%
80-160 acres	126	15,422	238	48,428	3%	61%
40-80 acres	207	12,867	445	61,295	5%	77%
20-40 acres	277	8799	**722**	**70,094**	**8%**	**88%**
10-20 acres	290	4523	1,012	74,617	11%	94%
5-10 acres	232	1787	1,244	76,404	14%	96%
2-5 acres	384	1213	1,628	77,617	18%	98%
<2 acres	7,284	1984	8,912	79,601	100%	100%

Flow Meters

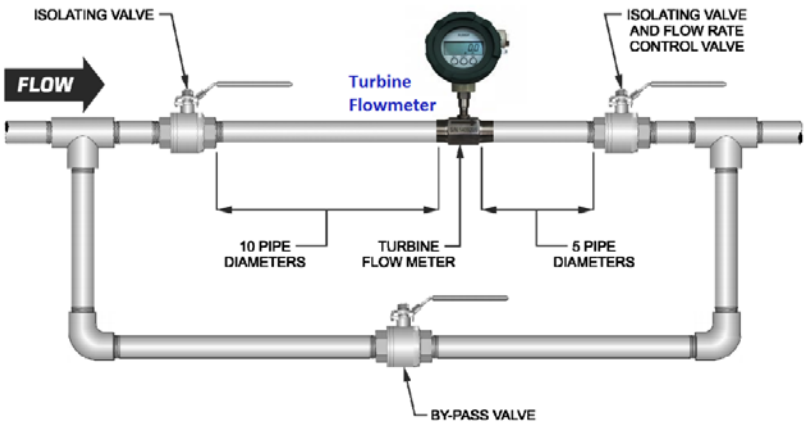
- Flow Meter Types
  - Propeller/Turbine
  - Electromagnetic
  - Acoustic/Ultrasonic

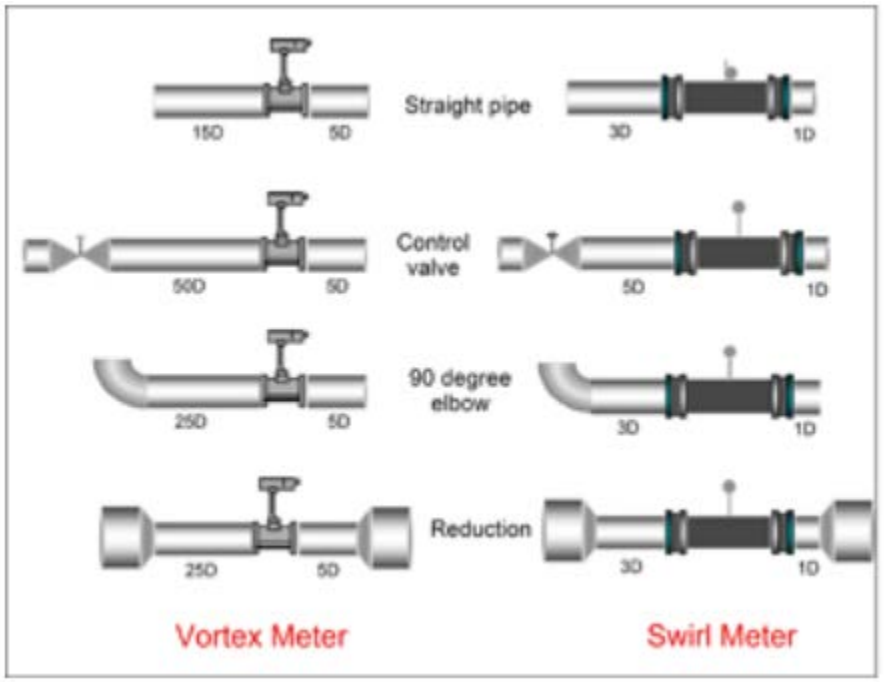


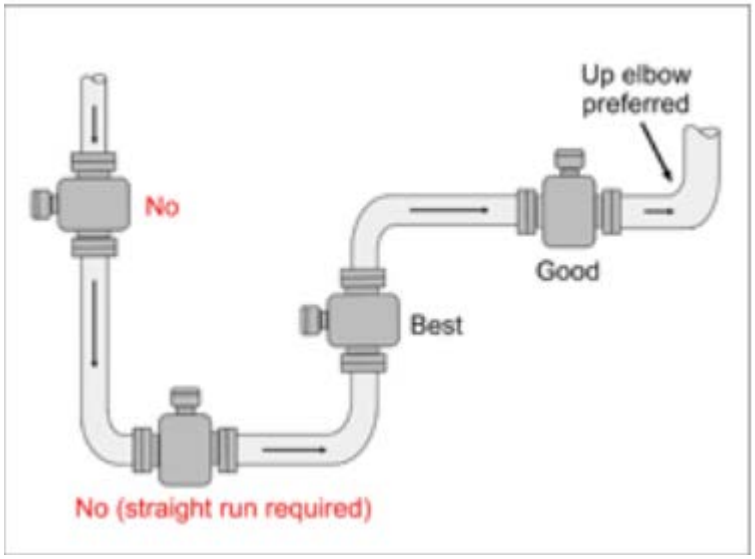
Meter Installation Considerations



Wellhead Requirements







Maintenance
Calibration
Record-keeping

Direct Measurement Methods

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- Power Consumption
  - Utility records
  - “Smart” meters
  - No wellhead mods
  - Accuracy varies

Pump power consumption related to flow

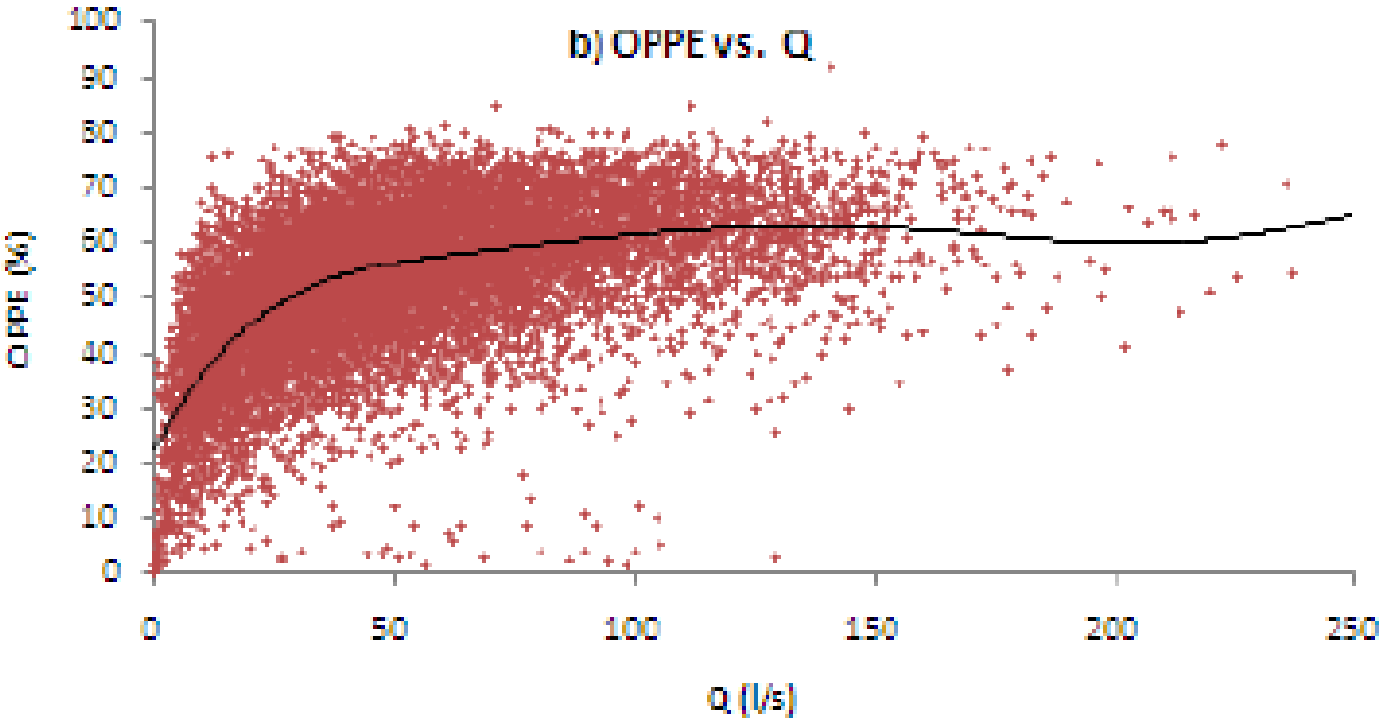
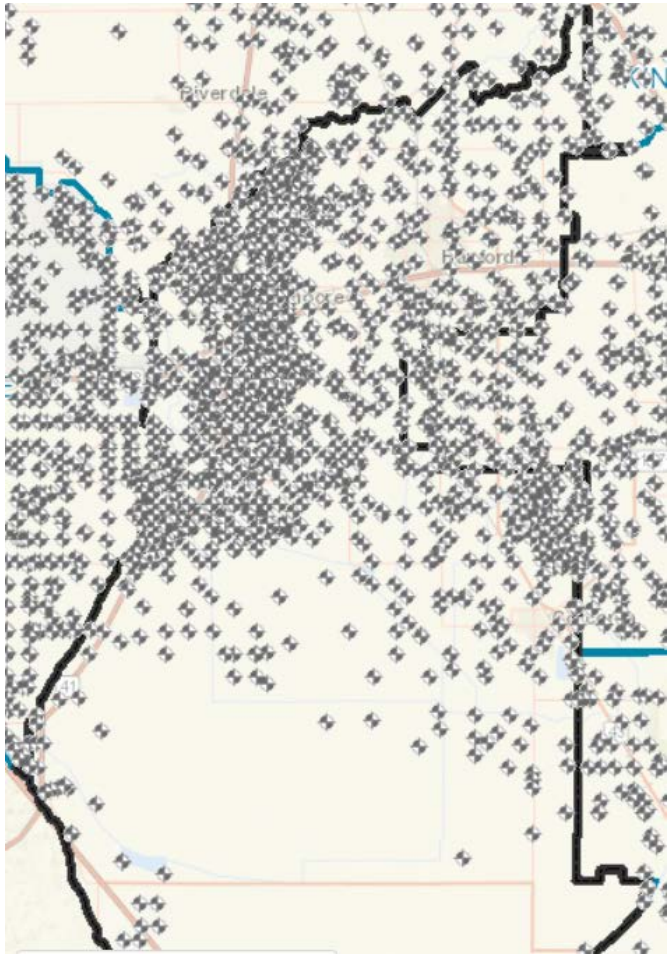


Figure 1. Well pump performance in California's Central Valley (Perez and Burt, 2012)

(OPPE) Operating performance relates to power consumption

Direct Measurement Methods



- Data Capture
  - Remote vs manual
  - Reporting structure
  - Installation, O&M
  - QA/QC
- Data Management
  - Database/GIS
  - Collection frequency
  - Data processing and workflow
  - Confidentiality
  - Parcel vs well

Indirect Measurement Methods

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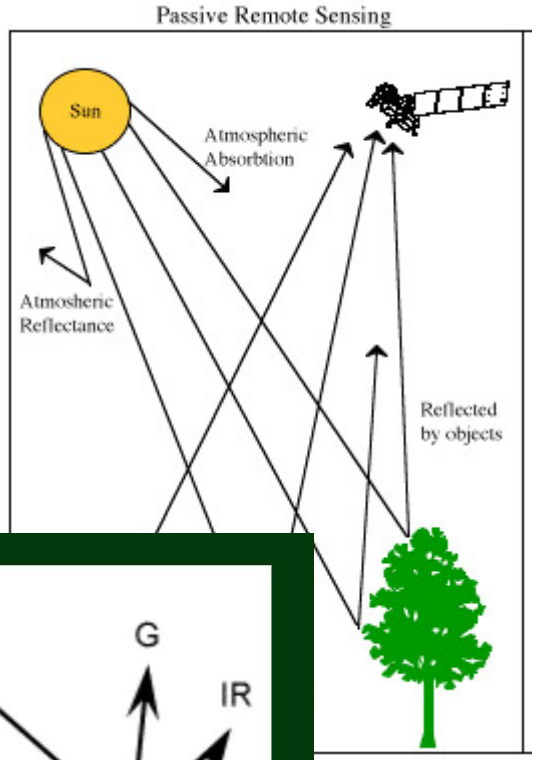
- Satellite Imagery
  - USGS/LANDSAT
  - European (ESA)
  - Commercial Services



In this picture,
IR is Infrared light
R is red light
G is green light
B is blue light

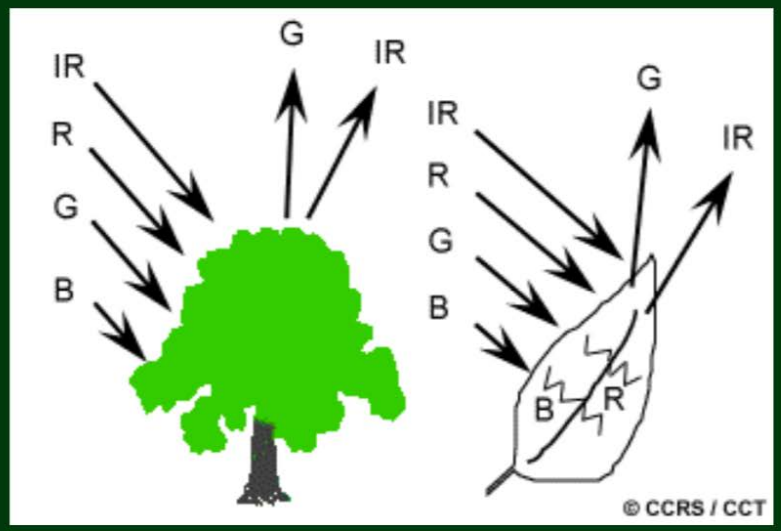
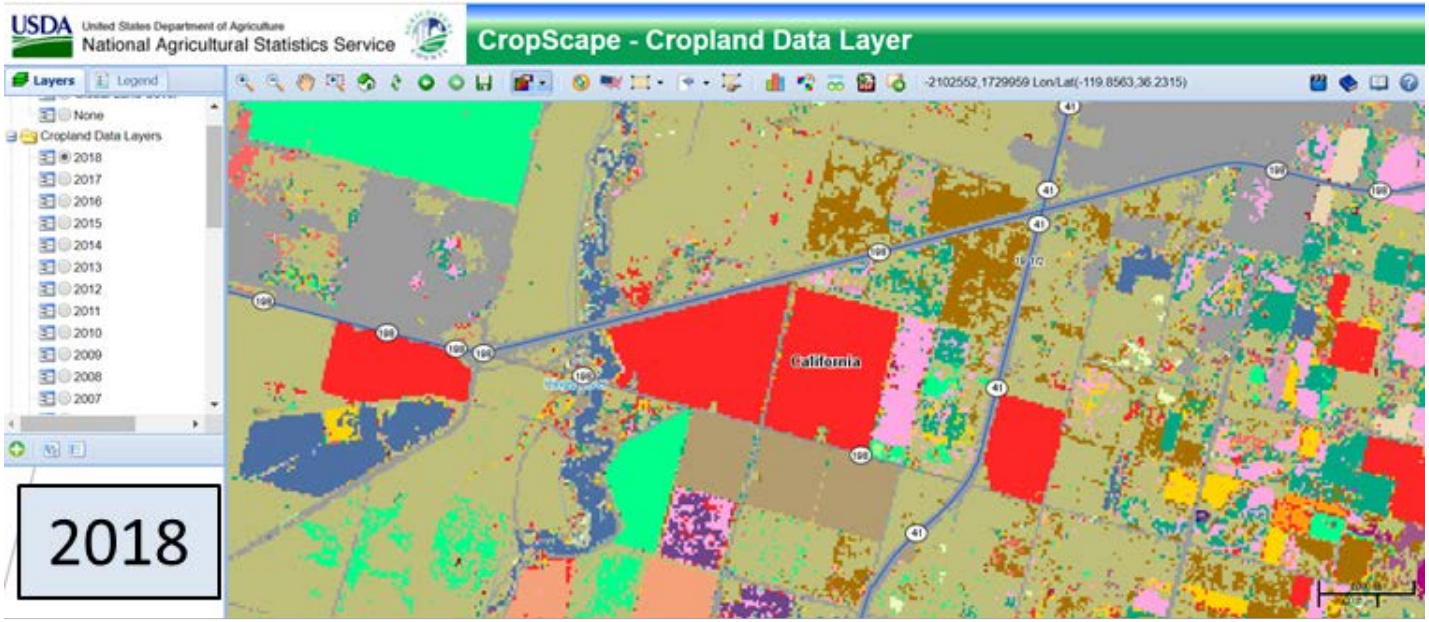


Image Credit: Canada Centre for Remote Sensing

Indirect Measurement Methods

Geosyntec consultants

- Crop-Type Detection
  - USDA/NASS (National Agricultural Statistics Service
  - CropScape “CDL” (Crop Detection Layer)
  - Available online and published annually



CropScape Crop Type History Example

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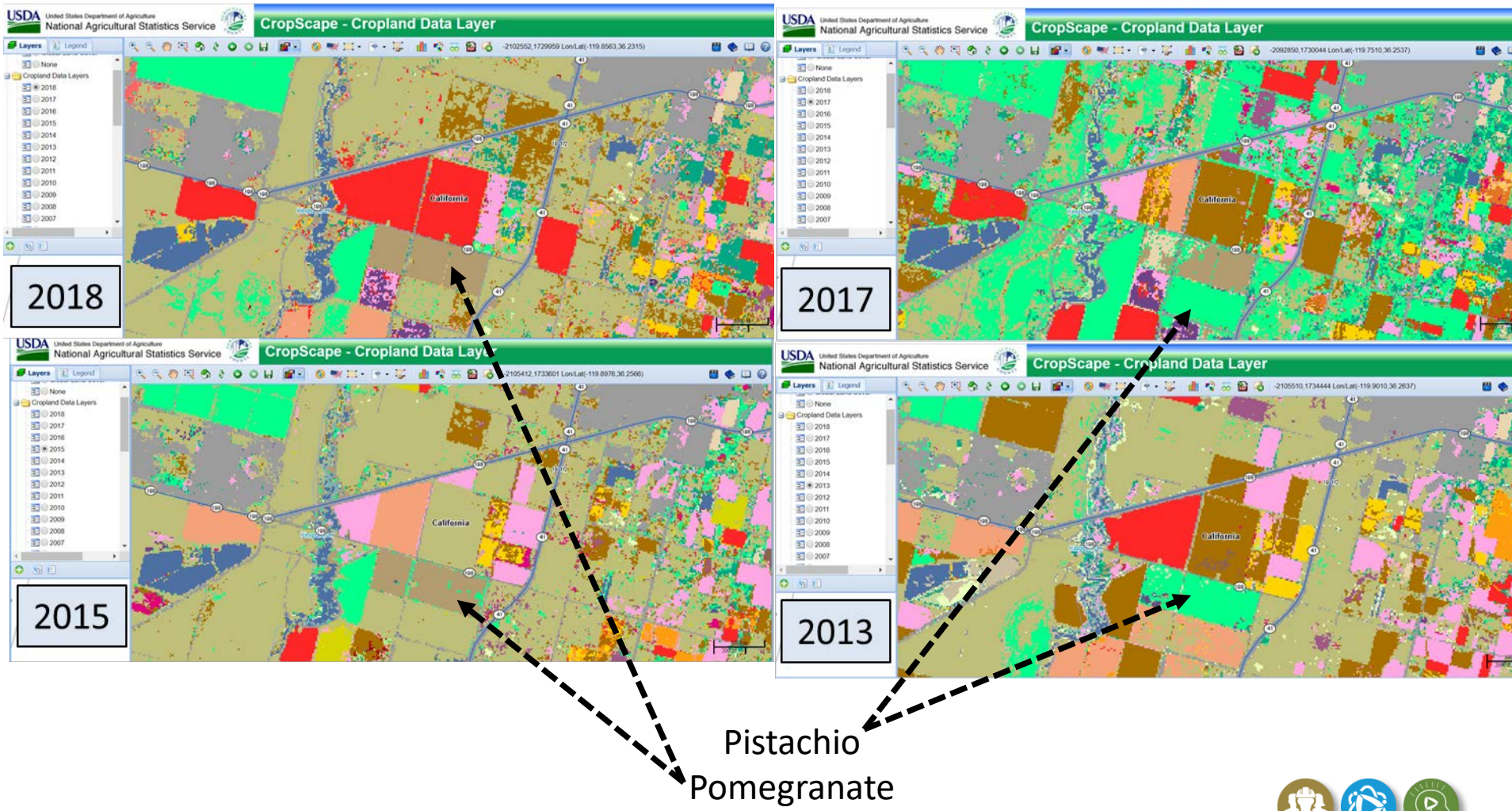
The equation relating crop type to satellite wavelength reflectance is not 100% accurate



CropScape Crop Type History Example

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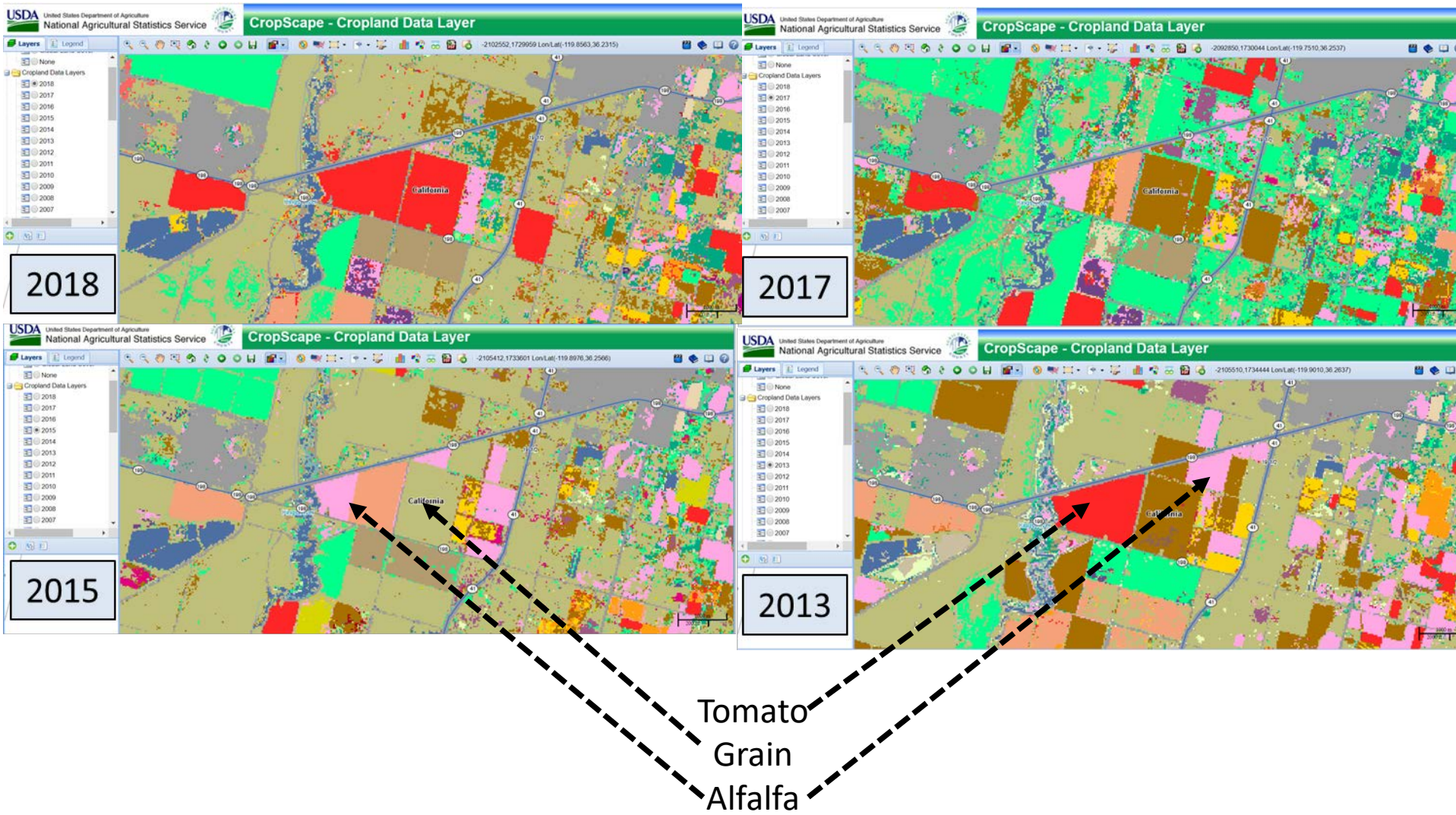
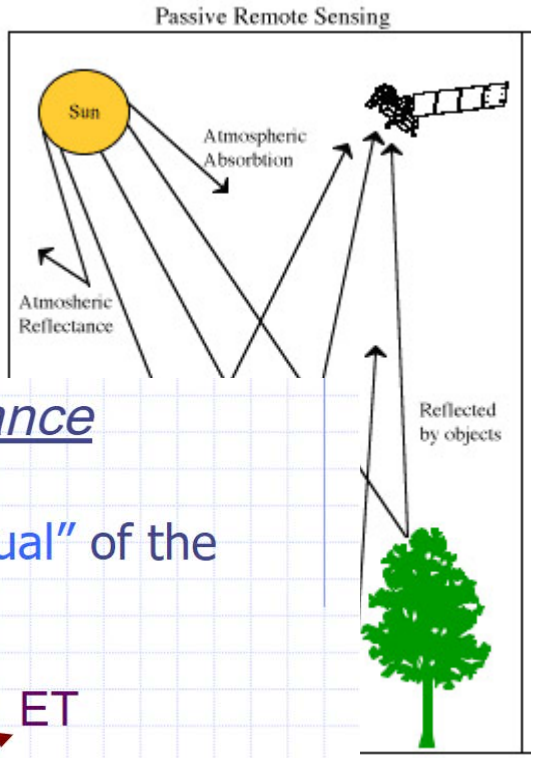
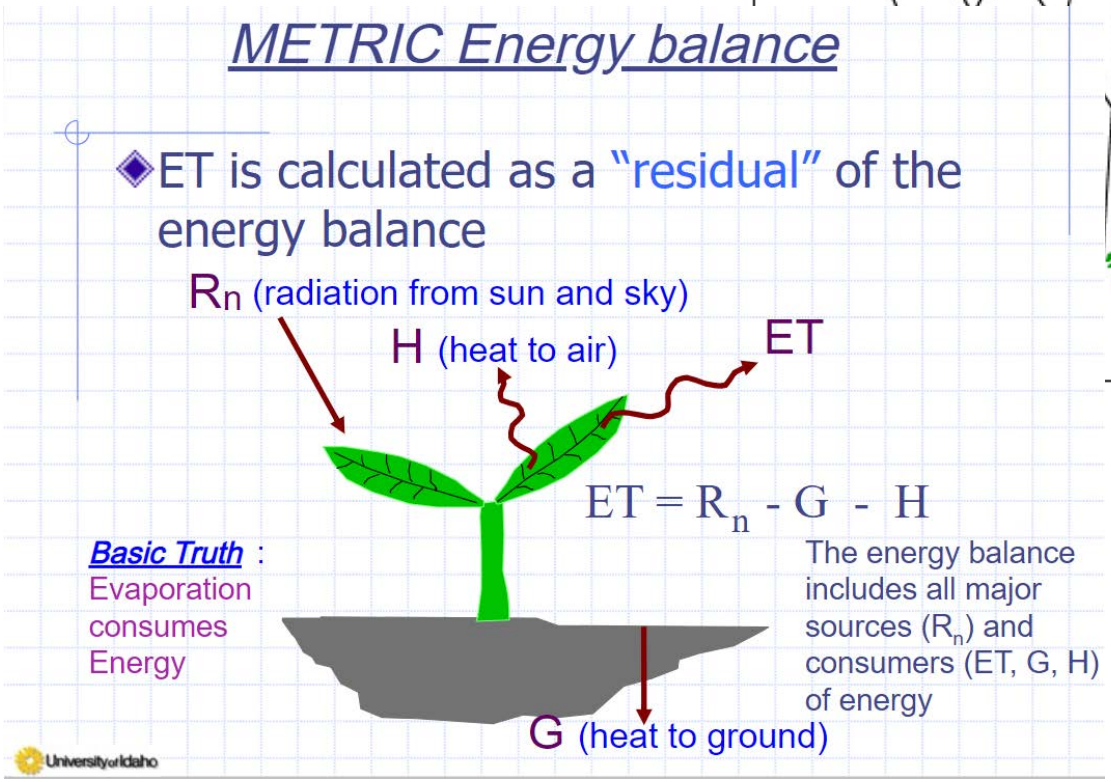


Indirect Measurement Methods

- "METRIC"
  - Evapotranspiration (ETo) Detection
  - Developed in Idaho (2007)





Indirect Measurement Methods

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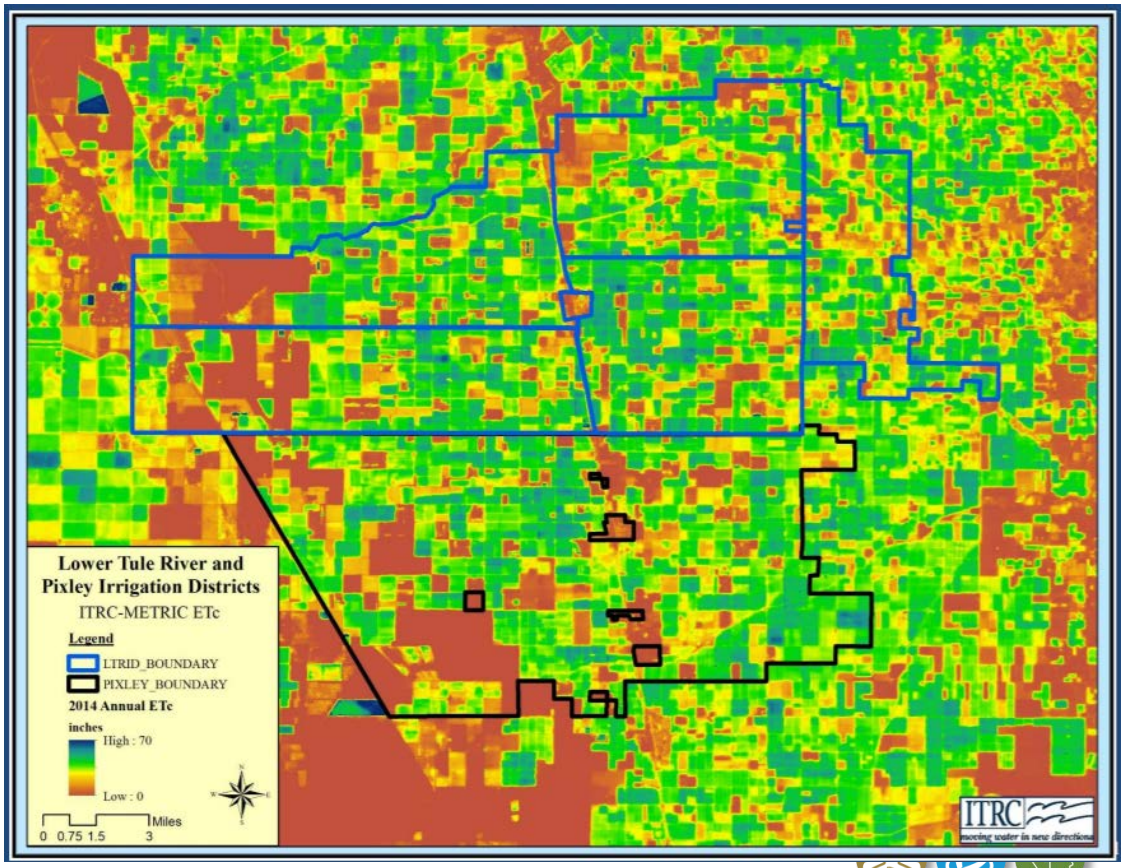
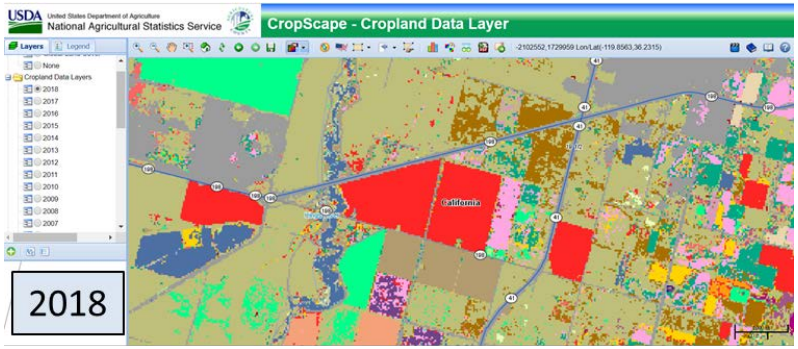
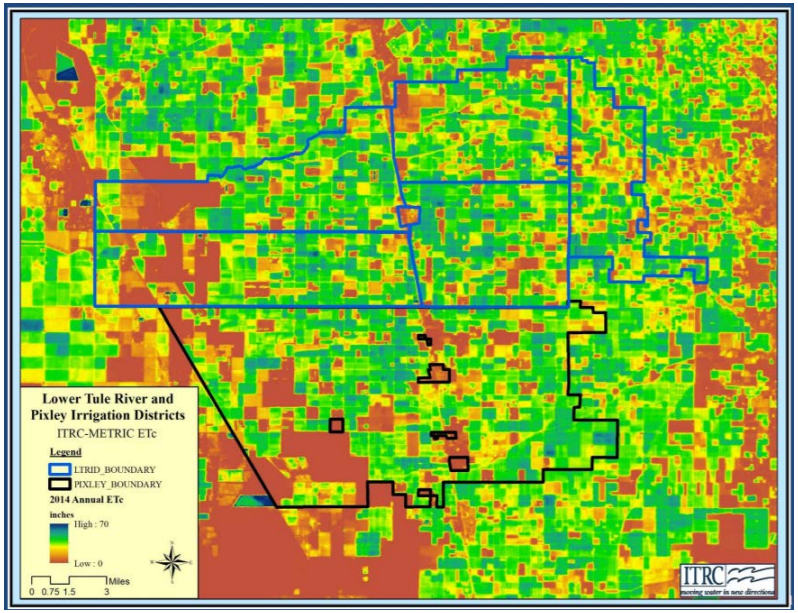
- "METRIC-ITRC"
  - Customized to California Climate Conditions
  - Cal Poly Irrigation Technology Research Center (ITRC)

Does NOT Identify crop type…..
only consumptive water use



Indirect Measurement Methods





- Image processing platform
  - Public (USDA)
  - Custom (ESA)
  - Proprietary (Commercial)
  - Academia (METRIC-ITRC)
- Data Management
  - Database/GIS
  - Collection frequency
  - Data processing & workflow
  - Parcel only

Local-Scale Survey Methods

- Landowner Survey
  - Mail/Electronic/Web
  - Workshops
  - Ground truthing
  - “Piggy-back” with other programs

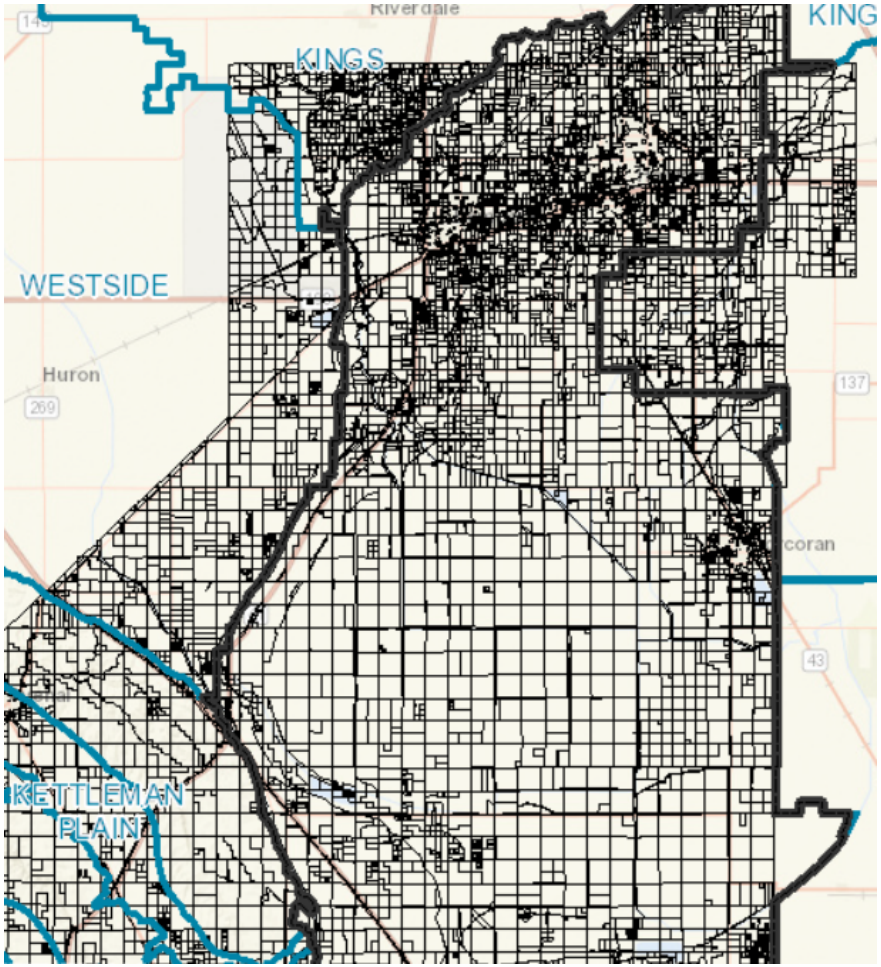
Landowner Survey of Water Use

Geosyntec consultants

Parcel size	Parcels	Acreage	Cumulative Parcels	Cumulative Acres
>640 acres	4	2,626	4	2,626
320-640 acres	28	12,135	32	14,761
160-320 acres	80	18,245	112	33,006
80-160 acres	126	15,422	238	48,428
40-80 acres	207	12,867	445	61,295
20-40 acres	277	8,799	722	70,094
10-20 acres	290	4,523	1,012	74,617
5-10 acres	232	1,787	1,244	76,404
2-5 acres	384	1,213	1,628	77,617
>2 acres	7,284	1,984	8,912	79,601

	Water Use						
Parcel size	Metered	Un-metered	Permanent Crop	Annual Crop	Drip	Sprinkler	Other
>640 acres							
320-640 acres							
160-320 acres							
80-160 acres							
40-80 acres							
20-40 acres							
10-20 acres							
5-10 acres							
2-5 acres							
>2 acres							

Local-Scale Survey Methods



- **Survey Design**
  - Collection frequency
  - Data requested
  - Confidentiality
  - Coordination
  - Response rate
- **Data Management**
  - Database/GIS
  - Data processing & workflow
  - Parcel only

Enforcement

- Regardless of measurement approach, SFKGSA may need to take enforcement actions based on measurement data
- Data on which actions are taken should be defensible and aligned with the type of action taken
  - Indirect (land cover) monitoring may be sufficient to support voluntary actions and incentives to manage pumping.
  - Direct pumping measurement would be required to monitor and enforce pumping restrictions.
  - Groundwater credits/trading may require both.
- All parcels do not necessarily need to be measured the same way

Phased Combination of Methods

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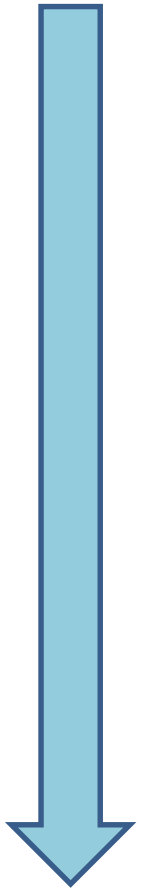
1. Remote Sensing
    1. USDA/CropScape
2. Landowner Survey (>5-10 acres)
    a. Mail/Electronic/Web/Workshops
    b. Ground Truthing
3. Voluntary "Opt-in" Measurement (>5-10 acres)
    a. Pumping/well data (direct)
    b. Crop type & irrigation (indirect)
    c. Other (direct/indirect)
4. Mandatory Measurement
    a. Pumping/well data
    b. Crop type & irrigation data
5. Enforcement



Increasing Accuracy Over Time

Geosyntec consultants

Thank You

Questions/Discussion