

RECLAMATION

Managing Water in the West

Remote Sensing and Evapotranspiration Estimates in the Lower Colorado River Basin

Presentation to: IBWC Citizens Forum Meeting

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U.S. Department of the Interior
Bureau of Reclamation

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Personal Introduction

- 10 Years with Reclamation
- Background
 - Bowen-Ratio calculated Evapotranspiration (ET)
 - Remote Sensing
- Current Projects
 - Lead in Lower Basin CUL Reporting

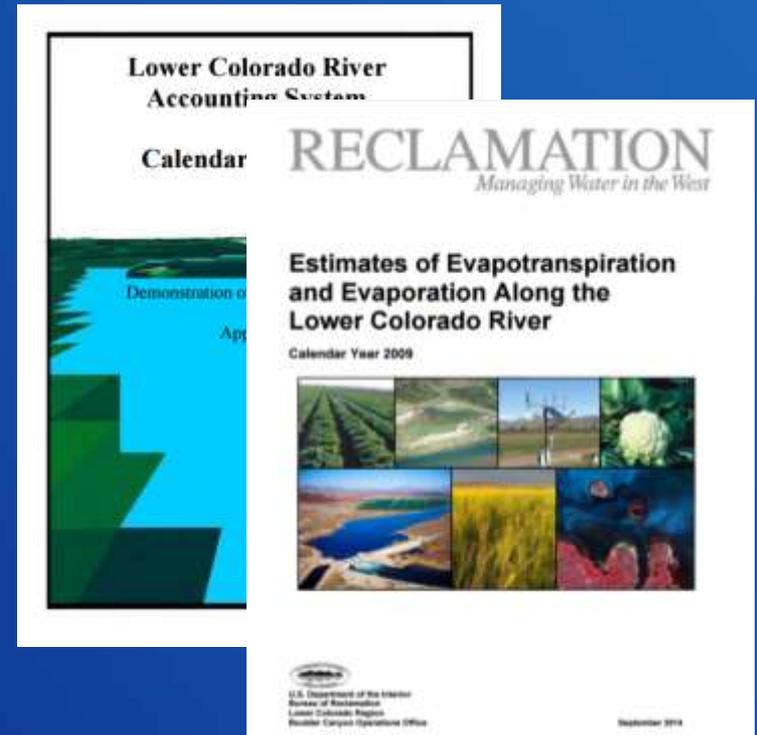


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History of Remote Sensing & Evapotranspiration in Lower Basin

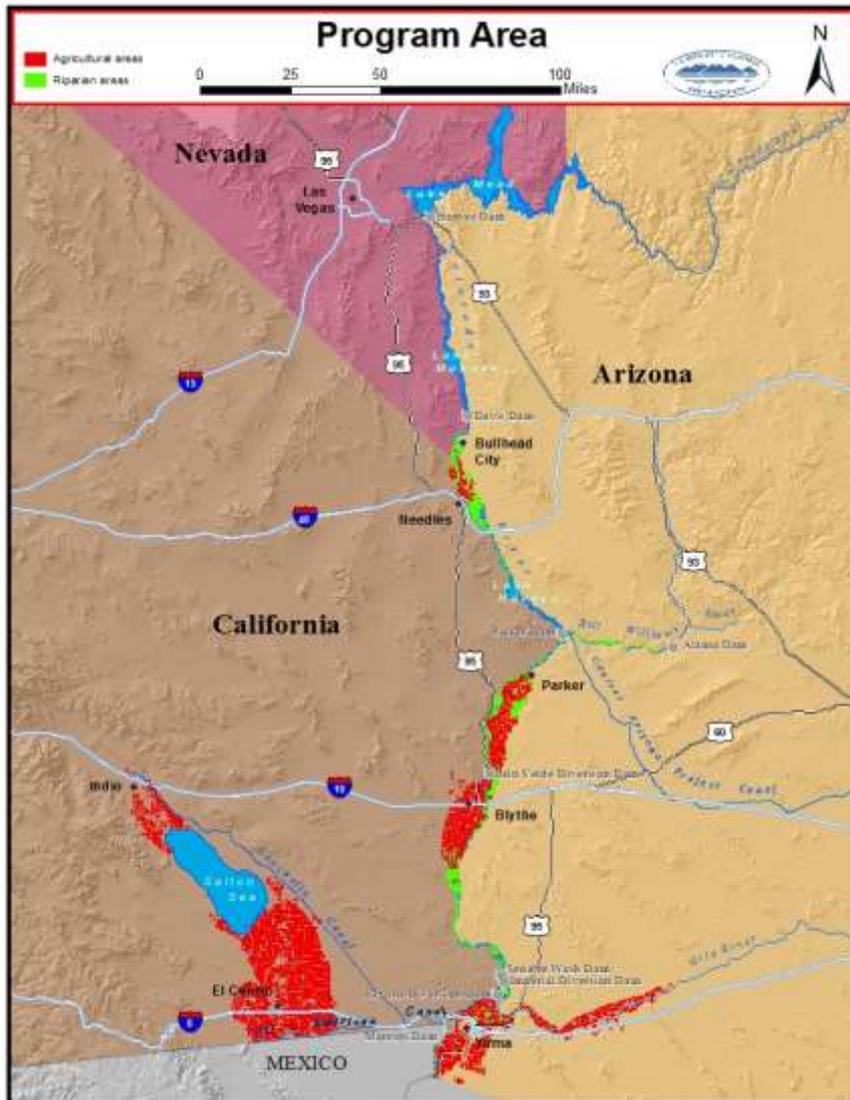
- Early 1980's Task Force on Unmeasured Return Flow
- Late 1980's USGS completes initial development
- 1995 First 'LCRAS' Report
- 2009 New report

<http://www.usbr.gov/lc/region/g4000/wtracct.html>



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Evapotranspiration Program Area



Diverter along the main stem of the Lower Colorado River from Hoover Dam to the Southern International Boundary of Mexico

Areas Added in 2004

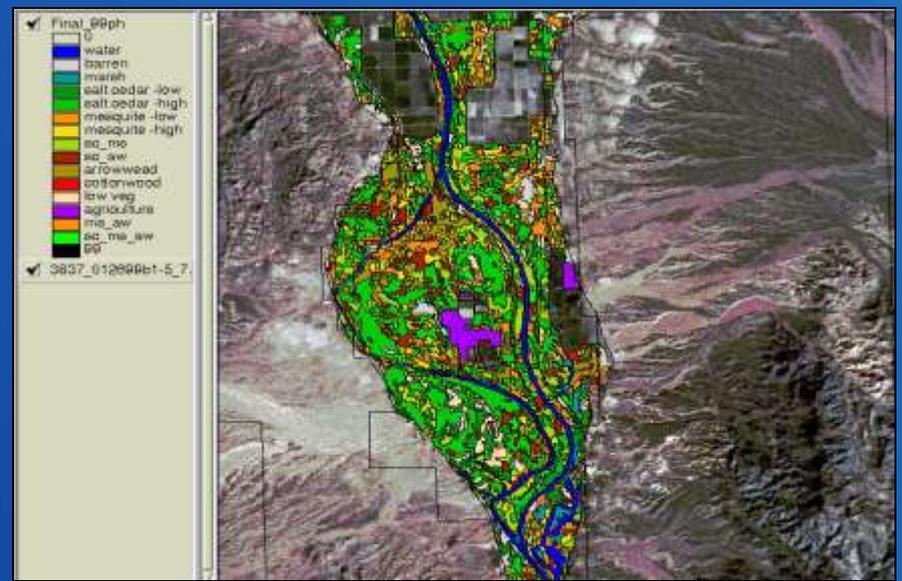
- Wellton Mohawk Irrigation Dist. , AZ.
- Imperial Irrigation Dist. , CA.
- Coachella Valley Water Dist. , CA.

Represents approximately 870,000 acres of irrigated lands, and 500,000 acres of riparian area

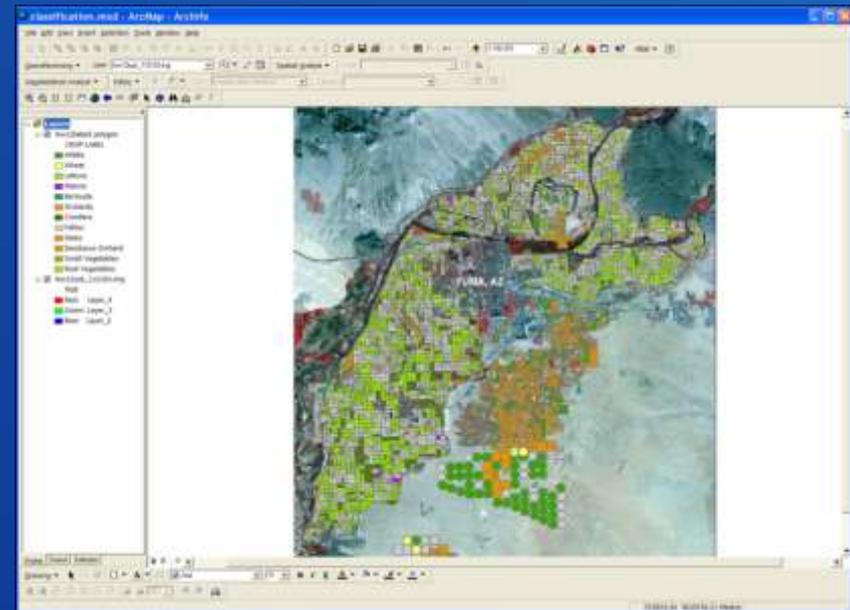
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Program Data

- Data Types
 - Crops
 - Type
 - Evapotranspiration
 - Gross cropped
 - Irrigable Acreage
 - Fallow
 - Riparian
 - Type
 - Evapotranspiration
 - Open Water
 - Evaporation
 - Mainstream vs Backwaters



Riparian Vegetation – Cibola NWR

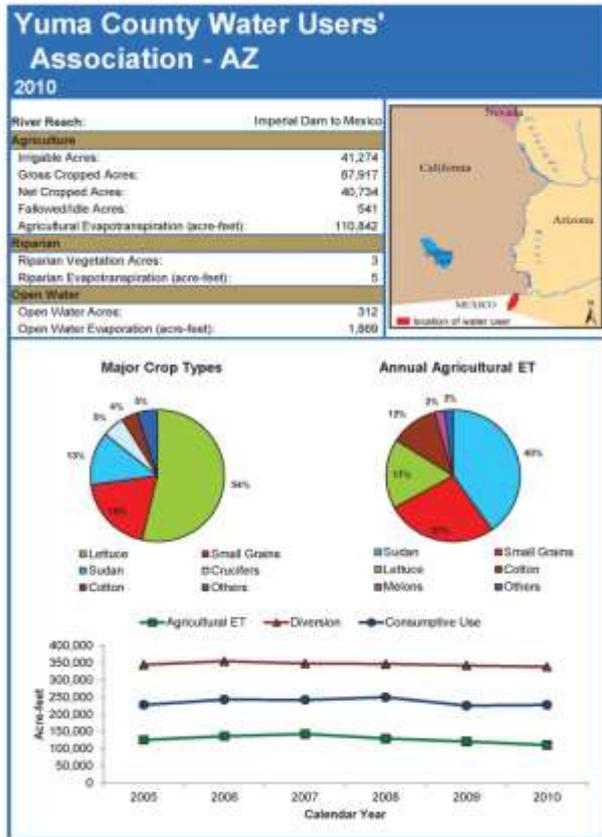


Crop Classification – Yuma Area

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Program Data Reporting

- Data is Summarized Diverter and Reach



Yuma County Water Users' Association - AZ 2010

Crop Type	Acres	Acres % Total	Annual ET (acre-feet)	Annual ET % Total
Alfalfa	171	<1	692	<1
Bermuda/Grass	349	<1	1,278	.1
Citrus	269	<1	888	<1
Cotton	3,462	.4	11,778	.11
Cruifers	4,734	.5	2,092	.2
Dates	254	<1	1,505	.1
Deciduous Orchards	119	<1	634	<1
Fed Grain	9	<1	19	<1
Grapes	1	<1	2	<1
Laguner/Solanum Veg	662	<1	1,688	.2
Lettuce	47,210	54	17,436	.16
Melons	1,509	.2	2,828	.2
Miscellaneous herbs	76	<1	219	<1
Nursery/Greenhouse	280	<1	608	<1
Oil Crops	11	<1	30	<1
Perennial Vegetables	2	<1	1	<1
Small Grains	16,790	19	27,463	.25
Small Vegetables	567	<1	632	<1
Sudan	11,463	13	41,122	.37
Total*	87,917	100%	110,842	100%

*Due to rounding, totals may differ from the sum of the individual values.

A1-22

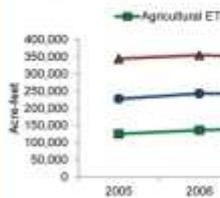
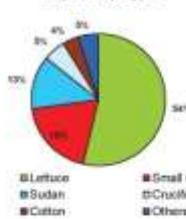
Program Data Reporting

- Data is Summarized Diverter and Reach

Yuma County Water Users' Association - AZ 2010

River Reach:
Agriculture
Irrigable Acres: 881,812
Gross Cropped Acres: 911,827
Net Cropped Acres: 894,209
Fallow/Idle Acres: 46,108
Agricultural Evapotranspiration (acre-feet): 1,086,500
Riparian
Irrigable Acres: 56,169
Riparian Evapotranspiration (acre-feet): 49,879
Open Water
Open Water Acres: 4,918
Open Water Evaporation (acre-feet): 28,469
Evaporation (acre-feet)
Evaporation (acre-feet): 9,028
Riparian Vegetation Acres:
Riparian Evapotranspiration (acre-feet):
Open Water
Open Water Acres:
Open Water Evaporation (acre-feet):

Major Crop Types



Imperial Dam to Mexico 2010

Agriculture
Irrigable Acres: 881,812
Gross Cropped Acres: 911,827
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Water Users within Reach

Water User within Reach	Crop Types within Reach	Acres	Annual ET (acre-feet)
Coachella Valley Water District - CA	Wheat	52,584	313,171
Colorado Indian Reservation (BIA), Pinal & Maricopa - AZ	Maize	79	184
Fort Yuma Indian Reservation & Pinal, Mohave Reservoir Area - CA	Barley/Oats	89,280	205,380
Fort Yuma Indian Reservation & Yuma Proving Ground - CA	Corn/Sorghum	981	2,381
Fort Yuma Indian Reservation & Horseheads - AZ	Corn	33,191	74,257
Fort Yuma Indian Reservation, Reed Line - CA	Cotton	19,920	47,180
Fort Yuma Indian Reservation - CA	Citrus	41,126	27,291
Fort Yuma Indian Reservation, Indian Line - CA	Sudan	13,613	36,840
Fort Yuma Indian Reservation, Indian State Wildlife Area & WFO - AZ	Ornamental Christmas	819	4,094
State Water Users - AZ	Peanut/Corn	13,094	38,341
Maricopa County, Imperial District - AZ	Wheat	4,121	34,191
Imperial Irrigation District - CA	Large Irrigation Pkg	11,208	17,237
Imperial National Wildlife Refuge - AZ & CA	Wheat	107,050	78,013
Imperial State Wildlife Area - AZ	Wheat	11,426	18,000
North (San Felipe) Irrigation & Drainage District - AZ	Wheat/Sorghum/Wheat	1,884	3,674
State of AZ (Other Users)	Wheat/Sorghum	1,172	3,000
State of AZ, Nevada-Mohave Area - AZ	Rumex/Grass/Straw	2,020	5,260
State of AZ - Lower Colorado Valley (MEST)	Other Crops	40	170
State of AZ - Lush/High Salinity	Potatoes/Vegetables	816	247
State of CA (Other Users)	Peanut/Corn	364	246
San Felipe Irrigation & Drainage District - AZ	Small Grains	111,208	160,062
University of Arizona Agricultural Station - AZ	Small Vegetables	38,000	45,100
Yuma County Water Users Association - AZ	Sudan	86,680	273,028
Yuma Irrigation District - AZ	Sugar Beets	85,007	89,931
Yuma Mesa Irrigation & Drainage District - AZ	Tomatoes	181	296
Yuma-Nevada Irrigation & Drainage District - AZ	Vegetable/Flange/Watermelon	222	4,021
Total		911,827	1,988,160

Evapotranspiration and Evaporation, 2005-2010



The origin of water used for agricultural irrigation and open water evaporation is considered to be from aquifers other than the Colorado River and therefore not included in reach calculations.

Yuma County Water Users' Association - AZ 2010

Acres % Total	Annual ET (acre-feet)	Annual ET % Total
<1	892	<1
<1	1,278	<1
<1	888	<1
<1	11,778	<1
0	2,092	0
<1	1,500	<1
<1	634	<1
<1	19	<1
<1	2	<1
<1	1,688	<1
54	17,436	88
<1	2,828	<1
<1	219	<1
<1	808	<1
<1	30	<1
<1	1	<1
19	27,463	26
<1	632	<1
13	41,122	37
100%	110,842	100%

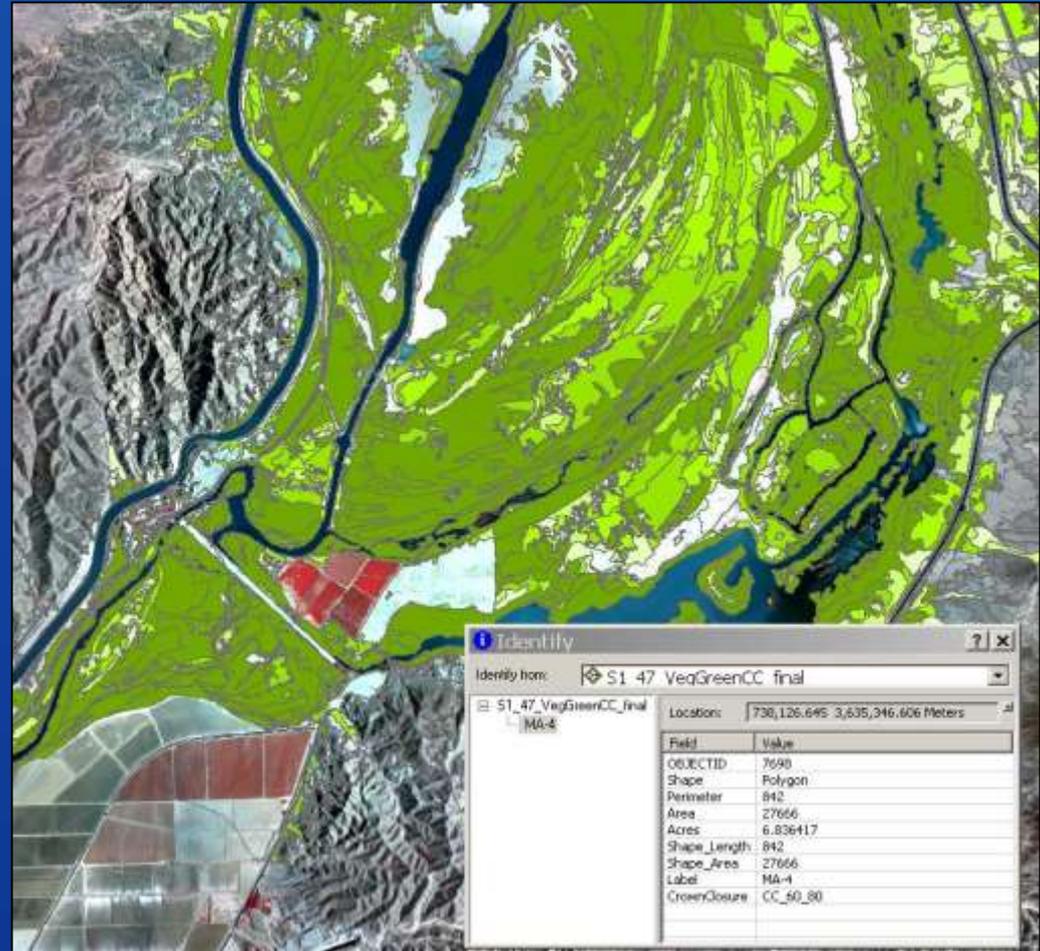
If the individual values

Supporting Activities

- 
- **Quantification of conserved water for various programs:**
 - **Fallowing Agreements and System Conservation**
 - **Intentionally Created Surplus**
 - **Inadvertent Overrun and Payback**
 - **Riparian habitat restoration and monitoring,**
 - **Economic impact analysis for land use conversions,**
 - **Develop consumptive use estimates for Decree Accounting, where gaged records are unavailable.**
 - **Maintain historical records of:**
 - **Evapotranspiration for agriculture and riparian areas**
 - **Evaporation from reservoirs, canals, and other open water areas**

How Evapotranspiration Data is Generated

- Acreage Data
 - Crop
 - Riparian
 - Open Water
- Reference ET (ET_0)
- Crop Coefficient (K_c)



Riparian crown closure map and relational database, Laguna Dam

Geo-Database Design

- Over 30,000 Fields Digitized
- GIS Database
 - Unique field ID – tracked and archived
 - Updated on routine bases



Imperial Irrigation District – Field Borders over Landsat Image

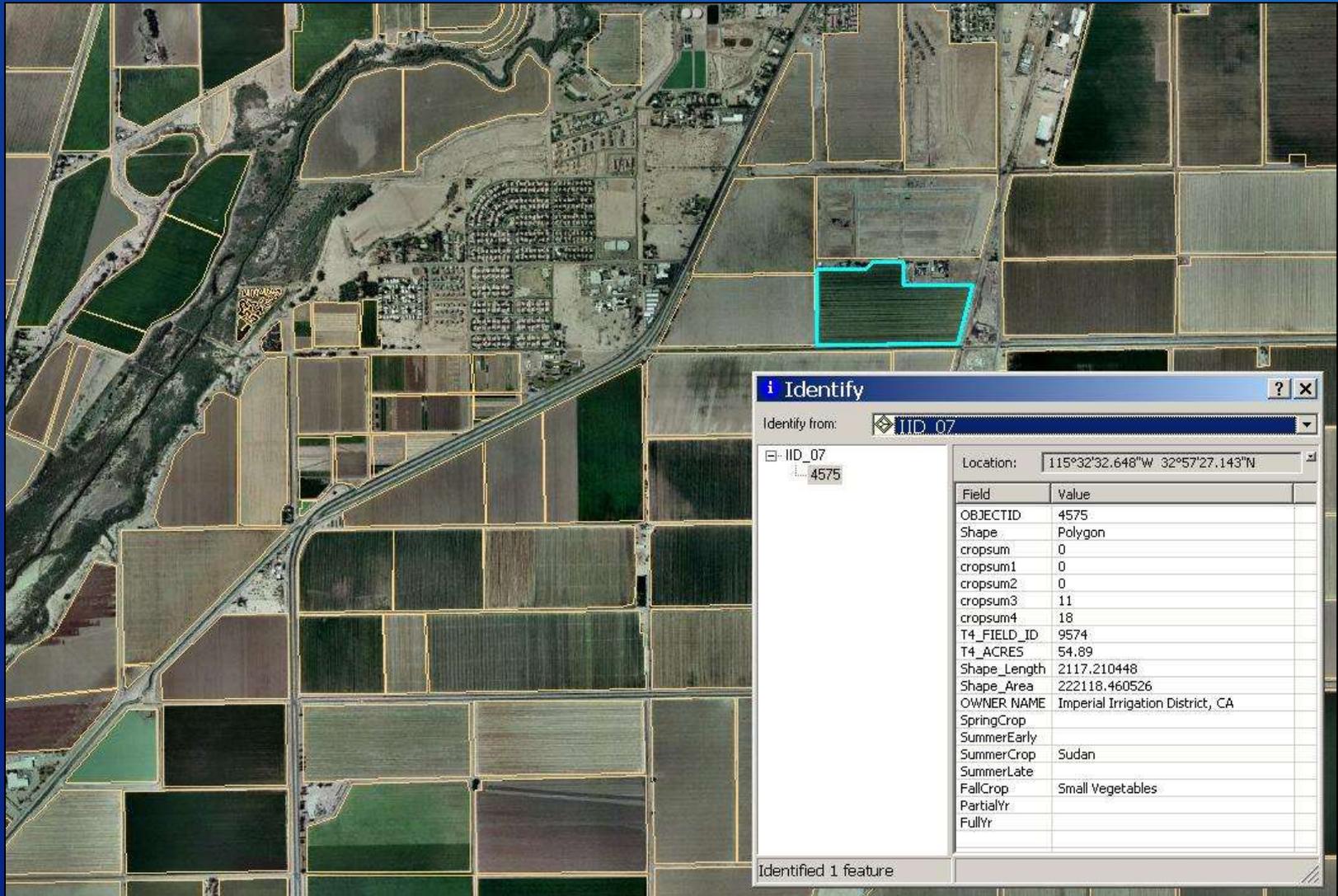
Database Design

- GIS database locates, identifies, and quantifies:
 - Crop Types
 - Riparian Types
 - Open Water Surface
- Provides for analysis at:
 - Field level, Irrigation Diverter, River Reach, State Boundaries, or other required geographic area
 - Multi-temporal database allows for historical analysis



Crop database - CVWD

Database Design

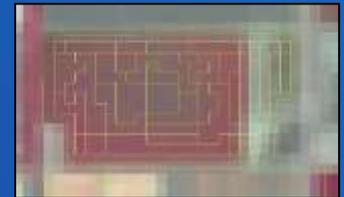


NAIP Imagery with Field Borders – IID, CA

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Populating Database - Procedures

- Ground Reference Data Collection
- Spectral Crop Signature Development
- Automated Crop Classification
- Classification Accuracy Assessment



Ground Referenced Data - Crops

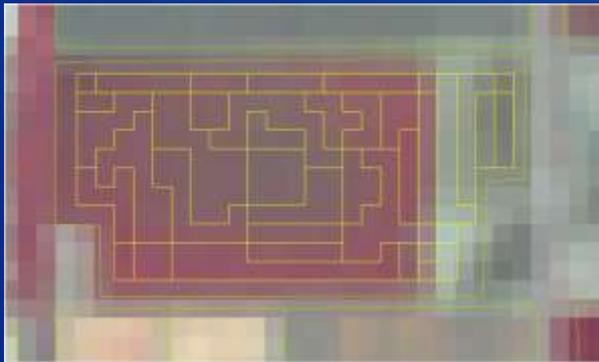
- Ground Truthing
 - 4 Times Annually
 - 4 Individuals
 - 2 Weeks
- Sample approximately 12% of fields
- Collect
 - crop type
 - condition representing spectral variability



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Spectral Crop Signature Development

- 10% of Ground sample reserved for accuracy assessment
- Segmentation algorithms generate spectral signature “objects”



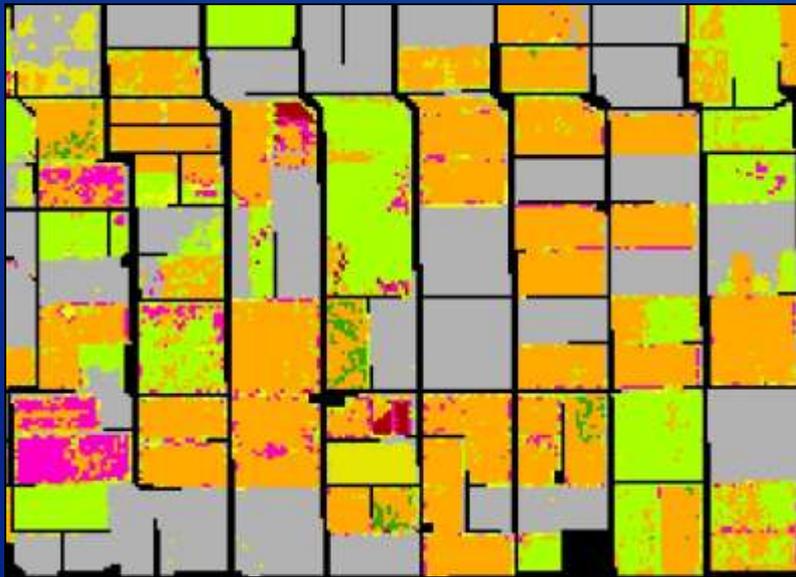
Signature Objects in a single training field



Signature Objects over TM imagery

Automated Crop Classification

- Signature “Objects” used to classify individual pixels
- Fields receive crop label based on plurality rule



Individual Pixels classified from signature objects



Crop label assigned to each fields based on plurality rule

Classification Overview

Multispectral Imagery

Landsat TM (30 meter resolution)

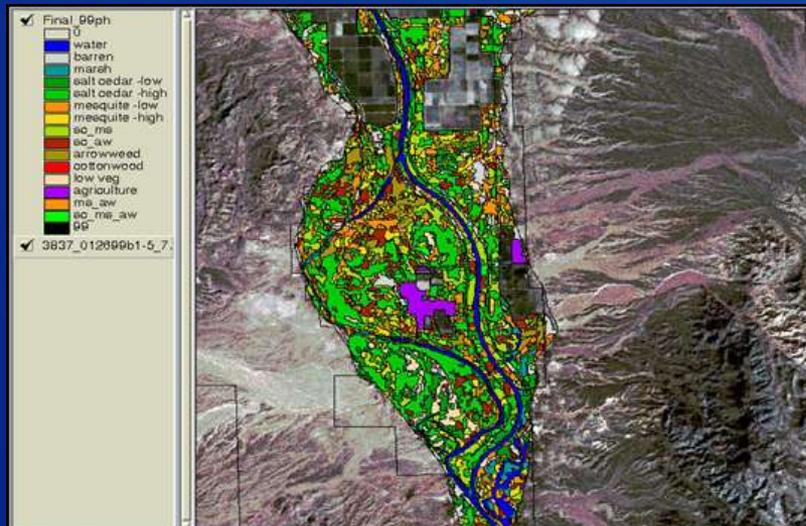
NAIP (1 meter resolution)

Data Classification Procedure

Crops: 4 times per year. Automated Classification.

Riparian: Object-based Classification & Annual Change Detection

Open Water : Annually. Visual Classification



Riparian Vegetation – Cibola NWR

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ET and Evaporation Calculation

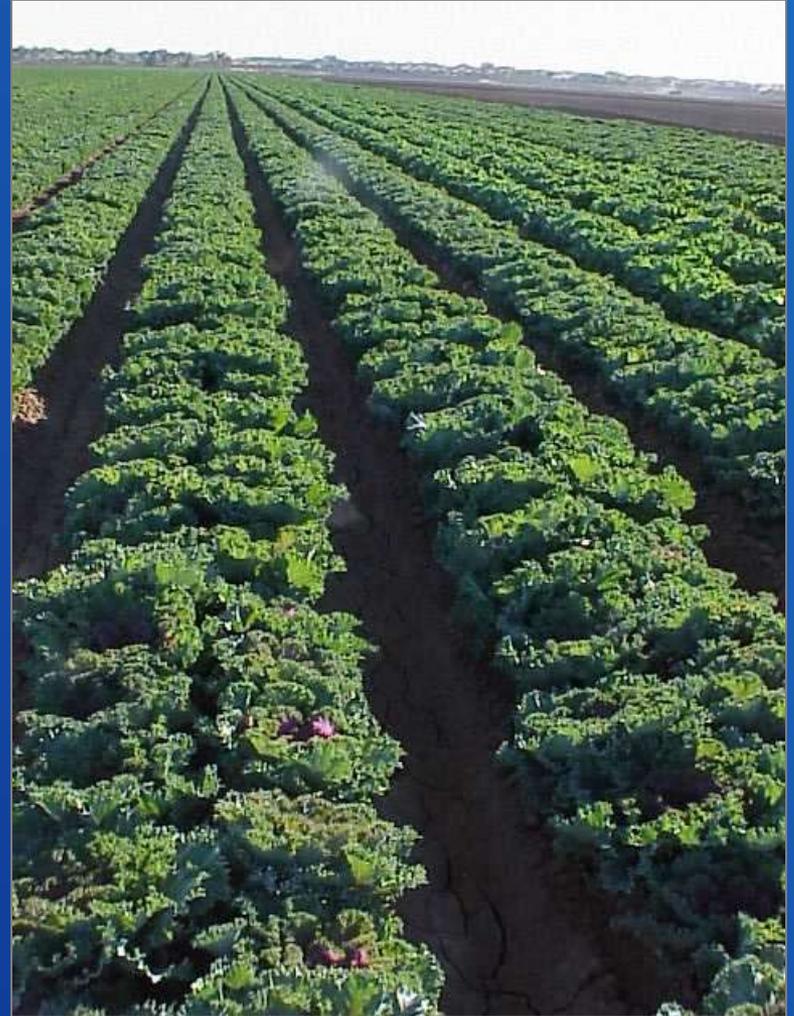
- AZMET & CIMIS stations
 - Reference ET
- Crop Coefficients developed using FAO standard procedures



AZMET, Mohave area, AZ

Developing Activities

- Data is being integrated into water management activities requiring crop, riparian, and associated ET information
- Integration of emerging remote sensing technologies such as energy balance (SEBAL, METRIC, and SSEBop) to improve or enhance current methods
- Development of web-based applications to allow broader access to data



Discussion



Topock Marsh – 1 foot CIR

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