

RECLAMATION

Managing Water in the West

Geographical Assessment of Potential for Beneficial Use of Produced Water

Steve Dundorf

Katie Benko

(Denver - Technical Service Center)



U.S. Department of the Interior
Bureau of Reclamation

Outline

- Reclamation Role
- Produced Water Potential
- 3 Examples

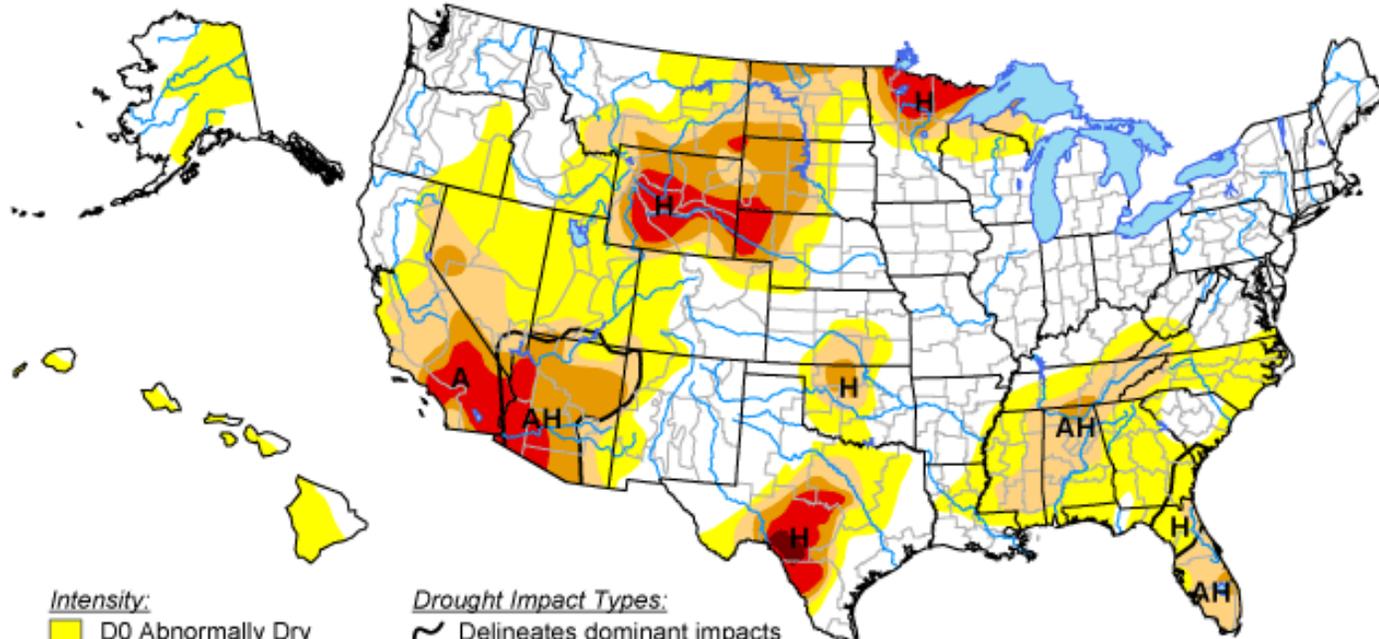


RECLAMATION

Desalination in the U.S.

U.S. Drought Monitor

March 20, 2007
Valid 8 a.m. EDT



Intensity:

-  D0 Abnormally Dry
-  D1 Drought - Moderate
-  D2 Drought - Severe
-  D3 Drought - Extreme
-  D4 Drought - Exceptional

Drought Impact Types:

-  Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

<http://drought.unl.edu/dm>



Released Thursday, March 22, 2007
Author: Brad Rippey, U.S. Department of Agriculture

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Bureau of Reclamation

The mission of the Bureau of Reclamation is to:

Manage, Develop, & Protect Water and related resources in an Environmentally and Economically sound manner in the interest of the American public.

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Bureau of Reclamation

Where do we fit in to Produced Water?

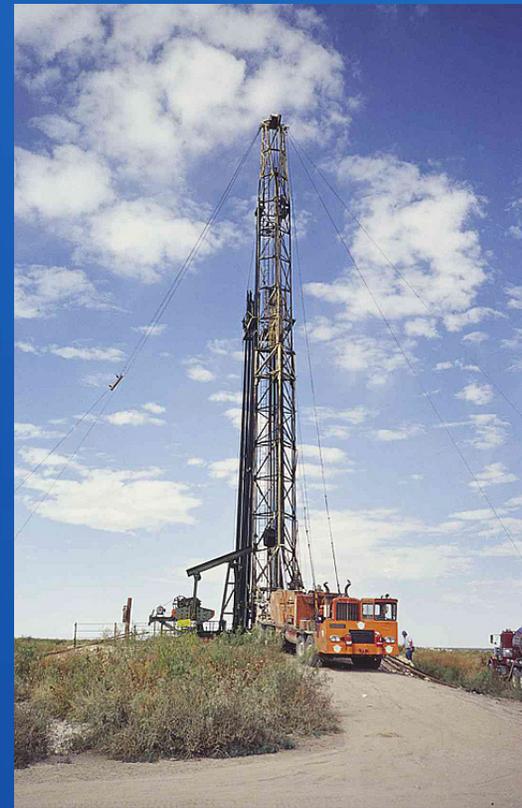
- Develop new water sources
- Develop in an environmentally sound manner
- Assist states in maintaining river compacts
- Fulfilling Indian Trust responsibilities

Potential Specific Uses of Produced Water

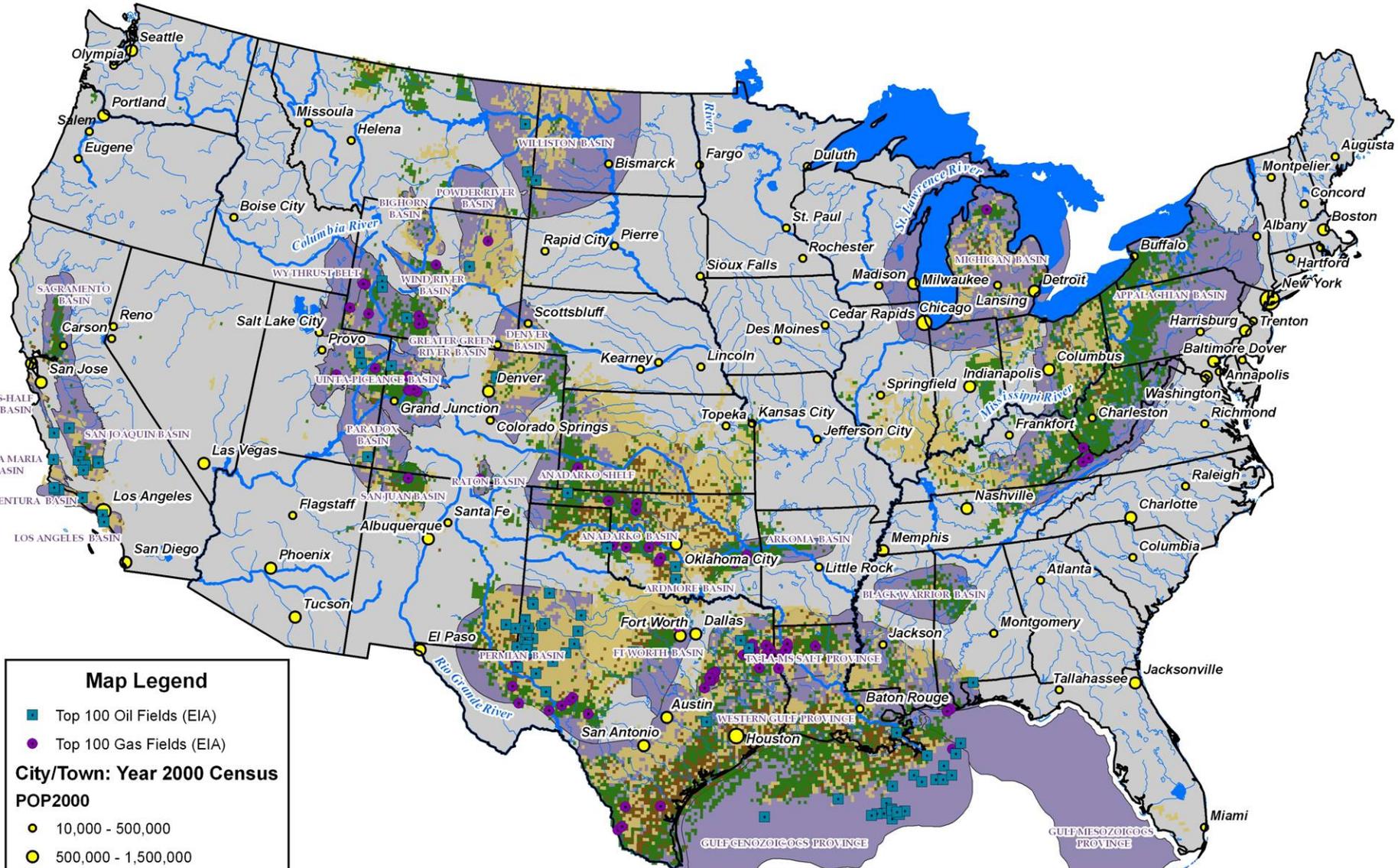
- Discharge to streams
- Agricultural use
- Municipal & Industrial use (indirect or direct)

Outline

- Reclamation Role
- **Produced Water Potential**
- 3 Examples



RECLAMATION



Map Legend

- Top 100 Oil Fields (EIA)
- Top 100 Gas Fields (EIA)

City/Town: Year 2000 Census POP2000

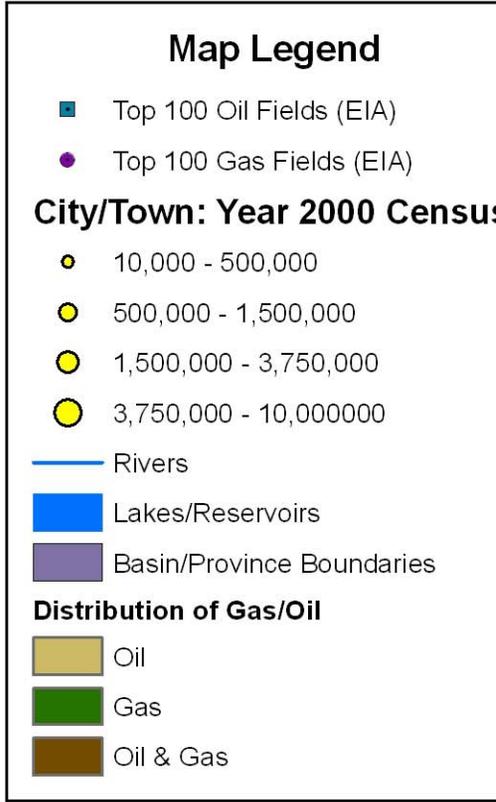
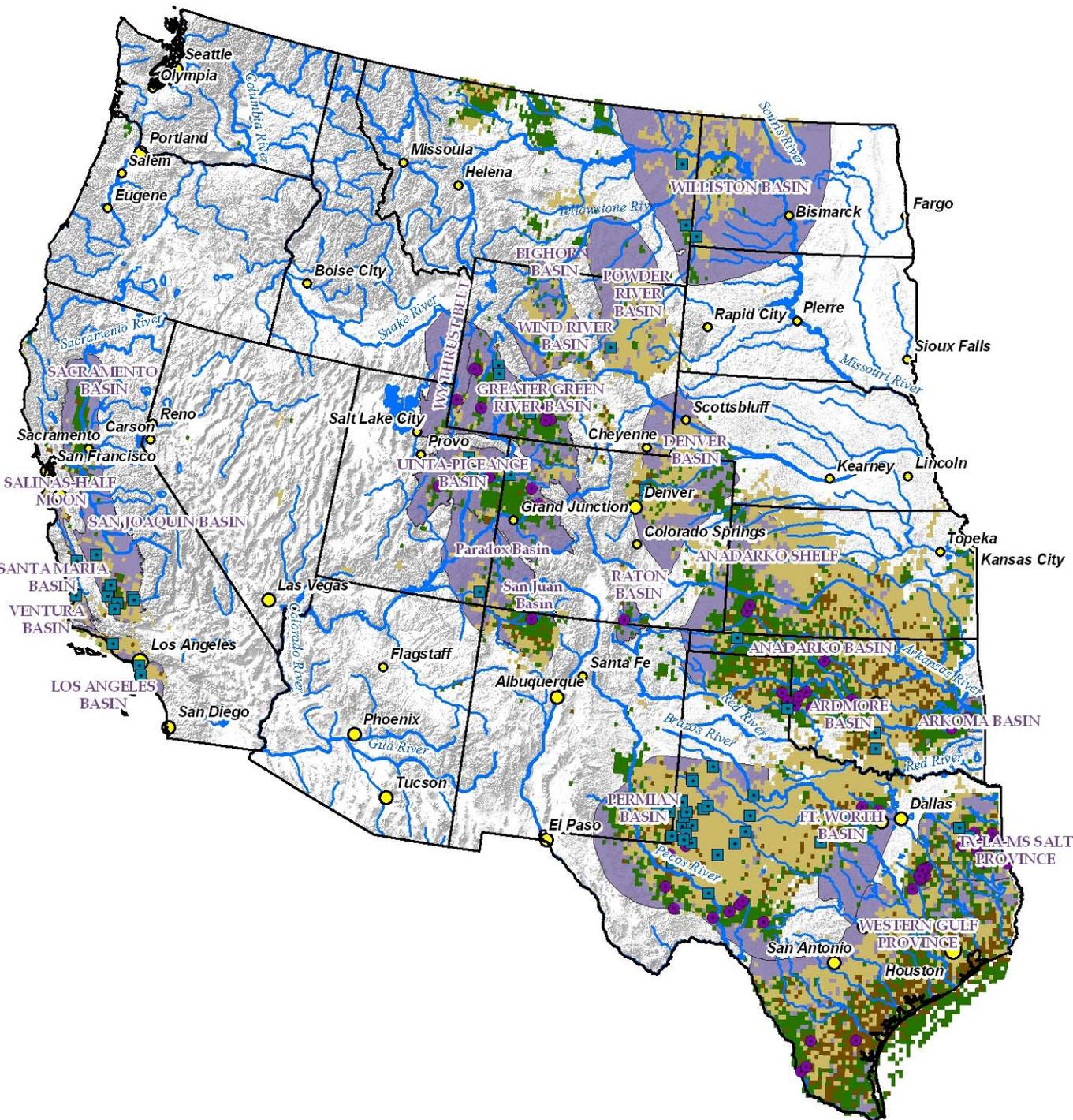
- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

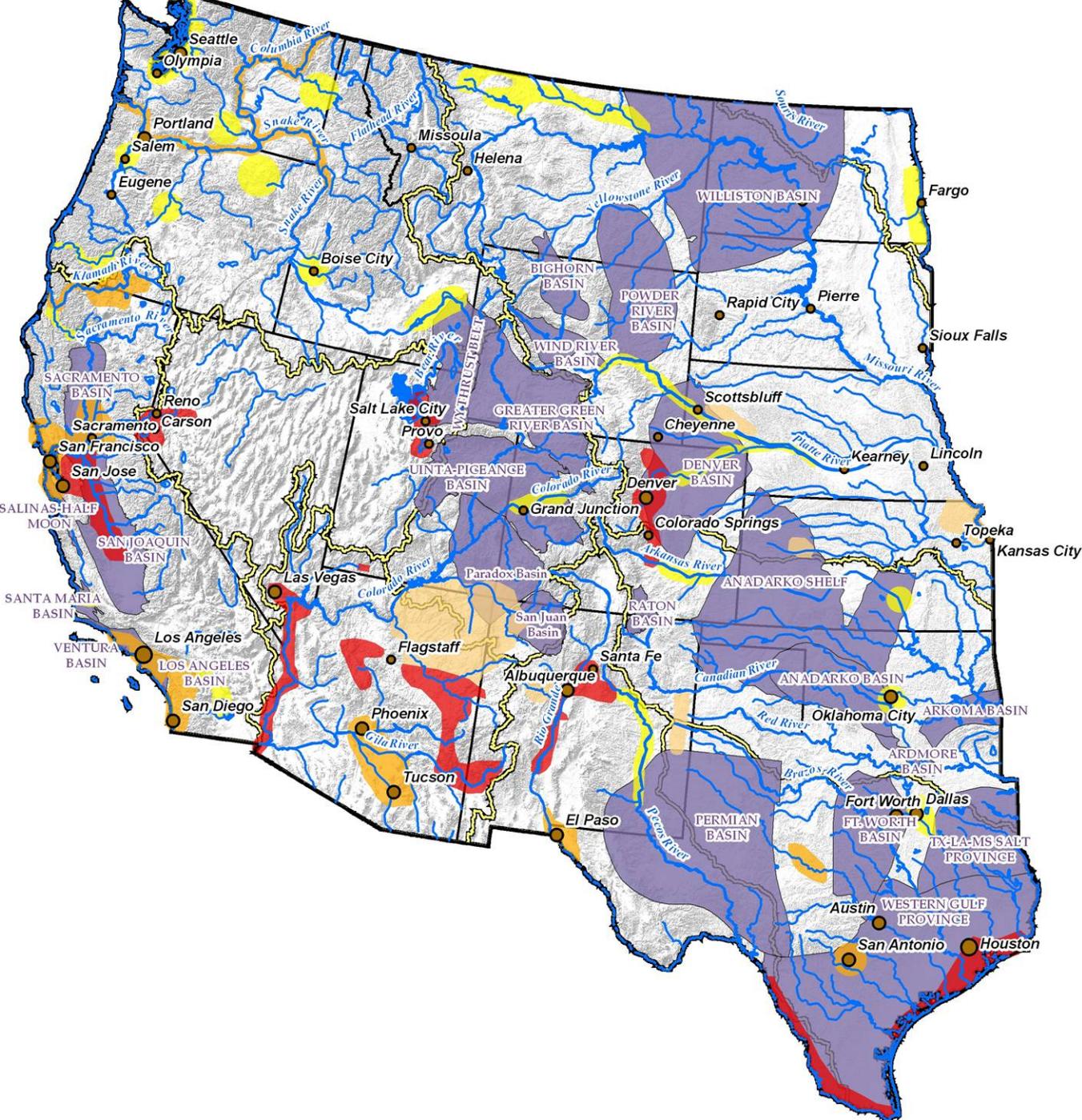
Basin/Province Boundaries

- Basin/Province Boundaries

Distribution of Gas/Oil

- Oil
- Gas
- Oil & Gas





Map Legend

Cities/Towns (Year 2000 Census)

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

Watershed Boundaries (HUC2)
 Basin/Province Boundaries

Water 2025: Supply Issue Areas

SEVERITY

- Unmet Rural Water Needs
- Conflict Potential-- Moderate
- Conflict Potential-- Substantial
- Conflict Potential-- Highly Likely

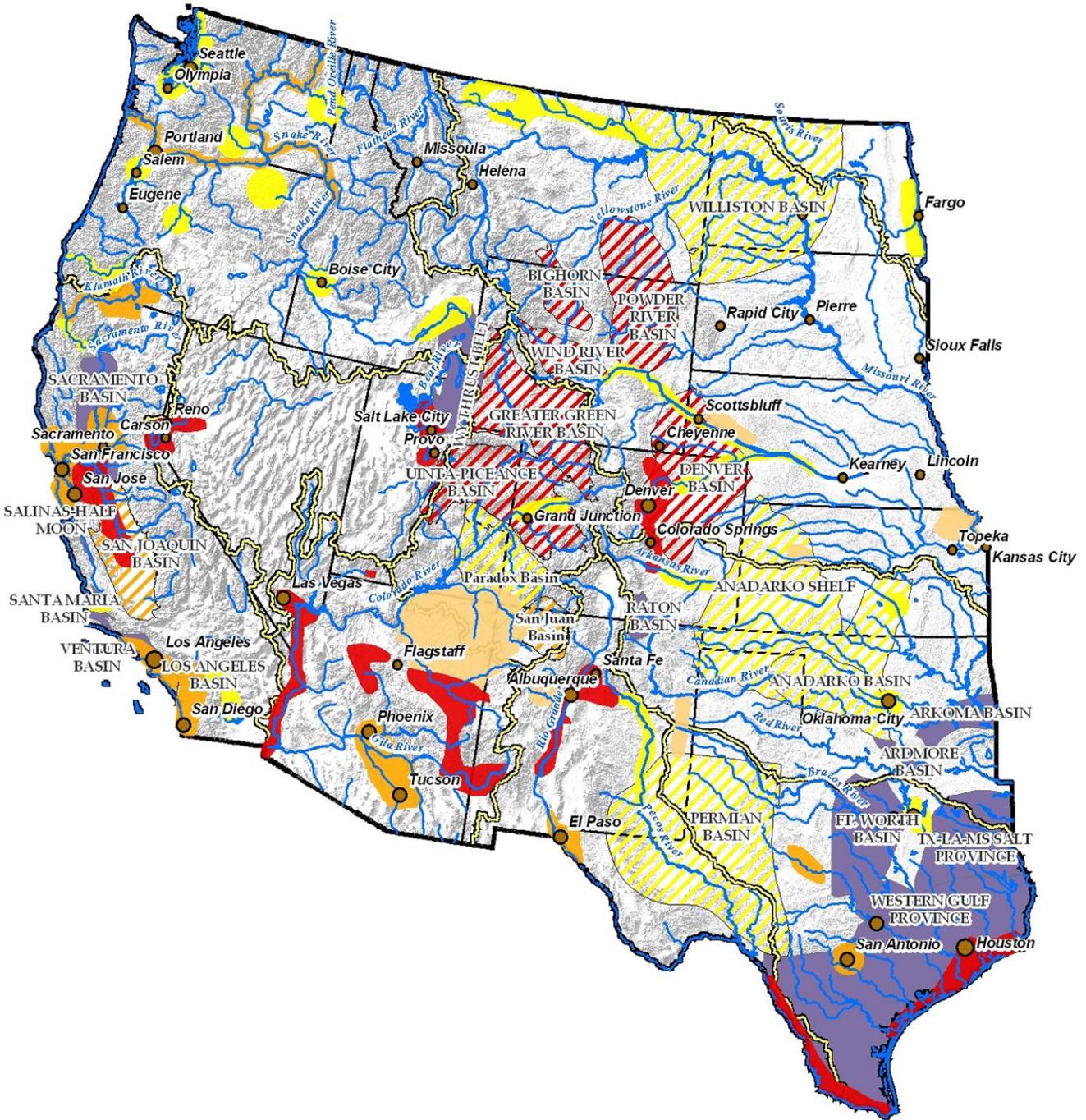
Occurrence of PW in Western U.S.

**Conventional
oil and gas
co-produced
water
generation**

Geologic Basin	Water Production		Median TDS	Potential for treatment
	m ³ /day	mgd	(mg/L)	
Williston	18,000	4.9	132,400	Low
Powder River	370,000	97	7,300	Very high
Big Horn	360,000	94	4,900	Very high
Wind River	54,000	14	5,300	Very high
Green River	41,000	11	9,400	High
Denver	14,000	3.8	10,200	High
Uinta-Piceance	42,000	11	13,200	High
Paradox	21,000	5.6	67,000	Low
San Juan	14,000	3.6	22,700	Medium
Anadarko	34,000	8.9	132,200	Very low
Permian*	250,000	65	89,200	Low
San Joaquin	NA	NA	22,700	Medium
Los Angeles	NA	NA	30,330	Medium

* For natural gas only and only for the New Mexico portion of the Permian Basin.

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Map Legend

Cities/Towns (Year 2000 Census)

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

Water 2025: Supply Issue Areas

SEVERITY

- Unmet Rural Water Needs
- Conflict Potential-- Moderate
- Conflict Potential-- Substantial
- Conflict Potential-- Highly Likely
- states_temp_Dissolve
- Watershed Boundaries (HUC2)

Basins: Potential for Treatment

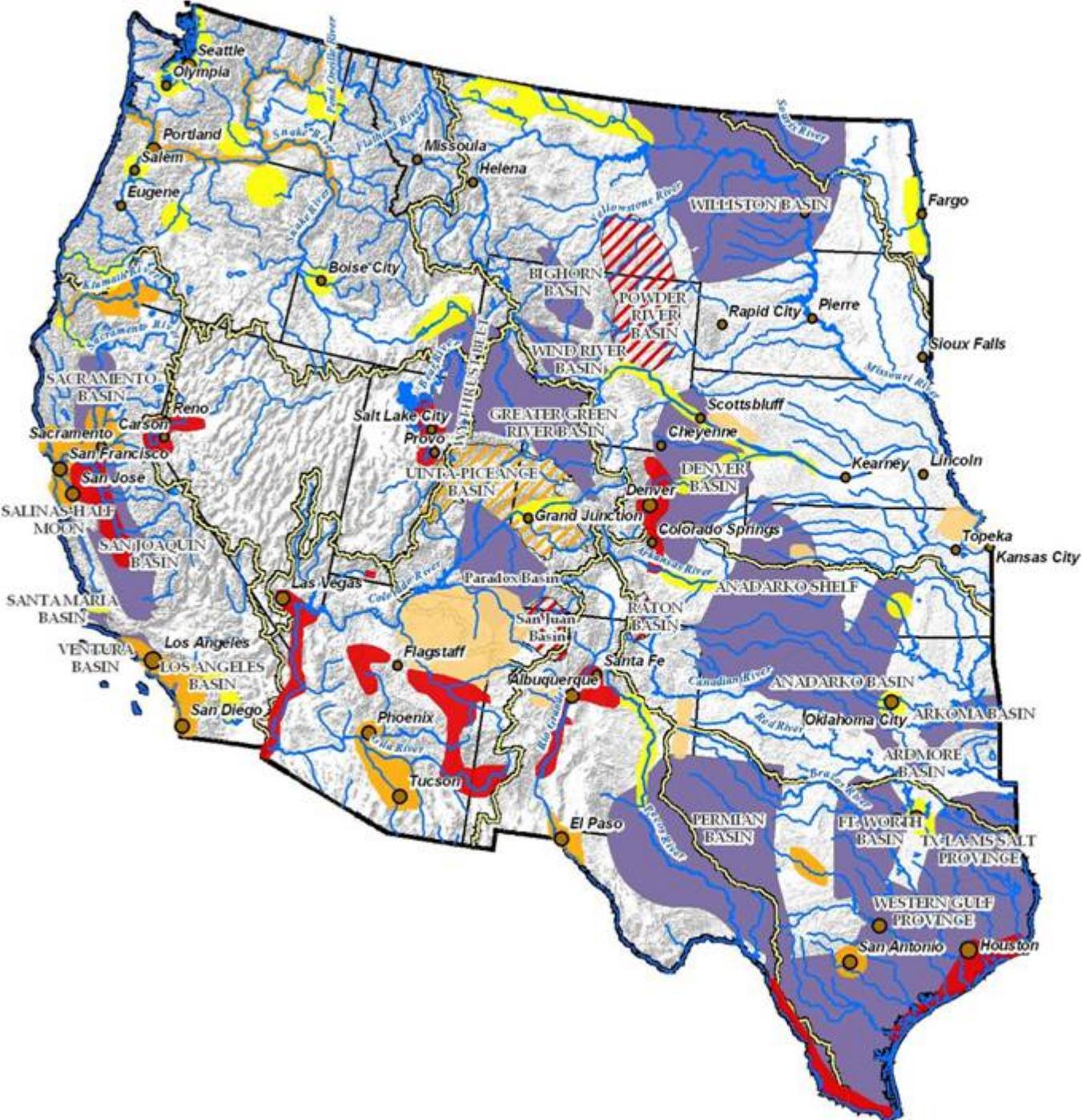
Conventional Oil & Gas

- High
- Medium
- Low
- N/A

Occurrence of PW in Western U.S.

Coalbed Methane Co-Produced Water Generation (Partial List)

Geologic Basin	Water Production		Median TDS (mg/L)	Potential for Treatment
	m ³ /day	mgd		
Powder River	170,000	46	840	Very High
Uinta	19,000	5.1	15,000	Medium
San Juan	12,000	3.2	8,000	High
Raton	13,000	3.6	1,500	High



Map Legend

Cities/Towns (Year 2000 Census)

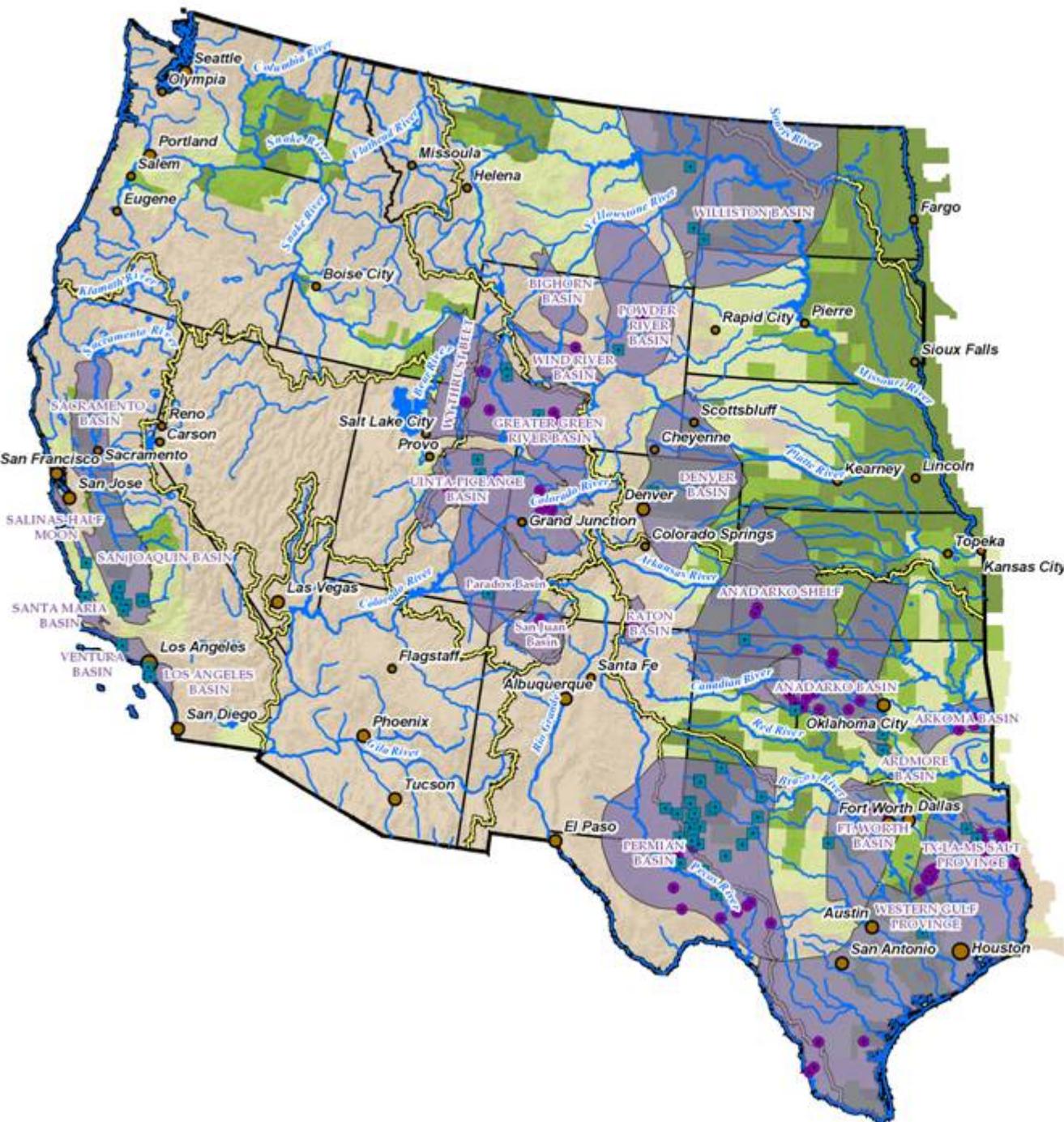
- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

Water 2025: Supply Issue Areas SEVERITY

- Unmet Rural Water Needs
- Conflict Potential- Moderate
- Conflict Potential- Substantial
- Conflict Potential- Highly Likely
- states_temp_Dissolve
- Watershed Boundaries (HUC2)

Basins: Potential for Treatment Coalbed Methane

- High
- Medium
- Low
- N/A



Map Legend

- Top 100 Oil Fields (EIA)
- Top 100 Gas Fields EIA

Cities/Towns (Year 2000 Census)

POP2000

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

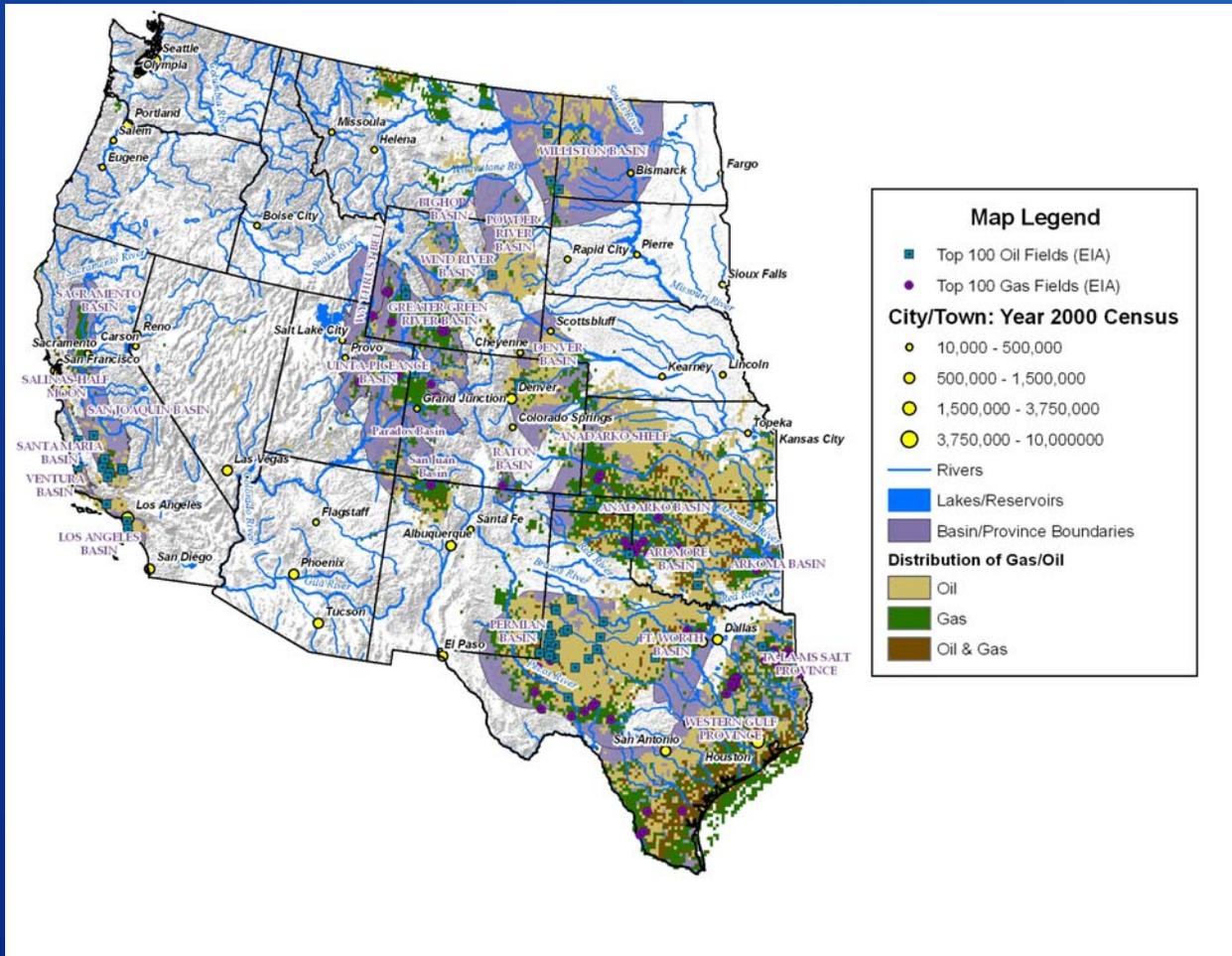
- Watershed Boundaries (HUC2)
- Basin/Province Boundaries

Agriculture

Acres of Total Cropland

- 50 or more
- 31 - 50
- 10 - 30
- Less than 10

Occurrence of Produced Water in U.S.



RECLAMATION

Water

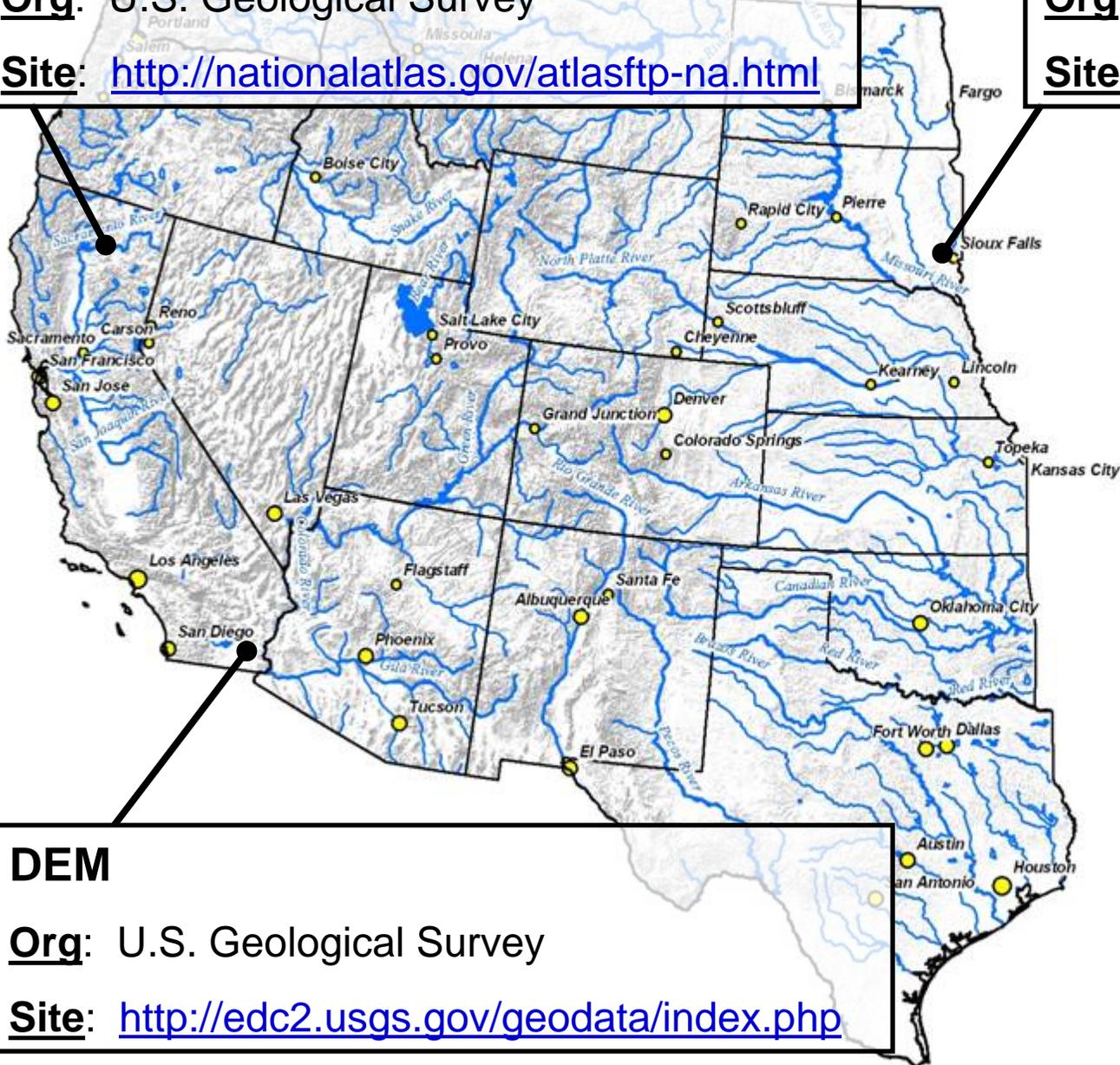
Org: U.S. Geological Survey

Site: <http://nationalatlas.gov/atlasftp-na.html>

Cities

Org: ESRI - Redlands, CA

Site: www.esri.com



Map Legend

City/Town: Year 2000 Census

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

— Rivers

■ Lakes/Reservoirs

DEM

Org: U.S. Geological Survey

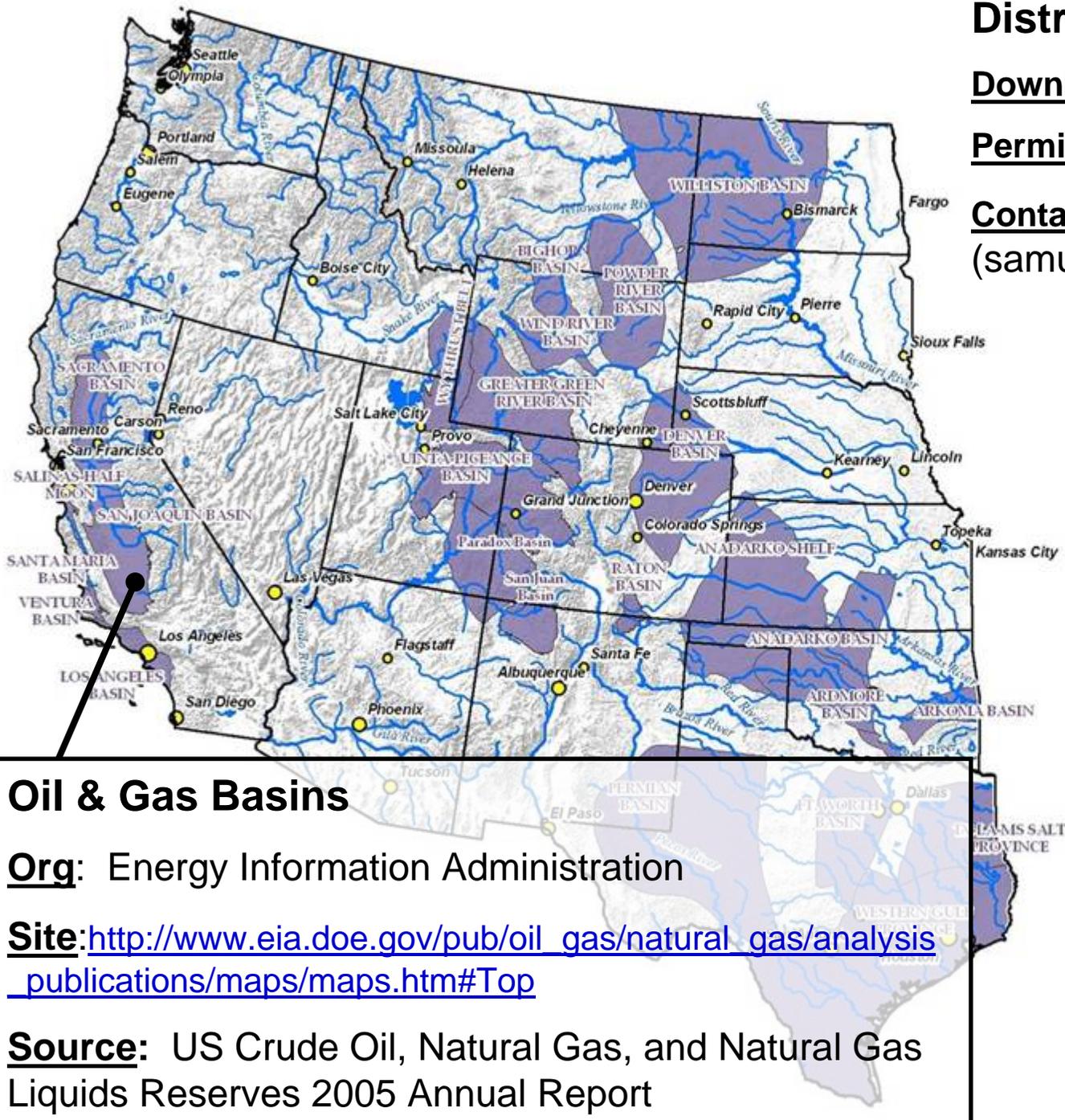
Site: <http://edc2.usgs.gov/geodata/index.php>

Distribution

Download: No

Permission: On a request basis

Contact: Samuel Limerick
(samuel.limerick@eia.doe.gov)



Map Legend

City/Town: Year 2000 Census

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
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■ Lakes/Reservoirs

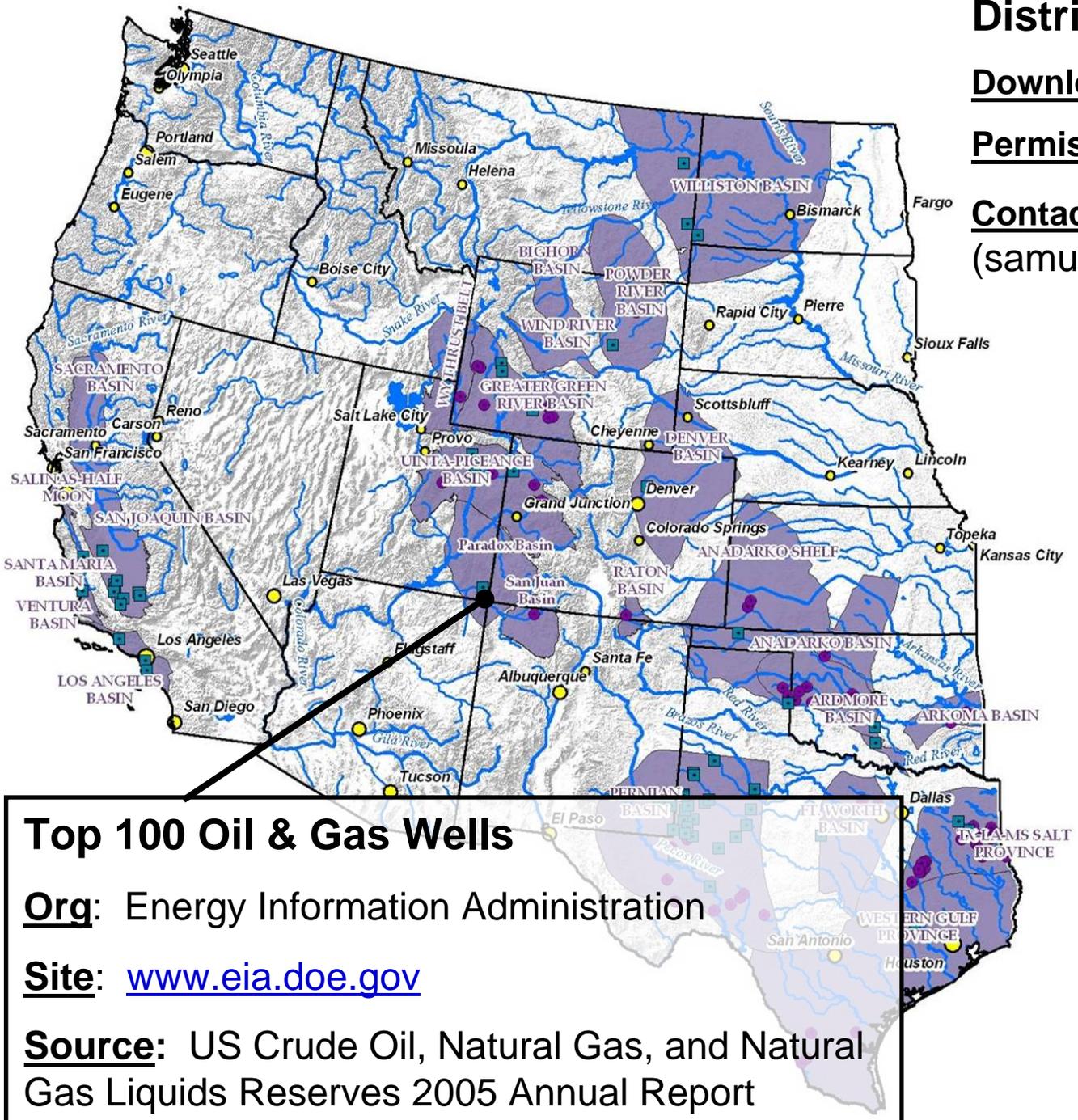
■ Basin/Province Boundaries

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Map Legend

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- 1,500,000 - 3,750,000
- 3,750,000 - 10,000,000

- Rivers
- Lakes/Reservoirs
- Basin/Province Boundaries

Top 100 Oil & Gas Wells

Org: Energy Information Administration

Site: www.eia.doe.gov

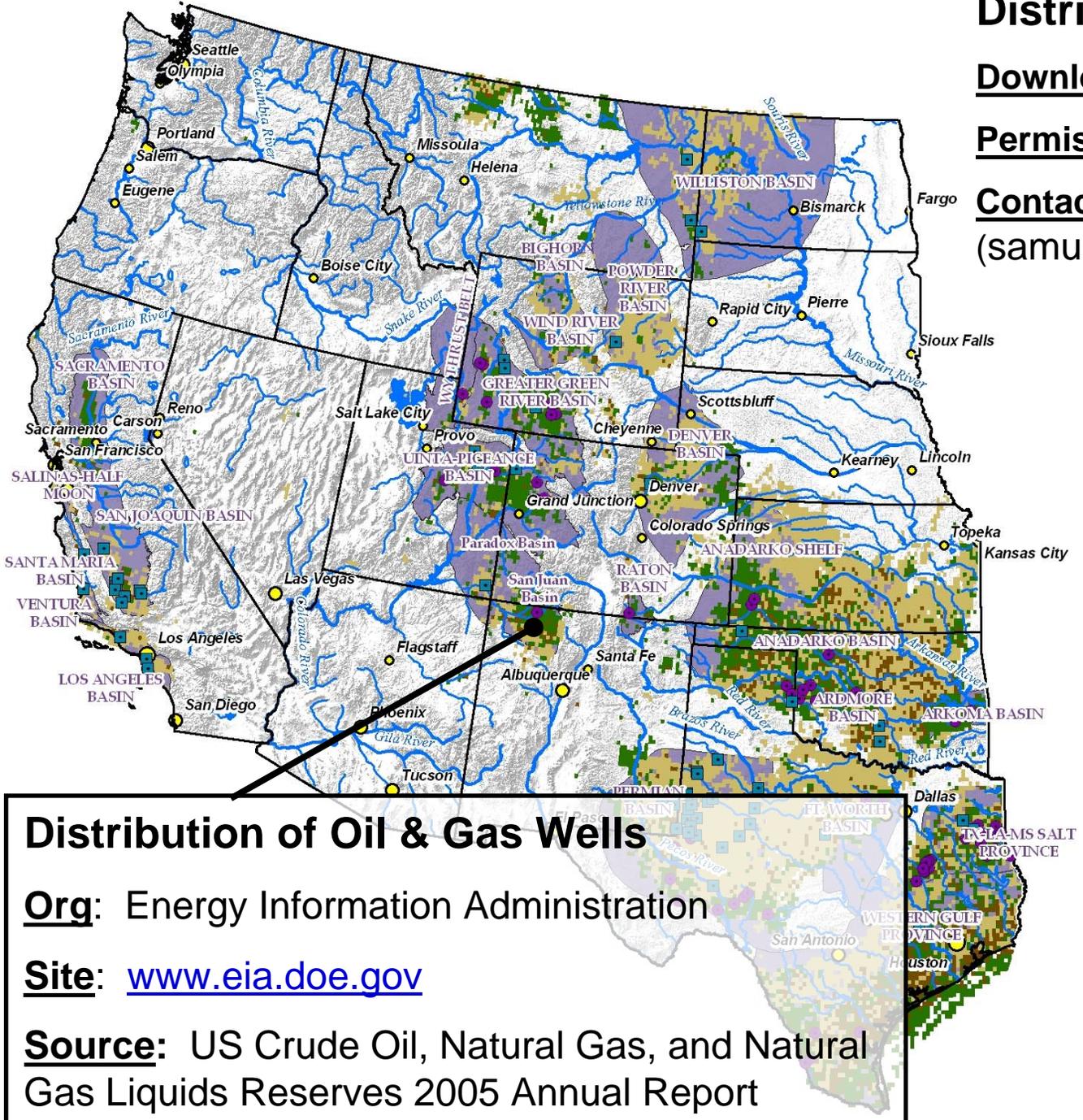
Source: US Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2005 Annual Report

Distribution

Download: No

Permission: On a request basis

Contact: Samuel Limerick
(samuel.limerick@eia.doe.gov)



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- Top 100 Gas Fields (EIA)

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- Lakes/Reservoirs
- Basin/Province Boundaries

Distribution of Gas/Oil

- Oil
- Gas
- Oil & Gas

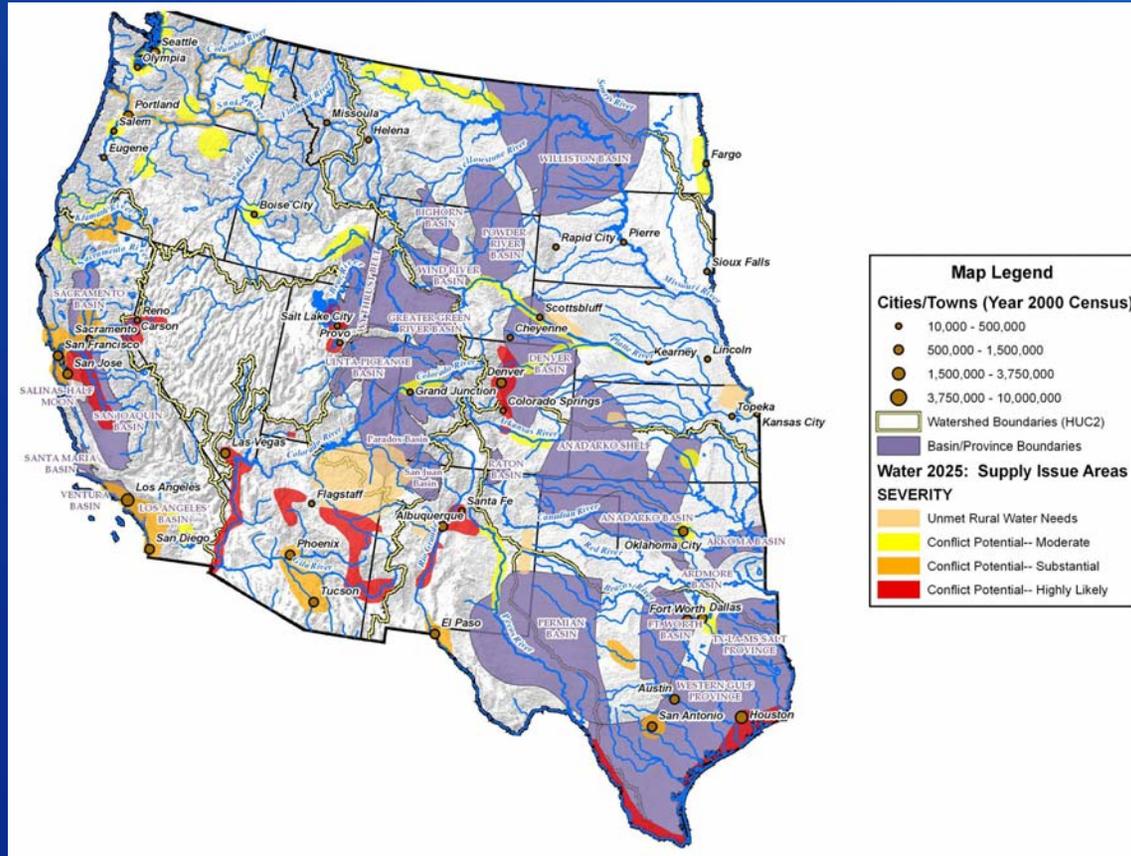
Distribution of Oil & Gas Wells

Org: Energy Information Administration

Site: www.eia.doe.gov

Source: US Crude Oil, Natural Gas, and Natural Gas Liquids Reserves 2005 Annual Report

PW in Relation to Conflict Potential & Hydrologic Units

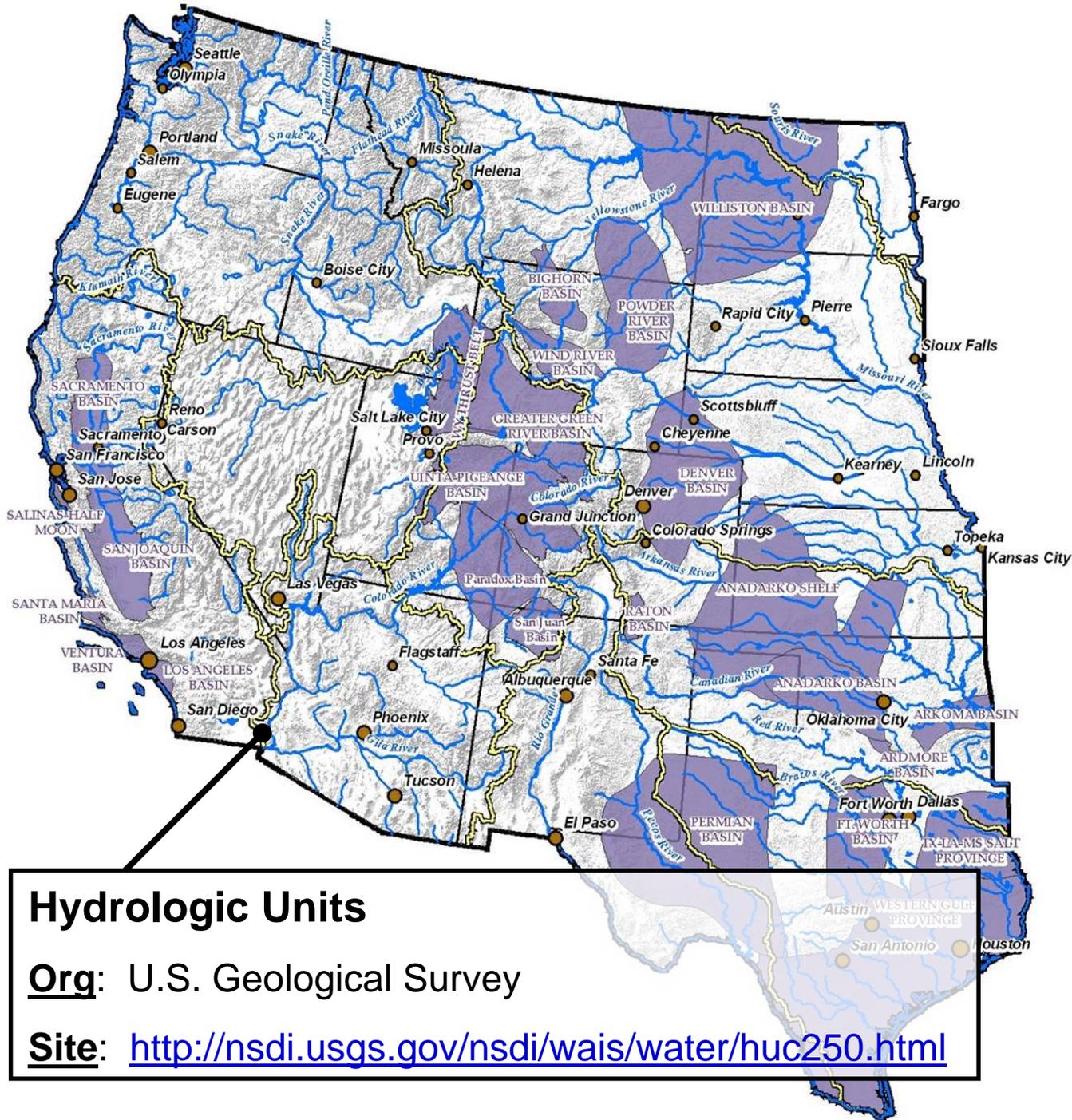


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Distribution

Download: Yes

HUC 2 to HUC 8



Hydrologic Units

Org: U.S. Geological Survey

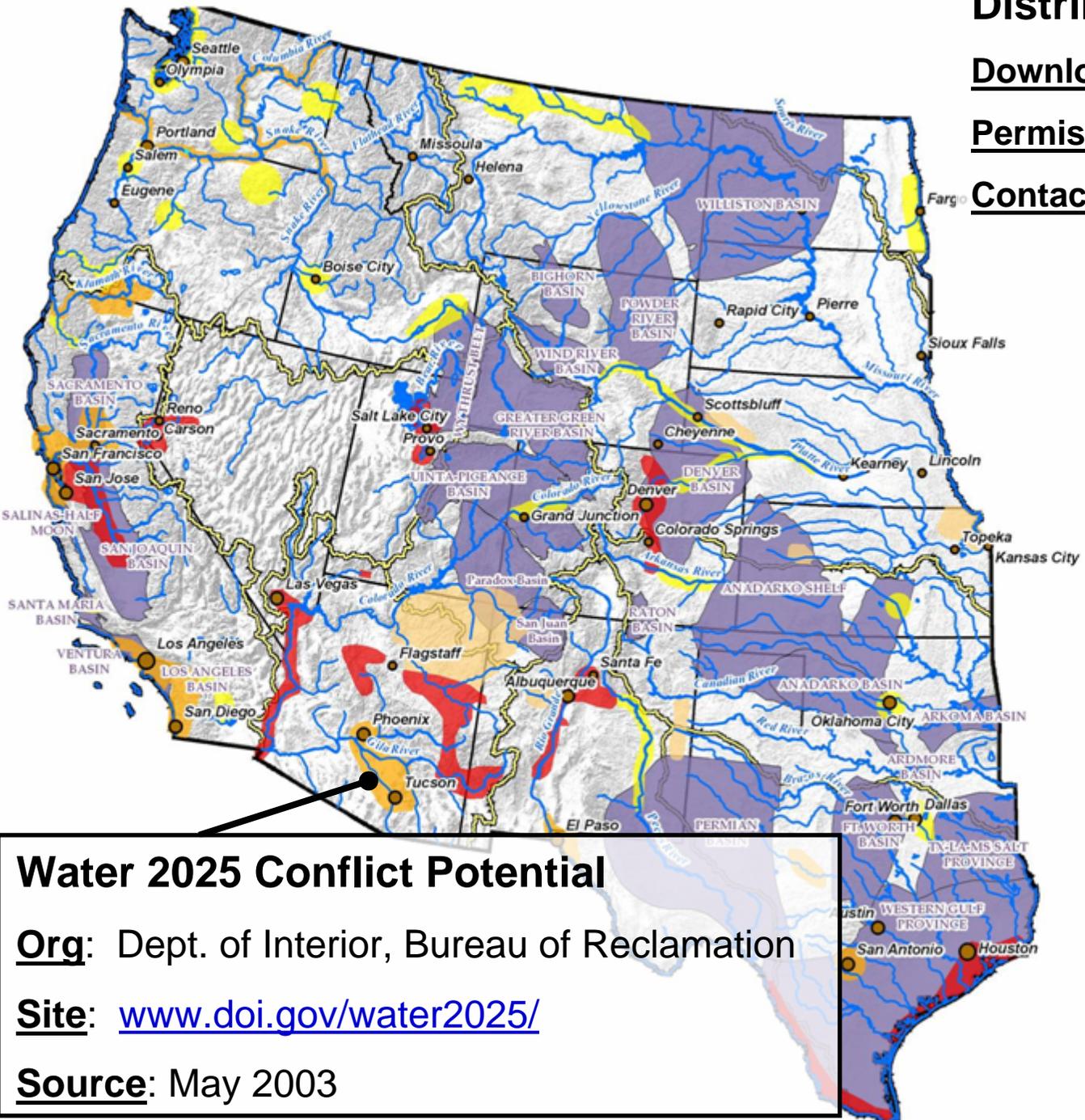
Site: <http://nsdi.usgs.gov/nsdi/wais/water/huc250.html>

Distribution

Download: No

Permission: On a request basis

Contact: Miguel Rocha



Map Legend

Cities/Towns (Year 2000 Census)

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
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▭ Watershed Boundaries (HUC2)

▭ Basin/Province Boundaries

Water 2025: Supply Issue Areas

SEVERITY

- ▭ Unmet Rural Water Needs
- ▭ Conflict Potential-- Moderate
- ▭ Conflict Potential-- Substantial
- ▭ Conflict Potential-- Highly Likely

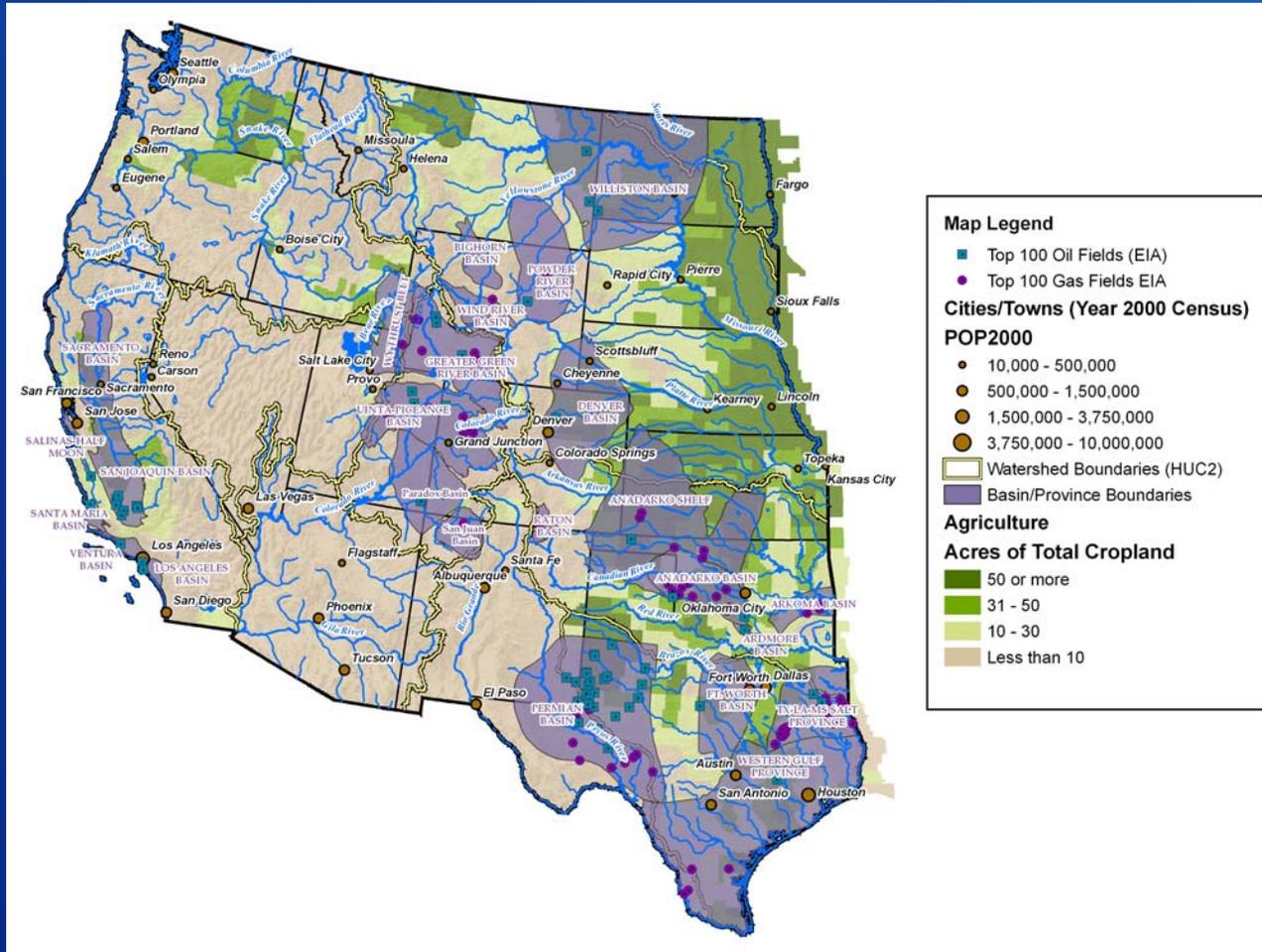
Water 2025 Conflict Potential

Org: Dept. of Interior, Bureau of Reclamation

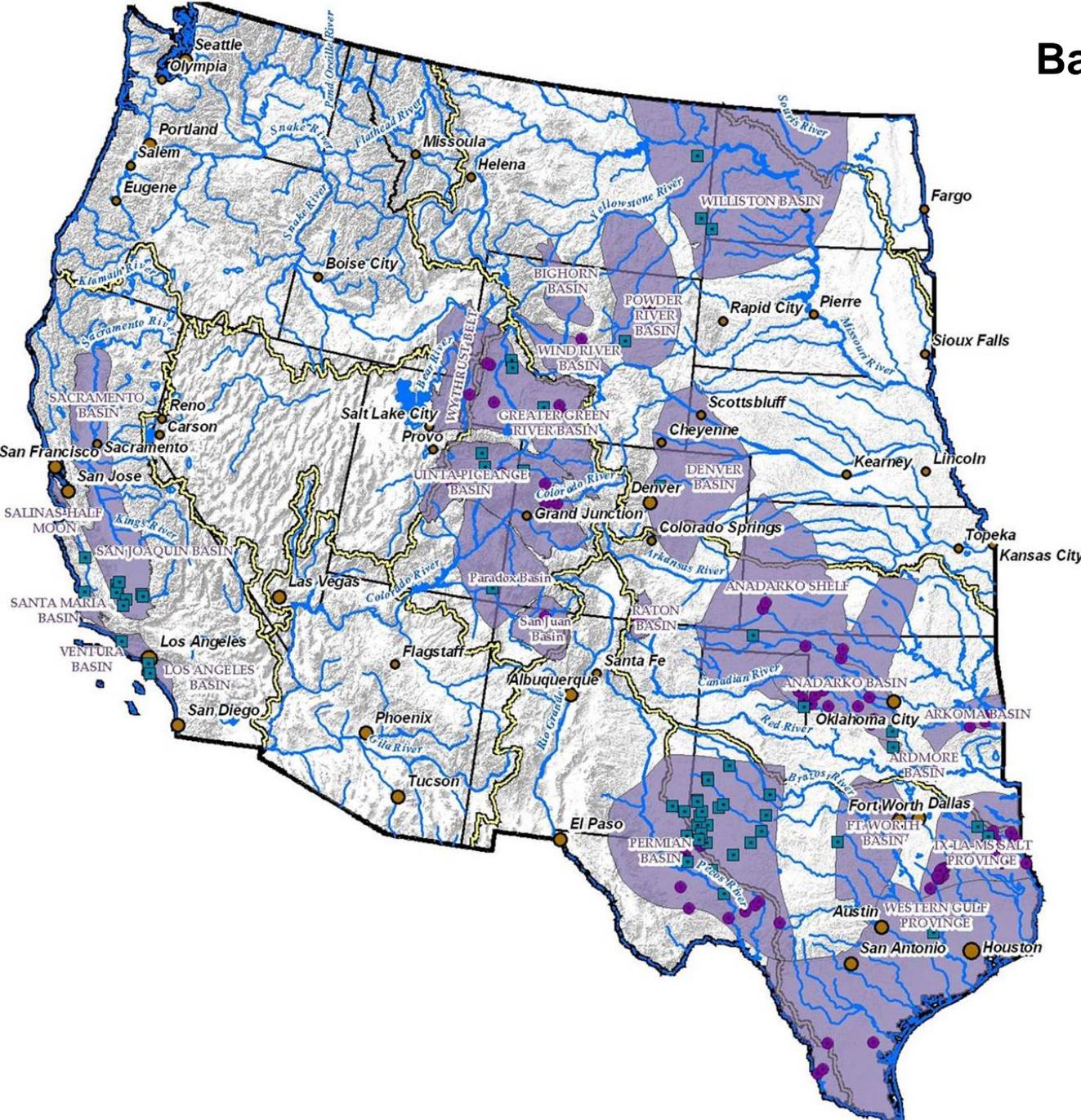
Site: www.doi.gov/water2025/

Source: May 2003

PW in Relation to Agriculture



Base Map



Map Legend

- Top 100 Oil Fields (EIA)
- Top 100 Gas Fields EIA

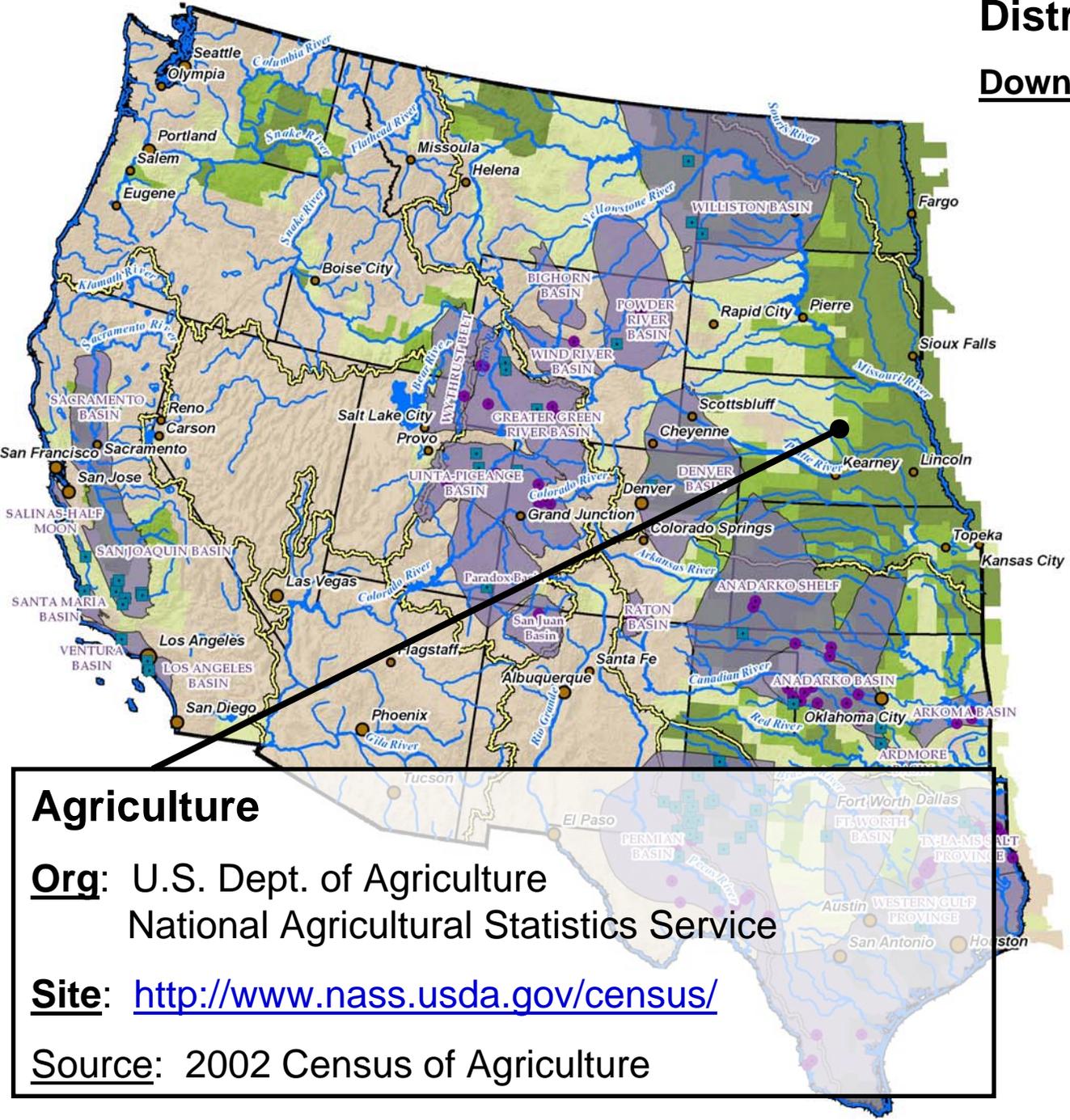
Cities/Towns (Year 2000 Census)

- 10,000 - 500,000
- 500,000 - 1,500,000
- 1,500,000 - 3,750,000
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- Watershed Boundaries (HUC2)
- Basin/Province Boundaries

Distribution

Download: Yes



Map Legend

- Top 100 Oil Fields (EIA)
- Top 100 Gas Fields EIA

Cities/Towns (Year 2000 Census)

POP2000

- 10,000 - 500,000
- 500,000 - 1,500,000
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- Watershed Boundaries (HUC2)
- Basin/Province Boundaries

Agriculture

Acres of Total Cropland

- 50 or more
- 31 - 50
- 10 - 30
- Less than 10

Agriculture

Org: U.S. Dept. of Agriculture
National Agricultural Statistics Service

Site: <http://www.nass.usda.gov/census/>

Source: 2002 Census of Agriculture

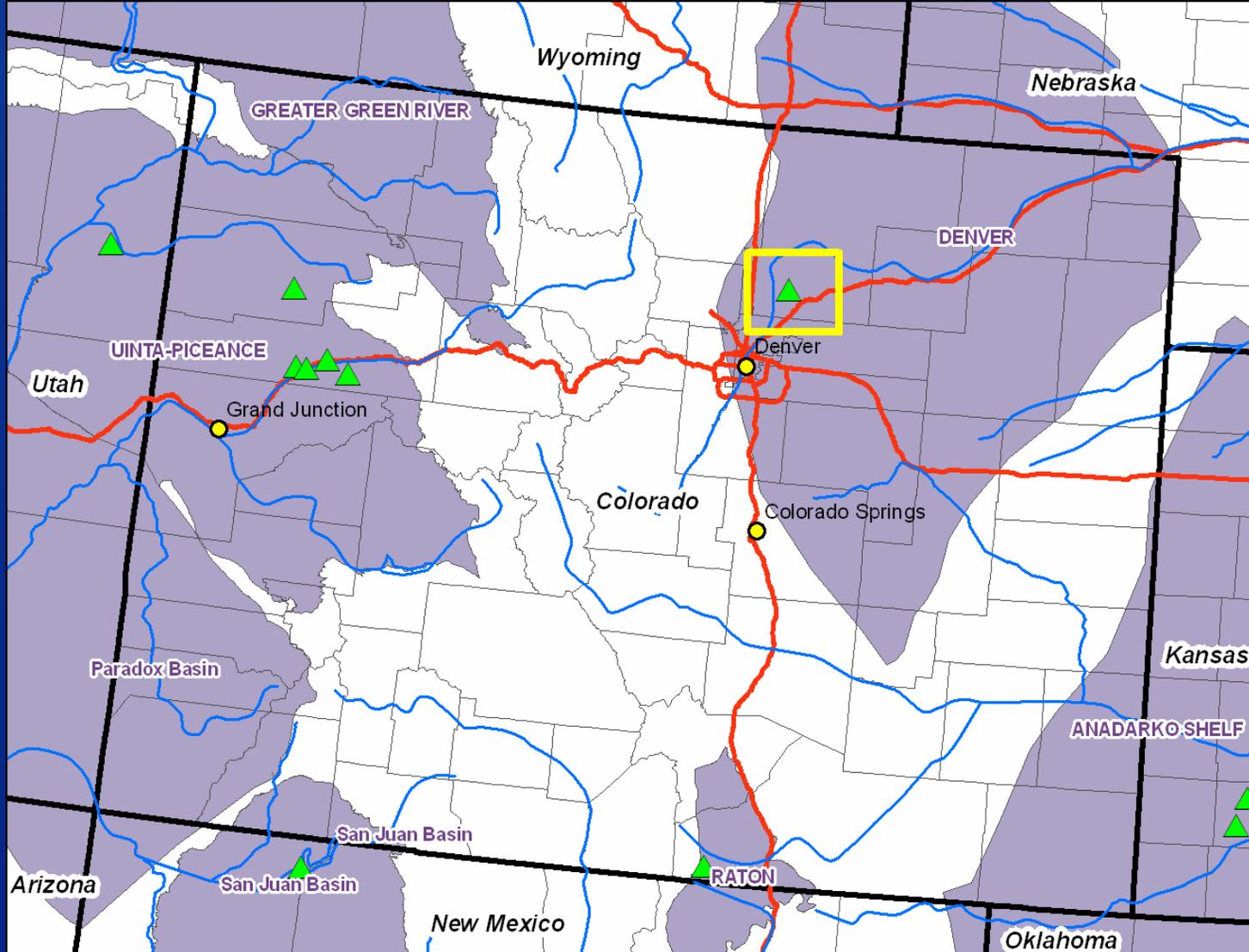
Outline

- Reclamation Role
- Produced Water Potential
- **3 Examples**

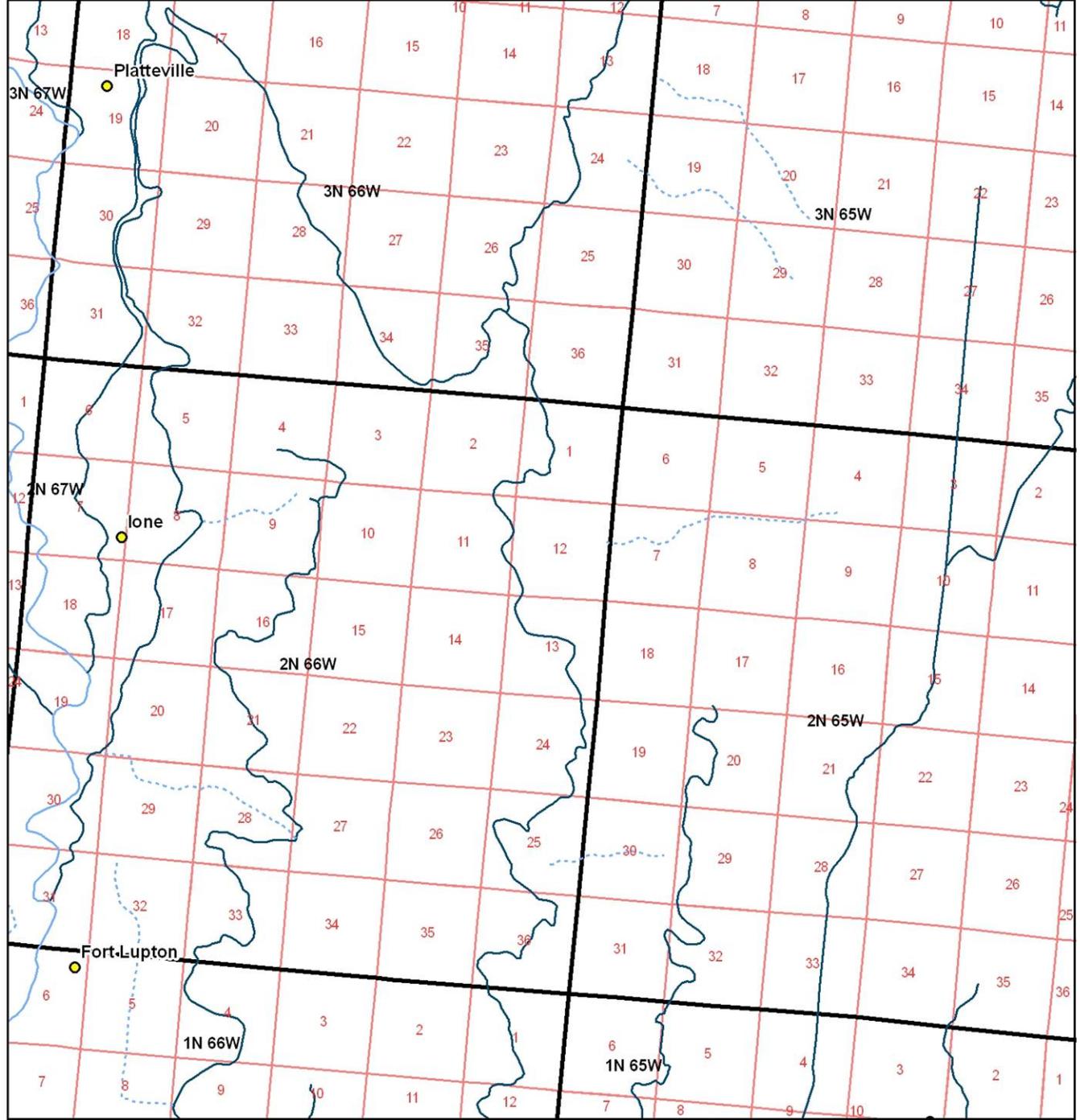


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Denver Basin Example

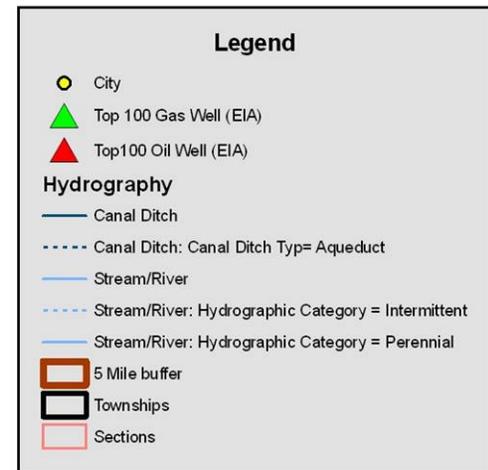
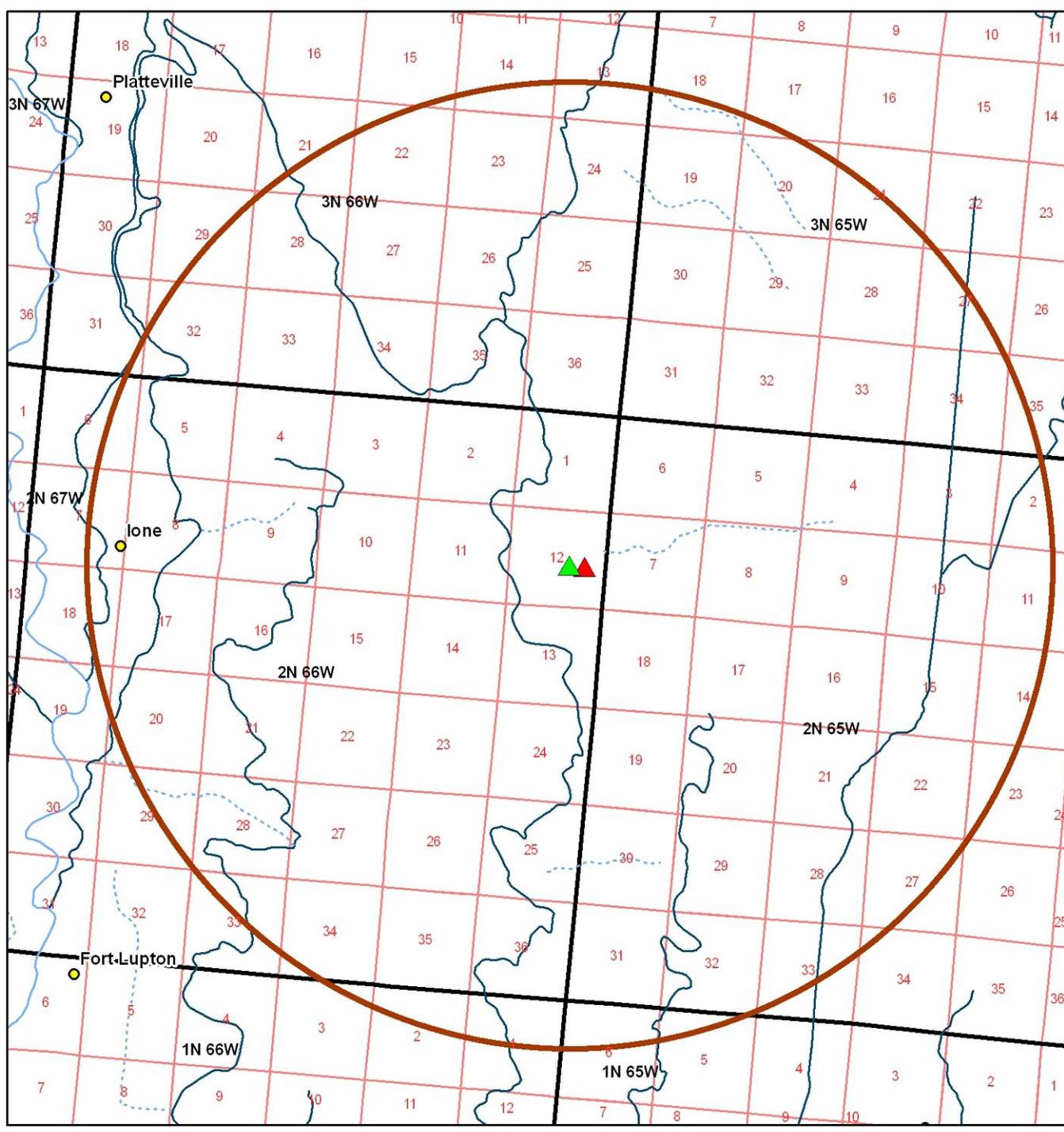


RECLAMATION



Legend

- City
- Hydrography**
- Canal Ditch
- - - Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- - - Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial
- Townships
- Sections



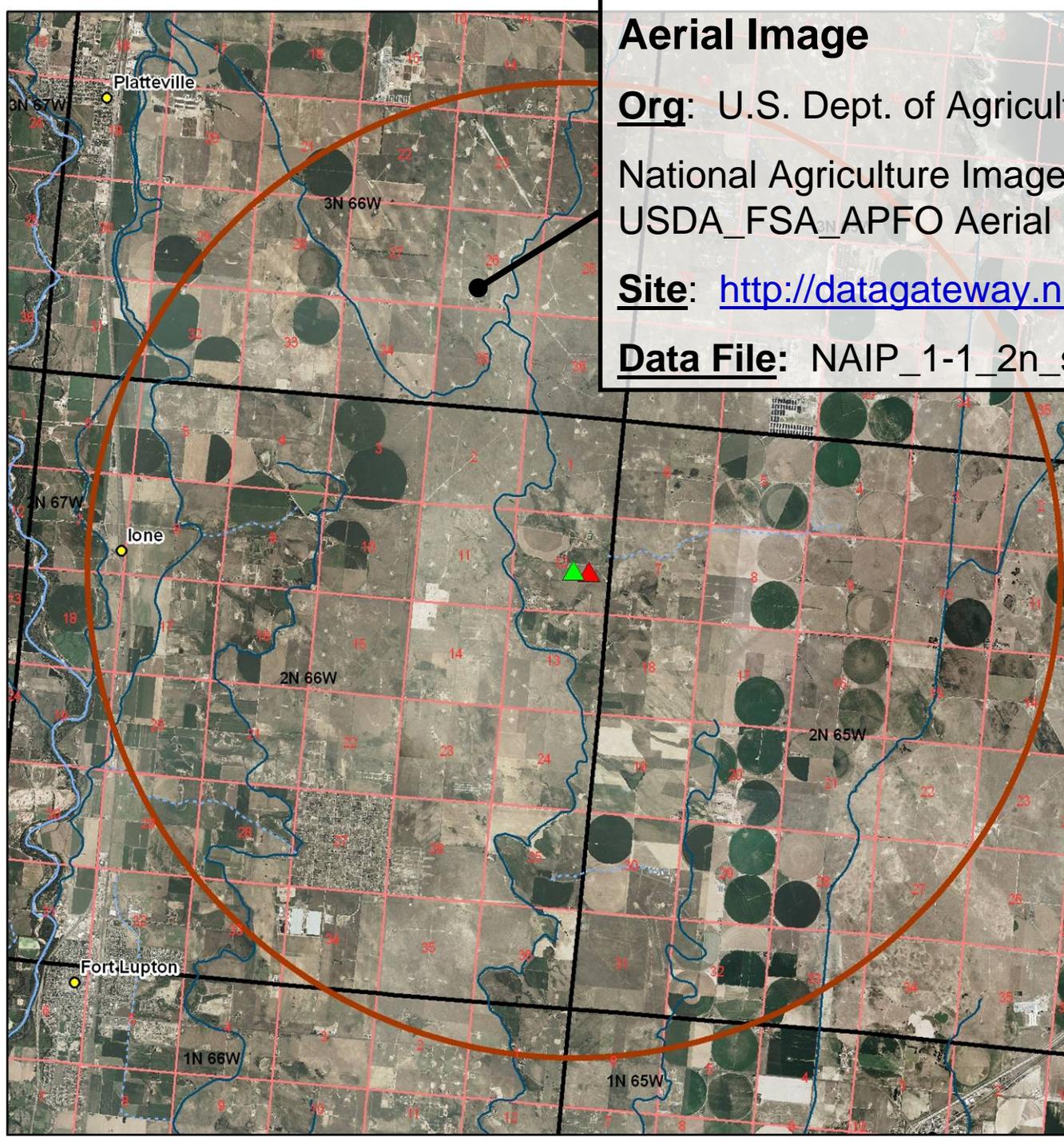
Aerial Image

Org: U.S. Dept. of Agriculture

National Agriculture Imagery Program (NAIP);
USDA_FSA_APFO Aerial Photography Field Office

Site: <http://datagateway.nrcs.usda.gov/>

Data File: NAIP_1-1_2n_s_co123_2006_1.sid



Legend

- City
- Top 100 Gas Well (EIA)
- Top 100 Oil Well (EIA)
- Hydrography
 - Canal Ditch
 - Canal Ditch: Canal Ditch Typ= Aqueduct
 - Stream/River
 - Stream/River: Hydrographic Category = Intermittent
 - Stream/River: Hydrographic Category = Perennial
- 5 Mile buffer
- Townships
- Sections

Distribution

Download: Yes

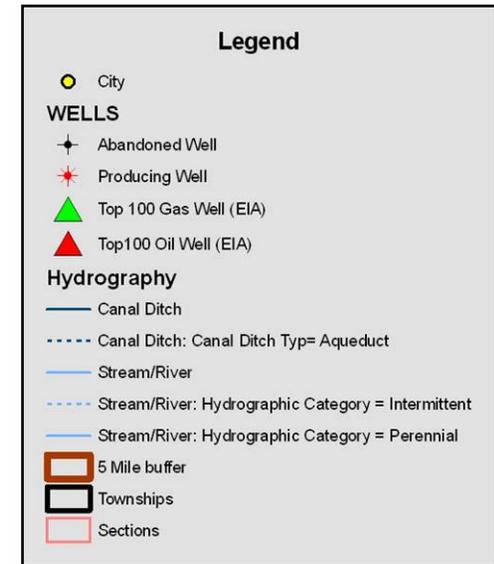
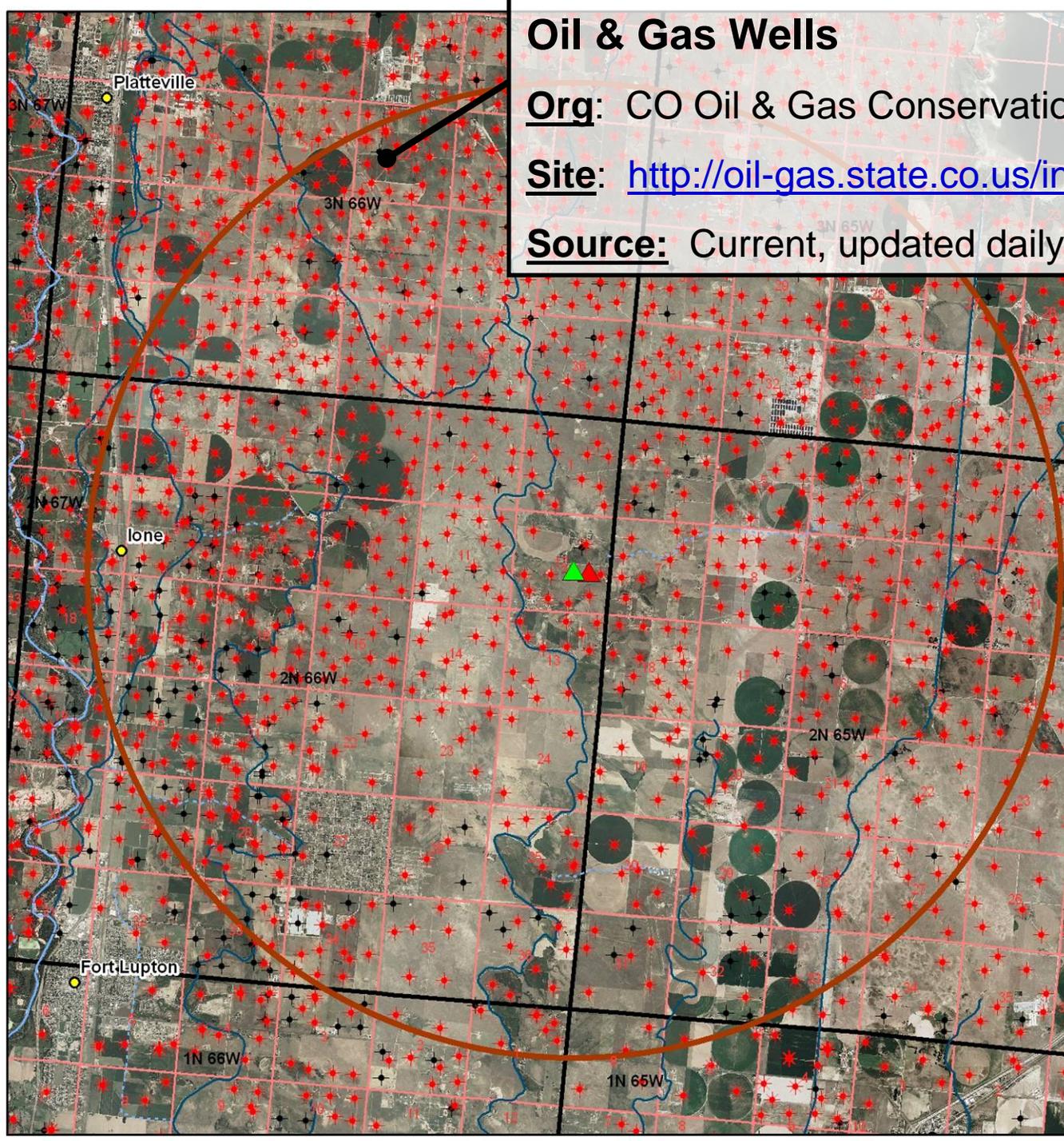
Oil & Gas Wells

Website Easy to
Navigate

Org: CO Oil & Gas Conservation Commission

Site: <http://oil-gas.state.co.us/infosys/Maps/gismain.cfm>

Source: Current, updated daily



Distribution

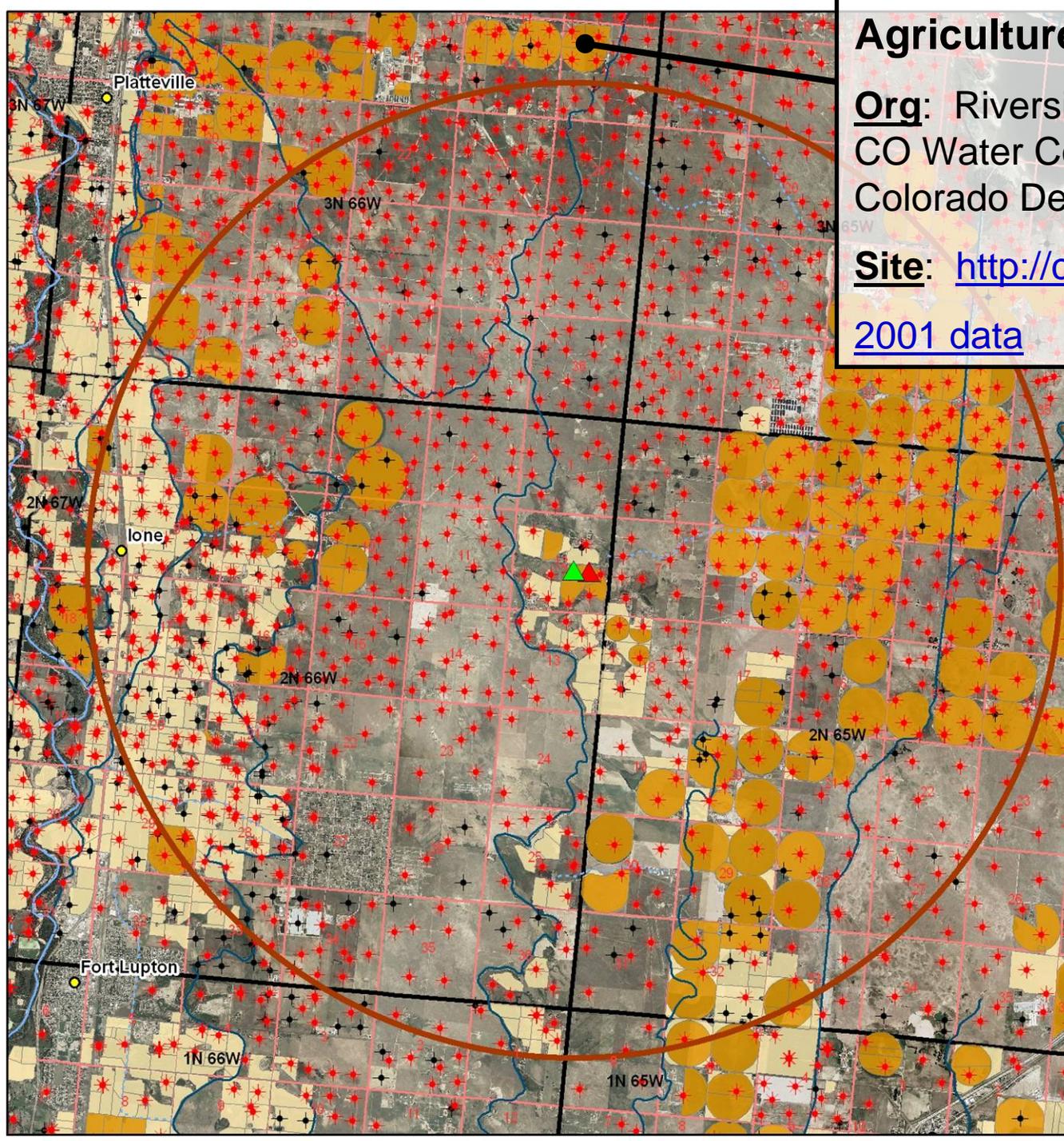
Download: Yes

Agriculture

Org: Riverside Technology, inc for
CO Water Conservation Board
Colorado Decision Support System

Site: <http://cdss.state.co.us>

2001 data



Legend

WELLS

- Abandoned Well
- Producing Well
- Top 100 Gas Well (EIA)
- Top 100 Oil Well (EIA)

Hydrography

- Canal Ditch
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- Stream/River
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- Stream/River: Hydrographic Category = Perennial

5 Mile buffer

Townships

Sections

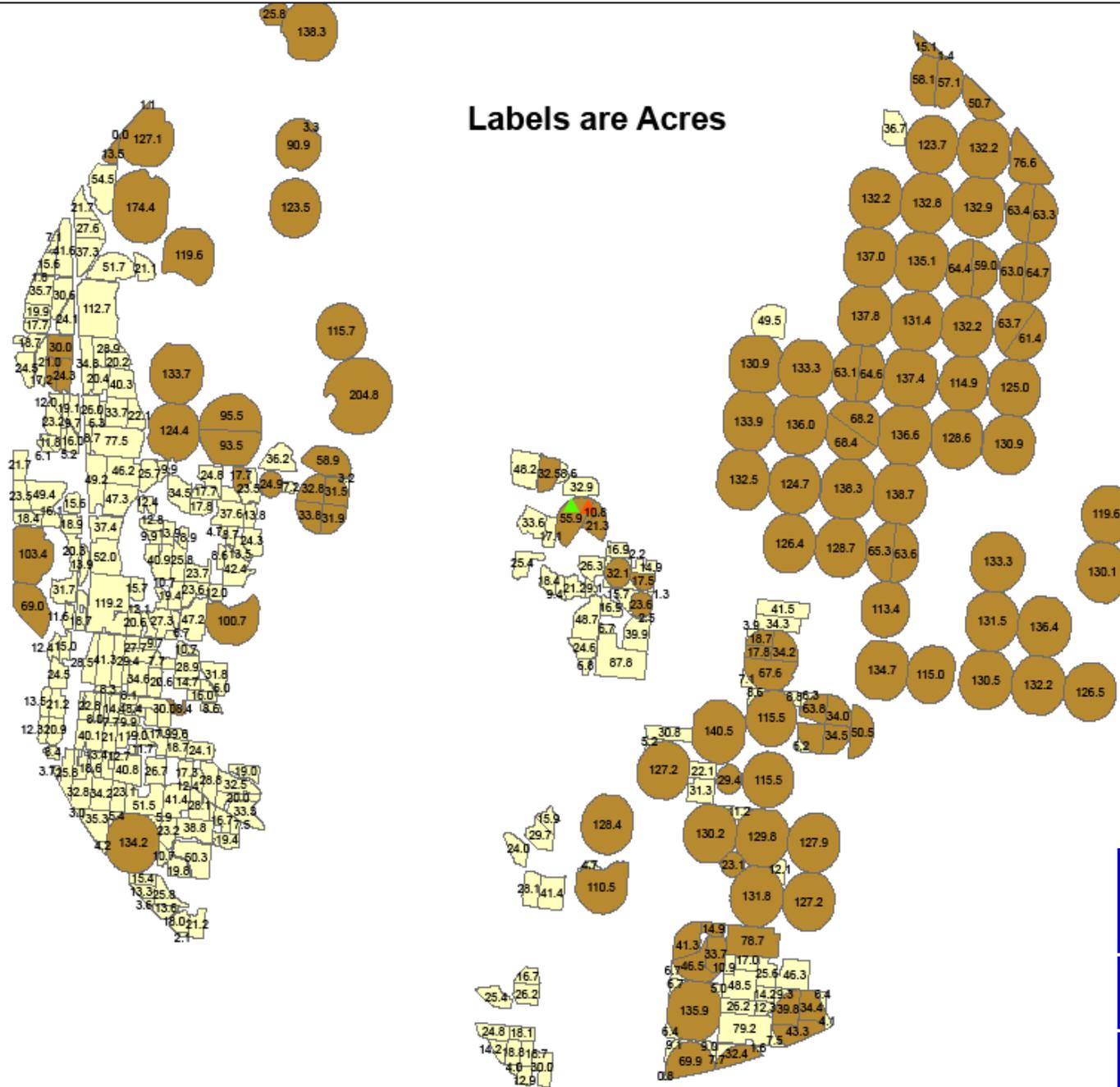
Irrigation Type

- FLOOD
- SPRINKLER

Distribution

Download: Yes

Labels are Acres



Legend

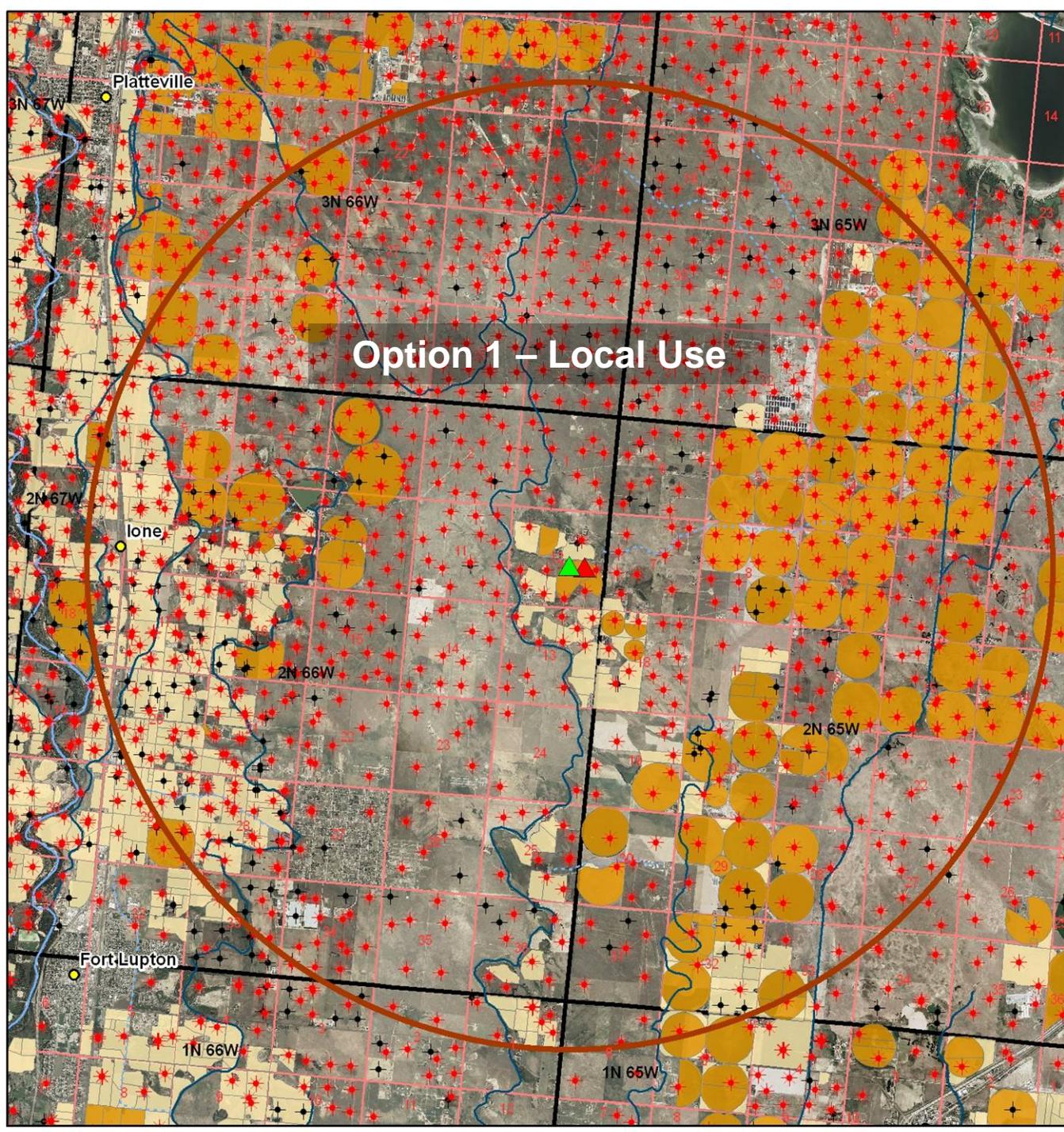
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- ▲ EIA_Top100oil_20

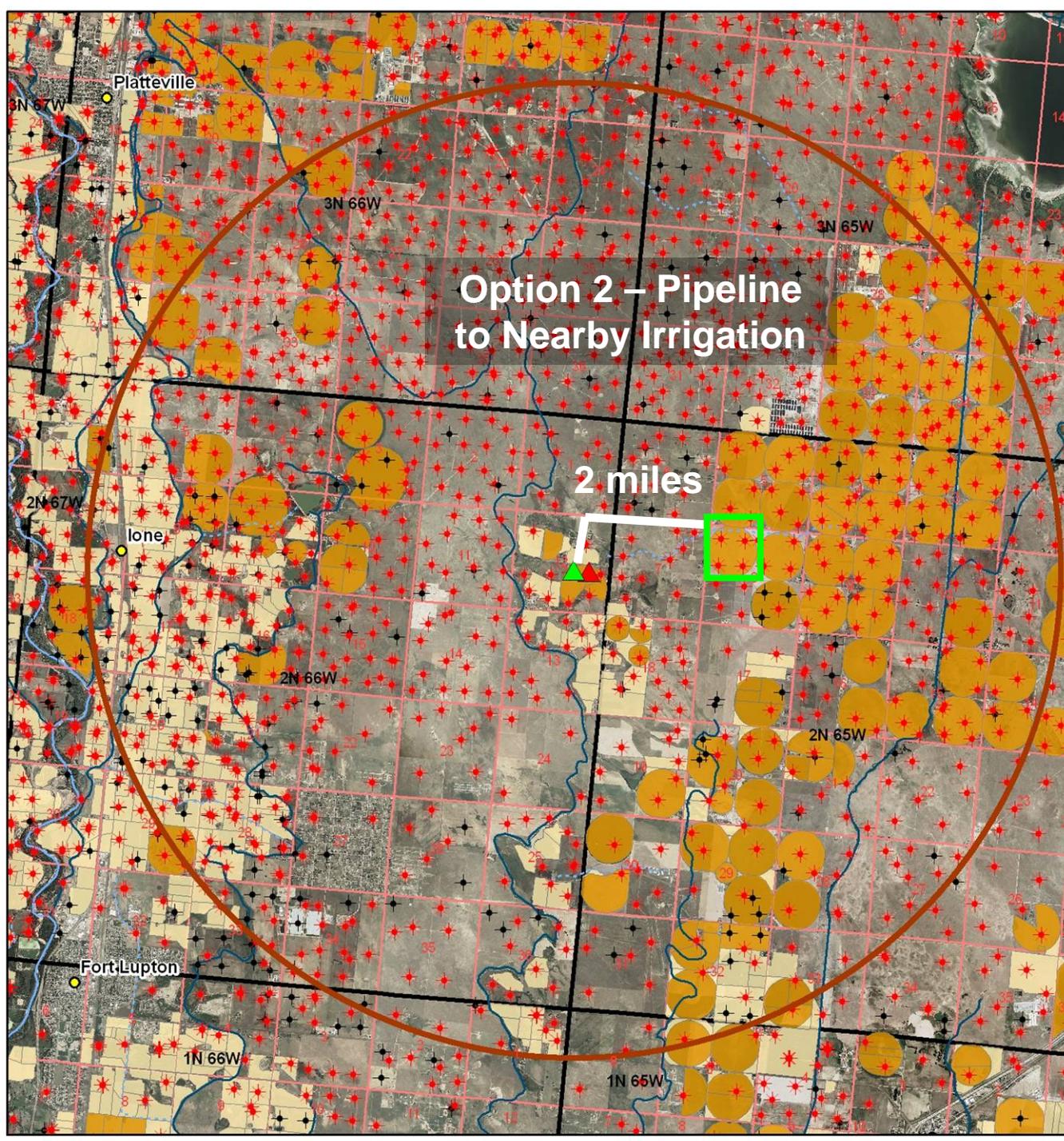
CO_Irrigated_Clip

IRRIG_TYPE

- FLOOD
- SPRINKLER

Irrigation Type	Area (Acres)
Flood	5565
Sprinkler	10,809





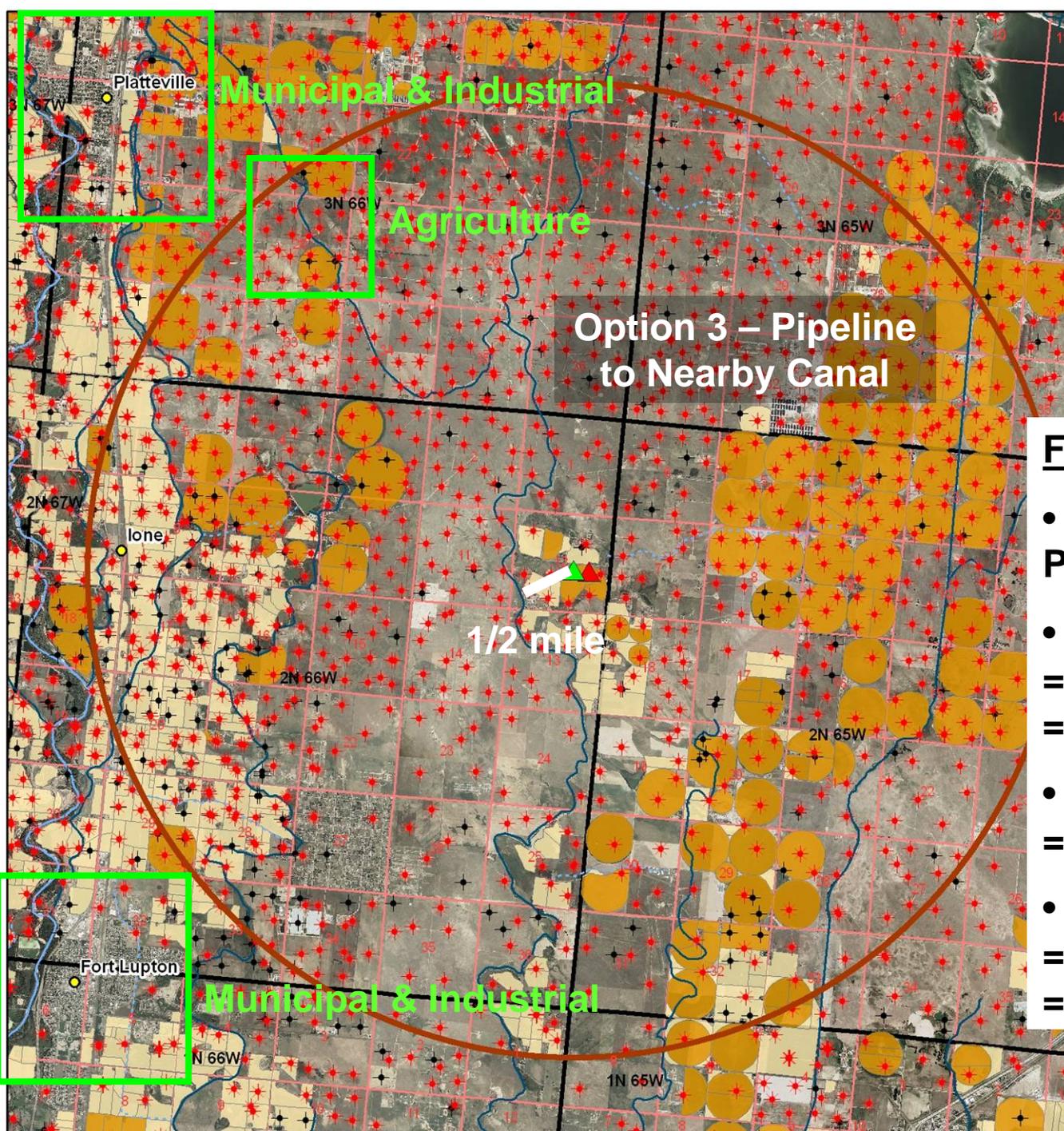
Within Square

- Area = 125 acres
- 700 gpm per circle

Single Well

- Flow = 20 gpm
- Need combined well system of 35 wells
 - “+” wells w/ treatment
 - “-” wells w/ water storage

Crop	Rate (in.)
Wheat	26
Corn for Grain	39
Alfalfa	54

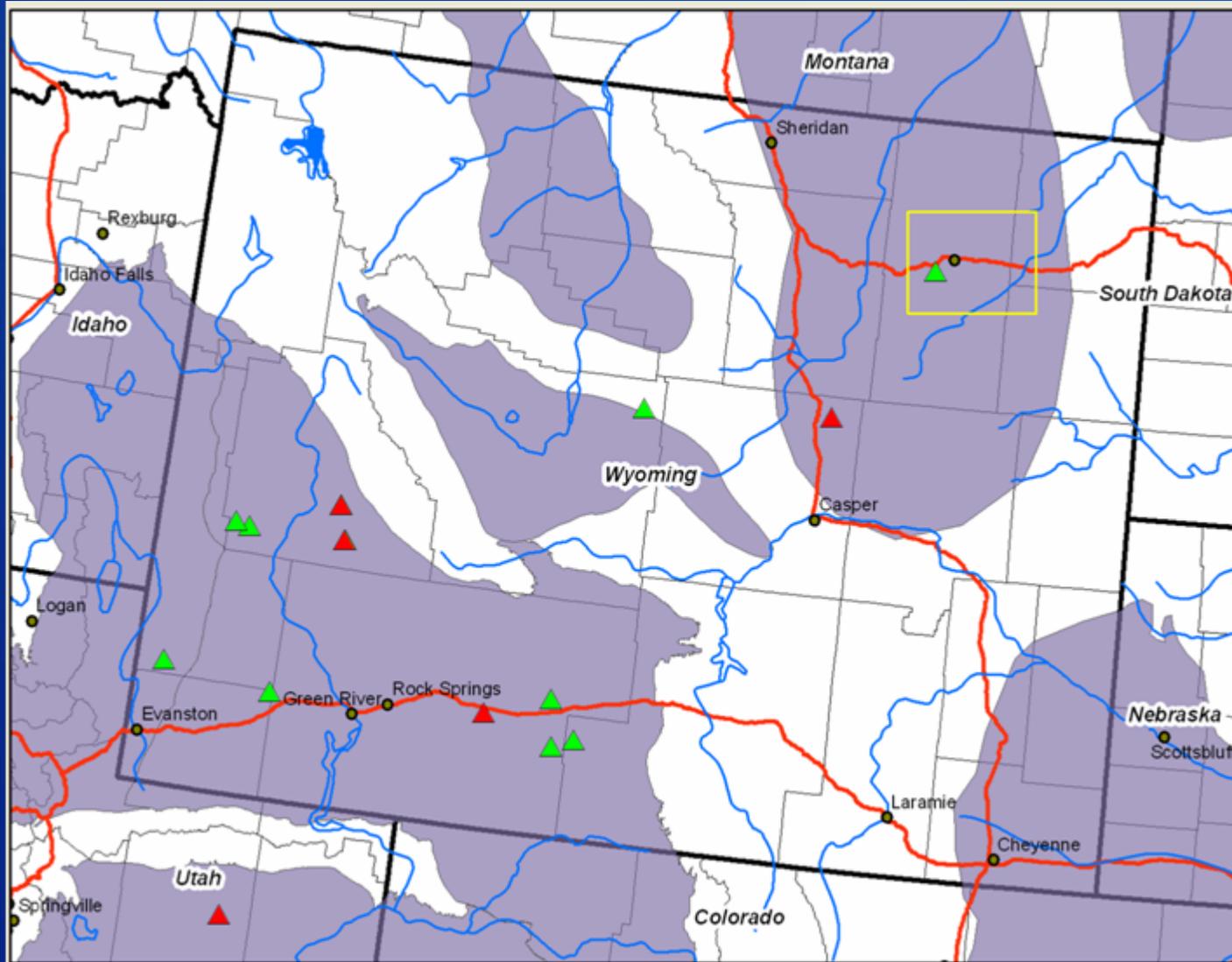


Option 3 – Pipeline to Nearby Canal

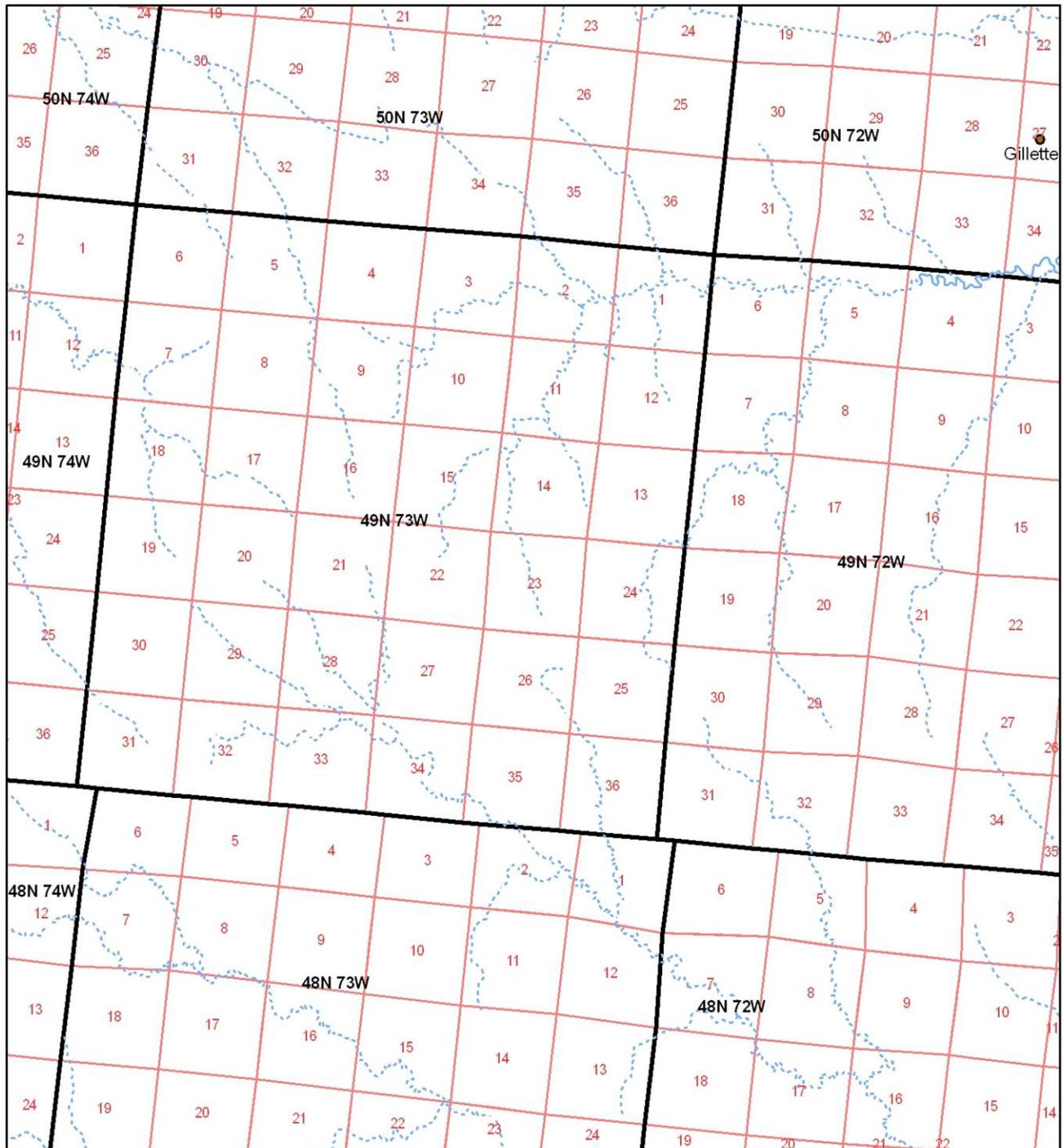
Fort Lupton

- **Treated Water Production = 4.3 MGD**
- **Raw Water Cost = \$1 mil per year = \$1.67 per 1000 gal**
- **Treatment Cost = \$0.50 per 1000 gal**
- **Total Water Cost = \$2.17 per 1000 gal = \$0.10 per barrel**

Powder River Basin



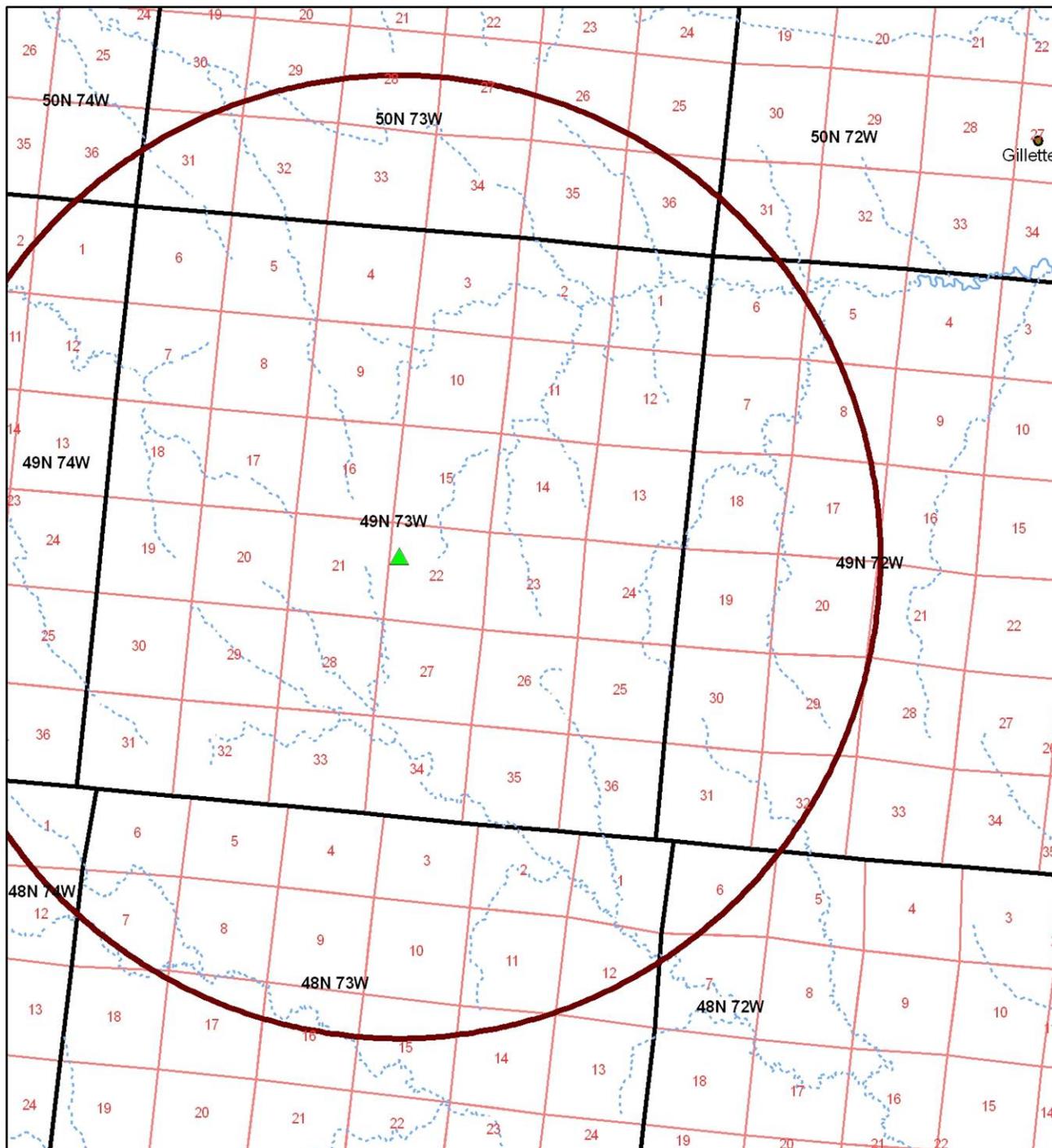
RECLAMATION



Gillette

Legend

- Cities
- Hydrography**
- Canal Ditch
- - - Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- · - · - Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial
- ▭ Townships
- ▭ Sections



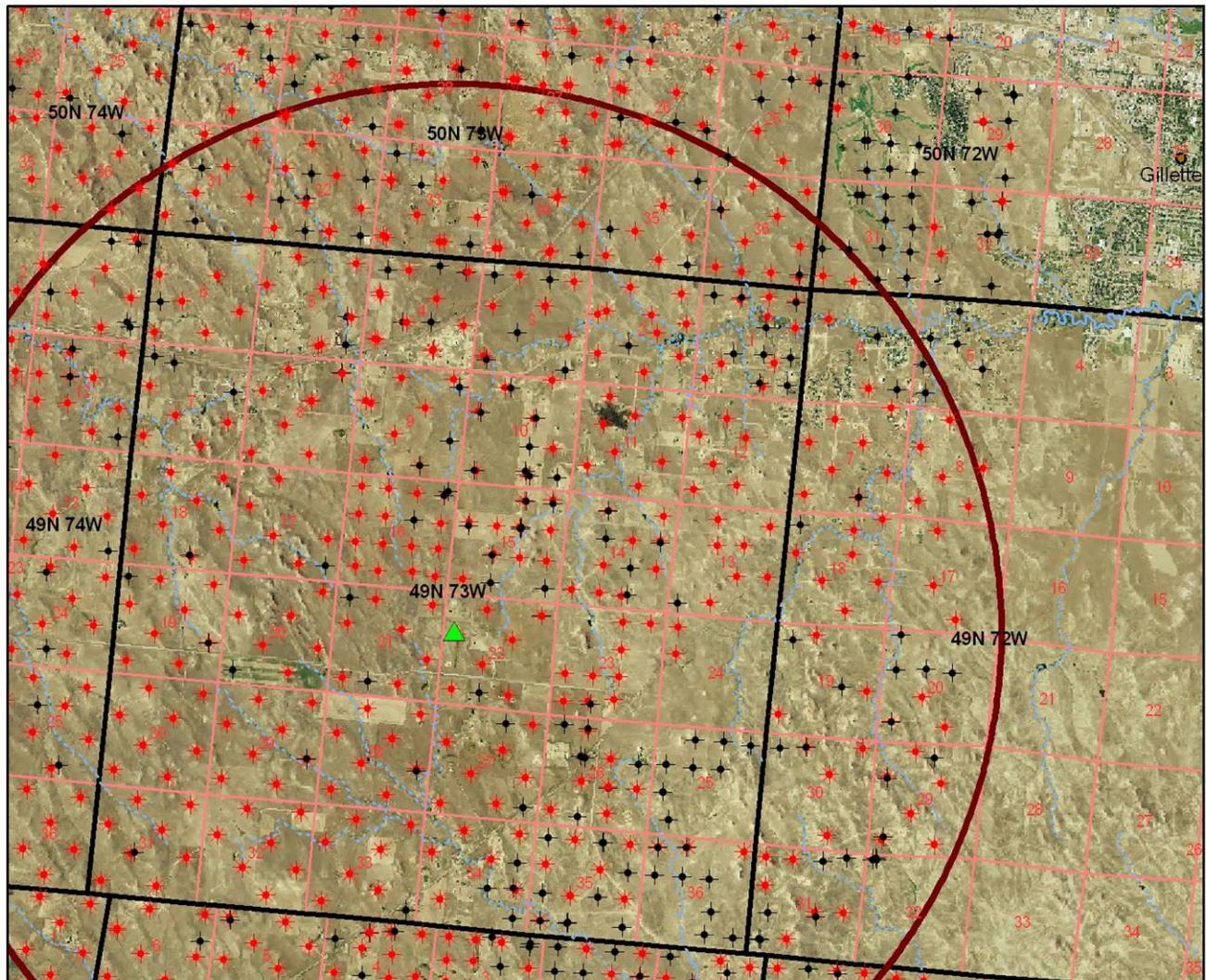
Legend

- Cities
- ▲ Top100 Gas 2005 (EIA)
- ▲ Top100 Oil 2005 (EIA)
- ◻ 5 mile buffer

Hydrography

- Canal Ditch
- - - Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- · - · - Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial

- ◻ Townships
- ◻ Sections



Legend

- Cities
- ▲ Top100 Gas 2005 (EIA)
- ▲ Top100 Oil 2005 (EIA)

Wells

- ★ Producing Well
- ★ Abandoned Well
- ▭ 5 mile buffer

Hydrography

- Canal Ditch
- - - Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
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- ▭ Townships
- ▭ Sections

Oil & Gas Wells

Org: WY Oil & Gas Conservation Commission

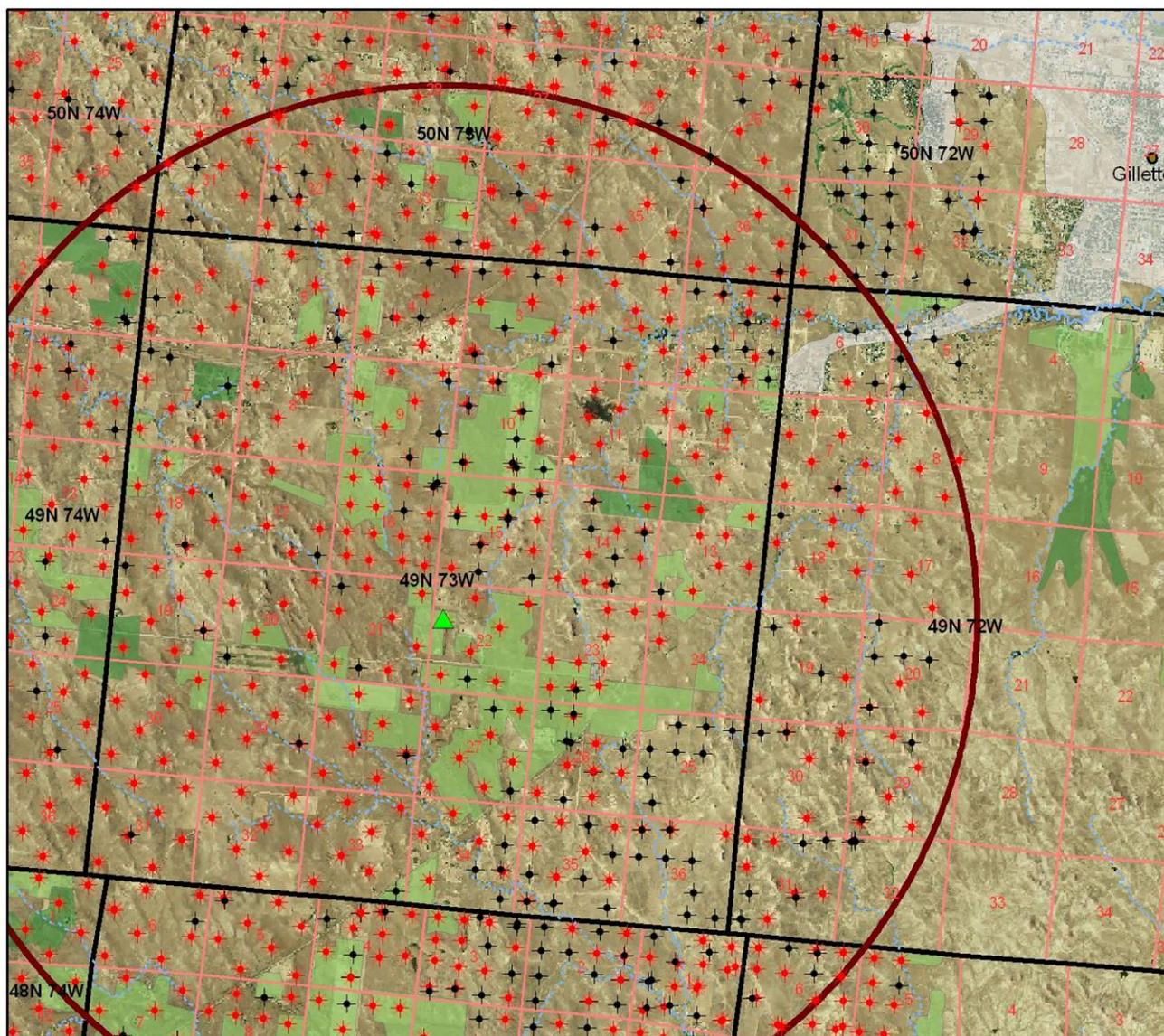
Site: <http://wogccms.state.wy.us/>

Source: 2005 (More recent data is restricted)

Difficult to
Obtain Data

Distribution

Download: Yes



Legend

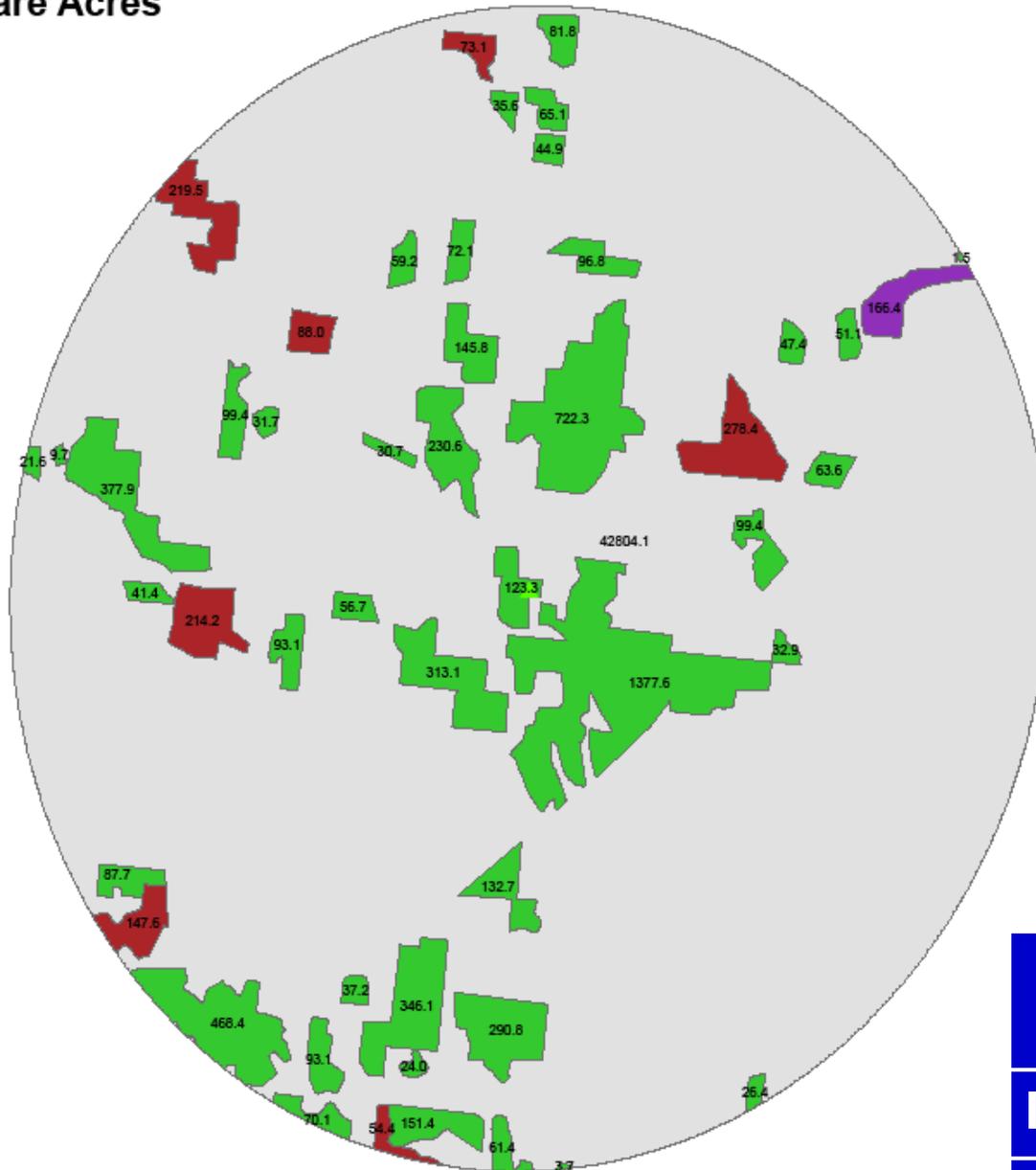
- Cities
 - ▲ Top100 Gas 2005 (EIA)
 - ▲ Top100 Oil 2005 (EIA)
- Wells**
- ★ Producing Well
 - ✦ Abandoned Well
 - ▭ 5 mile buffer
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 - Stream/River: Hydrographic Category = Perennial
- Townships**
- ▭ Townships
- Sections**
- ▭ Sections
- Irrigation Type**
- Irrigated Cropland
 - Non-irrigated Cropland
 - Urban/Built up

Agriculture

Org: Wyoming Water Resources Center

Site: www.sdvc.uwyo.edu/clearinghouse/gw_vuln.html

Labels are Acres



Legend

▲ EIA_Top100gas_

▲ EIA_Top100oil_2

WY_Irrigated_Clip

DESCRIBE

■ Irrigated

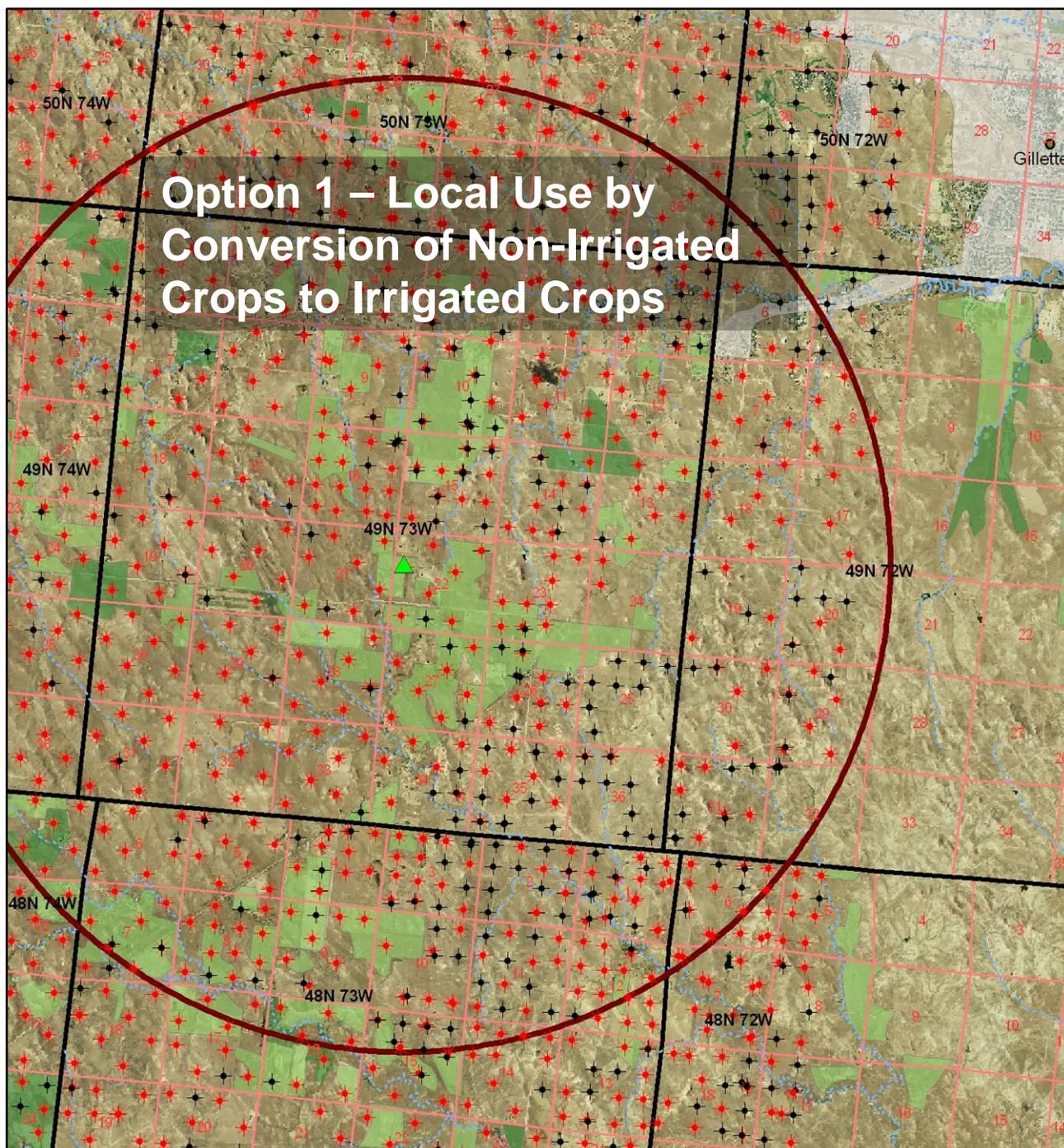
■ na

■ Non - Irrigated

■ Urban

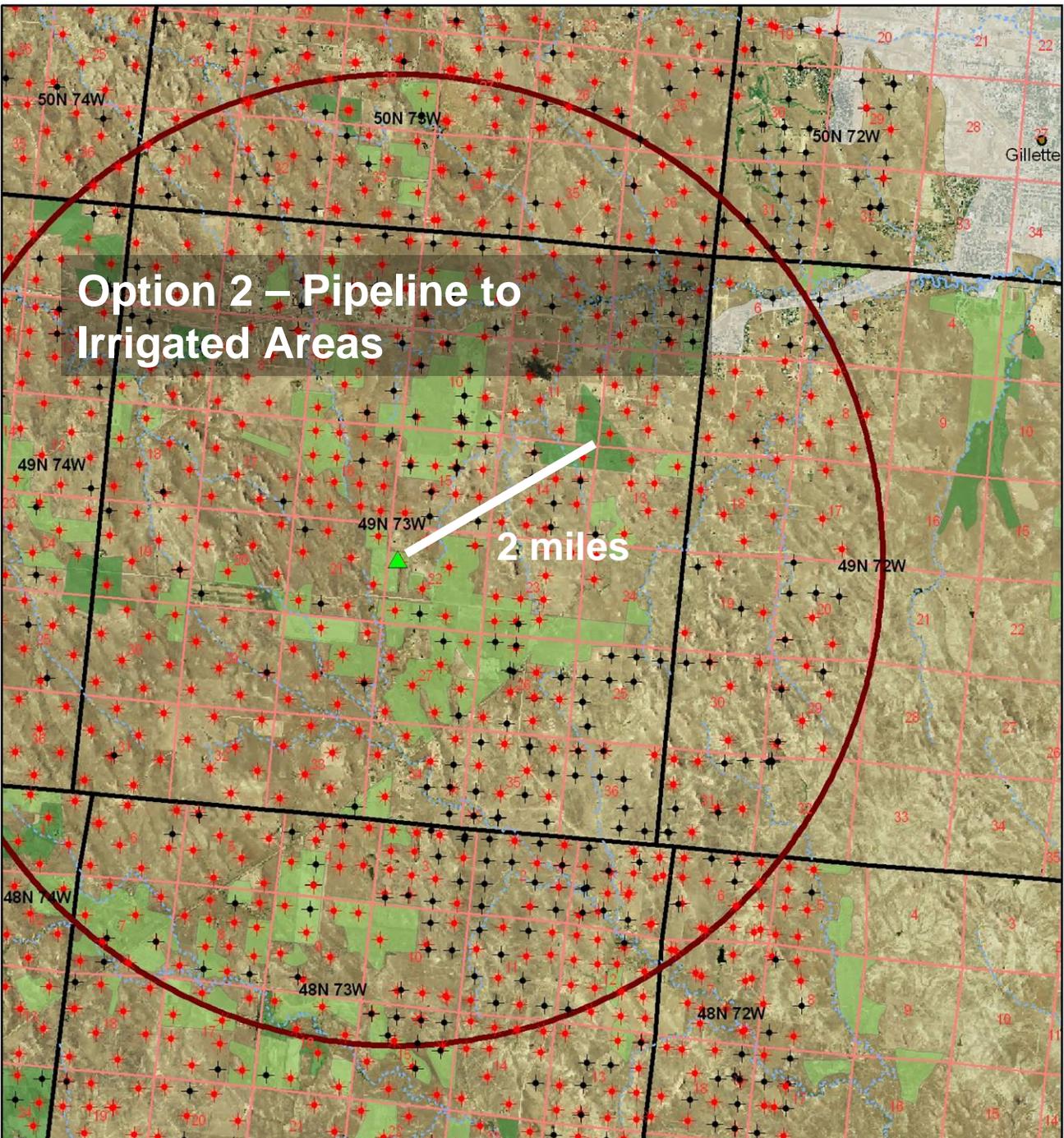
Crop	Area (Acres)
Irrigated	1075
Non-Irrigated	6219

Option 1 – Local Use by Conversion of Non-Irrigated Crops to Irrigated Crops



Legend

- Cities
 - ▲ Top100 Gas 2005 (EIA)
 - ▲ Top100 Oil 2005 (EIA)
- Wells**
- ★ Producing Well
 - ★ Abandoned Well
 - 5 mile buffer
- Hydrography**
- Canal Ditch
 - - - Canal Ditch: Canal Ditch Typ= Aqueduct
 - Stream/River
 - - - Stream/River: Hydrographic Category = Intermittent
 - Stream/River: Hydrographic Category = Perennial
- Townships**
- Townships
- Sections**
- Sections
- Irrigation Type**
- Irrigated Cropland
 - Non-irrigated Cropland
 - Urban/Built up



Option 2 – Pipeline to Irrigated Areas

2 miles

Legend

- Cities
- ▲ Top100 Gas 2005 (EIA)
- ▲ Top100 Oil 2005 (EIA)

Wells

- ★ Producing Well
- ★ Abandoned Well

5 mile buffer

Hydrography

- Canal Ditch
- - - Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- - - Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial

Townships

Sections

Irrigation Type

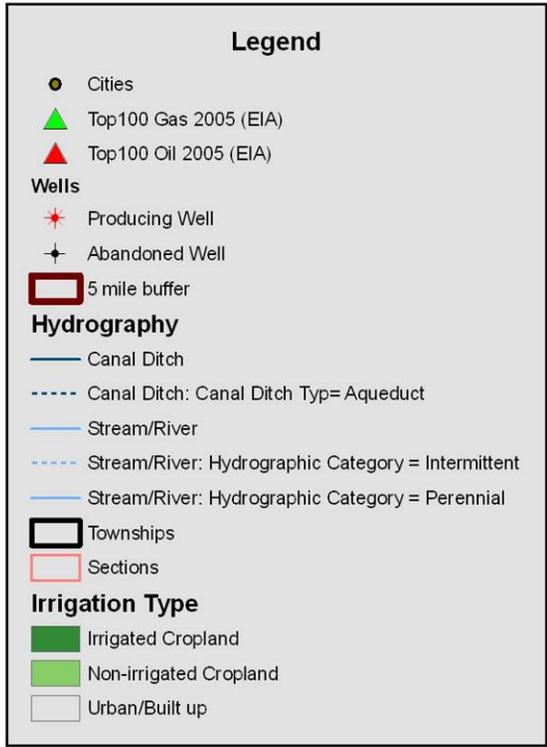
- Irrigated Cropland
- Non-irrigated Cropland
- Urban/Built up

Option 3 – Municipal & Industrial

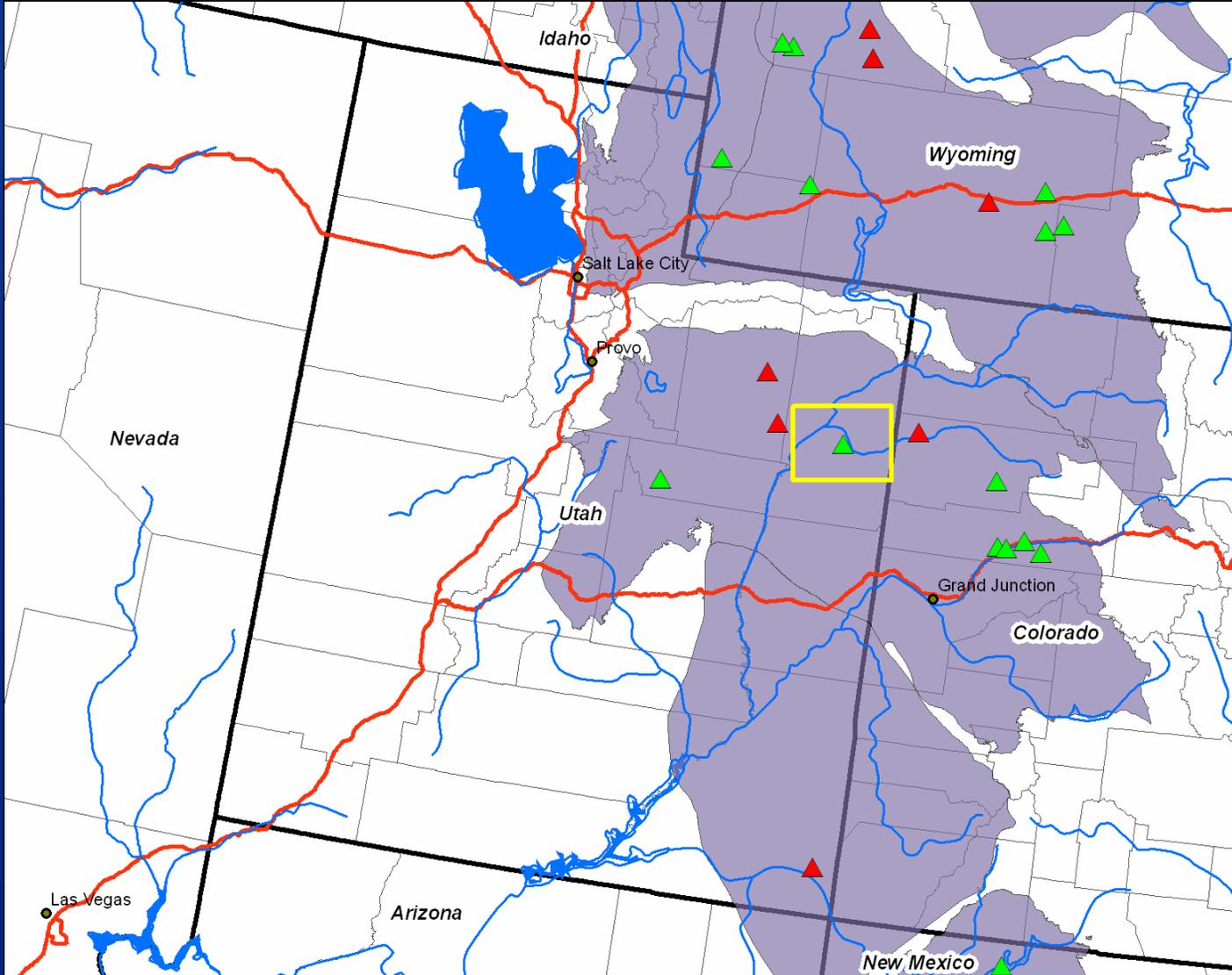
Pipeline
4 miles

Direct Discharge to
approved Drainage

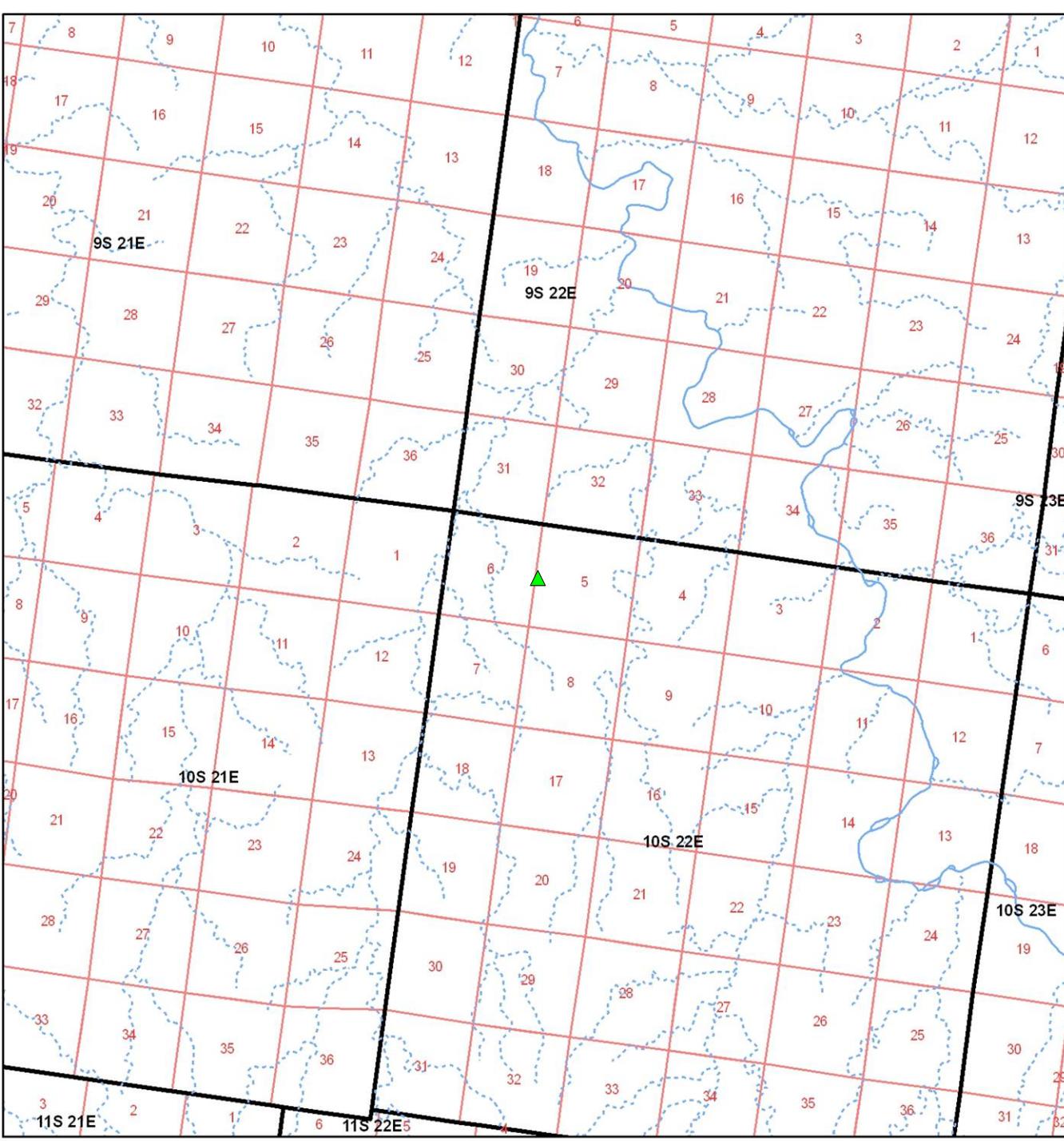
Surface Discharge
Groundwater Injection



Uinta-Piceance Basin



RECLAMATION



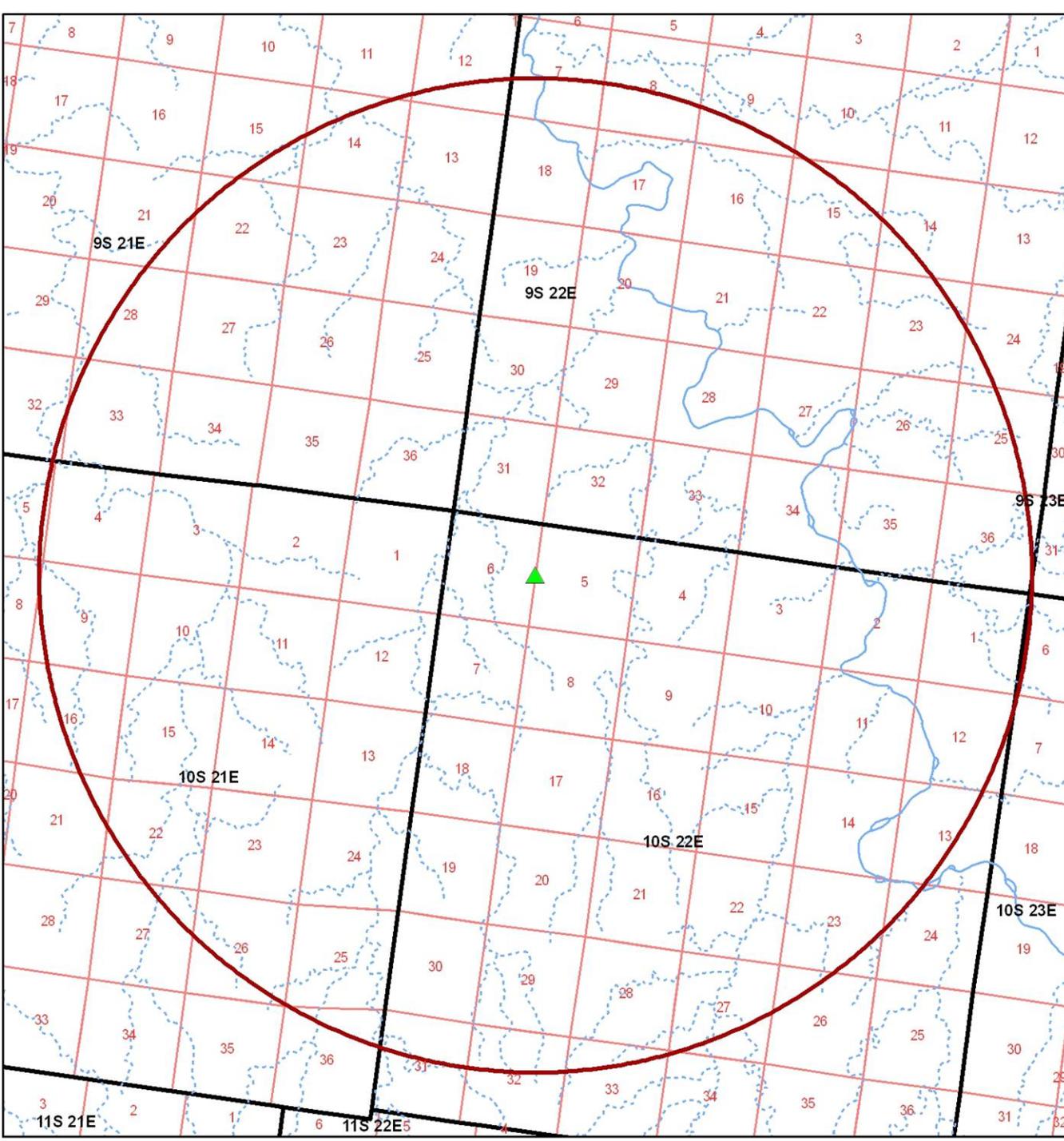
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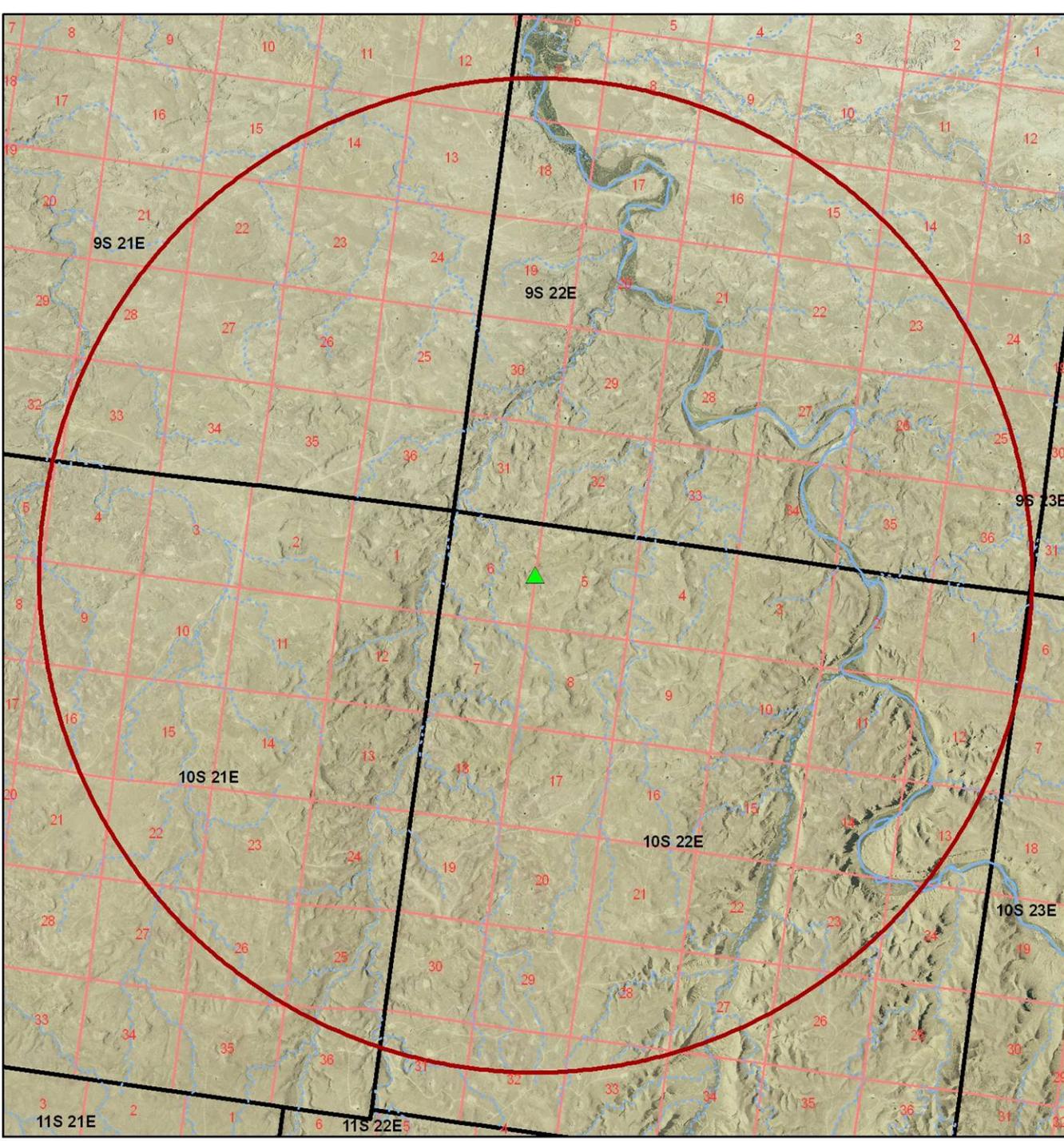
Hydrography

- Canal Ditch
- - - Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- · - · - Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial

▭ Townships

▭ Sections





Legend

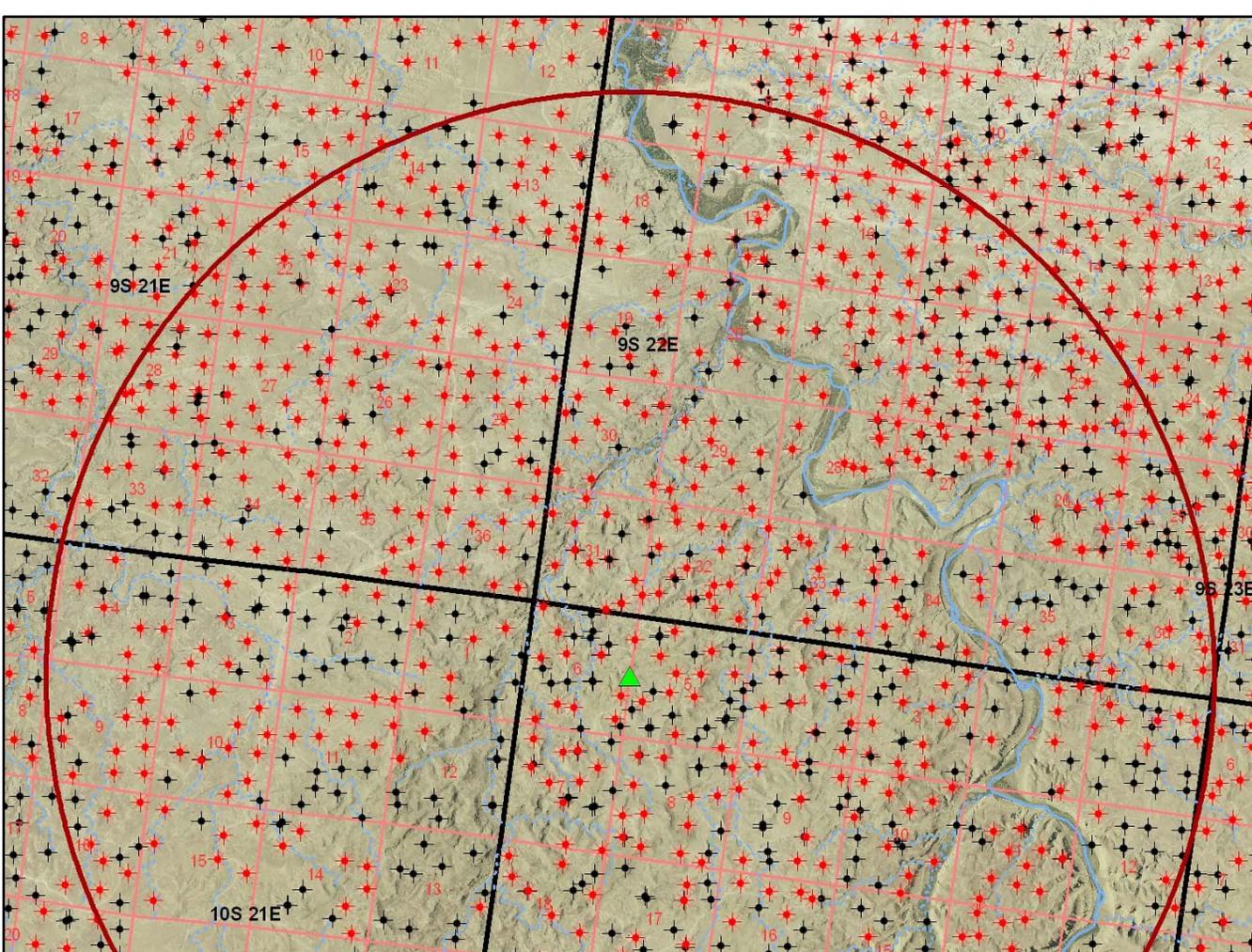
- 5 mile Buffer
- Top 100 Gas 2005 (EIA)
- Top 100 Oil 2005 (EIA)

Hydrography

- Canal Ditch
- Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial

Townships

Sections



Legend

5 mile Buffer

Wells

STATUS

- Abandoned Well
- Producing Well
- Top 100 Gas 2005 (EIA)
- Top 100 Oil 2005 (EIA)

Hydrography

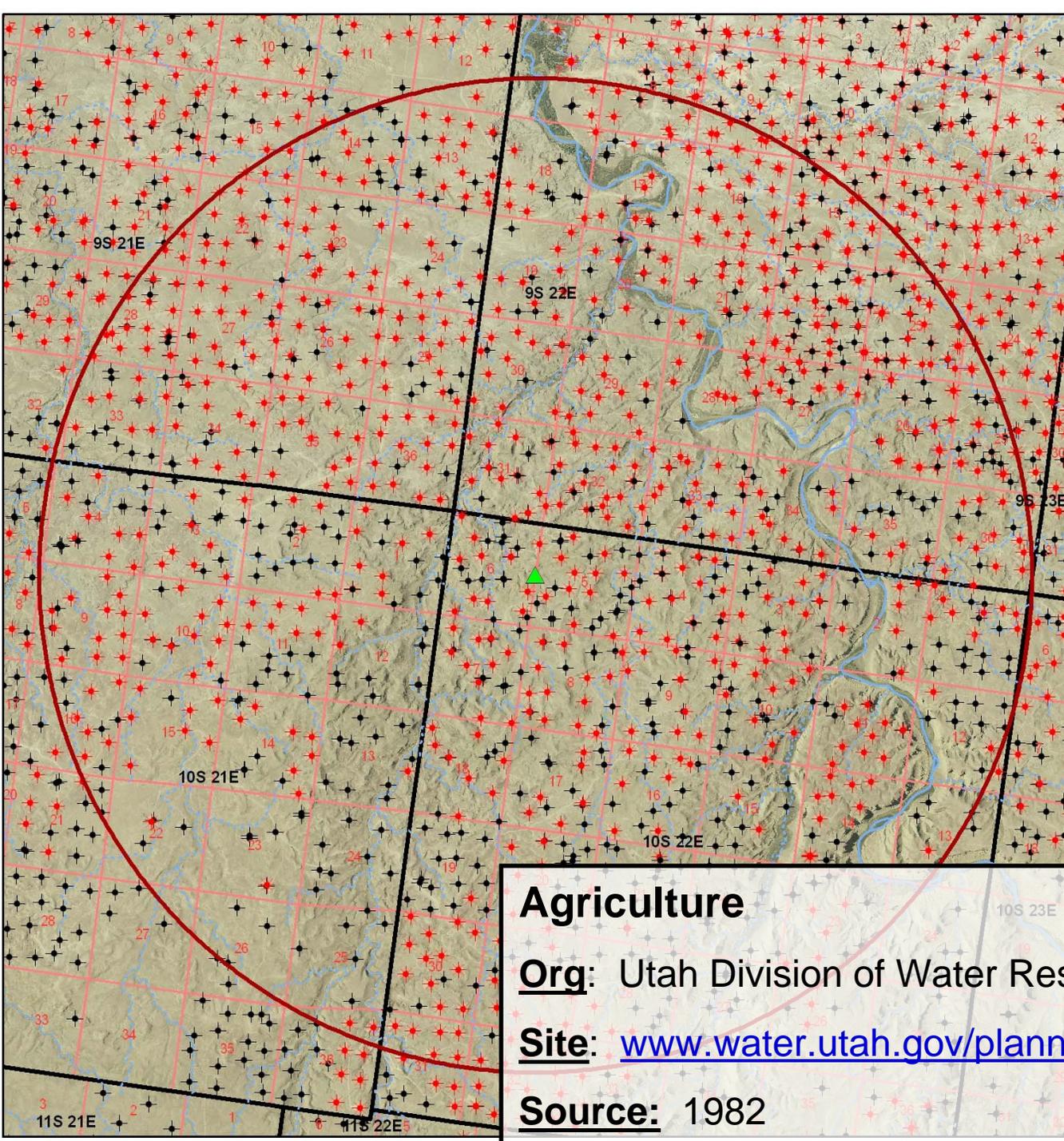
- Canal Ditch
- Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial
- Townships
- Sections

Oil & Gas Wells

Org: Utah Department of Natural Resources
Oil Gas and Mining Division.

Site: http://agrc.utah.gov/agrc_sgid/sgidlib/SGID_U100_DNROilGasWells.htm

Source: Updated daily (<http://ogm.utah.gov>)



Legend

- 5 mile Buffer

Wells

STATUS

- Abandoned Well
- Producing Well
- Top 100 Gas 2005 (EIA)
- Top 100 Oil 2005 (EIA)

Hydrography

- Canal Ditch
- Canal Ditch: Canal Ditch Typ= Aqueduct
- Stream/River
- Stream/River: Hydrographic Category = Intermittent
- Stream/River: Hydrographic Category = Perennial

Townships

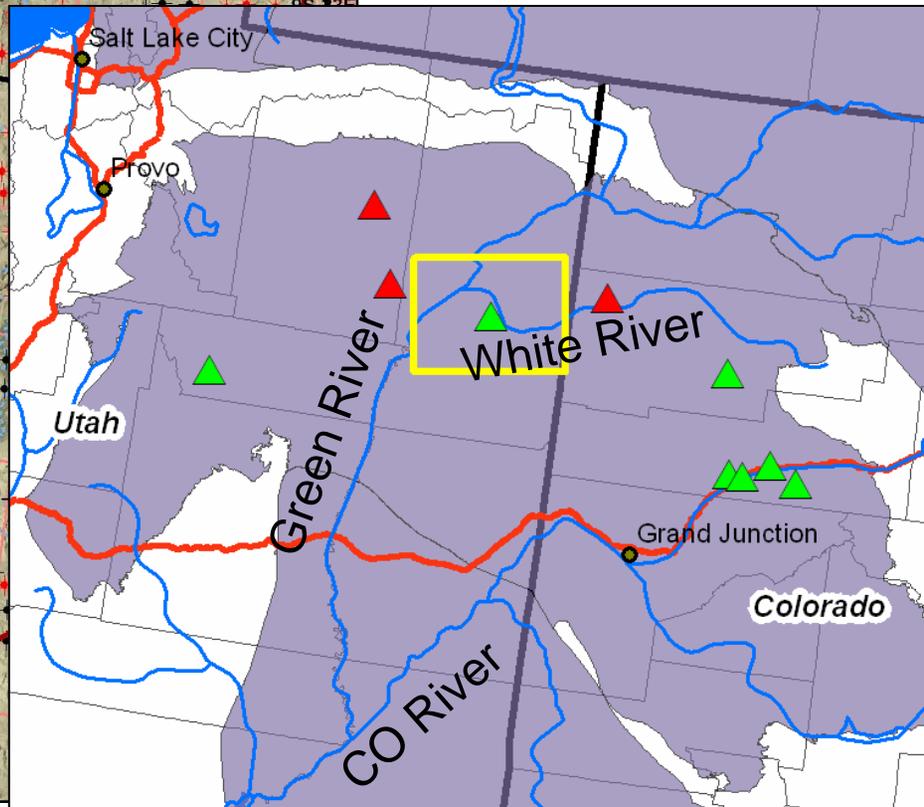
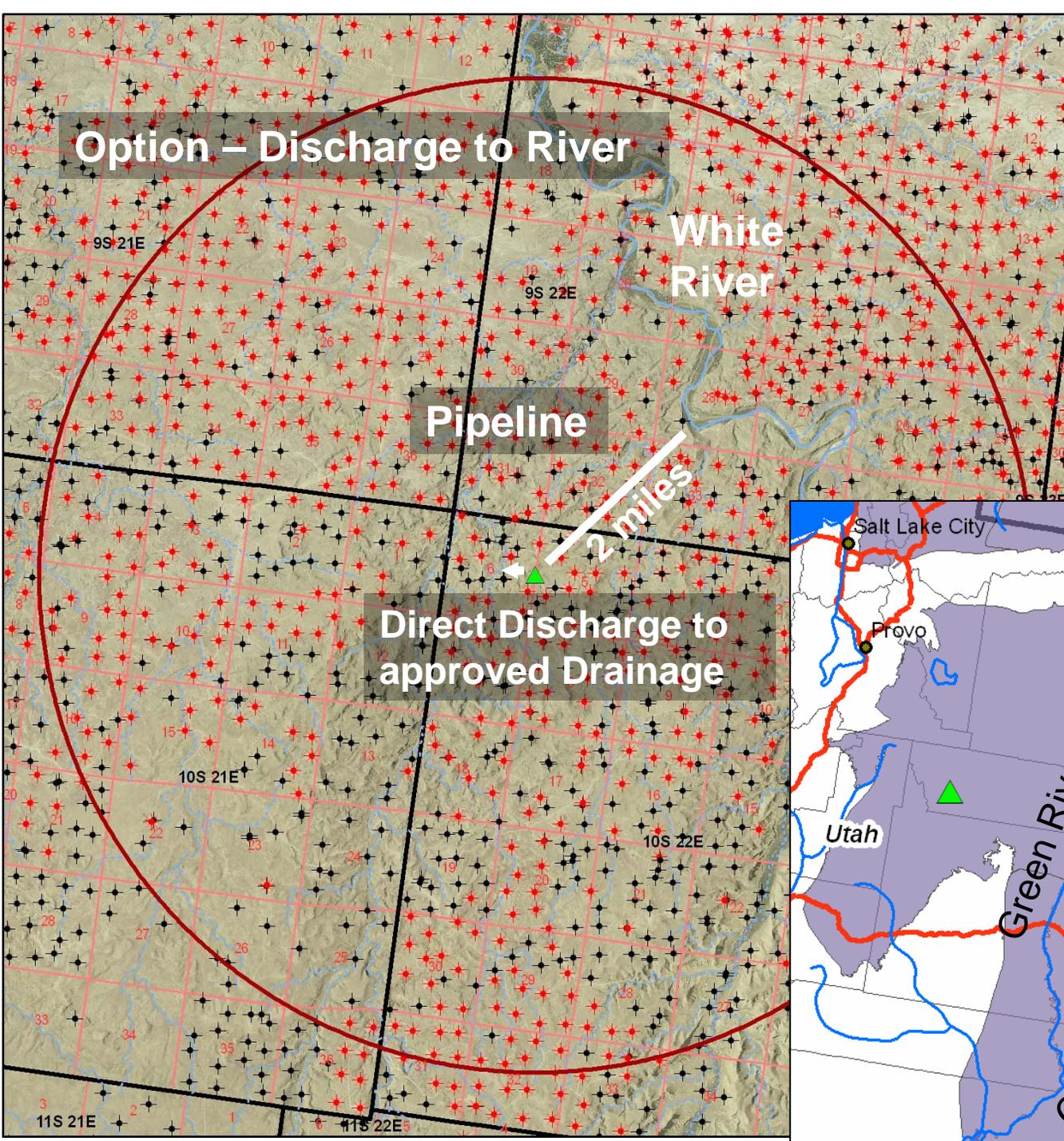
Sections

Agriculture

Org: Utah Division of Water Resources

Site: www.water.utah.gov/planning/landuse/index.html

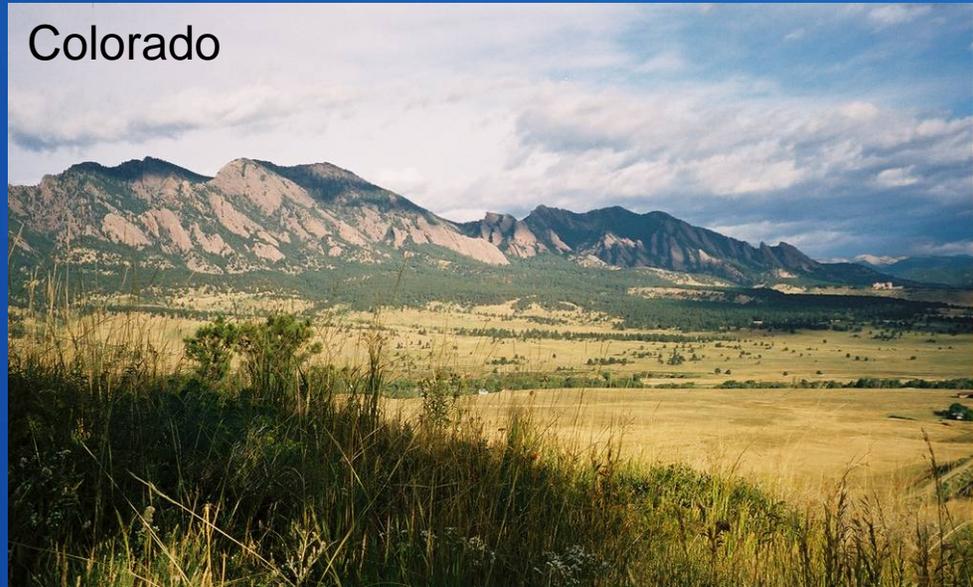
Source: 1982



Thank You



Colorado



Geographical Assessment of Potential for Beneficial Use of Produced Water

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RECLAMATION

Presented @ 2007 IPEC Conference - Houston

Wednesday – 11/07/07

Session: Beneficial Re-use of Produced Water

Time: 10:05 – 10:30 am

Presentation Length: 25 minutes (5th presentation)