



**Florida Department of Environmental Protection**

# **Salinity Network Workgroup**

**A Workgroup of the Florida Water  
Resources Monitoring Council**

**Session L8**

**(National Monitoring Conference - Tampa, FL)**

**May 2-6, 2016**

Chair: Rick Copeland, FL Dept. Environmental Protection





# Topics

- Why have a Florida Salinity Network Workgroup (SNW)?
- What is the SNW?
- What are Current SNW Priorities?

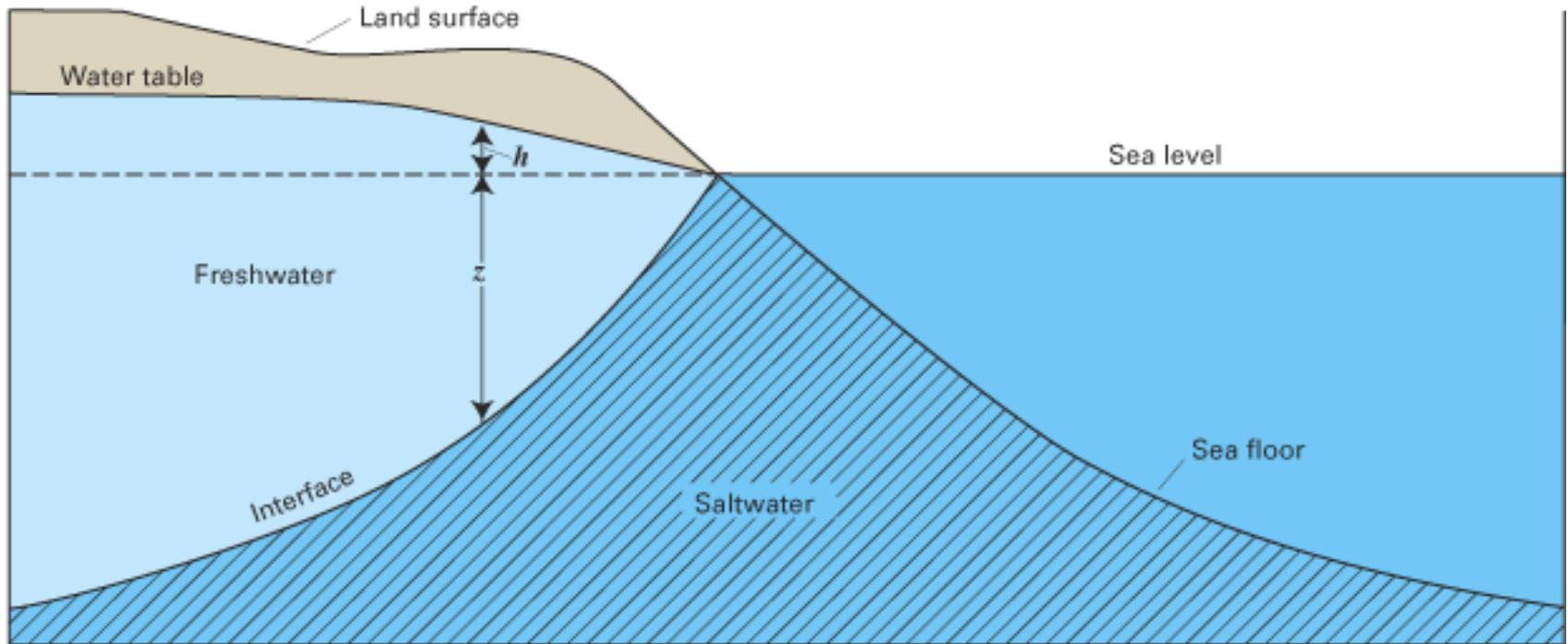


# Why Have a Salinity Network?

- Since 1990s, Florida has had below normal rainfall and less recharge
- Water Levels in DEP Trend Wells generally decreased; Spring discharge generally decreased
- Salinity indicator concentrations generally increased
  - Na, Cl, TDS, SC, and SO<sub>4</sub>

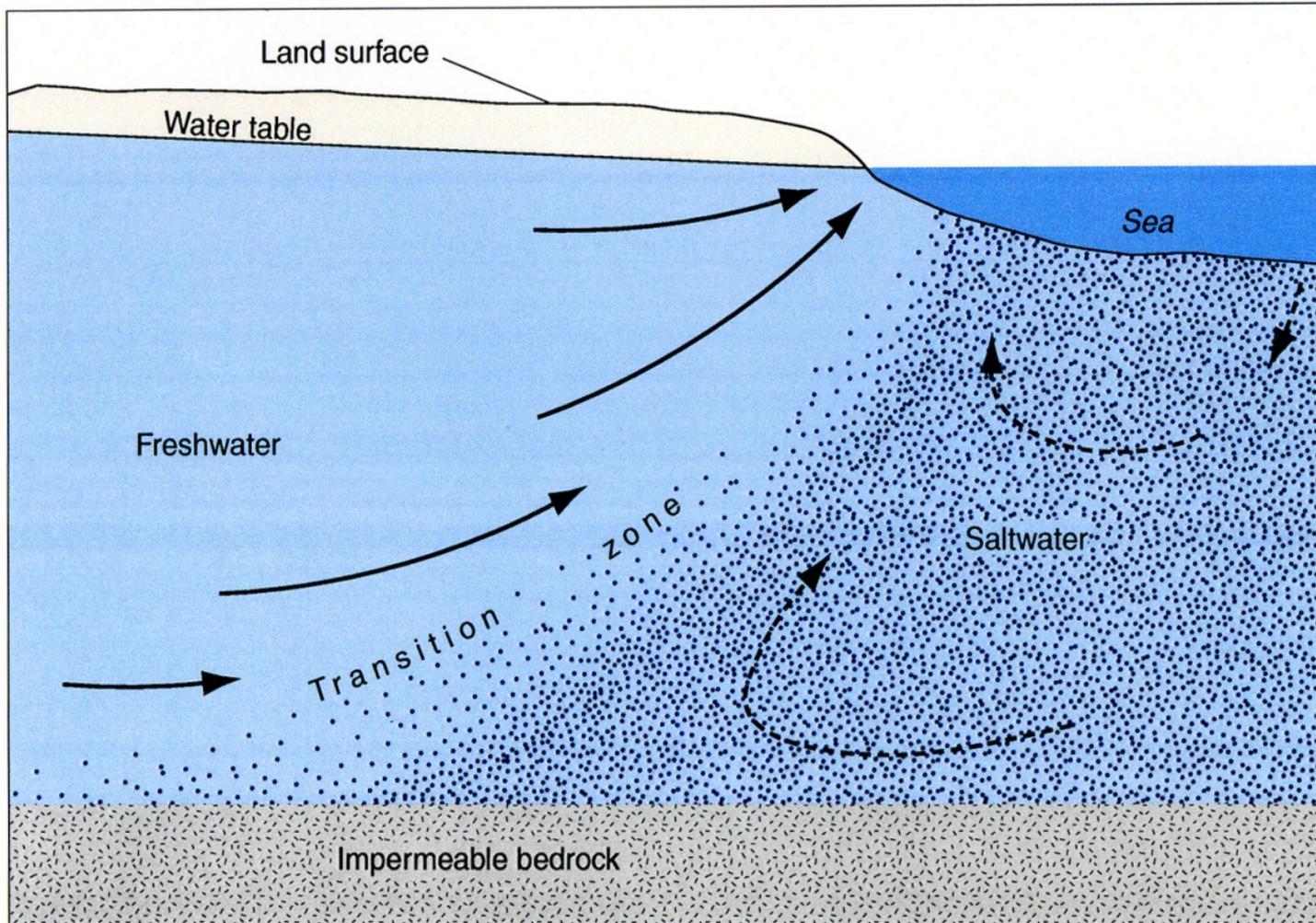


# Gyben-Herzberg Principle





# Saltwater Transition Zone

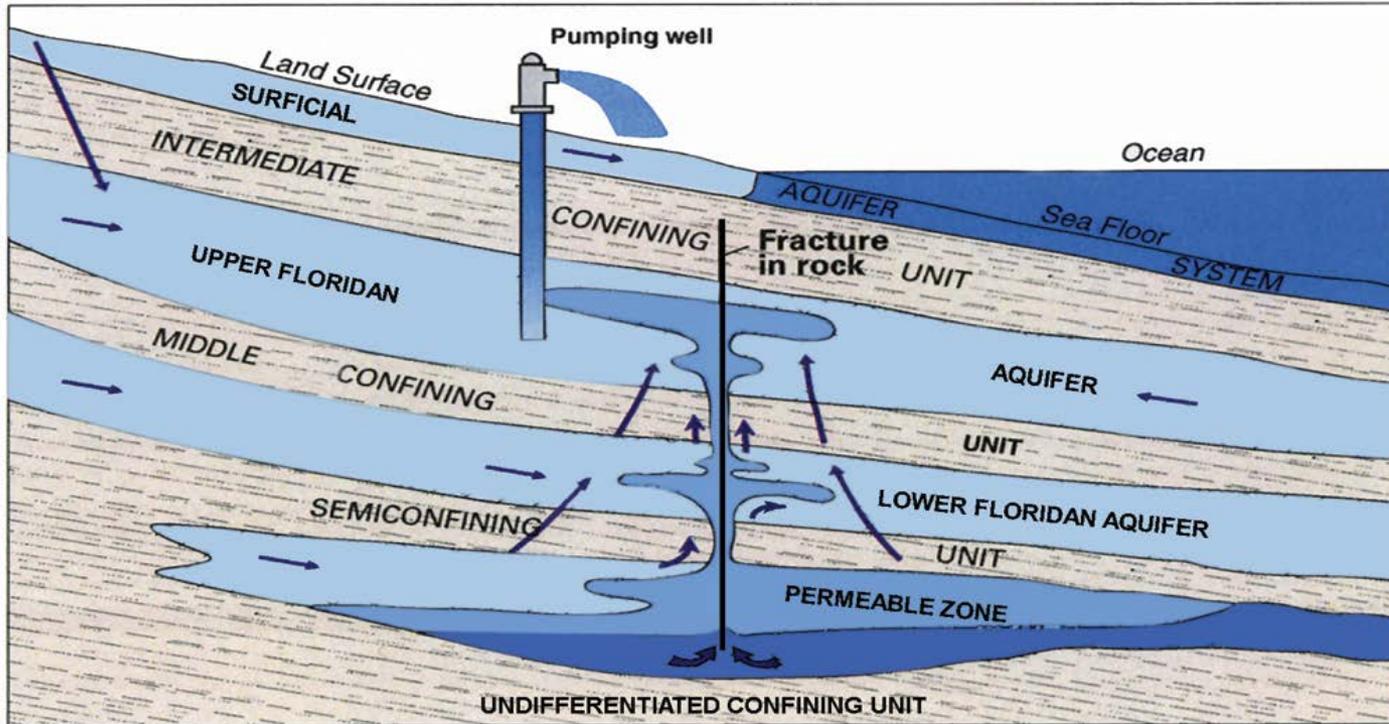


Not to scale

Modified from Cooper (1964)



# Generalized Hydrostratigraphy



Modified from Krause and Randolph (1989) and Spechler (1994)

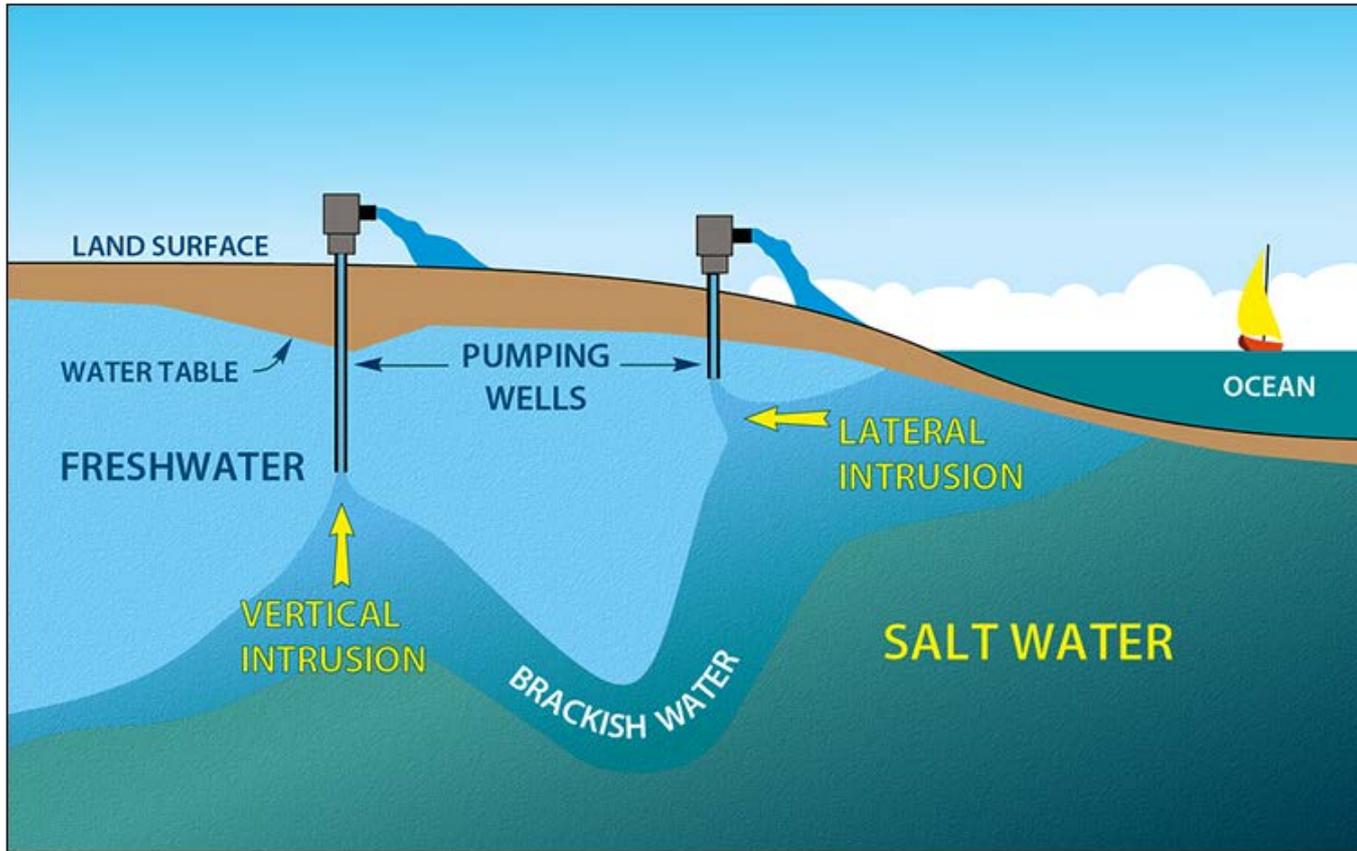
## EXPLANATION

-  Brackish water
-  Saltwater
-  Freshwater

 Direction of ground-water flow



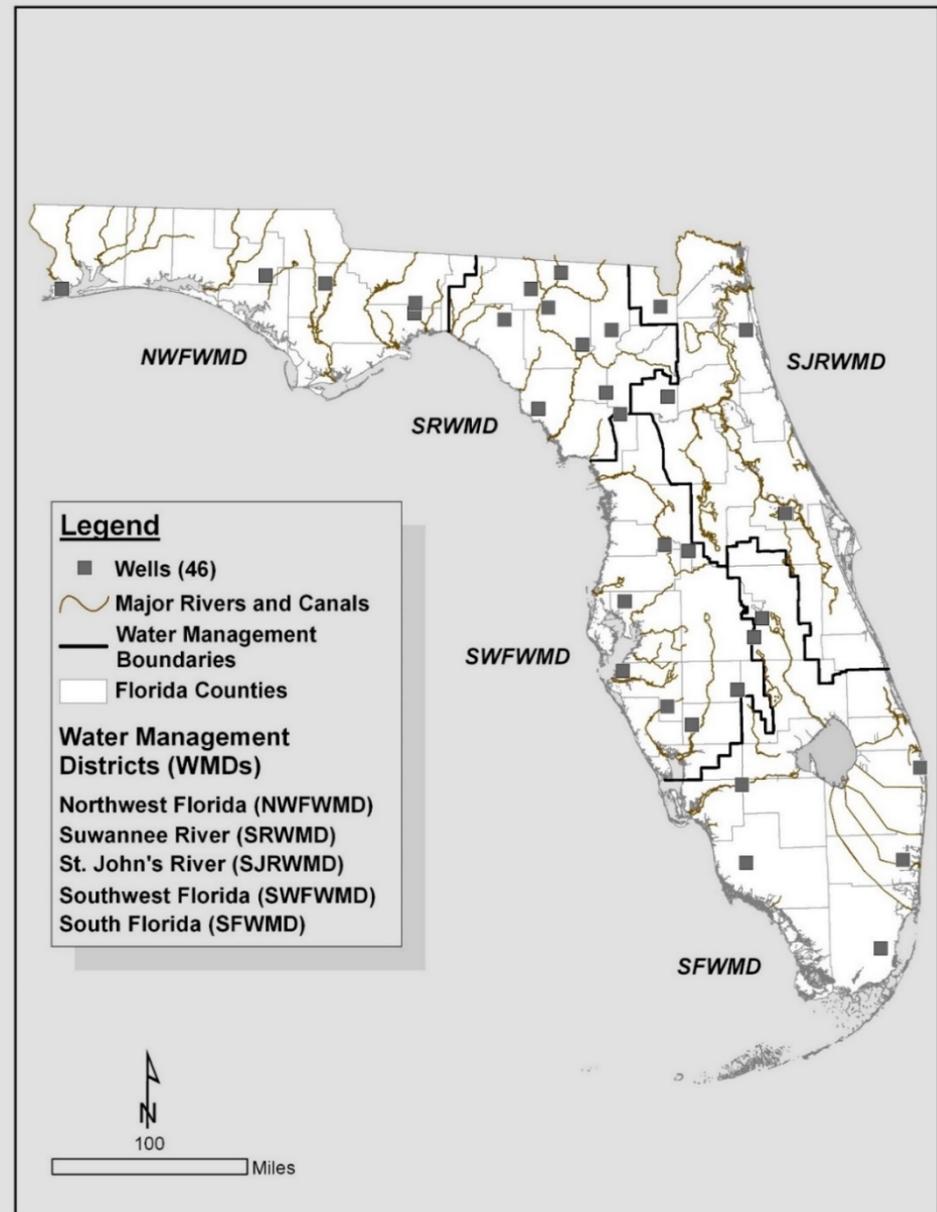
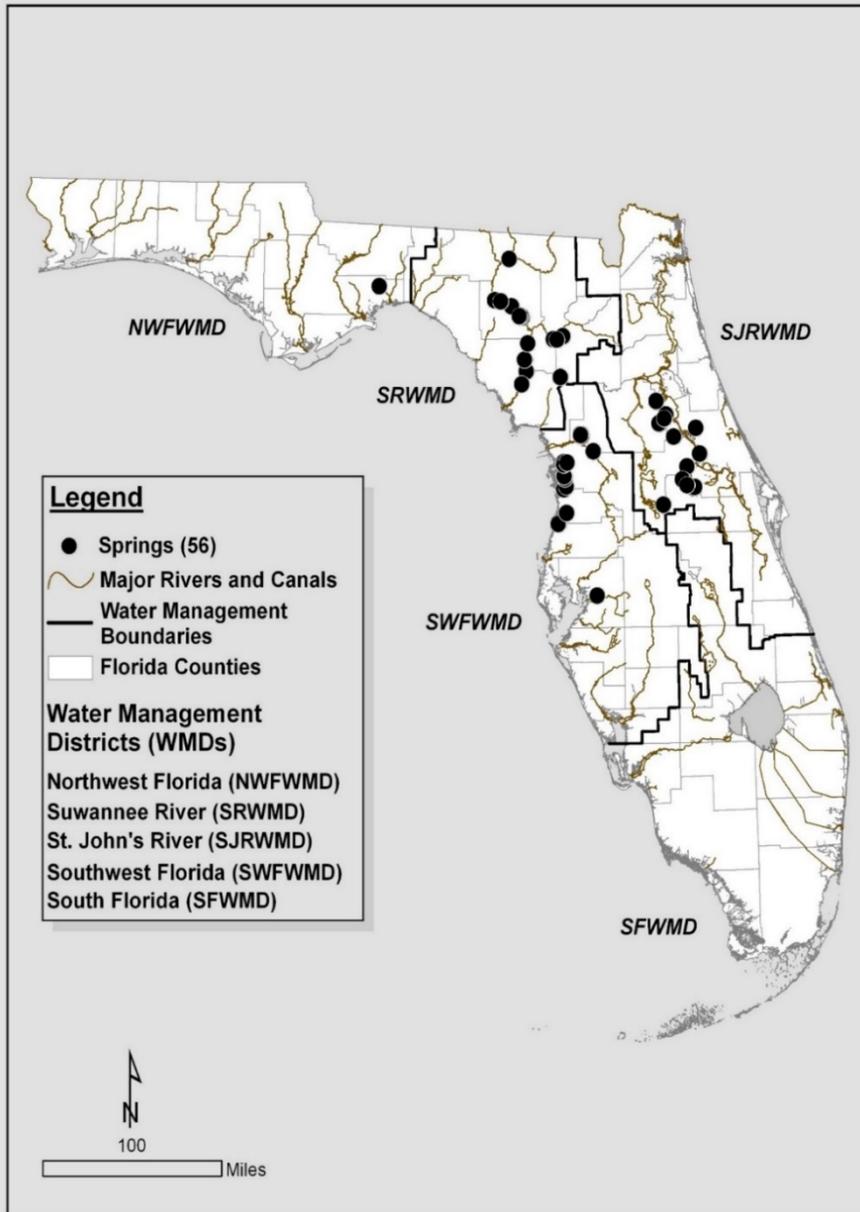
# Saltwater Intrusion



From St. Johns River Water Management District (date unknown)

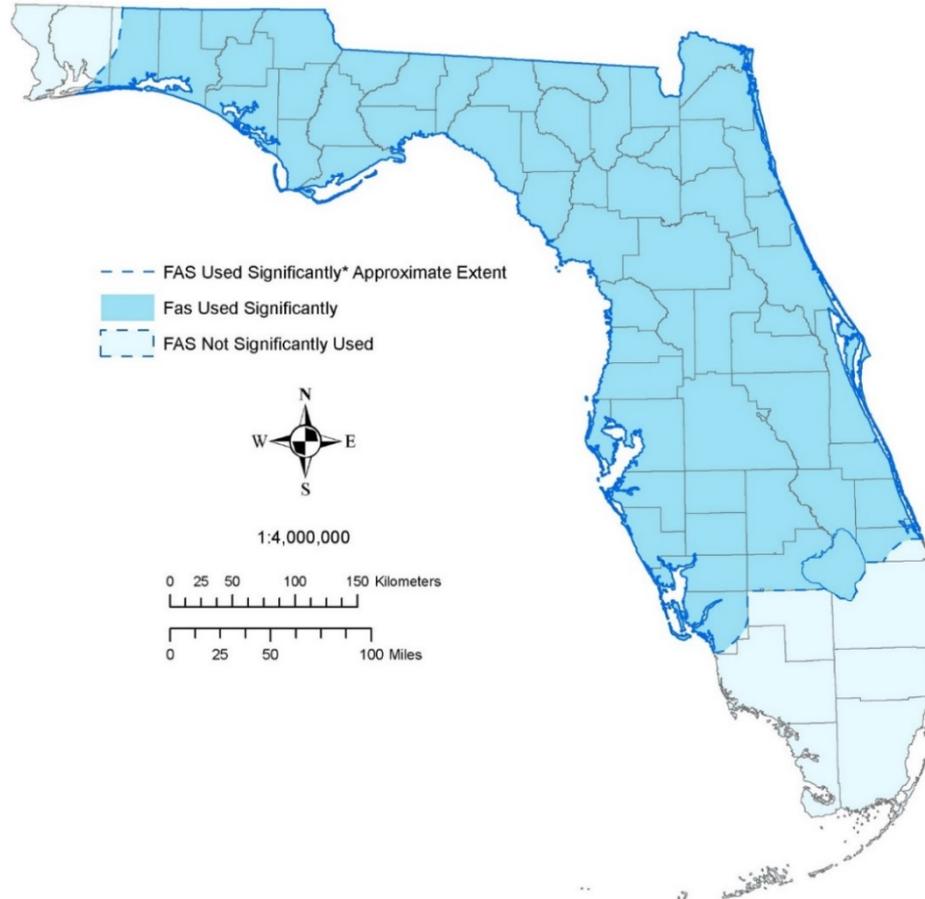


# Location of Springs and Trend Wells





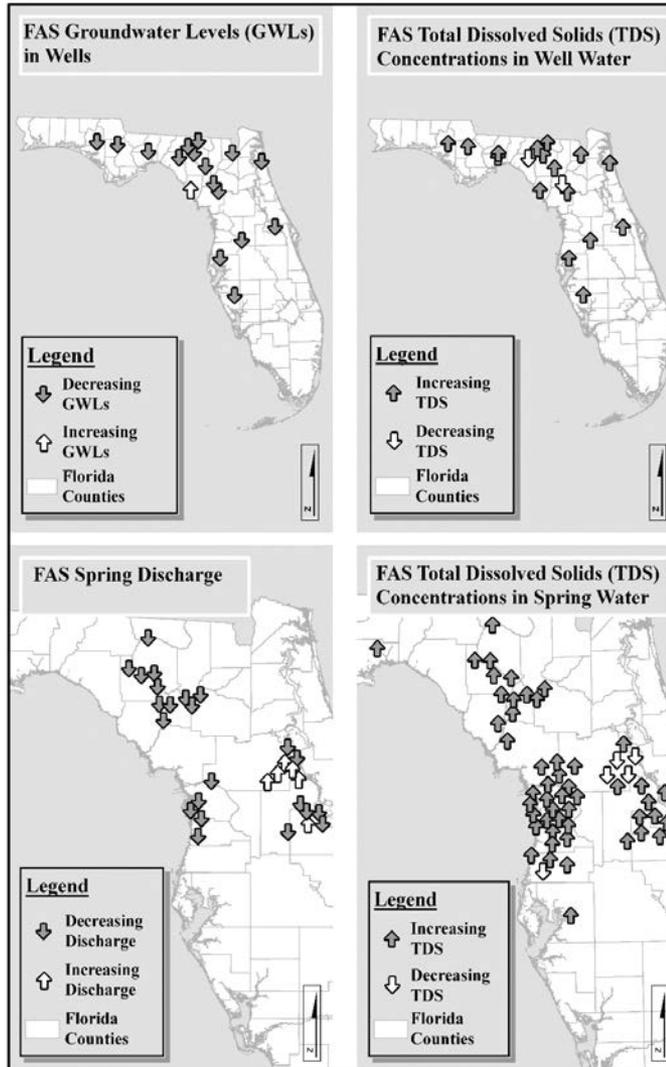
# Floridan Aquifer System (FAS)



\* Significant is greater than 5% of county groundwater use based on 2000 data from Marella and Bendt (2005).

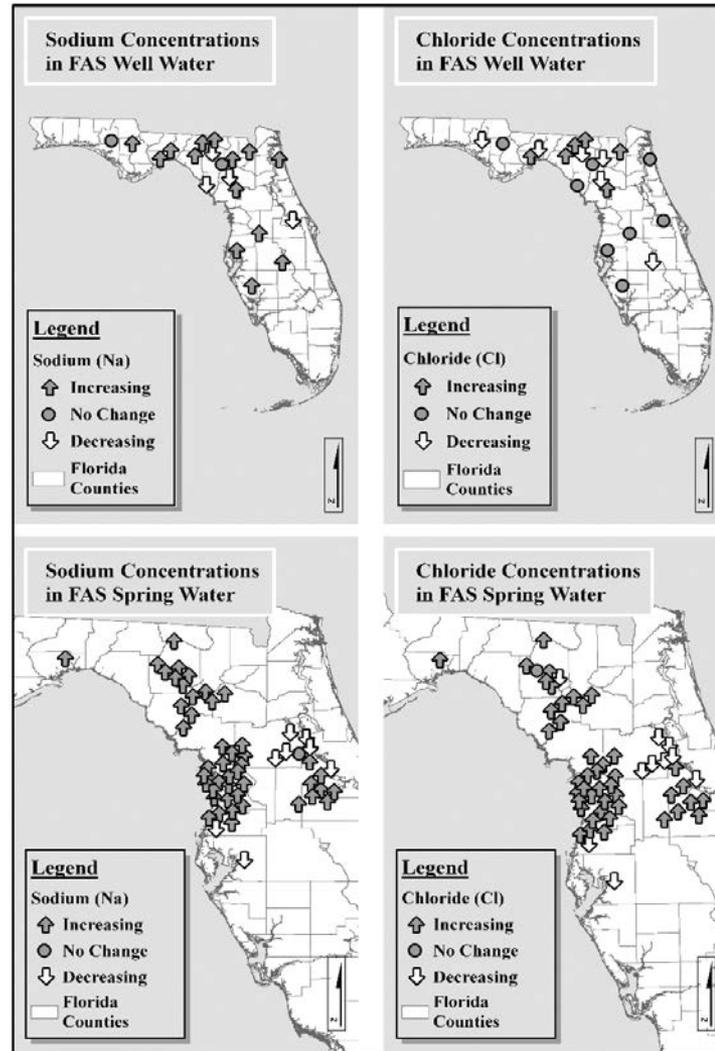


# Spring Flow, TDS (1991-2011) (Trend Wells and Springs)



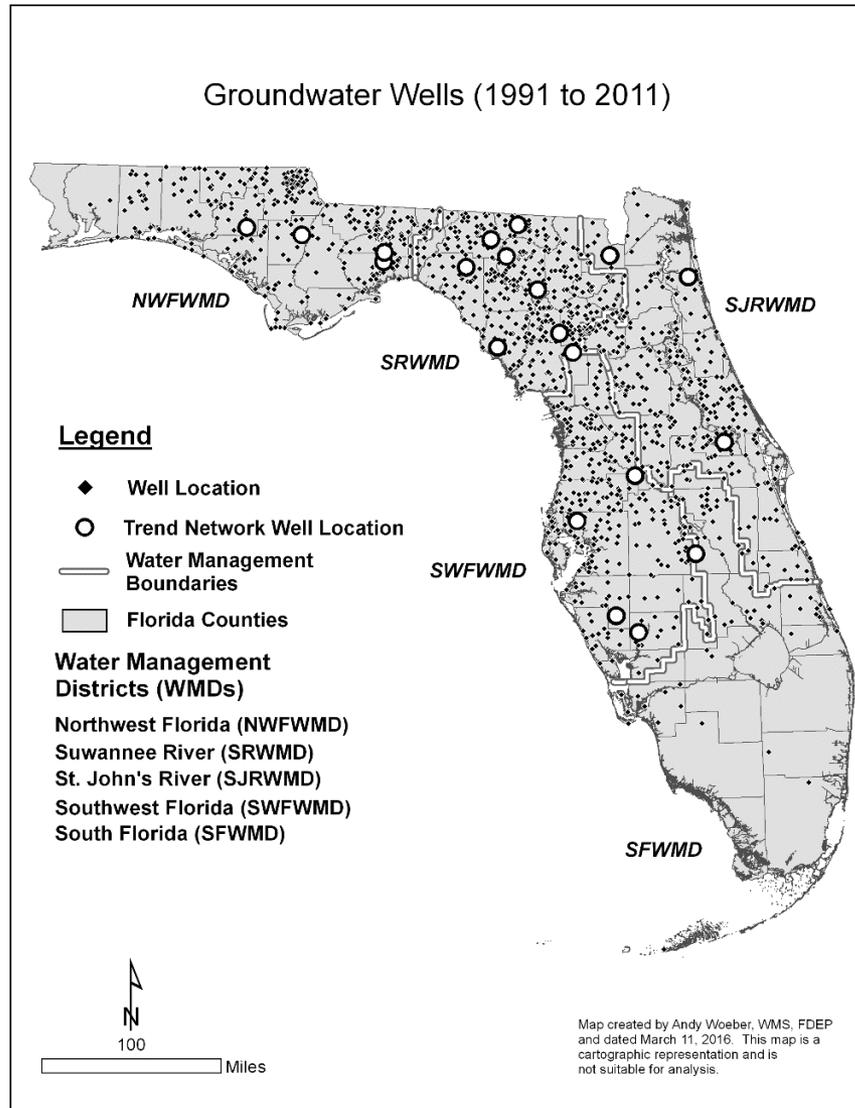


# Changes in Na and Cl (1991-2011) (Trend Wells and Springs)





# FAS - Wells with Na and Cl data





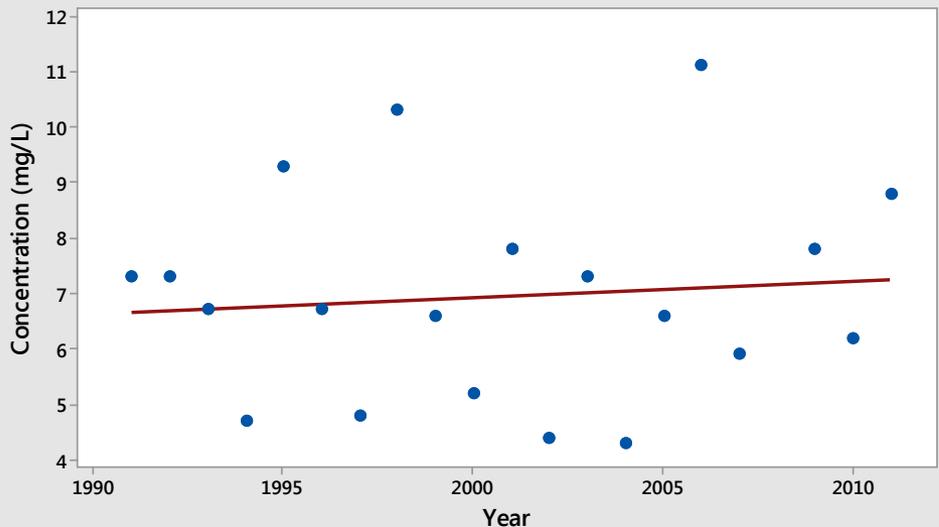
# 1451 FAS Monitoring Wells

- Sampled 60-366 per year, across FL
- Obtained annual medians
  - Na and Cl
- Plotted medians per year



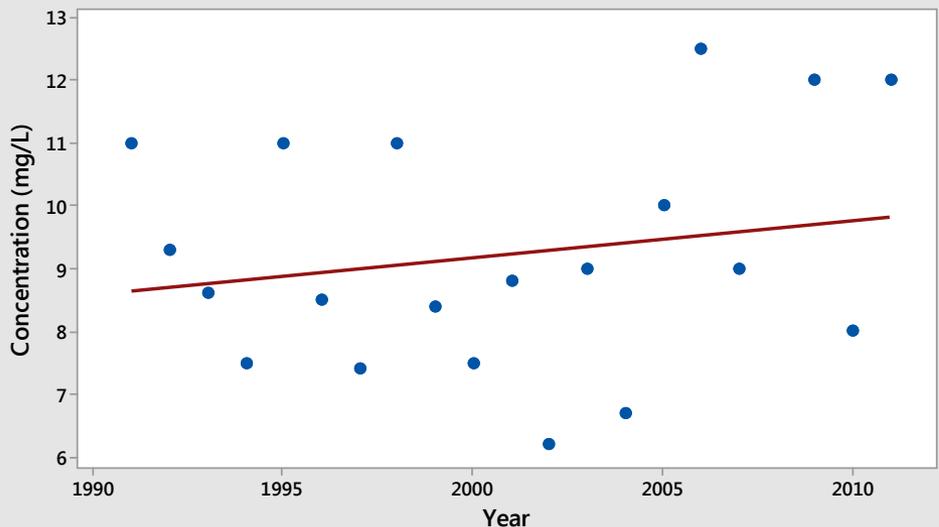
Annual Medians

Median Sodium Concentrations - BN and SN Wells (1991-2011)



Outlier (2008) was removed for visual reasons.

Median Chloride Concentrations - BN and SN Wells (1991-2011)



Outlier (2008) was removed for visual reasons.



# Salinity Network Workgroup (SNW)

- Established in 2012
- Under the umbrella of the Florida Water Resource Monitoring Council (FWRMC)
- Audience
  - General Public
  - Policy Makers
  - Scientists
- Network of Existing Networks
- Meet via webinar every six months
- “Success is in our ability to cooperate”



# SNW

- Predominantly GW
- But committed to Working Closely with Surface-Water Monitoring Programs
- Currently made up of > 20 entities  
State and Federal Agencies, Water Management Districts (WMDs), Counties, Universities, and the private sector



# Major Objectives

- Monitor...Florida's freshwater ...as related to saltwater encroachment
- Encourage ...monitoring programs ...to participate in the FWRMC (Council) activities
- **Develop and use indices**...to evaluate the status and trends of encroachment that... are uniform among monitoring entities...relatively easy to understand by the general public, policy makers and the scientific community



# Current Top Priorities

- **Produce GWL Percentile Ranking (PR) Maps**
- **Establish Coastal Salinity Monitoring Network  
in addition to the Salinity Network**

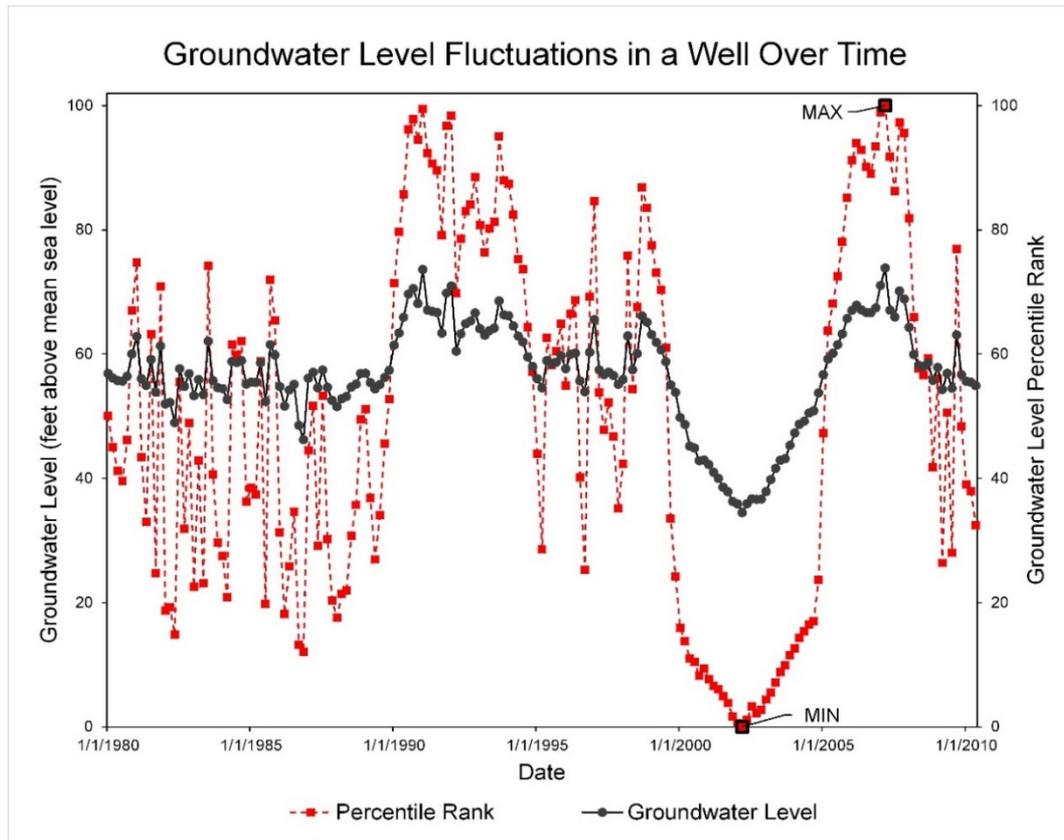


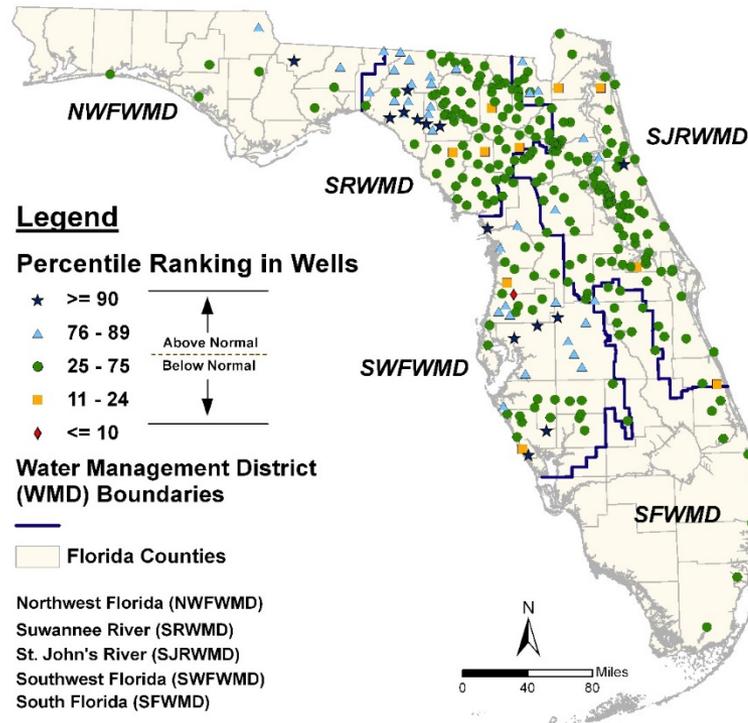
# 1. GWL Percentile Ranking Index Pilot Study

- Decided on a Percentile Ranking (PR)
  - Why? ↓ GWL ↑ potential encroachment
  - Spring 2010: Upper Floridan aquifer
- **Purpose**
  - To overcome (internal, external) obstacles
  - To reach consensus
  - Note - the GWL PR Index can be used for a variety of aquifers, and at various scales



# Example of GWLs and Percentile Ranks





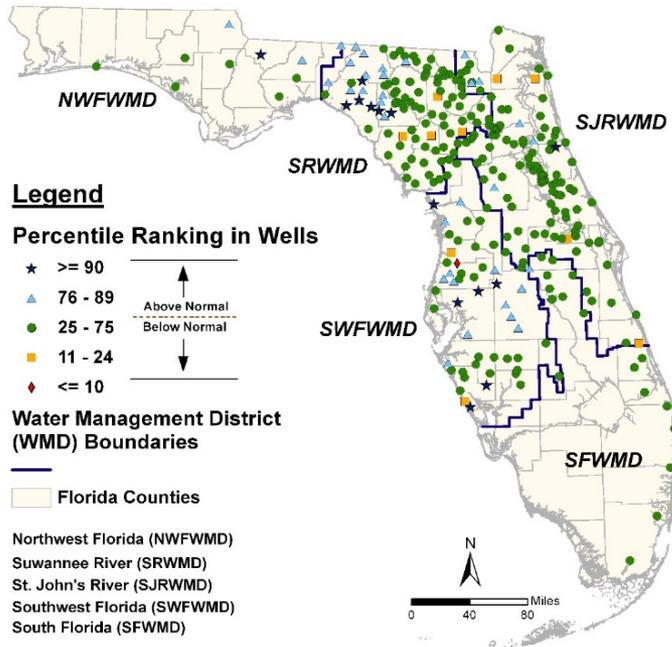
Source data provided by members of the Salinity Network Workgroup.

Created March 18, 2015. Map credited to the Watershed Monitoring Section, DEAR, FDEP.  
The map content is a cartographic representation and is not intended for further analysis.

**Groundwater level conditions in the Upper Floridan aquifer in Florida in percentile ranks, May 2010.**



# Issues to be addressed



Source data provided by members of the Salinity Network Workgroup.

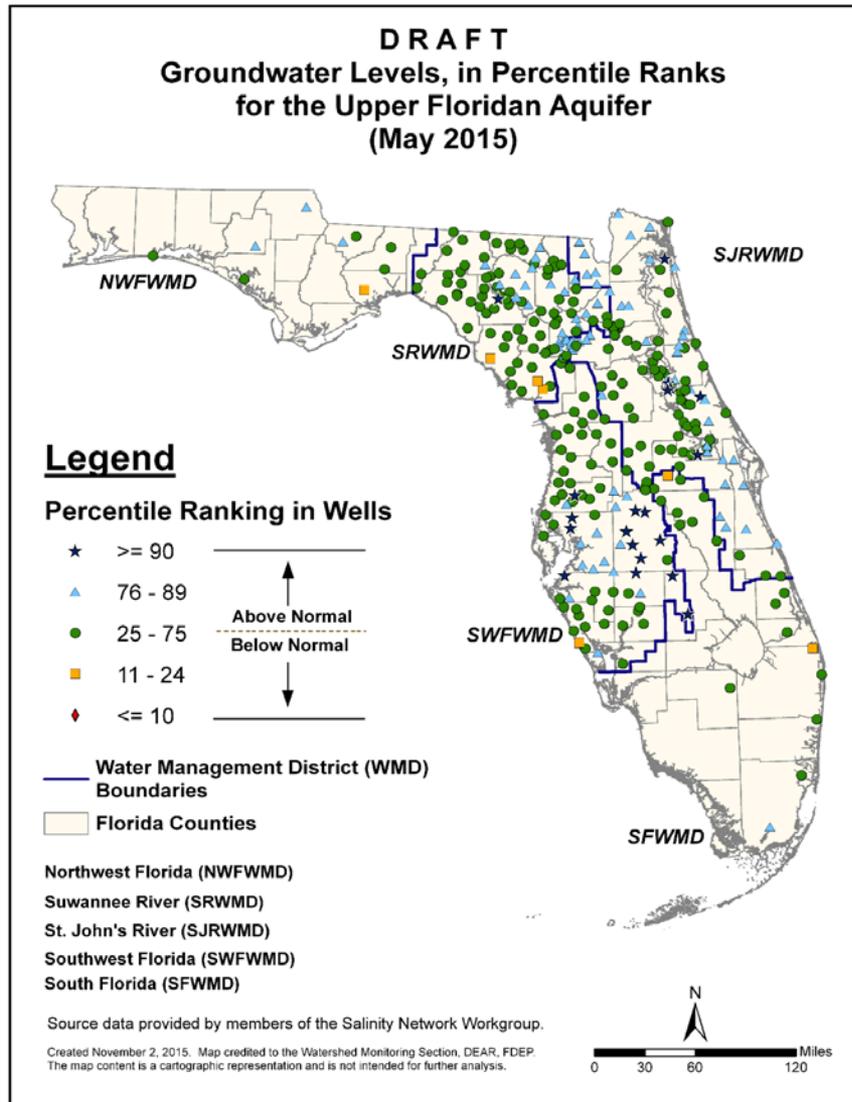
Created March 18, 2015. Map credited to the Watershed Monitoring Section, DEAR, FDEP.  
The map content is a cartographic representation and is not intended for further analysis.

**Groundwater level conditions in the Upper Floridan aquifer in Florida in percentile ranks, May 2010.**

- PR map is composite
  - Inconsistent POR
  - and methodologies
- For PR map
  - Decrease density of wells in some regions
  - Over time PORs may become more consistent
  - Over time, change to one standard methodology?



# PRI Map (UFA) – May, 2015





# Map and Text

- Each map to be accompanied by an explanation page
- Lag time – Currently working on September, 2015 map.
- When complete, each map/text is uploaded to a link

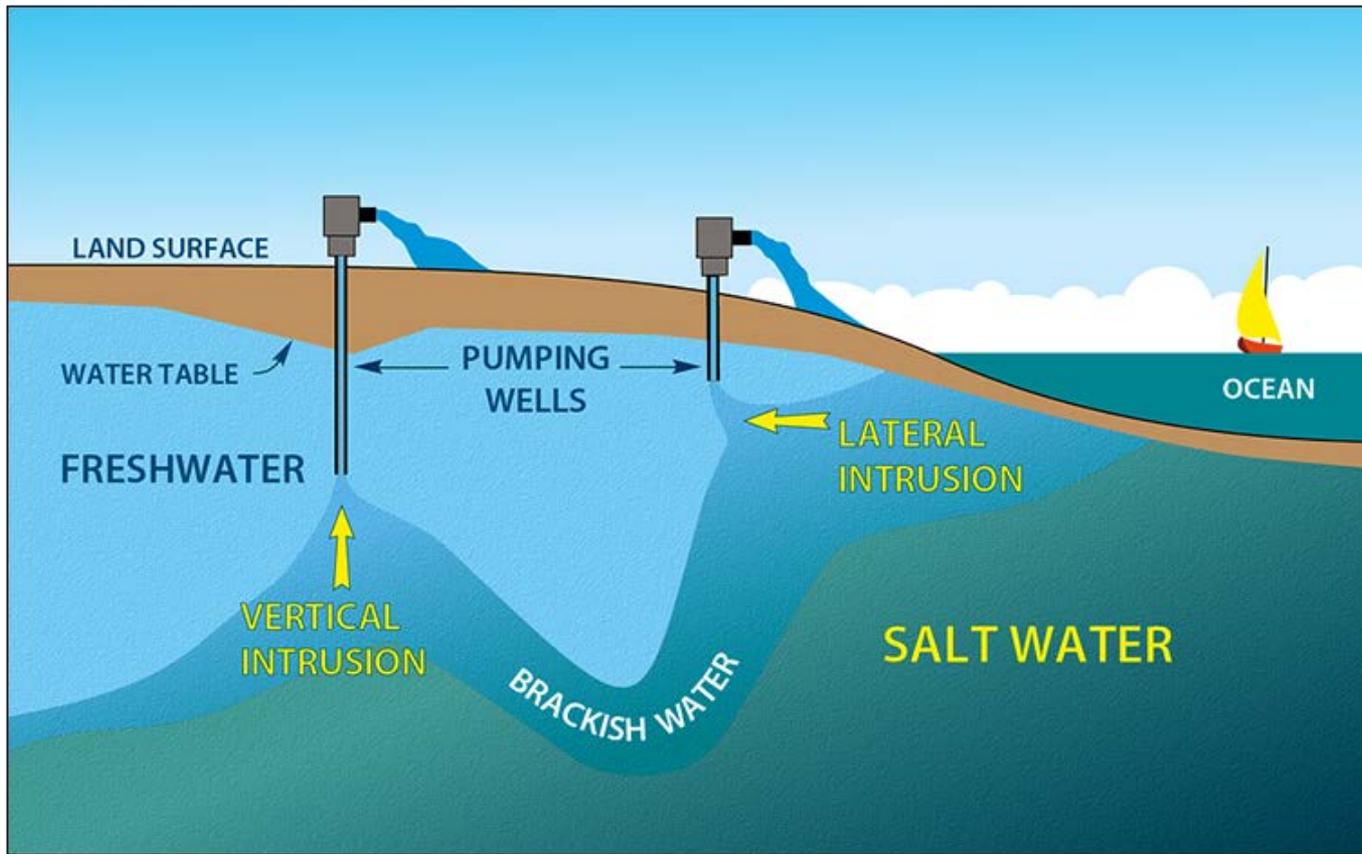


## 2. Development of Coastal Salinity Mon. Network

- Not only the Salinity Network, but also a Coastal Salinity Monitoring Network (CSMN)-  
“Rind around the state”
  - Networks-of-existing networks
    - **No new \$**
  - Add wells and surface water sites in future



# Coastal Salinity Network



From St. Johns River Water Management District (date unknown)



# Development of Coastal Salinity Network

- “Let data suggest where to build Coastal SalNet”



# Saline Chemical Concentrations (Major Aquifers)

- Data are from DEP Status Monitoring Network
- GW samples between 2000-2014;
- Most wells have only one sample
- If multiple samples at a site, used most recent
  - > 2000 Wells

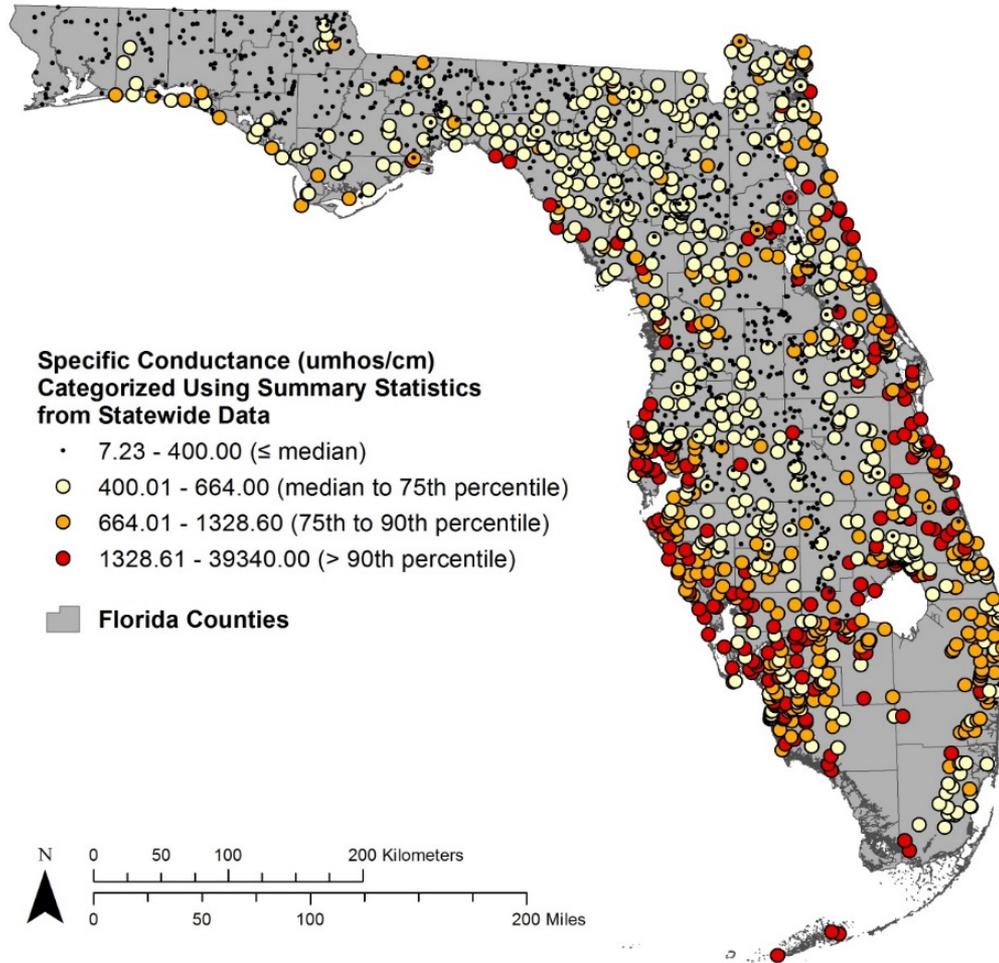


# All Aquifers

- Four analytes: TDS, SC, Cl, and SO<sub>4</sub>
- Determined selected percentiles from all samples across Florida
- Contour Maps
  - Then repeated by aquifer system



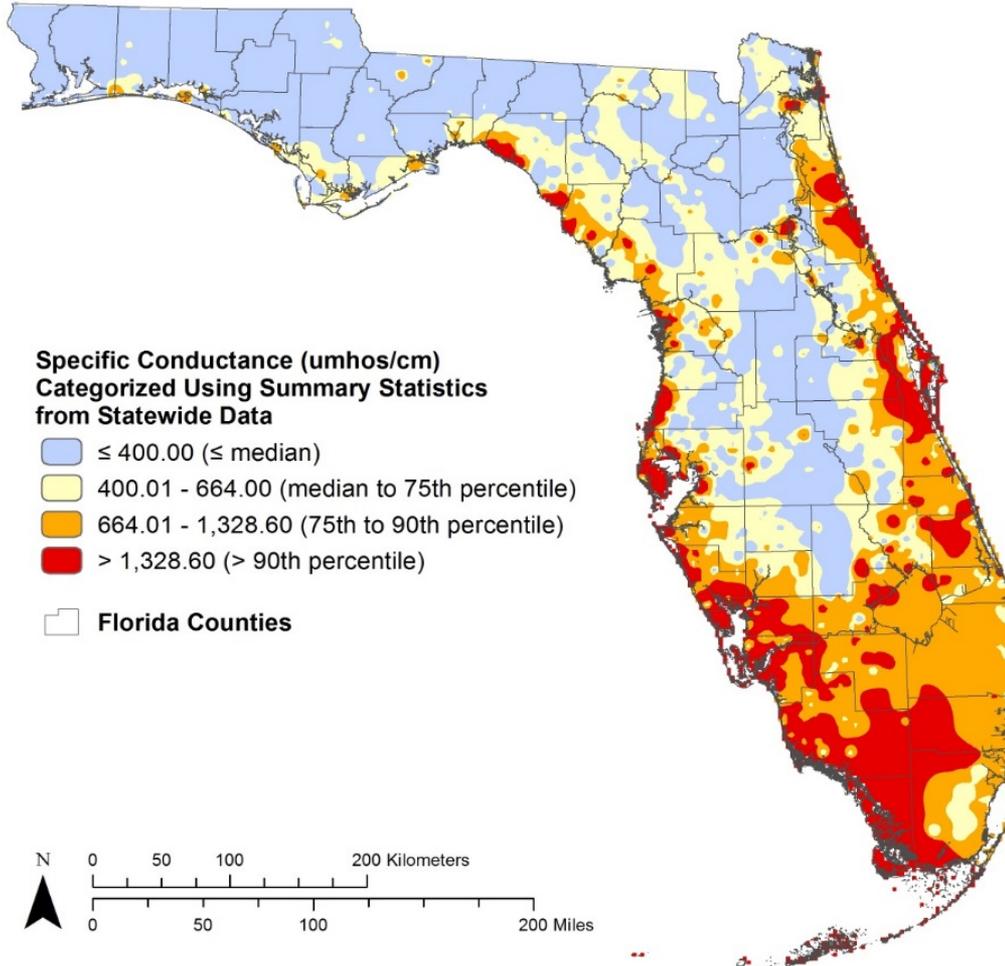
## Specific Conductance in Status Network Wells (All Aquifers)



Created May 8, 2015 by Florida Department of Environmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.



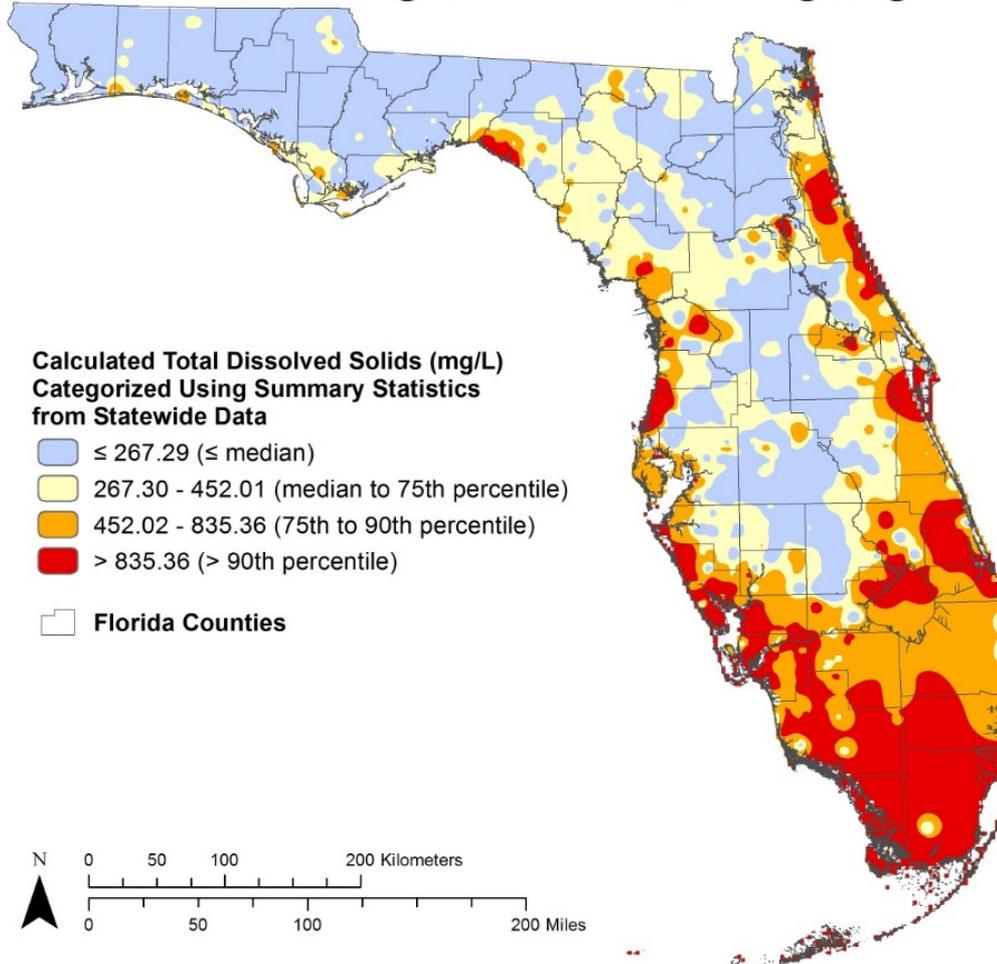
## Specific Conductance in Status Network Wells (All Aquifers) Modeled Using Inverse Distance Weighting



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# Calculated Total Dissolved Solids (TDS) in Status Network Wells (All Aquifers) Modeled Using Inverse Distance Weighting



**Calculated Total Dissolved Solids (mg/L)  
Categorized Using Summary Statistics  
from Statewide Data**

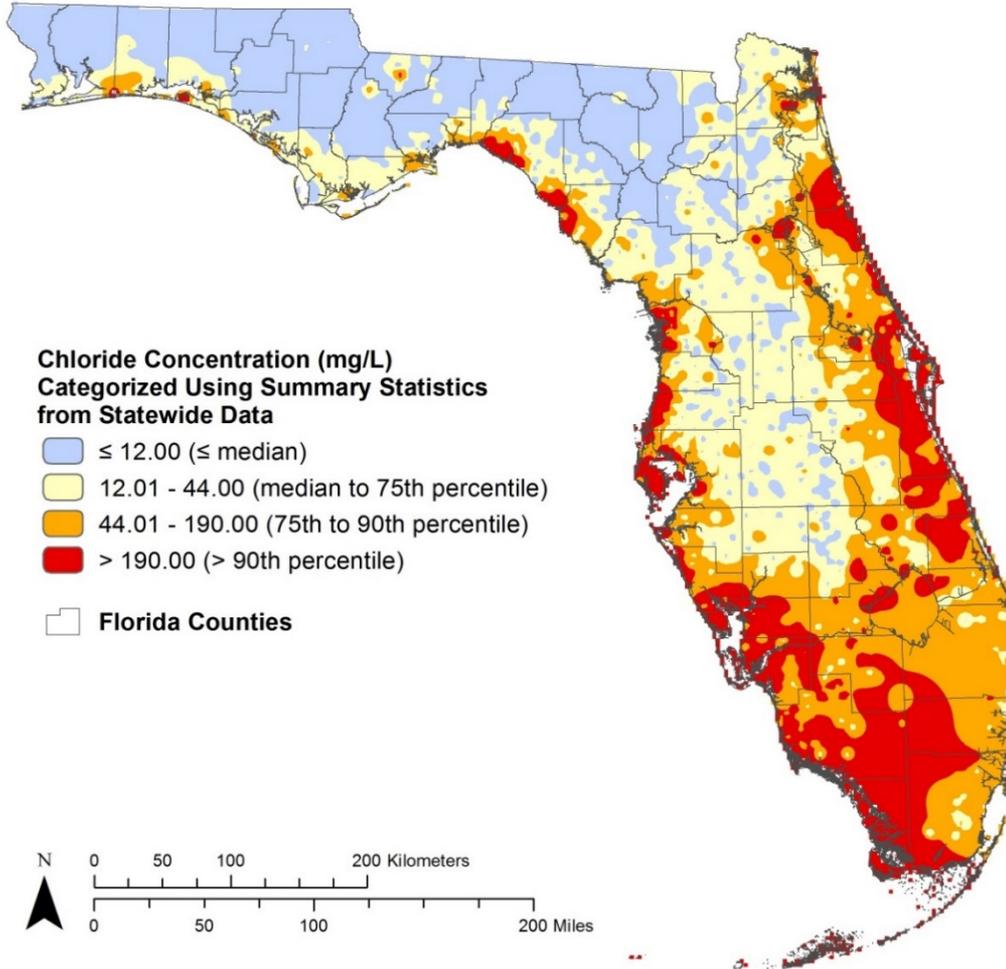
-  ≤ 267.29 (≤ median)
-  267.30 - 452.01 (median to 75th percentile)
-  452.02 - 835.36 (75th to 90th percentile)
-  > 835.36 (> 90th percentile)

 **Florida Counties**

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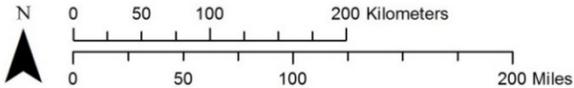
# Chloride in Status Network Wells (All Aquifers) Modeled Using Inverse Distance Weighting



**Chloride Concentration (mg/L)  
Categorized Using Summary Statistics  
from Statewide Data**

-   $\leq 12.00$  ( $\leq$  median)
-  12.01 - 44.00 (median to 75th percentile)
-  44.01 - 190.00 (75th to 90th percentile)
-   $> 190.00$  ( $>$  90th percentile)

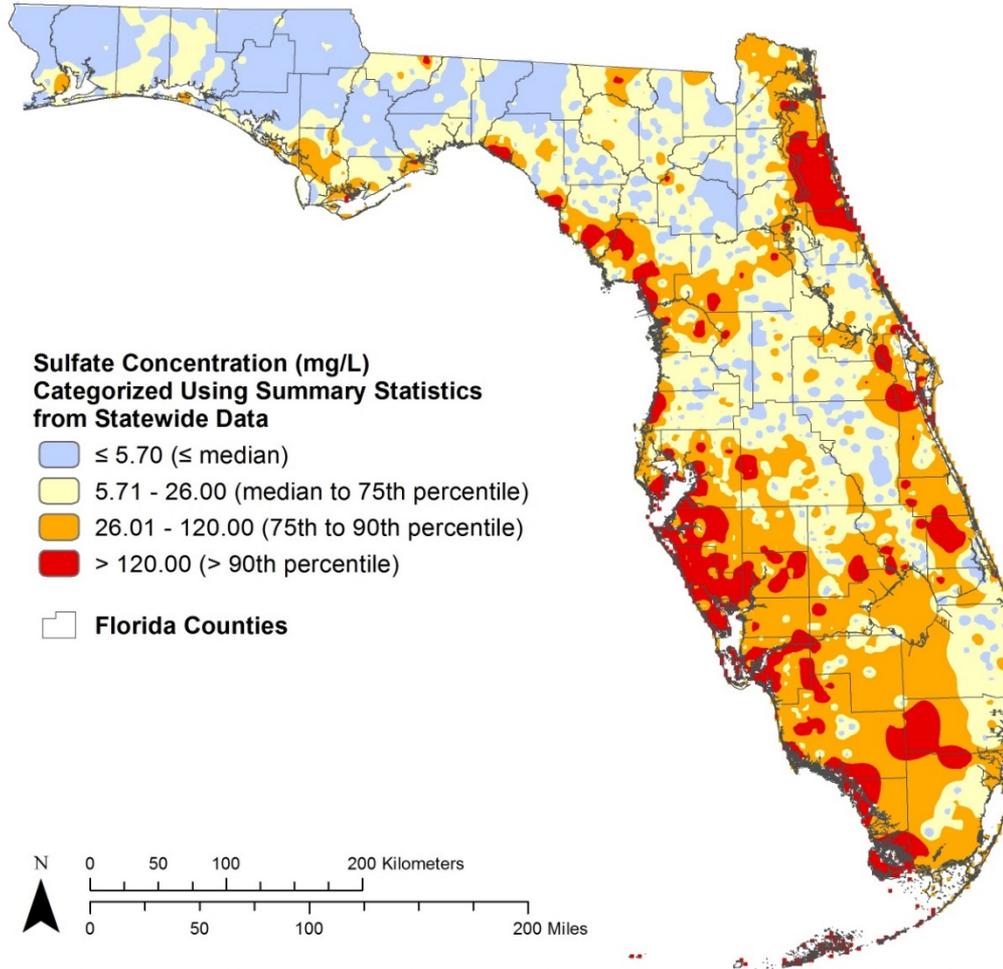
 **Florida Counties**



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# Sulfate in Status Network Wells (All Aquifers) Modeled Using Inverse Distance Weighting



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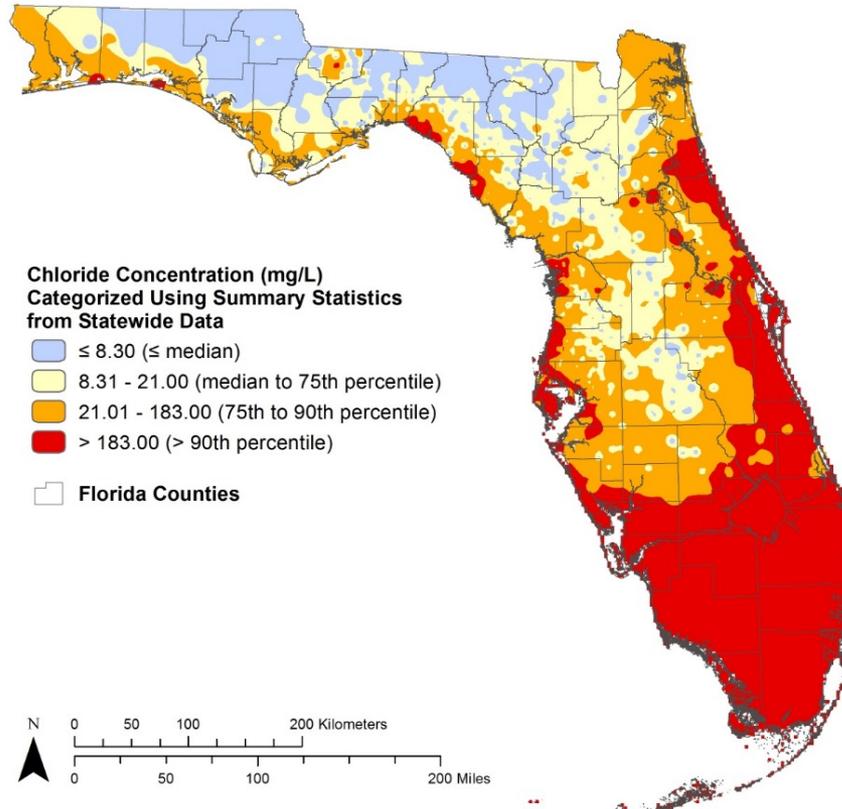
# Next, Aquifer/Aquifer System

- Because of time constraints, most of discussion pertains to Upper Floridan aquifer and All Aquifers



# Example: Saline Indicator for UFA

Chloride in  
Status Network Upper Floridan Aquifer Wells  
Modeled Using Inverse Distance Weighting

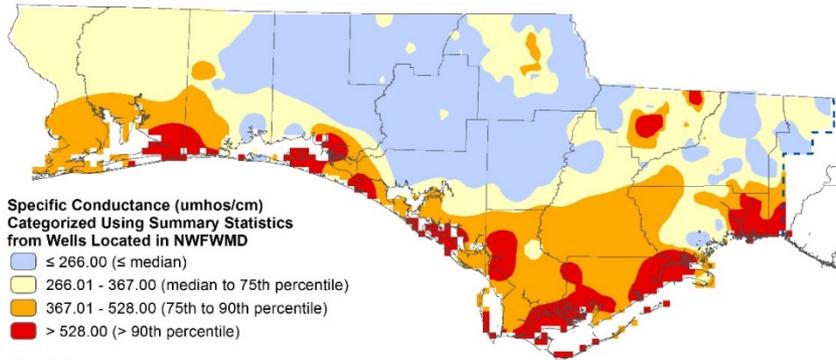


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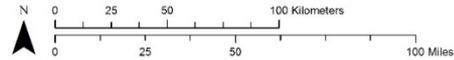
# NWFWMD

**Specific Conductance in  
Status Network Upper Floridan Aquifer Wells  
Modeled using Inverse Distance Weighting**



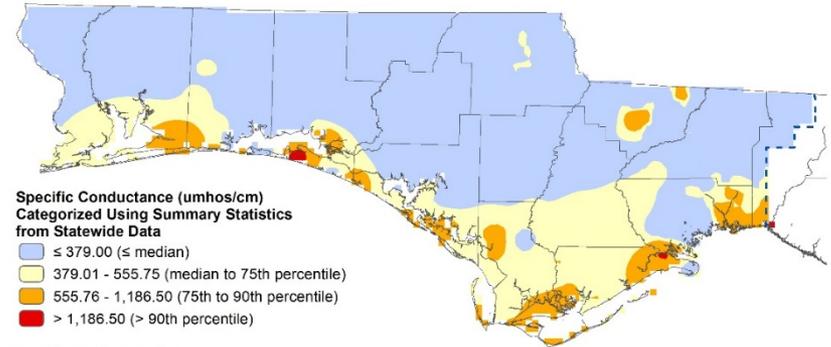
--- WMD Boundaries

□ Florida Counties



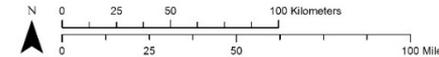
Created April 23, 2015 by Florida Department of Environmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

**Specific Conductance in  
Status Network Upper Floridan Aquifer Wells  
Modeled using Inverse Distance Weighting**



--- WMD Boundaries

□ Florida Counties

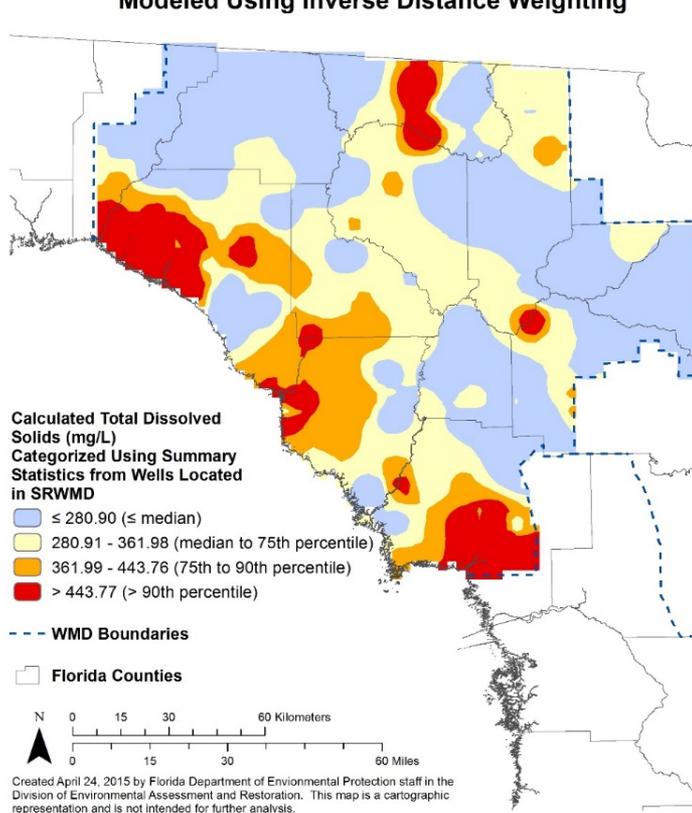


Created April 23, 2015 by Florida Department of Environmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

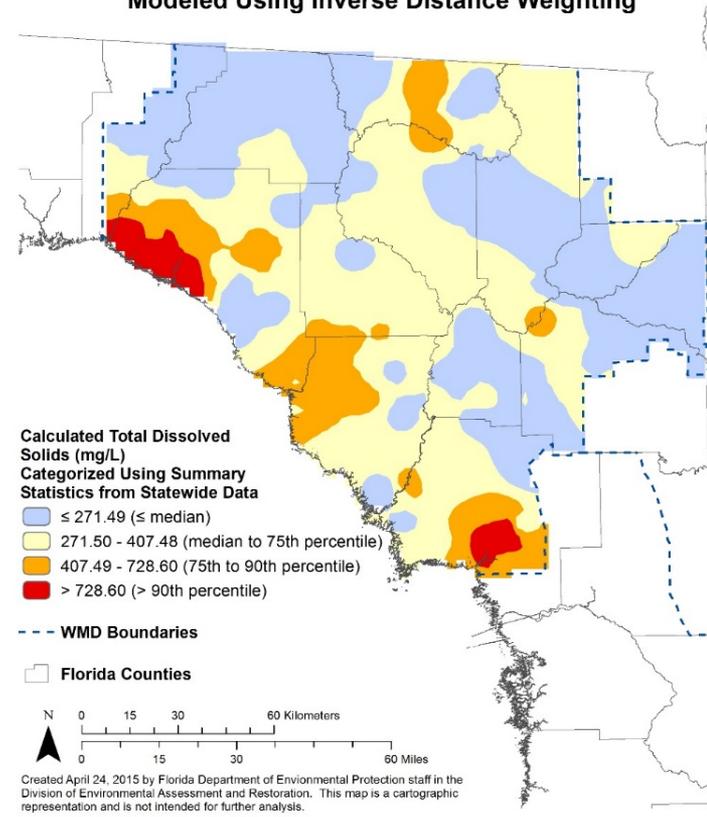


# SRWMD

**Calculated Total Dissolved Solids (TDS) in Status Network Upper Floridan Aquifer Wells Modeled Using Inverse Distance Weighting**



**Calculated Total Dissolved Solids (TDS) in Status Network Upper Floridan Aquifer Wells Modeled Using Inverse Distance Weighting**



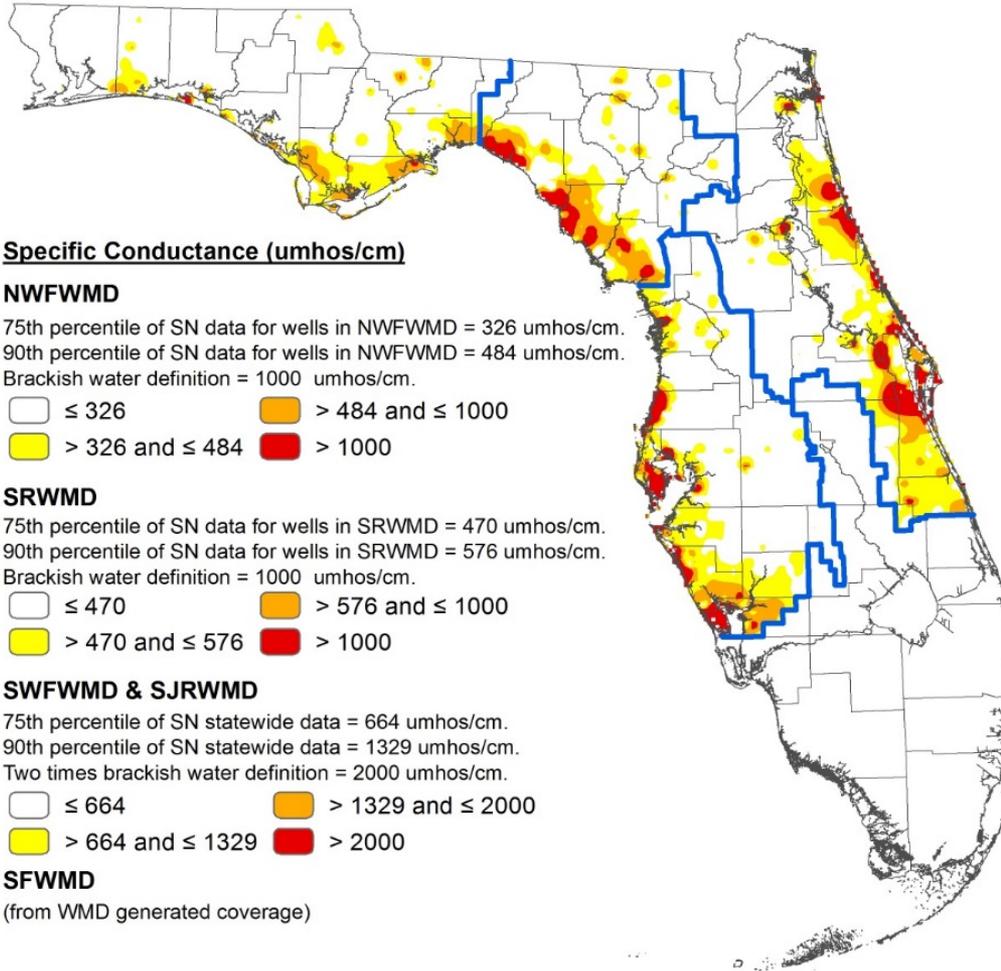


# Areas for CSMN wells

- In the following, GW chemistry data from FDEP
- Well location data are from WMDs



# Specific Conductance in Status Network (SN) Wells (All Aquifers) Modeled Using Inverse Distance Weighting



## Specific Conductance (umhos/cm)

### **NFWWMD**

75th percentile of SN data for wells in NFWWMD = 326 umhos/cm.

90th percentile of SN data for wells in NFWWMD = 484 umhos/cm.

Brackish water definition = 1000 umhos/cm.

□ ≤ 326	□ > 484 and ≤ 1000
□ > 326 and ≤ 484	□ > 1000

### **SRWMD**

75th percentile of SN data for wells in SRWMD = 470 umhos/cm.

90th percentile of SN data for wells in SRWMD = 576 umhos/cm.

Brackish water definition = 1000 umhos/cm.

□ ≤ 470	□ > 576 and ≤ 1000
□ > 470 and ≤ 576	□ > 1000

### **SFWWMD & SJRWMD**

75th percentile of SN statewide data = 664 umhos/cm.

90th percentile of SN statewide data = 1329 umhos/cm.

Two times brackish water definition = 2000 umhos/cm.

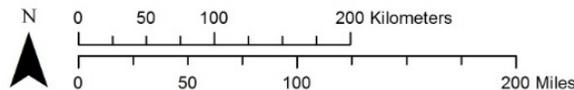
□ ≤ 664	□ > 1329 and ≤ 2000
□ > 664 and ≤ 1329	□ > 2000

### **SFWMD**

(from WMD generated coverage)

Water Management Districts

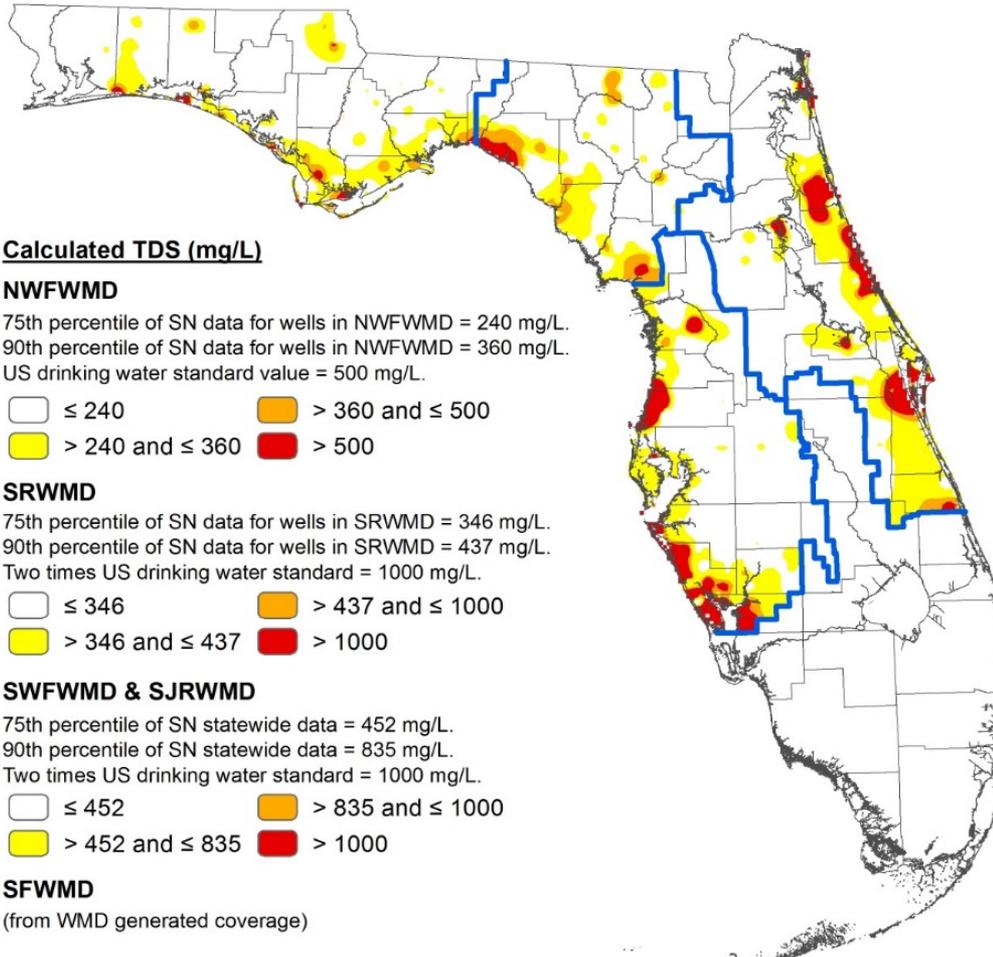
Florida Counties



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# Calculated Total Dissolved Solids (TDS) in Status Network (SN) Wells (All Aquifers) Modeled Using Inverse Distance Weighting



## Calculated TDS (mg/L)

### NWFWMD

75th percentile of SN data for wells in NWFWMD = 240 mg/L.  
90th percentile of SN data for wells in NWFWMD = 360 mg/L.  
US drinking water standard value = 500 mg/L.

- |                 |                 |
|-----------------|-----------------|
| ≤ 240           | > 360 and ≤ 500 |
| > 240 and ≤ 360 | > 500           |

### SRWMD

75th percentile of SN data for wells in SRWMD = 346 mg/L.  
90th percentile of SN data for wells in SRWMD = 437 mg/L.  
Two times US drinking water standard = 1000 mg/L.

- |                 |                  |
|-----------------|------------------|
| ≤ 346           | > 437 and ≤ 1000 |
| > 346 and ≤ 437 | > 1000           |

### SWFWMD & SJRWMD

75th percentile of SN statewide data = 452 mg/L.  
90th percentile of SN statewide data = 835 mg/L.  
Two times US drinking water standard = 1000 mg/L.

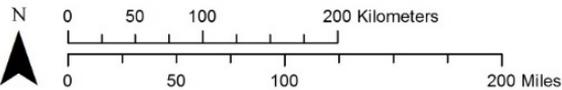
- |                 |                  |
|-----------------|------------------|
| ≤ 452           | > 835 and ≤ 1000 |
| > 452 and ≤ 835 | > 1000           |

### SFWMD

(from WMD generated coverage)

Water Management Districts

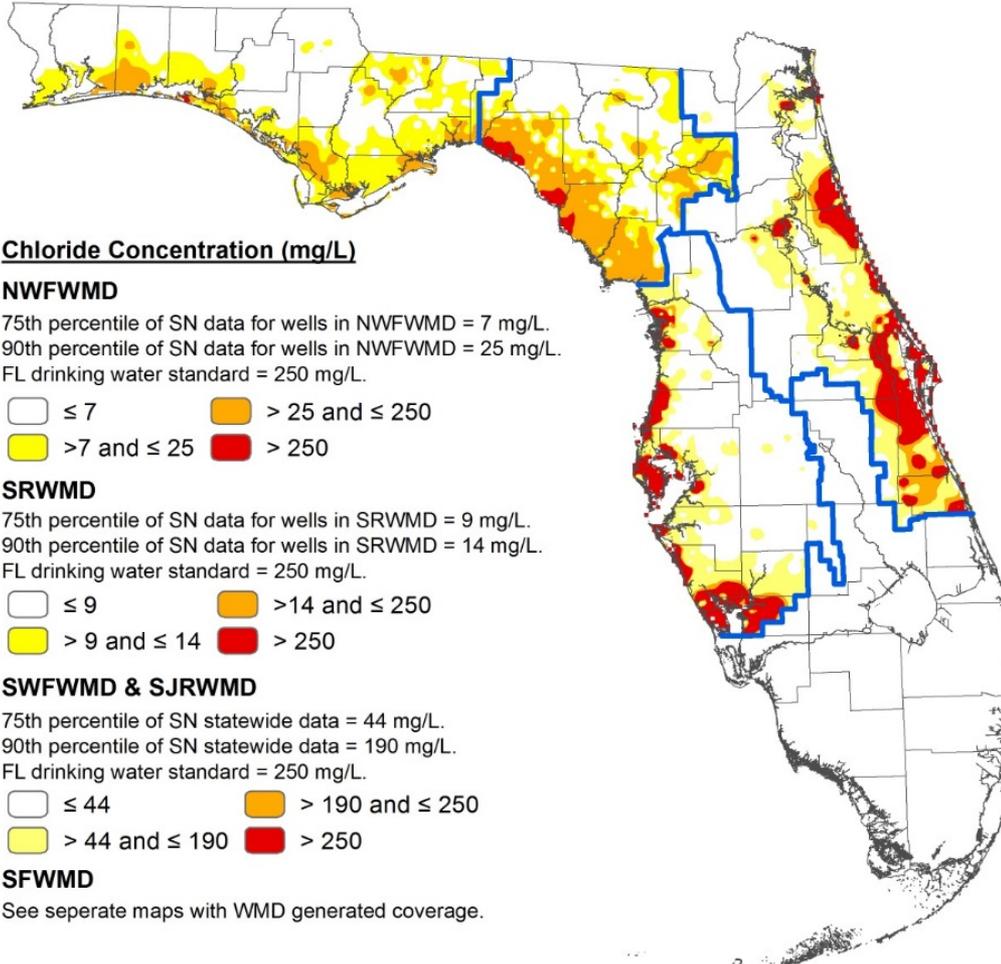
Florida Counties



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# Chloride in Status Network (SN) Wells (All Aquifers) Modeled Using Inverse Distance Weighting



## Chloride Concentration (mg/L)

### **NFWWMD**

75th percentile of SN data for wells in NFWWMD = 7 mg/L.  
90th percentile of SN data for wells in NFWWMD = 25 mg/L.  
FL drinking water standard = 250 mg/L.



### **SRWMD**

75th percentile of SN data for wells in SRWMD = 9 mg/L.  
90th percentile of SN data for wells in SRWMD = 14 mg/L.  
FL drinking water standard = 250 mg/L.



### **SWFWMD & SJRWMD**

75th percentile of SN statewide data = 44 mg/L.  
90th percentile of SN statewide data = 190 mg/L.  
FL drinking water standard = 250 mg/L.

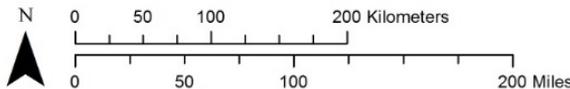


### **SFWMD**

See separate maps with WMD generated coverage.

**Water Management Districts**

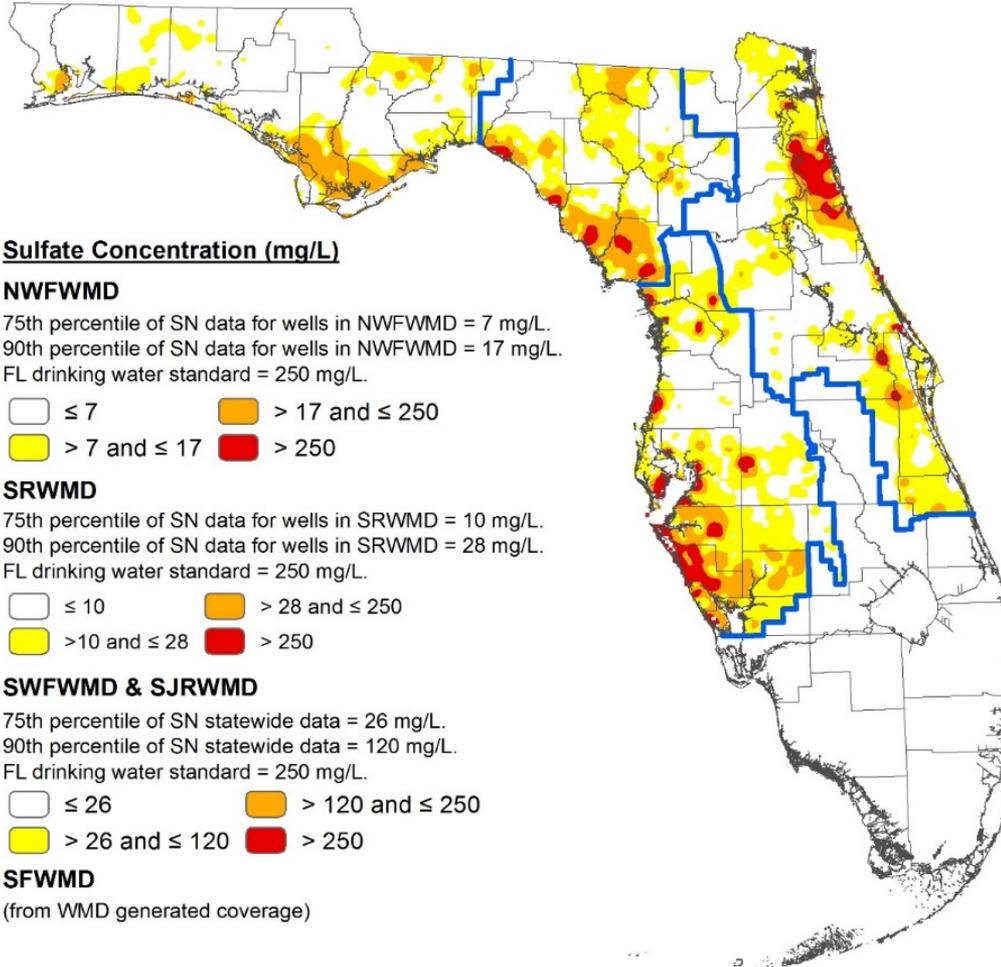
**Florida Counties**



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# Sulfate in Status Network (SN) Wells (All Aquifers) Modeled Using Inverse Distance Weighting



## Sulfate Concentration (mg/L)

### **NFWWMD**

75th percentile of SN data for wells in NFWWMD = 7 mg/L.  
90th percentile of SN data for wells in NFWWMD = 17 mg/L.  
FL drinking water standard = 250 mg/L.



### **SRWMD**

75th percentile of SN data for wells in SRWMD = 10 mg/L.  
90th percentile of SN data for wells in SRWMD = 28 mg/L.  
FL drinking water standard = 250 mg/L.



### **SWFWMD & SJRWMD**

75th percentile of SN statewide data = 26 mg/L.  
90th percentile of SN statewide data = 120 mg/L.  
FL drinking water standard = 250 mg/L.



### **SFWMD**

(from WMD generated coverage)

**Water Management Districts**

**Florida Counties**



0 50 100 200 Kilometers

0 50 100 200 Miles

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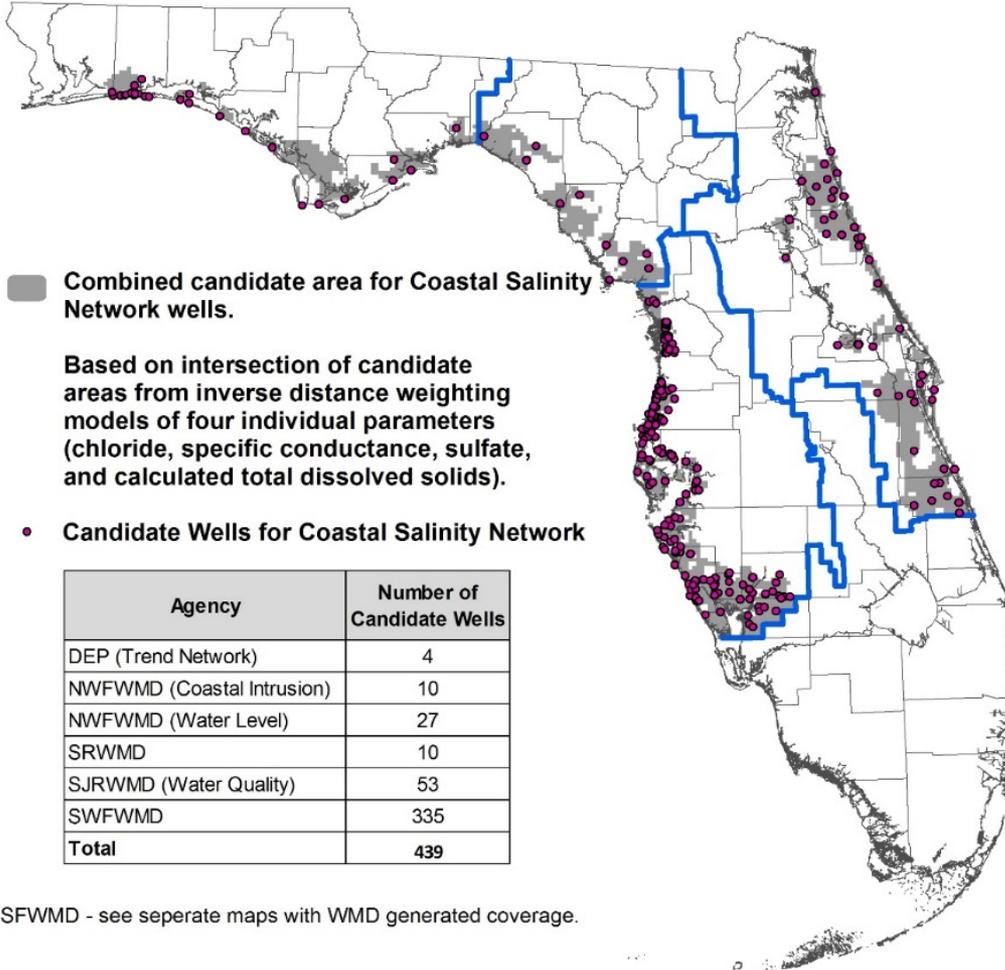


# Identify Potential WMD Wells

- Then used WMD wells as candidate wells



# Candidate Coastal Salinity Network Wells Based on Combined Modeled Data (Chloride, Specific Conductance, Sulfate, Calculated TDS)



■ Combined candidate area for Coastal Salinity Network wells.

Based on intersection of candidate areas from inverse distance weighting models of four individual parameters (chloride, specific conductance, sulfate, and calculated total dissolved solids).

● Candidate Wells for Coastal Salinity Network

Agency	Number of Candidate Wells
DEP (Trend Network)	4
NFWFMD (Coastal Intrusion)	10
NFWFMD (Water Level)	27
SRWMD	10
SJRWMD (Water Quality)	53
SFWWMD	335
<b>Total</b>	<b>439</b>

SFWWMD - see separate maps with WMD generated coverage.

Water Management Districts

Florida Counties



0 50 100 200 Kilometers

0 50 100 200 Miles

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# Candidate Coastal Salinity Network Wells in NFWWMD Based on Combined Modeled Data (Chloride, Specific Conductance, Sulfate, Calculated TDS)



■ Combined candidate area for Coastal Salinity Network wells.

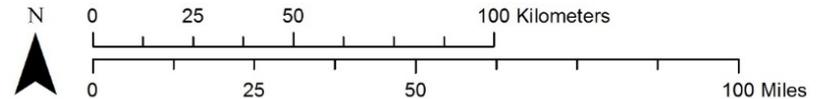
Based on intersection of candidate areas from inverse distance weighting models of four individual parameters (chloride, specific conductance, sulfate, and calculated total dissolved solids).

● Candidate Wells for Coastal Salinity Network

Agency	Number of Candidate Wells
NFWWMD (Coastal Intrusion)	10
NFWWMD (Water Level)	27
<b>Total</b>	<b>37</b>

■ NFWWMD

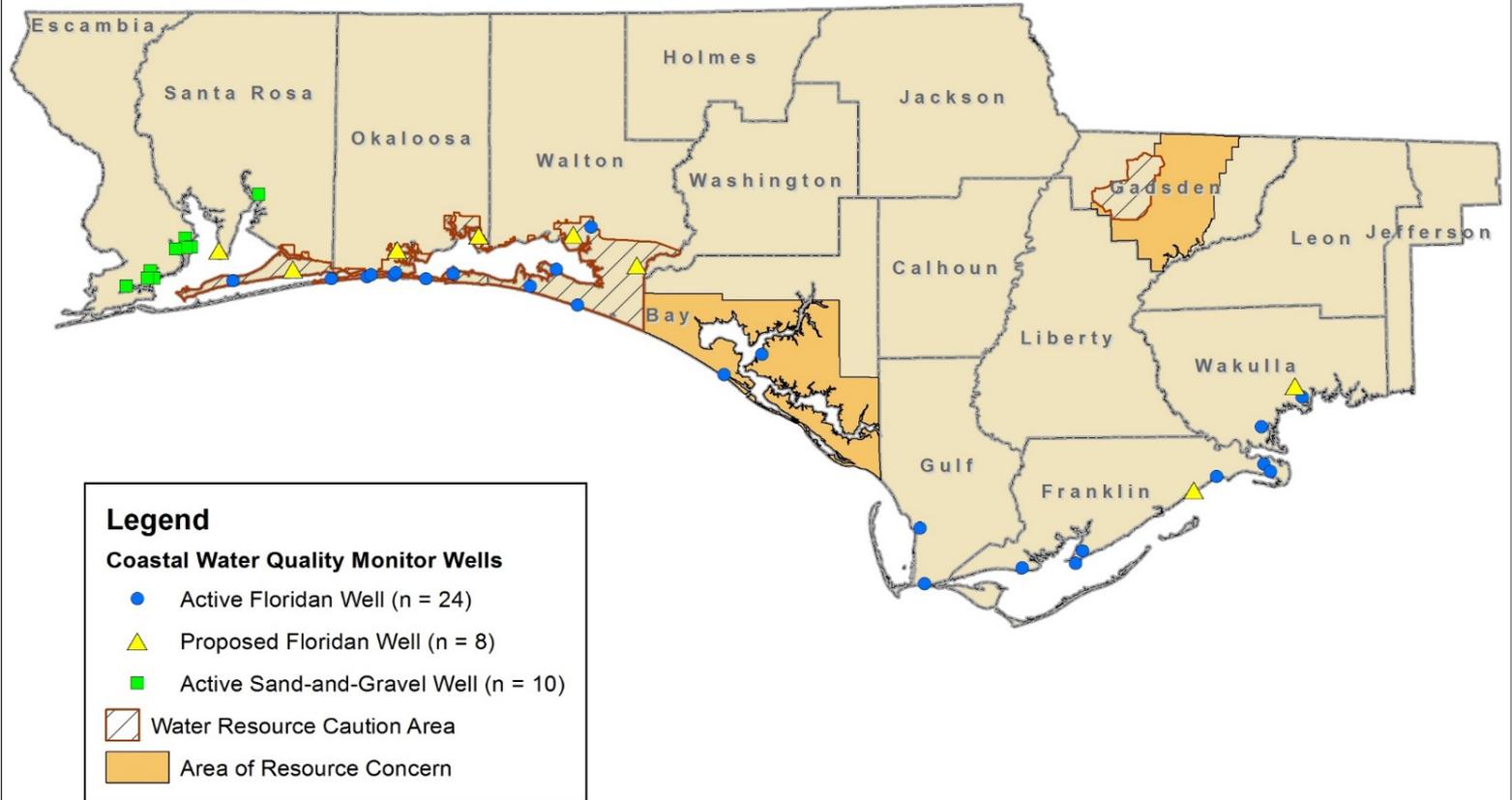
□ Florida Counties



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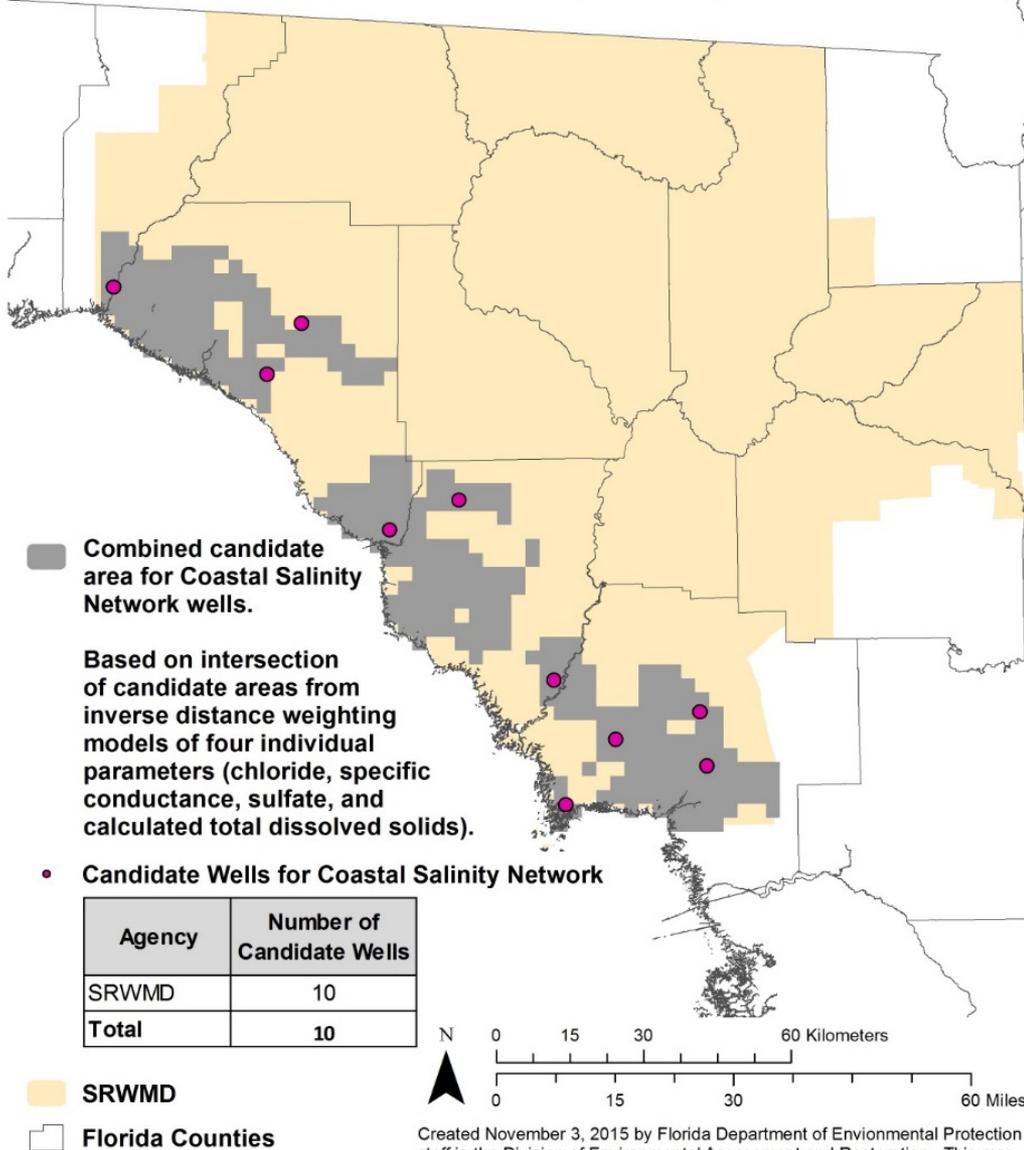


## Coastal Water Quality Monitoring Network Upper Floridan and Sand-and-Gravel Aquifers





# Candidate Coastal Salinity Network Wells in SRWMD Based on Combined Modeled Data (Chloride, Specific Conductance, Sulfate, Calculated TDS)

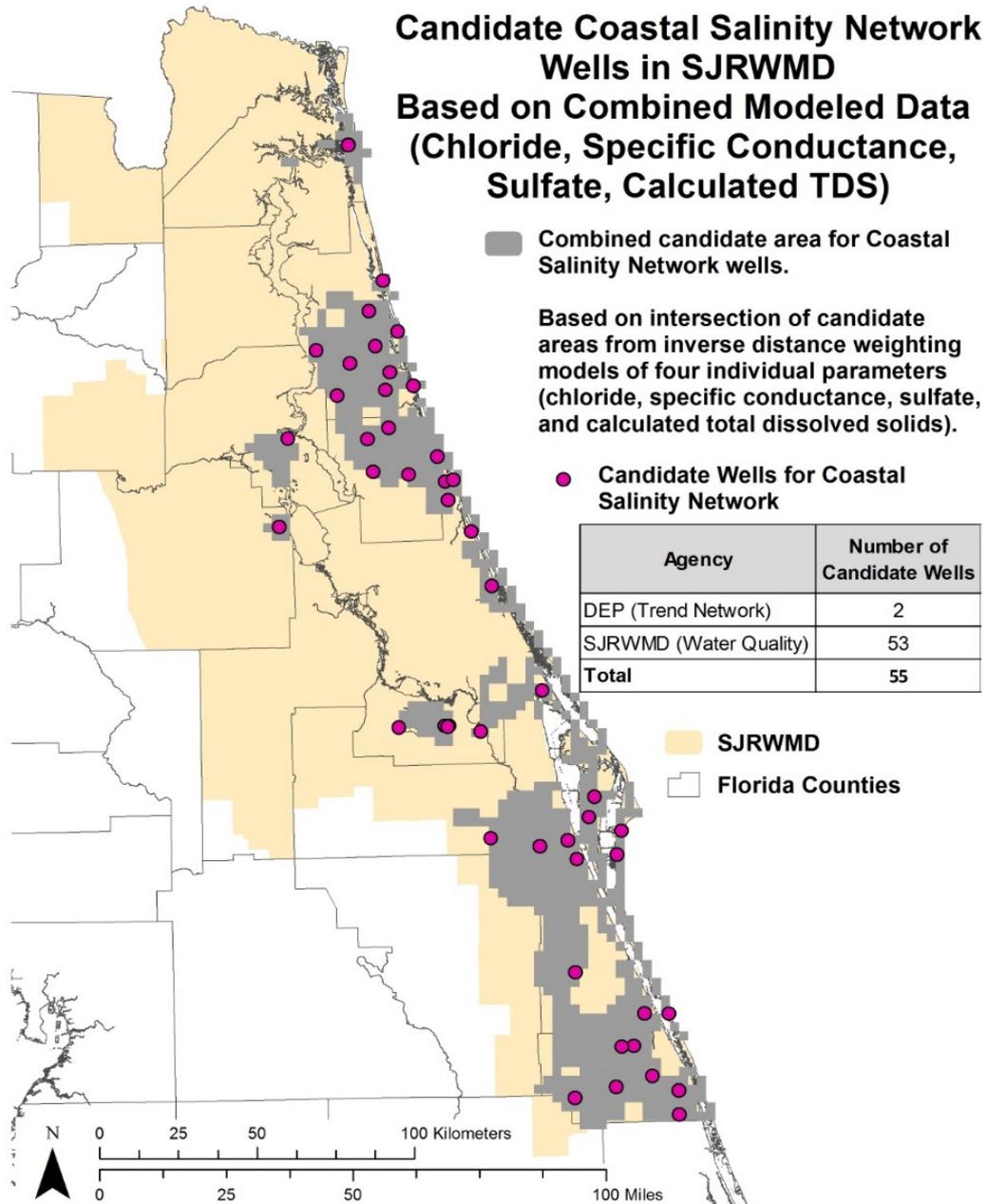


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# Candidate Coastal Salinity Network Wells in SJRWMD

## Based on Combined Modeled Data (Chloride, Specific Conductance, Sulfate, Calculated TDS)



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# Candidate Coastal Salinity Network Wells in SWFWMD Based on Combined Modeled Data (Chloride, Specific Conductance, Sulfate, Calculated TDS)

■ Combined candidate area for Coastal Salinity Network wells.

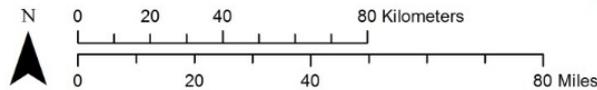
Based on intersection of candidate areas from inverse distance weighting models of four individual parameters (chloride, specific conductance, sulfate, and calculated total dissolved solids).

● Candidate Wells for Coastal Salinity Network

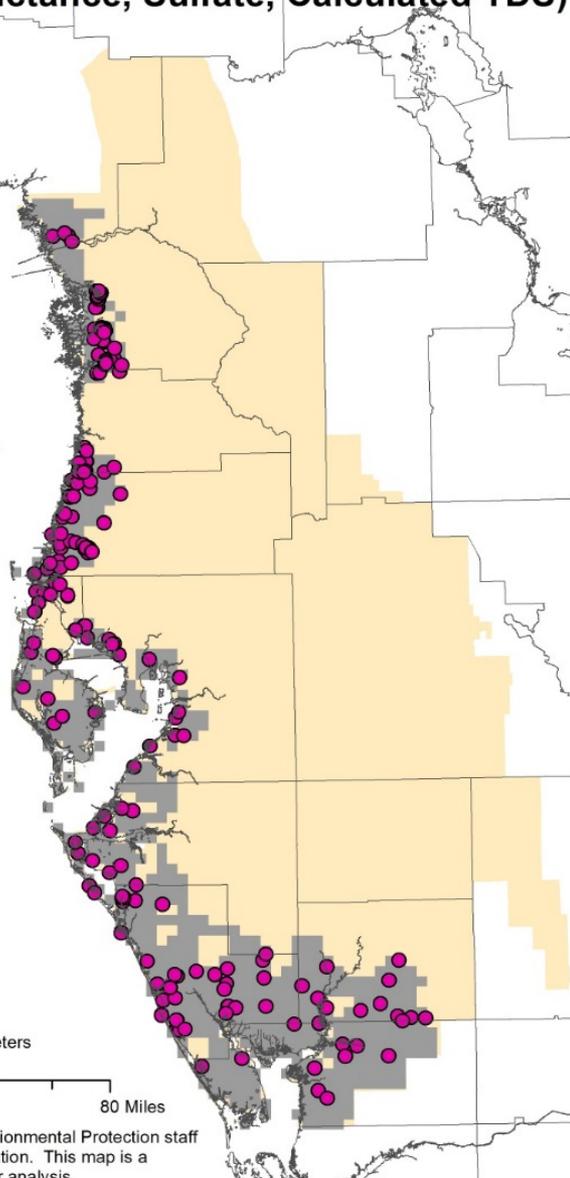
Agency	Number of Candidate Wells
DEP (Trend Network)	2
SWFWMD	335
<b>Total</b>	<b>337</b>

■ SWFWMD

□ Florida Counties



Created November 3, 2015 by Florida Department of Environmental Protection staff in the Division of Environmental Assessment and Restoration. This map is a cartographic representation and is not intended for further analysis.

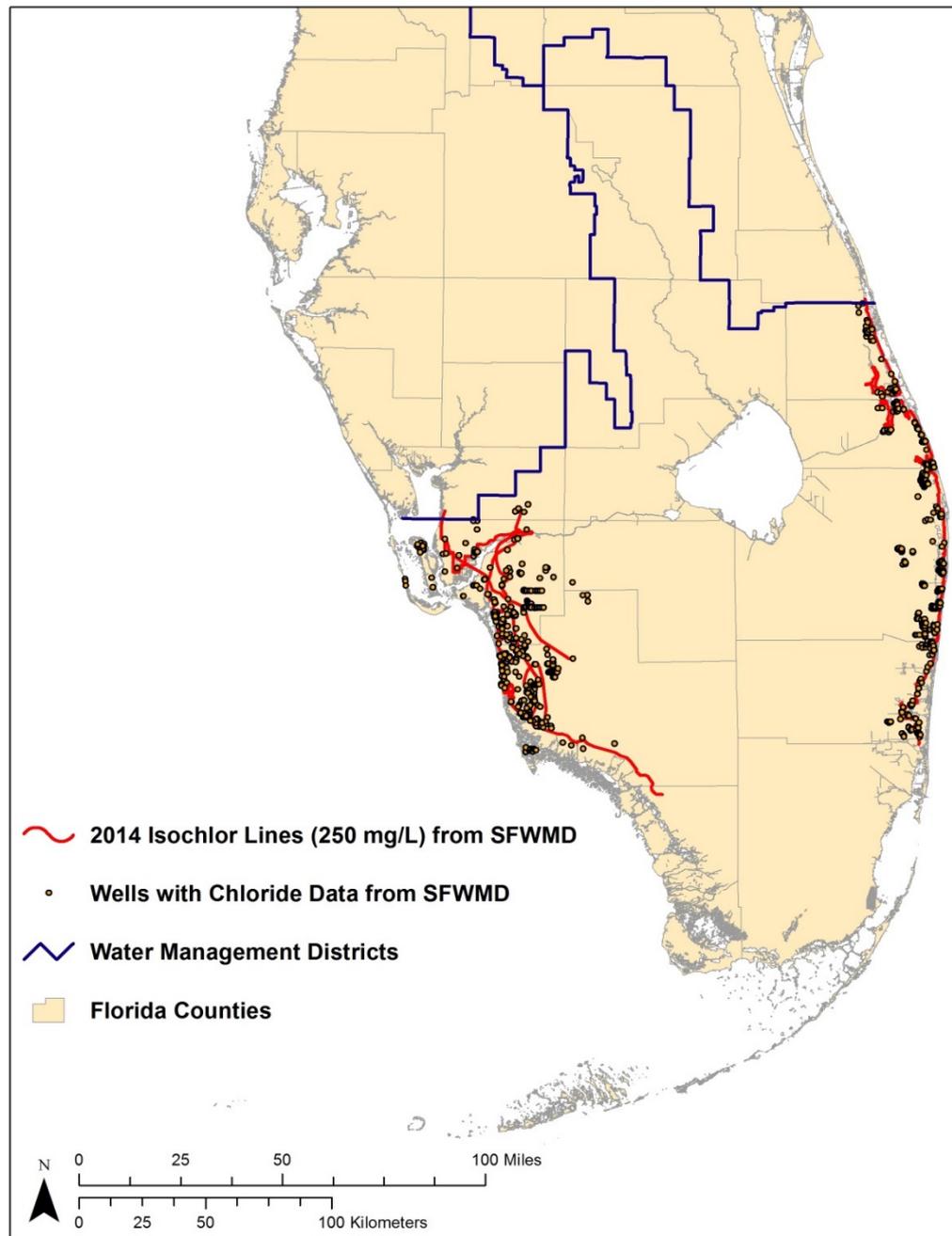




# SFWMD area



## Example of 250 mg/L isochlor maps for various aquifers in south Florida





# Example of 250 mg/L isochlor map, and more, of Biscayne aquifer in Miami-Dade County, FL

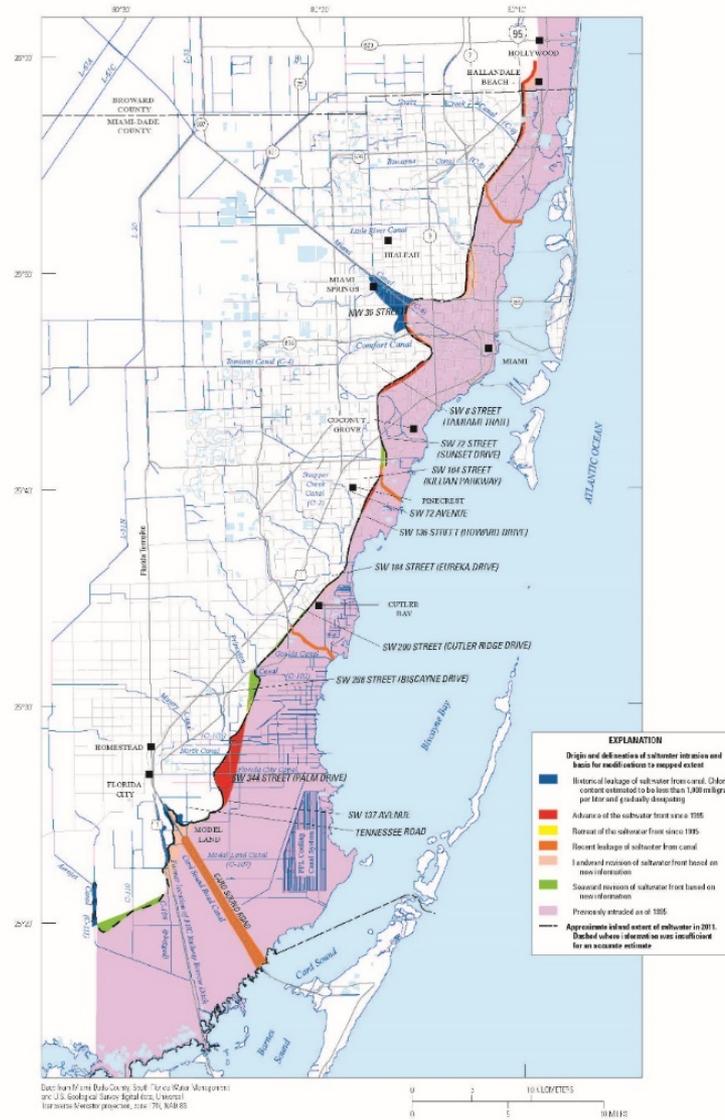


Figure 17. Map showing the origin and delineation of saltwater intrusion in the Biscayne aquifer and the basis for modifications to its mapped extent.



# Next Steps

- Select specific wells for CSMN
- Analytes: probably TDS, SC, Cl, and SO<sub>4</sub>
  - Possibly use SC to estimate other analyte concentrations
- Commence operations
- Specific questions:
  - Are concentrations changing over time?
  - If found, what is the scale of the issue?
  - Is the saltwater/fresh water interface moving?



# Florida Department of Environmental Protection

## Questions?

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