

Winter Strawberries Production in West Central Florida, at what cost? A GIS Analysis of the relationship between groundwater pumping for frost-freeze protection and sinkhole development

Mark Aurit, March, 31 2011
GEOG 596A

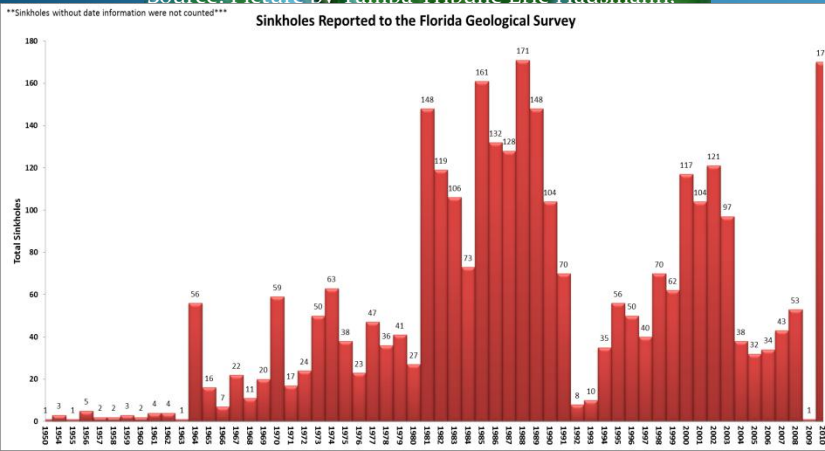


Source: Picture by Tampa Tribune Eric Hausmann.

Cell phone call saves woman after falling into sinkhole



Source: Picture by Tampa Tribune George Newman



Acknowledgements

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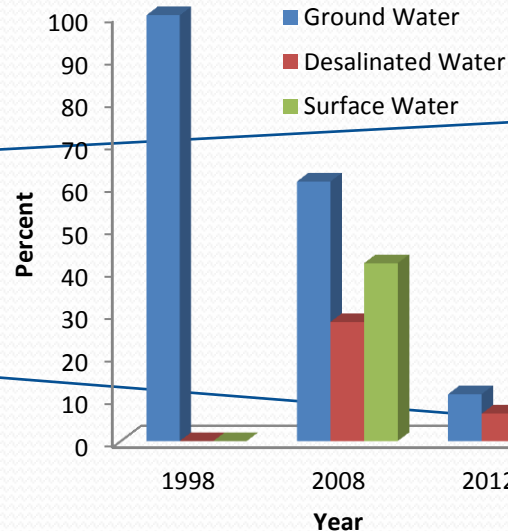
Tampa Bay Water





- manages water for SW Florida
- covers 10,000 square miles
- serves > 5 million people

- 3 cities and 3 counties in the Tampa Bay region.
- provide 186 million gallons drinking water /day

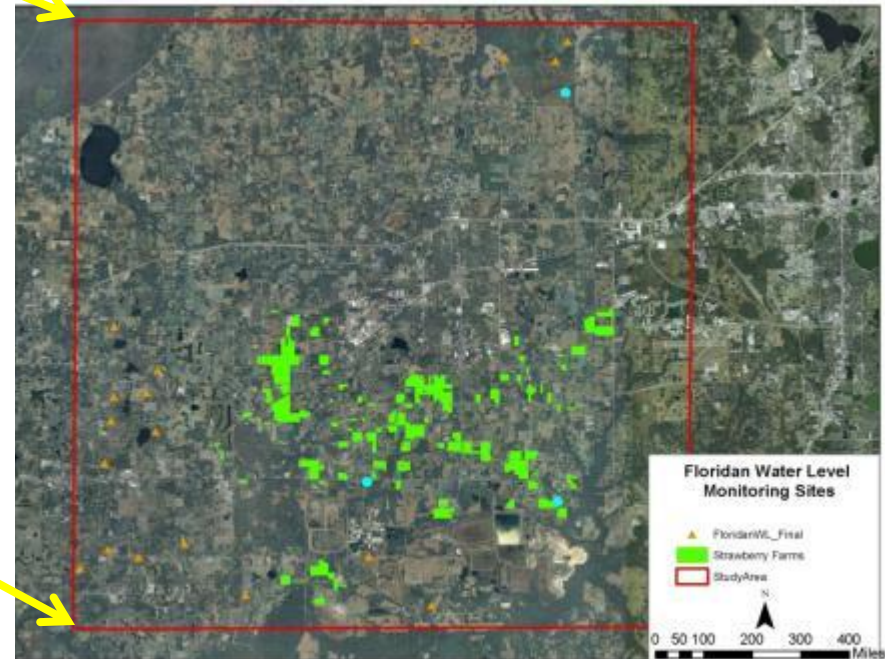
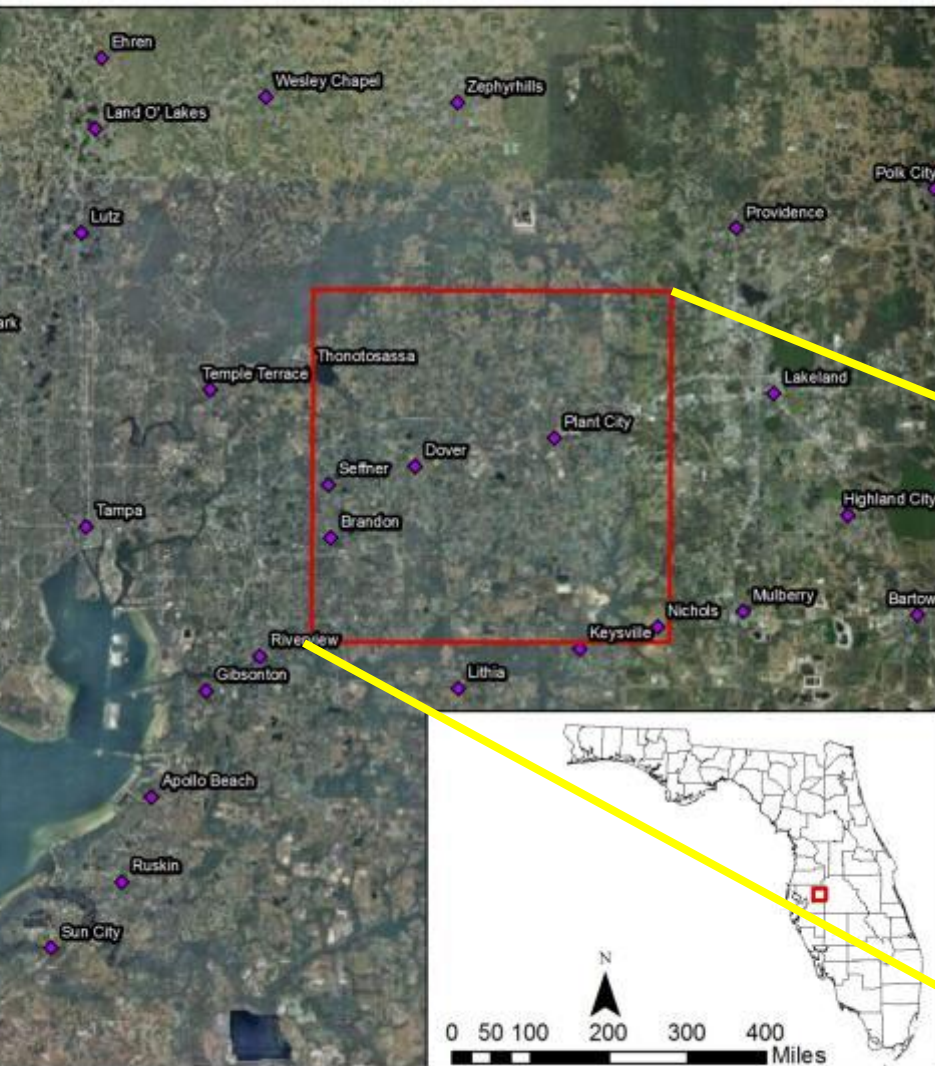


Strawberries: Dover / Plant City

Florida is the main producer of winter strawberries in the USA

Approximately 5800 acres are harvested in SW Florida

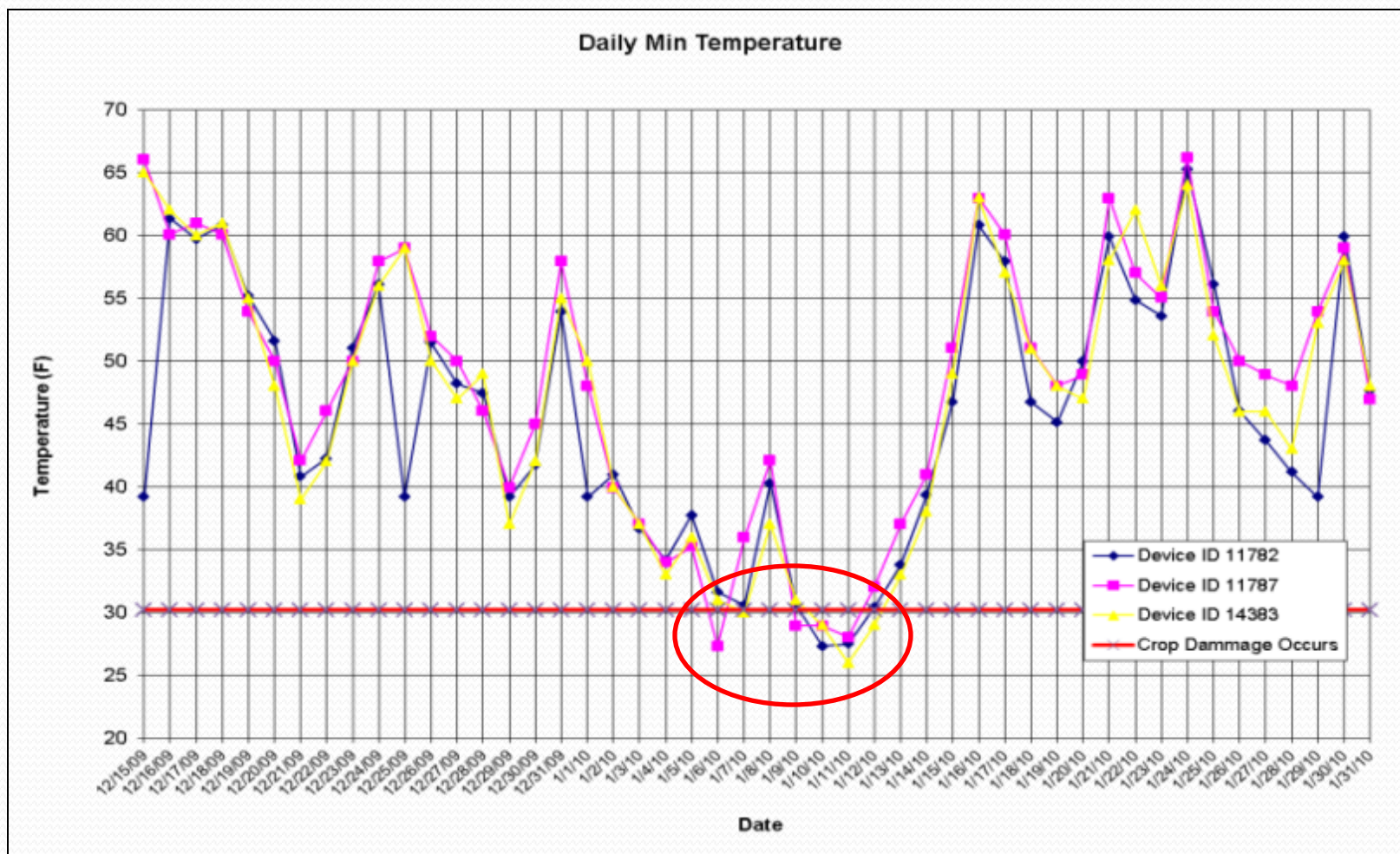
Protecting crops from frost-freeze events is important



Frost-freeze and damage

Floral/Fruit Stage Strawberry	Temperature at which 90% Damage Occurs (F)
Tight bud	22°F or -5.5°C
Tight with white petals	28°F or -2.2°C
Full bloom	32°F or -.5°C
Immature fruit	28°F or -2.2°C

Source: OMFRA, 2009



Crop protection during frost-freeze events

- Passive
 - Site selection
 - Cover



- Active
 - Heaters
 - Wind
 - Water

Table 4. Estimated approximate annual per hectare/hour operating costs (including amortization of investment, but with 0% interest and before taxes) for selected cold temperature (frost) protection systems used 120 hours per year.

Method	Estimated costs/ha/hr
Return Stack Oil Heaters (100/ha)*	\$ 93.08
Standard Propane Heaters (154/ha)*	103.98
Wind Machine (130 BHP propane)	33.36
Overcrop Sprinkling	4.10
Under Canopy Sprinkling	4.25
Frost-free site	0.00

* equal total heat output

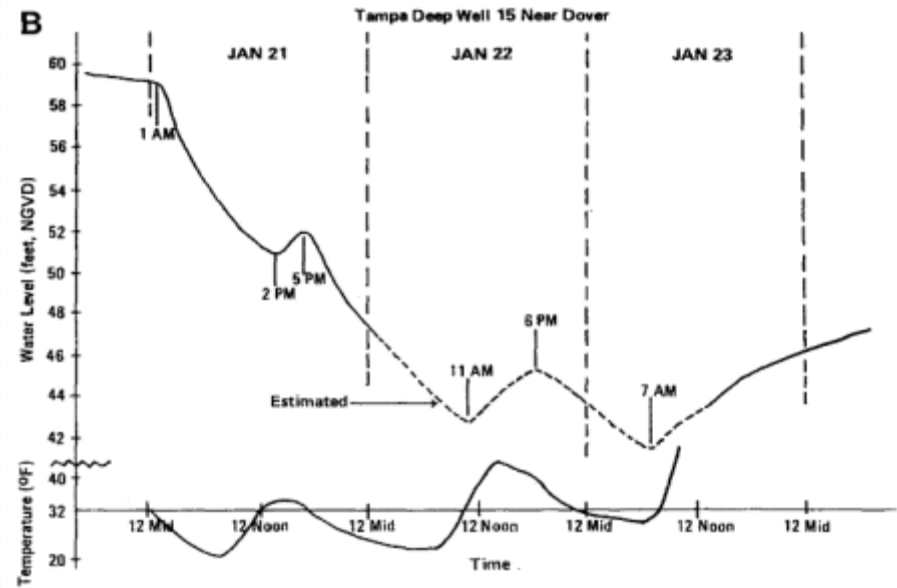
Known effects of water abstraction

Abstraction of water

Rapid reduction in water levels
(940 million gallons water/day vs 37 MGD)

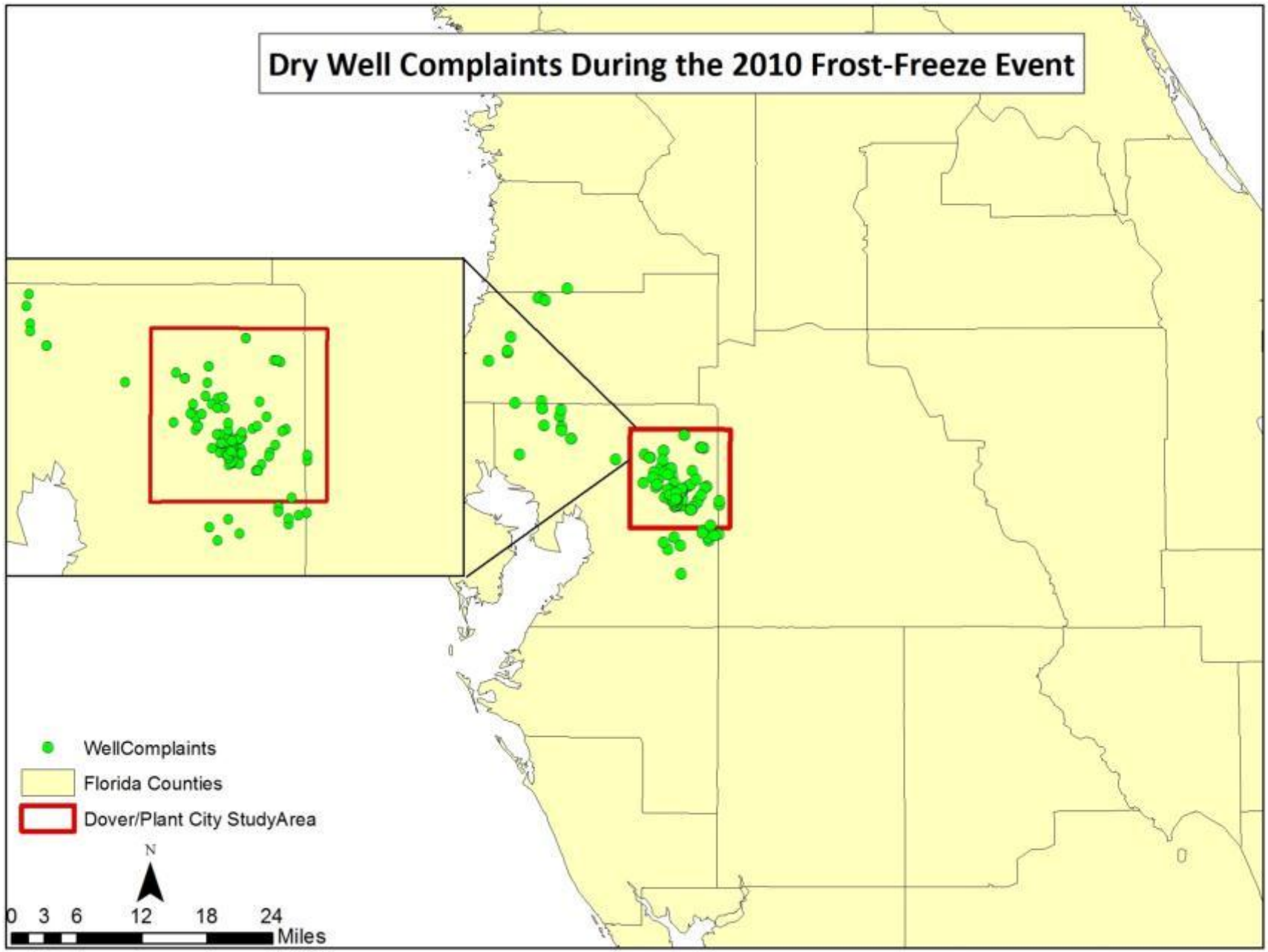
Result

- Dry wells
- Sinkhole development



Source: Bengtson, 1989

Dry Well Complaints During the 2010 Frost-Freeze Event



Costs to repair Dry Wells

- SWFWMD reports costs can range from \$1,000-\$10,000
- Tampa Bay Waters costs are similar to repair dry wells

Process	Detailed Description	Average Cost (\$)
Investigate Claim	Initial investigation to determine severity of the problem.	\$1,000
Option 1: Repair well OR drill new well using complainant vendor	Repair or drill new well using complainant vendor	Repair Well- \$5,000 New Well- \$14,000
Option 2: Repair Well	Water company repairs or drills new well	\$9,000
Well Completion	Final water quality tests to ensure water quality is to federal drinking water standards. Performed by independent consultant	\$4,000

Alternative Frost-Freeze Protection

Freeze Cloth

- Average Cost \$300 per acre
- Farmers pay 25-40% the rest is covered by SWFWMD Facilitating Agricultural Resource Management Systems (FARMS) program



Damage during 2010 frost-freeze

By GEORGE H. NEWMAN | The Tampa Tribune

31 Dec 2010



Sinkhole is 30 ft x 12 ft

Water levels dropped > 20 ft for 3 days

When temperatures dropped below-normal with freezing temperatures

Repairing Florida sinkholes are EXPENSIVE

Damage during 2010 frost-freeze

	Plant City Road Repairs	Trapnell Elementary School	Plant City Water Tower	Hillsborough County
Cost	\$1,600,000	\$900,000	\$250,000	\$4,900,000
Sinkhole	14	1	1	139



Picture illustrating how a 30 yard wide 40-50 foot deep sinkhole destroyed property in Plant City, FL (Source: Picture by Jay Nolan 2010)

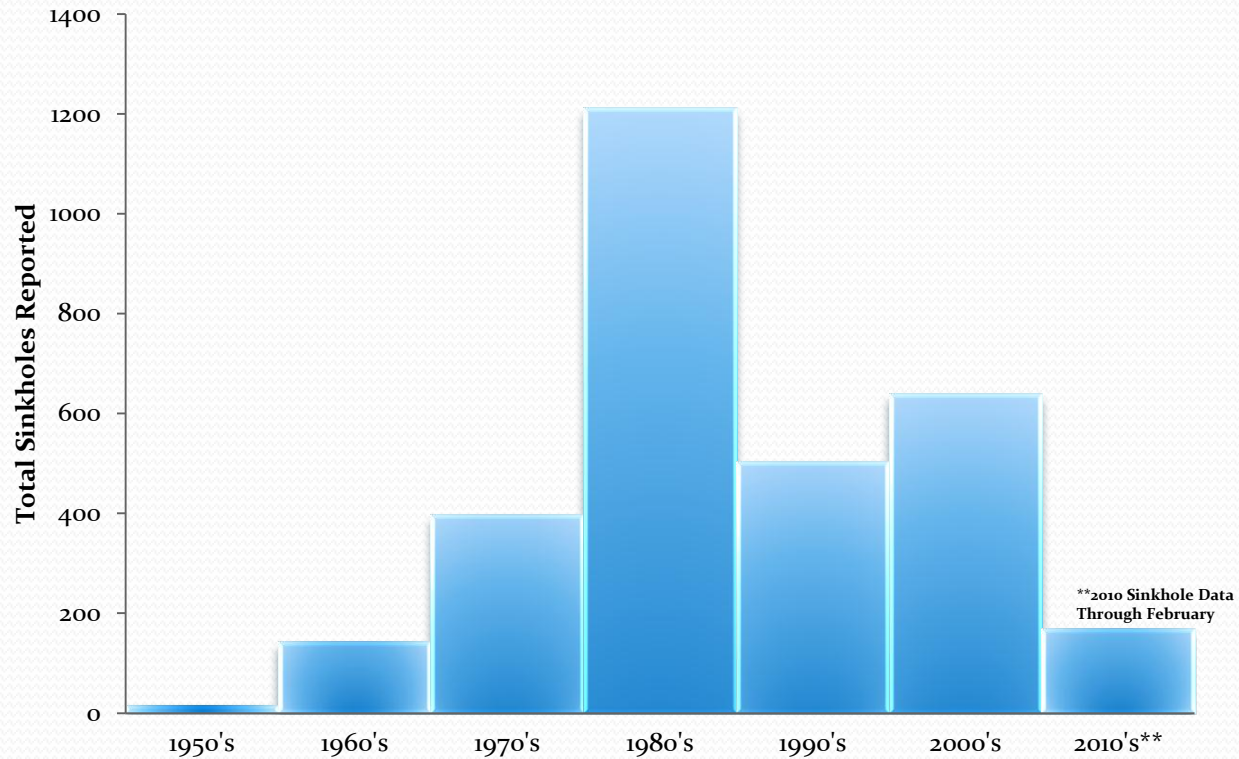


Damage caused by a sinkhole on Highway 27 near Interstate 4 connecting Tampa and Orlando, which resulting in the closure of three of four lanes on January 13, 2010. (Source: Picture by WMG-TV Jacksonville, 2010)

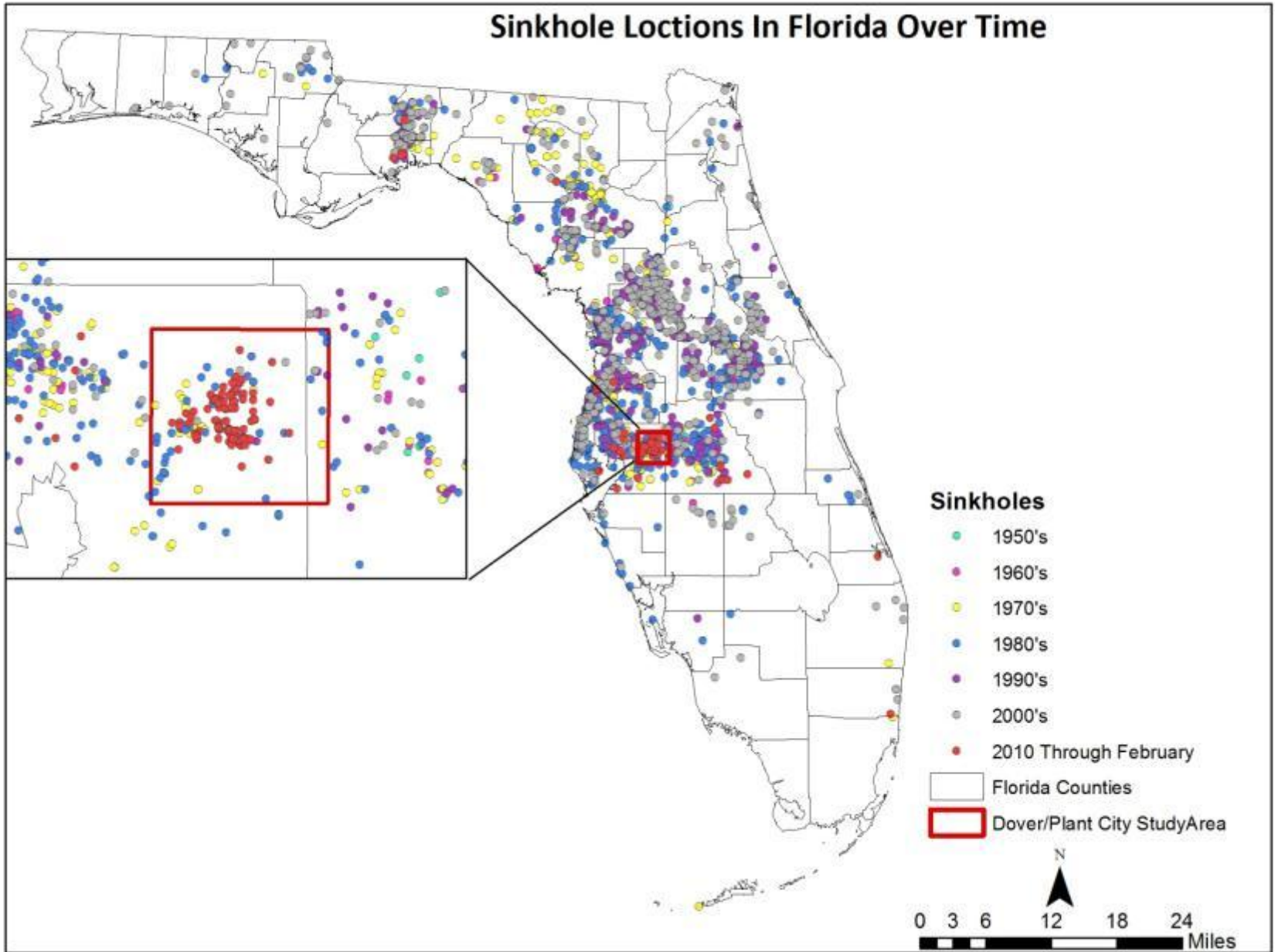
Sinkholes in Florida

Sinkholes without date information in the FGS database were not counted

Subsidence Incidents Reported to the Florida Geologic Survey



Sinkhole Locations In Florida Over Time



Objectives

Objective 1: How have frost-freeze event affected West Central Florida?

- *Examine how severe the frost-freeze event of 2010 was to the strawberry farmers.*
- *Examine how quickly water levels were depleted during the frost-freeze event and for how long*
- *Examine the number of sinkholes that were reported during and shortly after the frost-freeze event (with 5 days)*

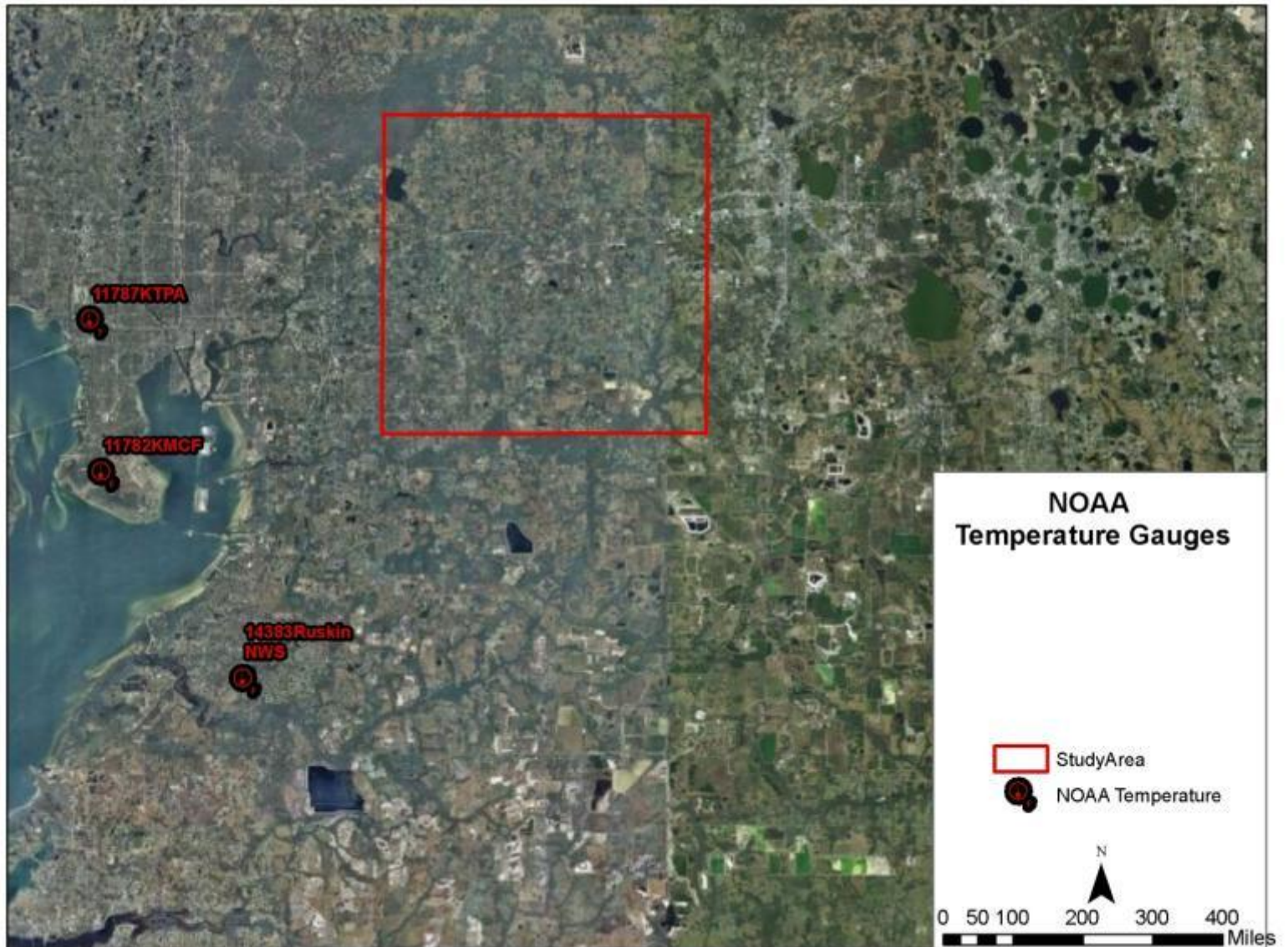
Objective 2: What is the economic impact of a frost-freeze event?

- *Determine cost of investigating, repairing or drilling new wells (costs as illustrated earlier).*
- *Determine cost of using alternative crop protection methods (e.g. freeze cloth – costs as illustrated earlier)*

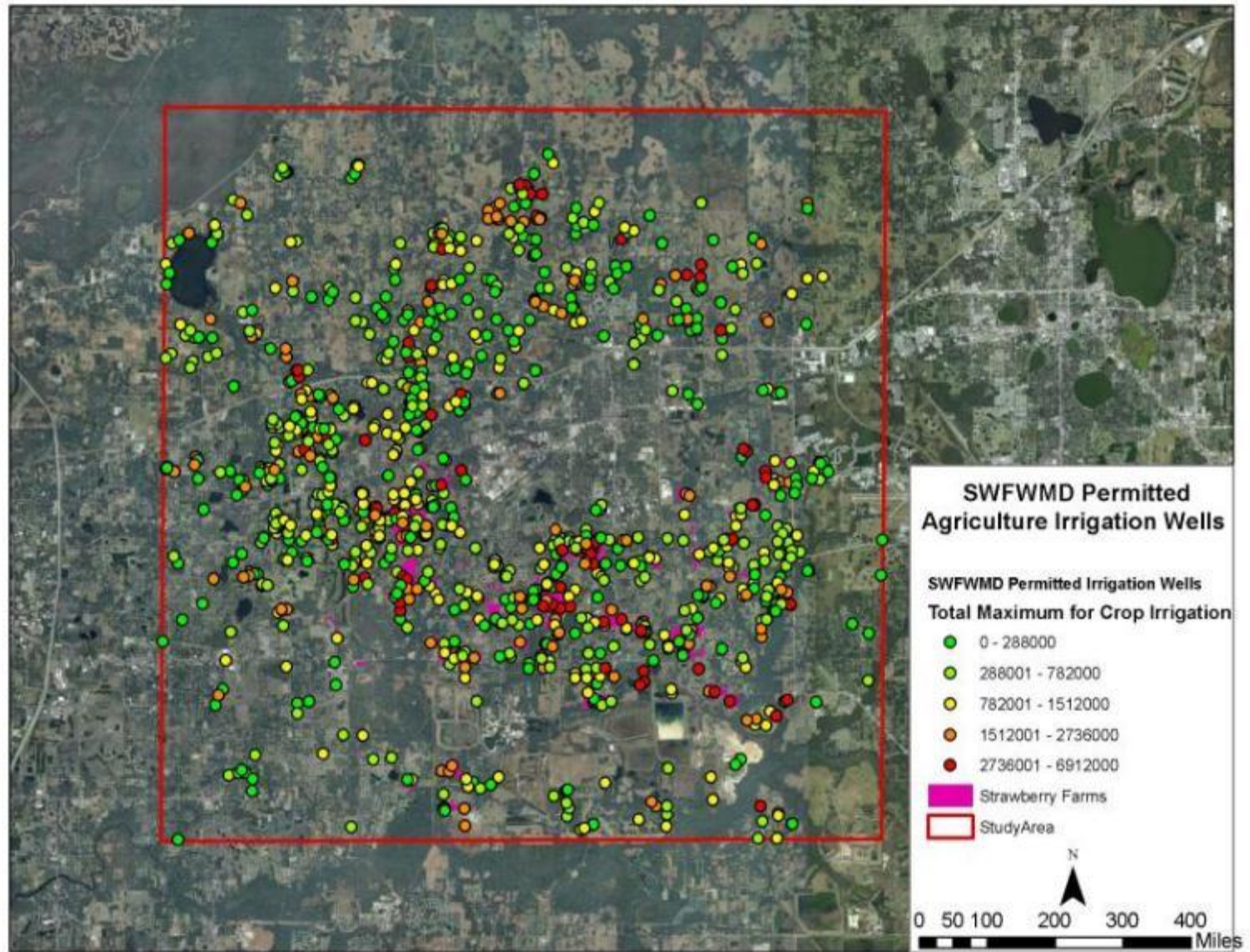
Data

Dataset	Publisher/Sou rce	Published	Data Type	Shape	Measure	Time Component
NOAA Temperatur e Data	National Oceanic and Atmospheric Administration	2010	Vector	Point	F°-Daily Minimum Temperature	Yes
Strawberry Farms	Department Of Revenue	2006	Vector	Polygon	N/A	No
Agricultural Irrigation Permits	Southwest Florida Water Management District	2010	Vector	Point	Maximum Daily Permitted Flow Gallons/Day	No
Floridan Aquafer Monitor Sites	Tampa Bay Water	2010	Vector	Point	N/A	Yes
Floridan Aquafer Water Levels	Tampa Bay Water	2010	CSV	Table	Daily Average	Yes
Well Complaints	Tampa Bay Water	2010	Vector	Point	N/A	Yes
SWFWMD 2010 Aerial Photos	Southwest Florida Water Management District	2010	Raster	N/A	N/A	No

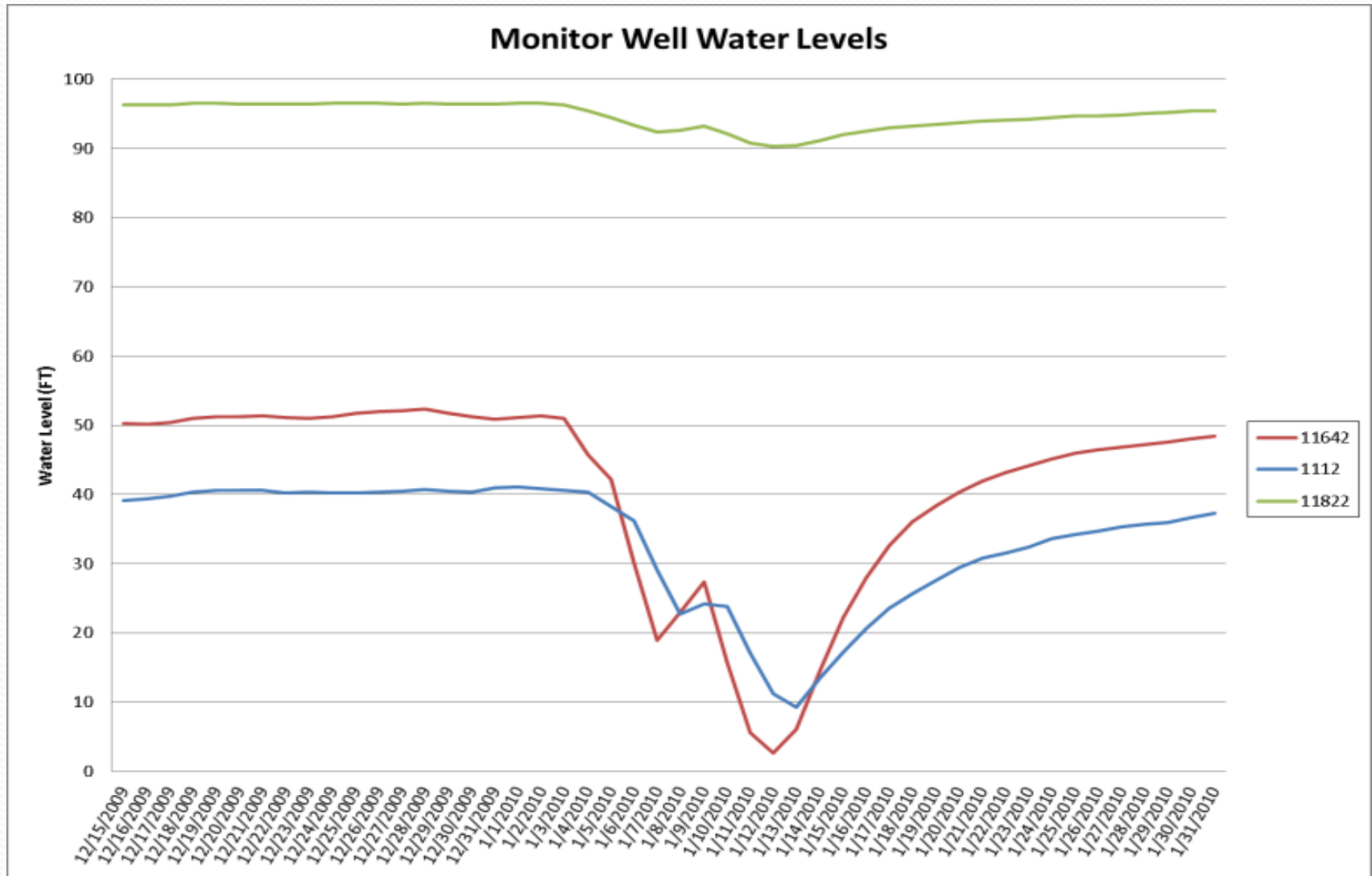
Meteorological Stations



Agricultural Irrigation Wells



Drop in water levels during a frost-freeze event, 2010



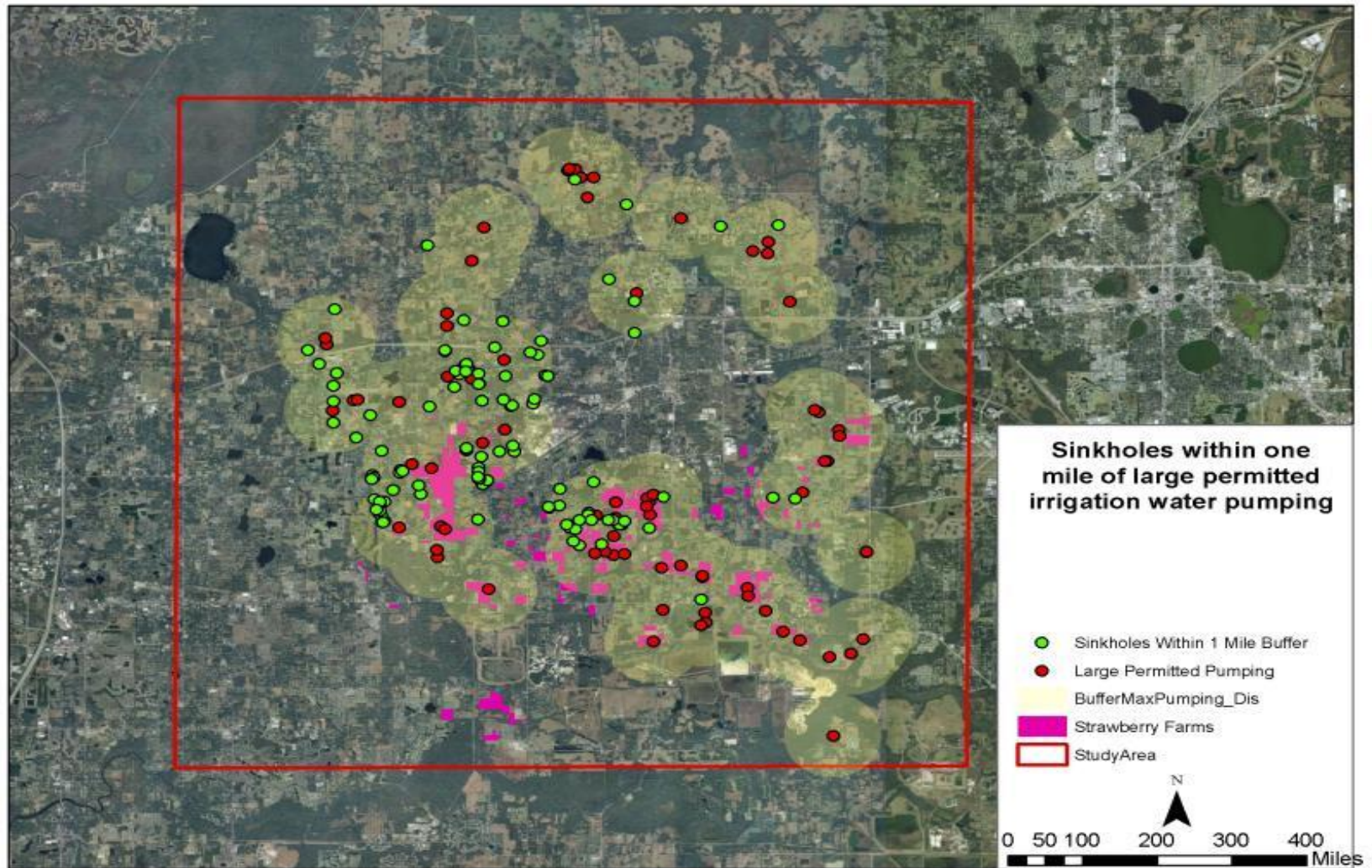
Methods

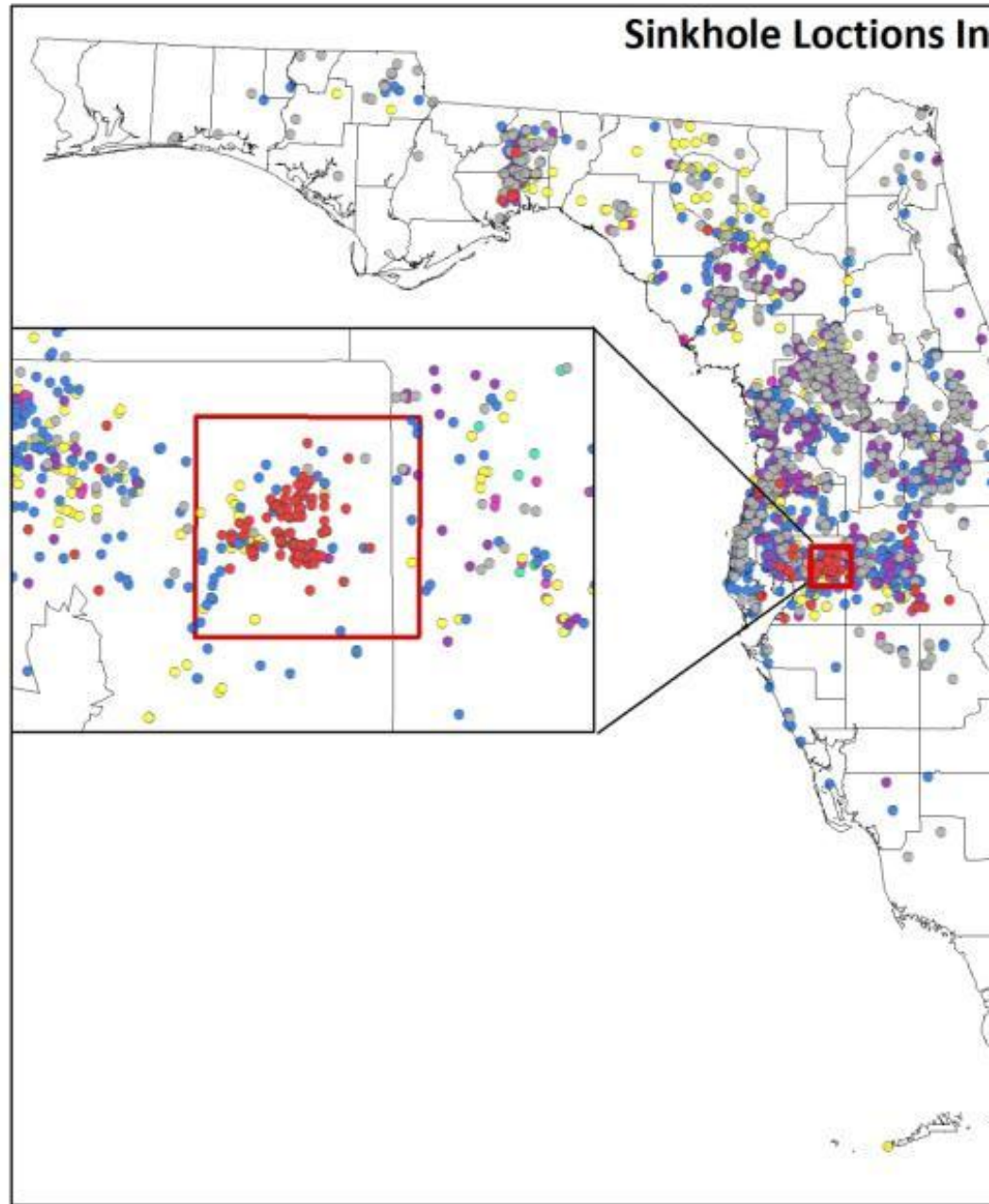
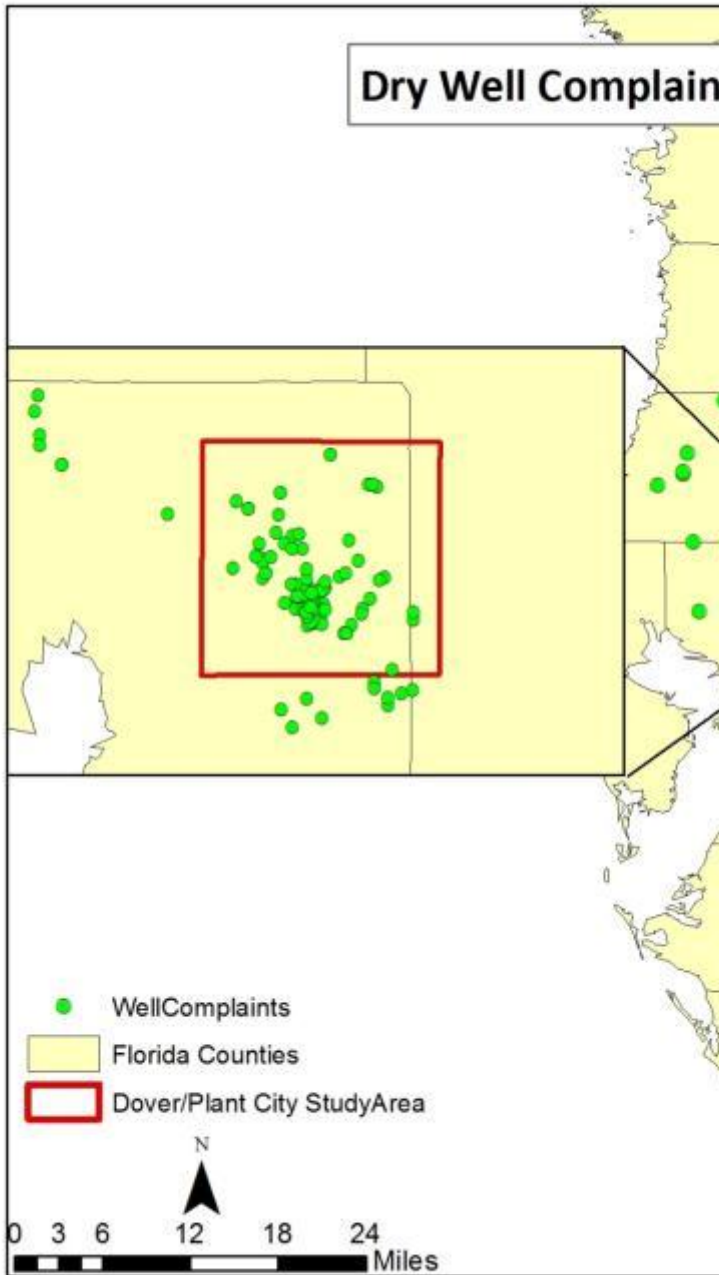
- Frost freeze event will be defined when temperature $< 32^{\circ}\text{F}$ (0°C)
- Spatial and temporal analysis of how a frost-freeze event and changes in water levels are related and examine if this was consistent throughout the study area.
- Use buffer, proximity, intersection and union methods
- Kernel density estimates of sinkholes and well complaints
- Create surfaces of daily water levels to examine rate of change
- Nearest-neighbor analysis to investigate randomness and clustering

Anticipated Results

1. Series of maps illustrating spatial distribution of complaints, water levels, sinkholes and strawberry farms.
2. Graphs representing temporal variation in daily minimum temperature, water levels, and sinkholes for the 2010 frost-freeze events.
3. Total cost incurred by water companies for damages to wells during 2010 and for using alternative methods (e.g. freeze cover)

Proximity of irrigation wells, sinkholes to strawberry farms





Timeline

- Winter 2011-Finish Project Proposal (GEOG 596A)
- Spring 2011-Complete Analysis (GEOG 596 B)
- Summer 2011- Final Publication/Presentation (TBD)



Questions

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