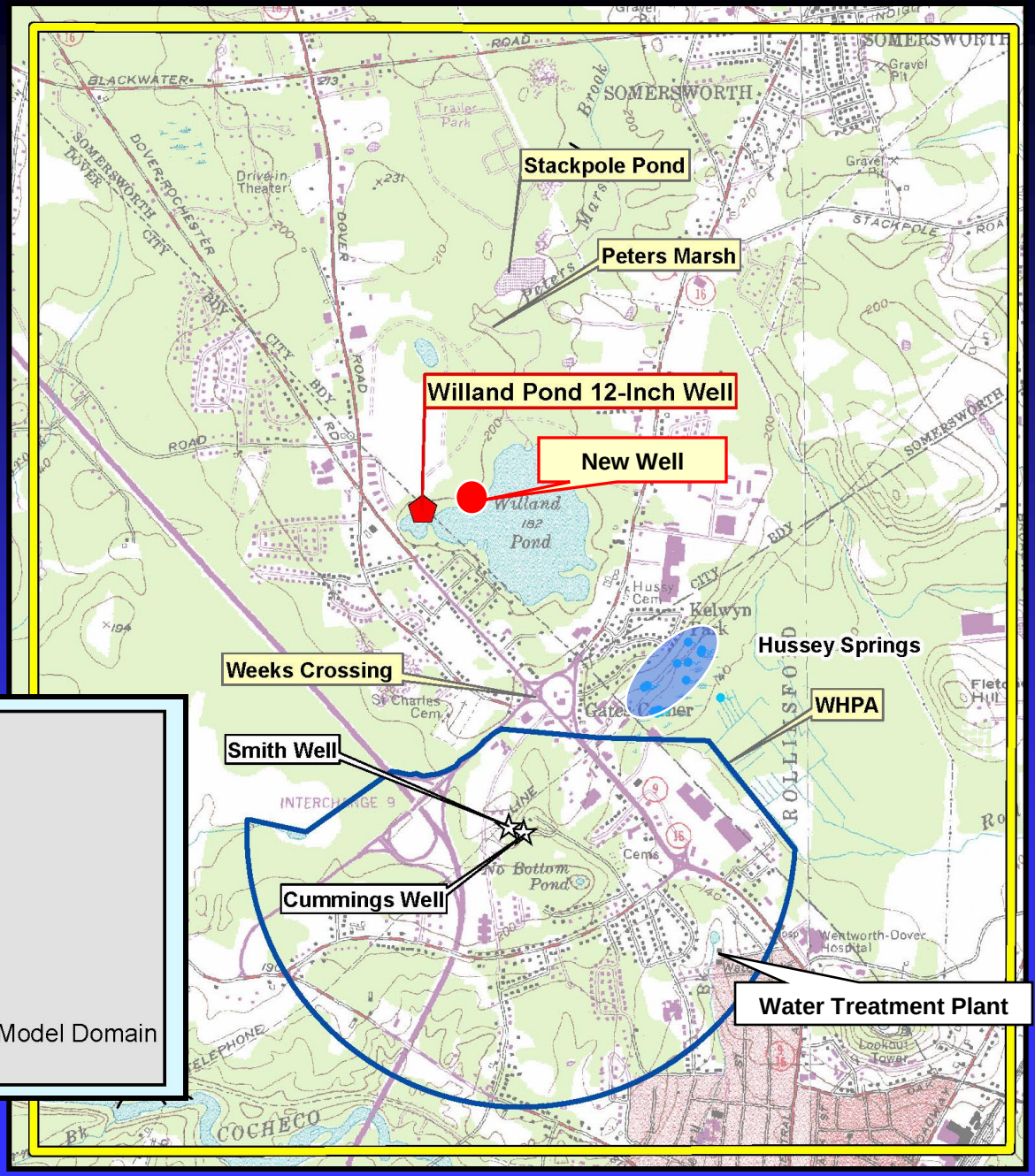

PHASES II and III
PROJECT UPDATE
WILLAND POND WELL
INVESTIGATION
HYDROGEOLOGIC
ASSESSMENT

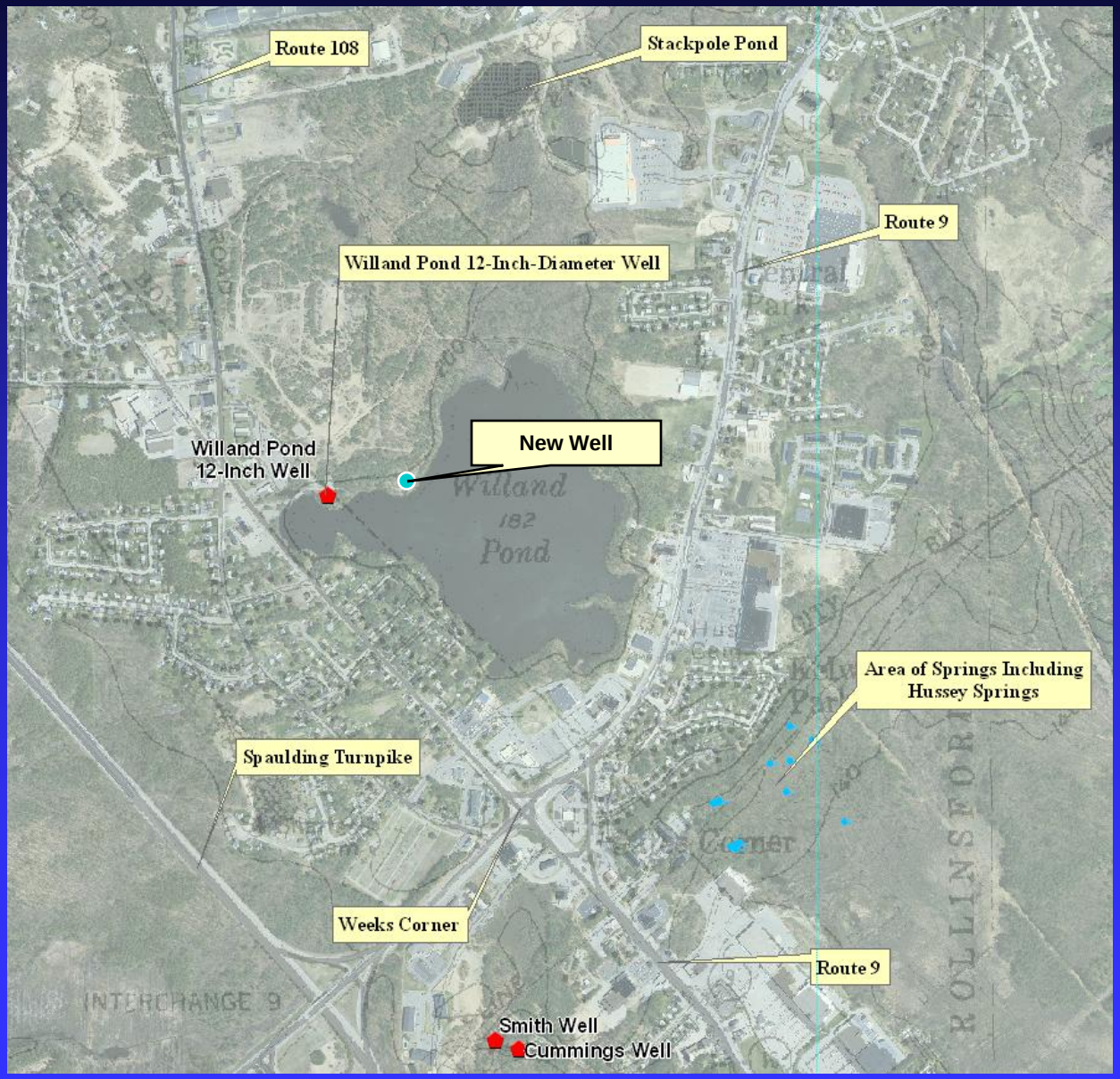
Location Map



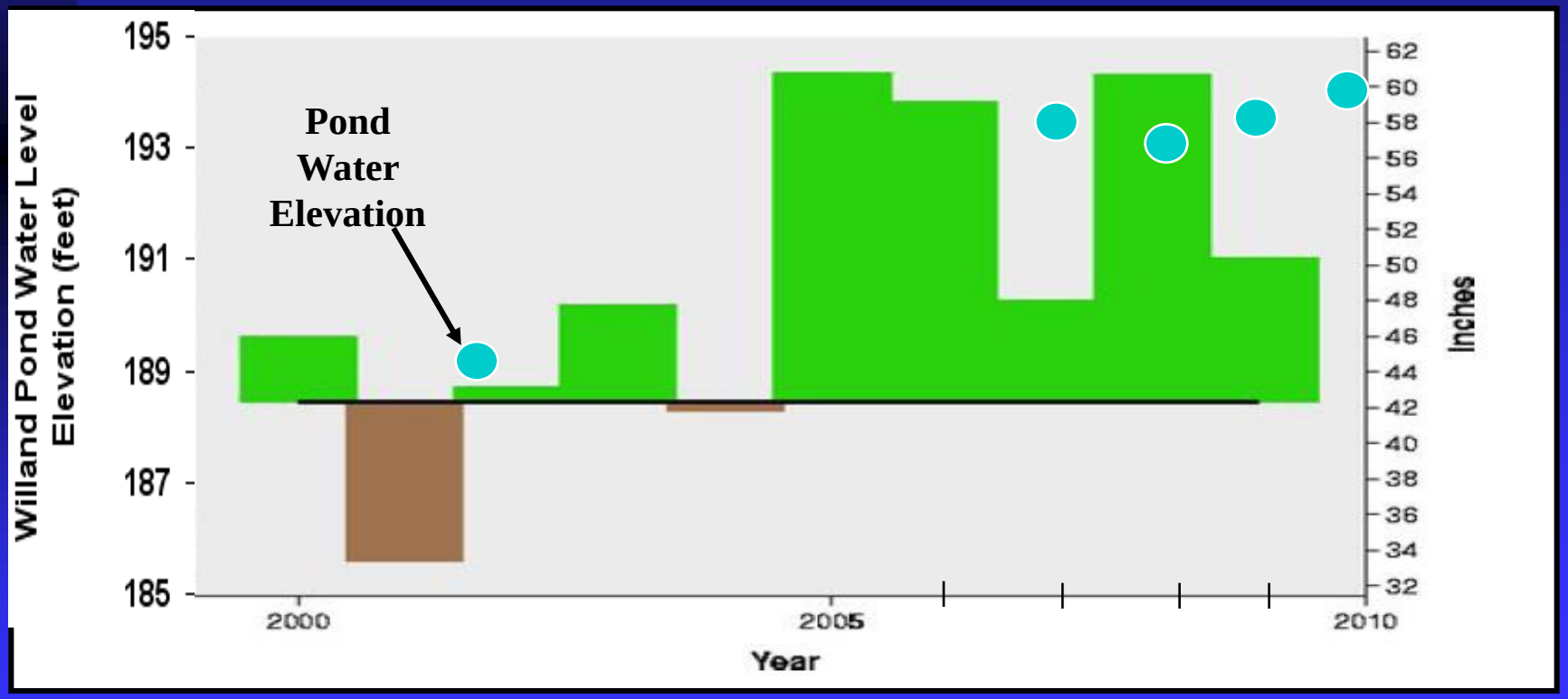
Legend

- Hussey Springs
- Existing Public Supply Well
- Proposed Production Well
- Existing Well Head Protection Area for Smith and Cummings Wells
- Willand Pond Aquifer Study Area and Model Domain

Aerial Photograph of Study Area



Above average precipitation between 2005 and 2010 had resulted in higher groundwater levels in the Willand Pond Aquifer, and higher surface water levels in Willand Pond.



The City of Dover initiated a program to evaluate if the existing Willand Pond 12-Inch-Diameter Well could be used to:

- Lower water levels in Willand Pond; and
- Serve as a public potable water supply for the City.

Willand Pond Water Resource Assessment Program

Phase I

Fatal Flaw Assessment

(Completed)

Phase II

Numerical Modeling of Willand Pond Aquifer

(Completed)

Willand Pond Water Resource Assessment Program

Phase III – Part I

Preliminary Well Evaluation and Geophysics

(Completed)

Phase III – Part II

Long-Term Pumping Test Program

(Completed)

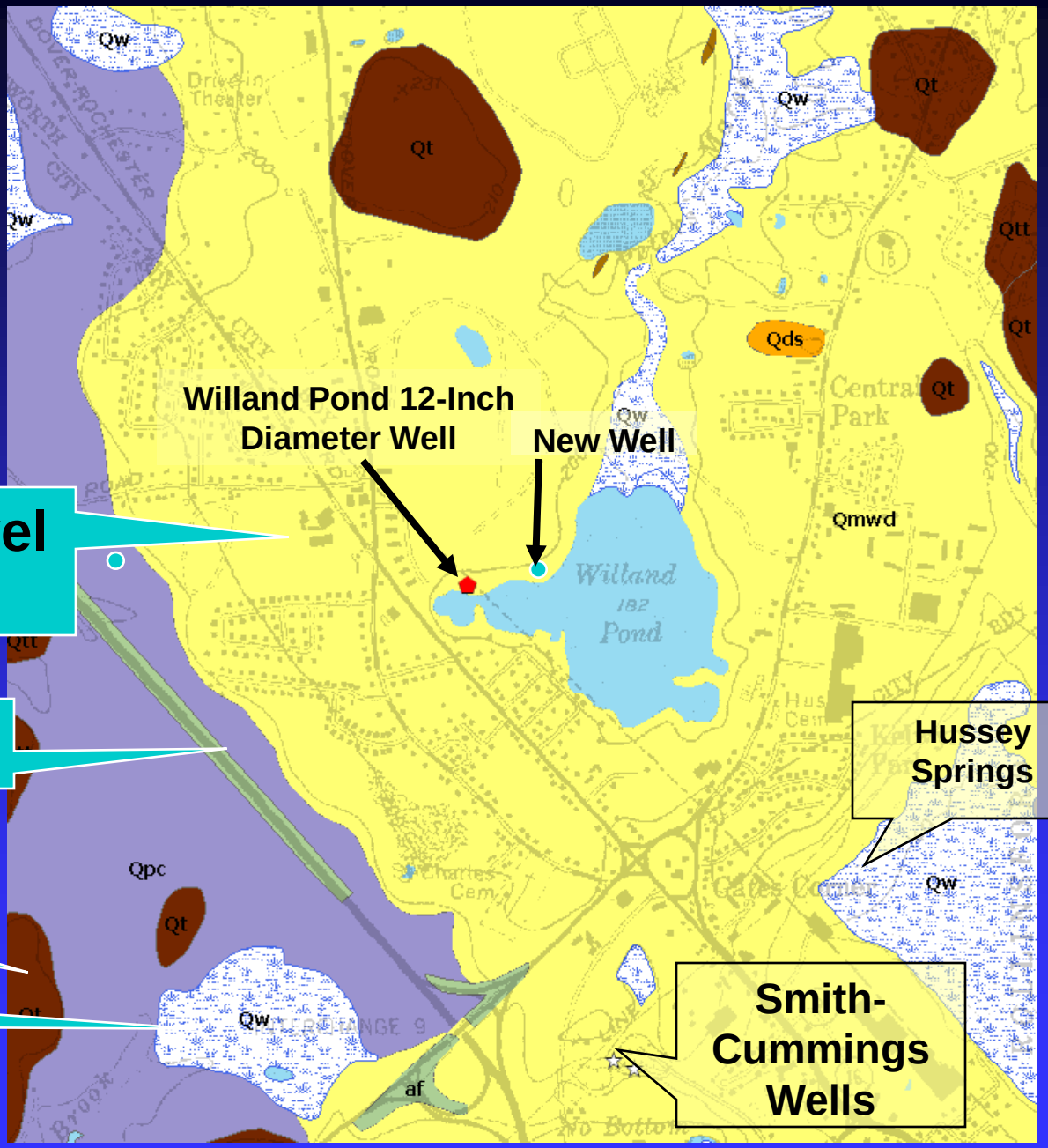
Willand Pond Water Resource Assessment Program

Phase III – Part III

Data Compilation, Analyses, and Permitting

(Ongoing)

Hydrogeologic Setting



Phase III - Part I

- Evaluate the construction status of the Existing Willand Pond 12-Inch Well. (Screen at 50-70 feet below ground surface).

- Evaluate the Willand Pond Aquifer through Geophysical Methods.

Rehabilitation of 12-Inch Well

Video Log – Selected Photographs

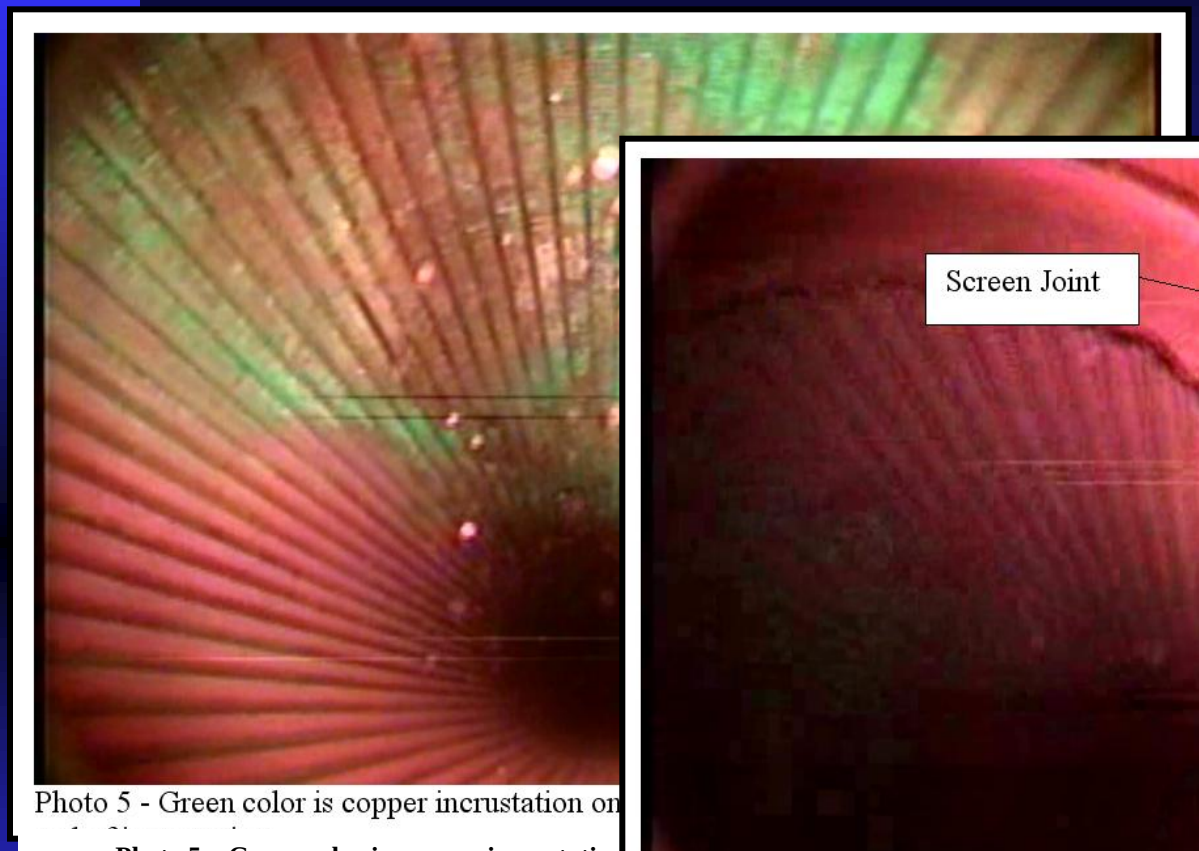


Photo 5 - Green color is copper incrustation on

Photo 5 – Green color is copper incrustation

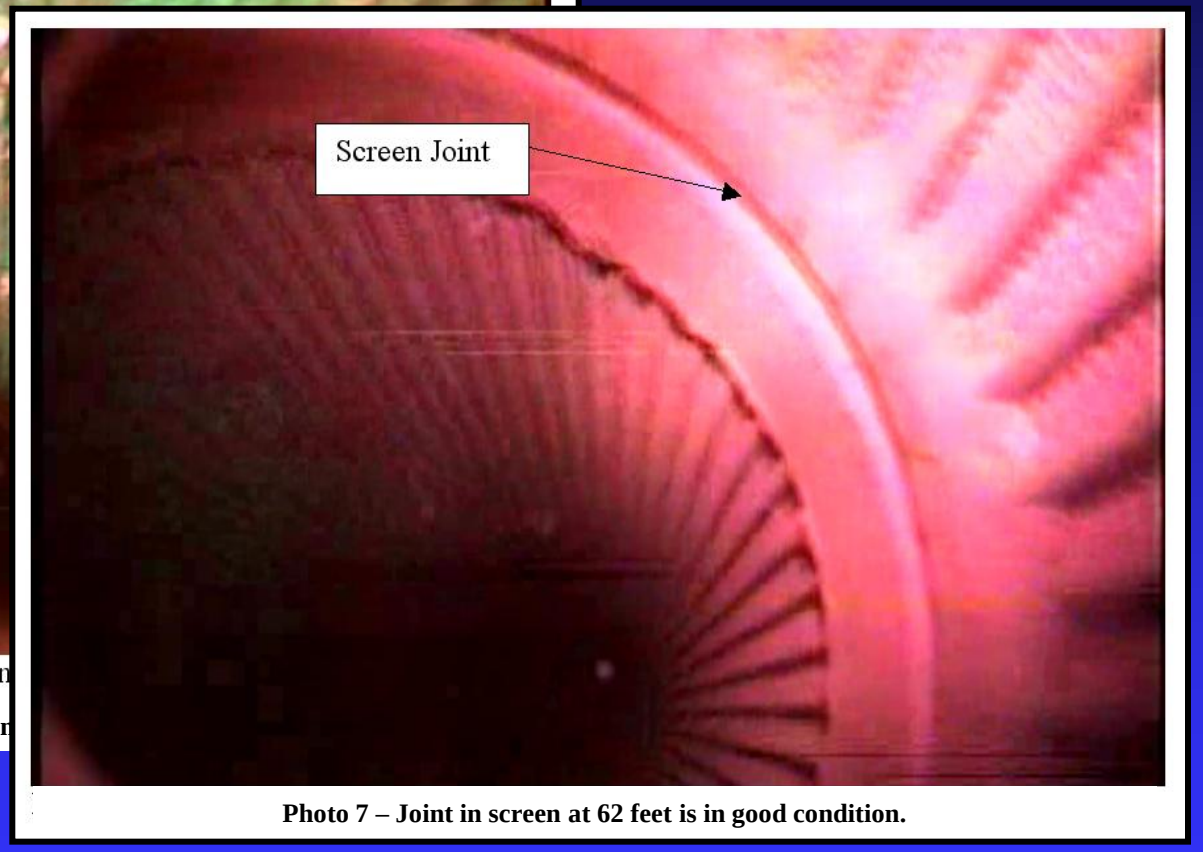
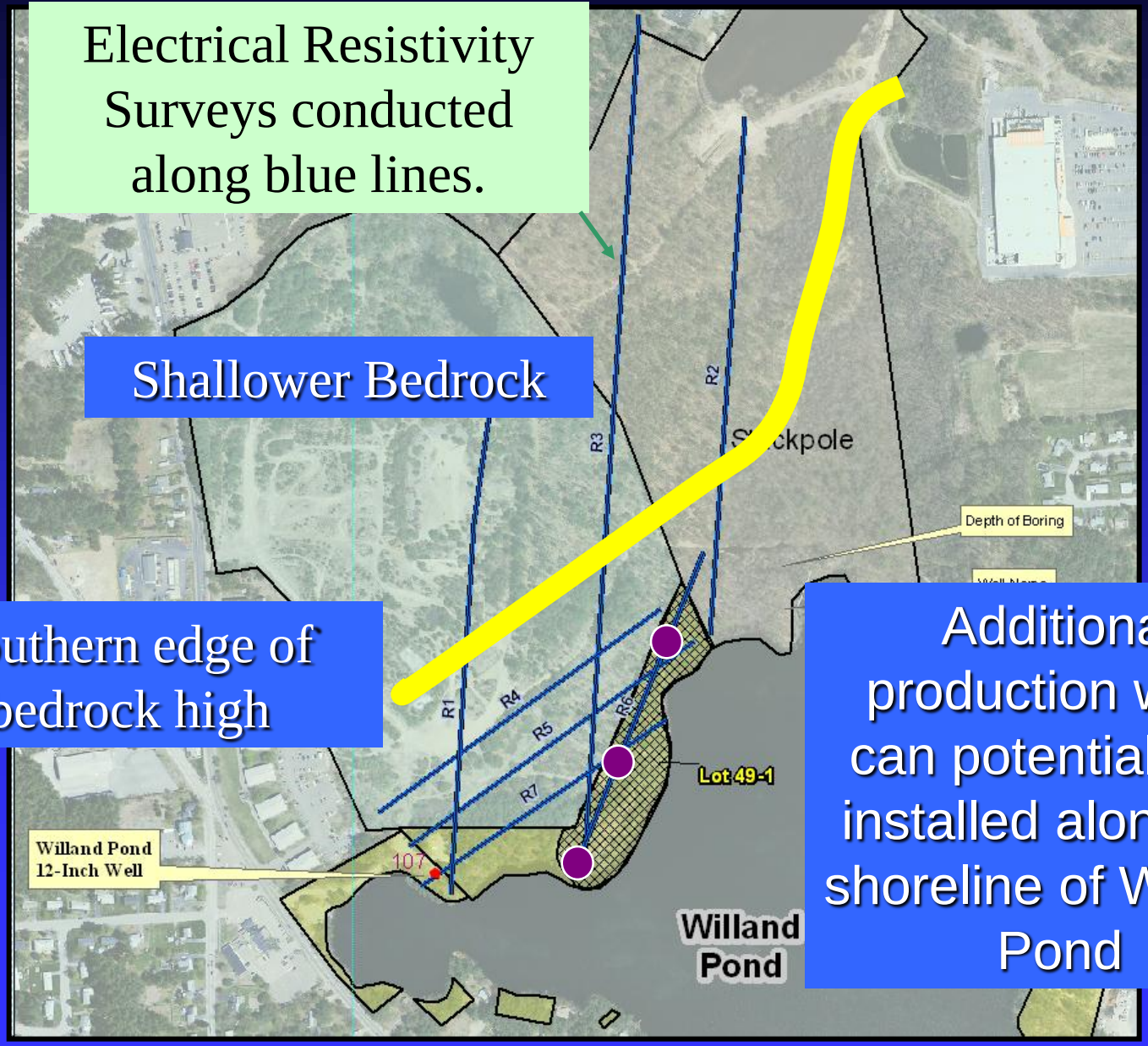


Photo 7 – Joint in screen at 62 feet is in good condition.

Well condition deemed sufficient for testing and potential long-term use.

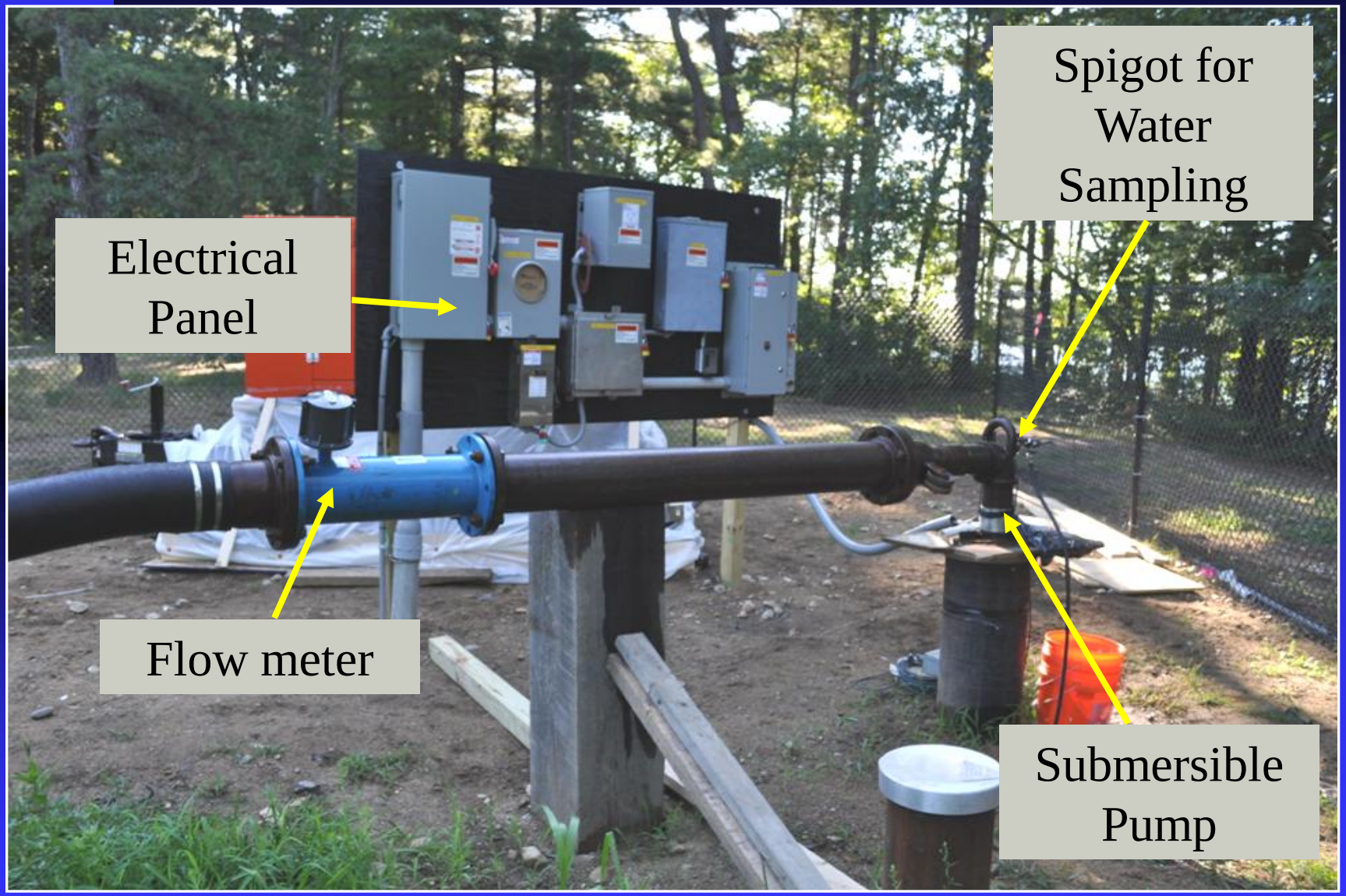
Results of Geophysical Assessment



Phase III - Part II

- NHDES Meeting – PT Plan Approved
- Purchase and Install Submersible Pump
- Install 3-Phase Power to Willand Pond 12-Inch Well (Performed by City)

Pump Setup


Spigot for Water Sampling
Electrical Panel
Flow meter
Submersible Pump

Phase III - Part II

- Conduct Exploratory Drilling
- Install Groundwater Monitoring Equipment at 41 Monitoring Stations

Drilling of 4 Exploratory Test Wells and 18 Monitoring Wells

Drilling of 4 Exploratory Test Wells and 18 Monitoring Wells

Drilling of 4 Exploratory Test Wells and 18 Monitoring Wells

Flush mount for public safety

Phase III Work Efforts

Phase III - Part II

- Install Pipeline for Discharge of Groundwater Pumped during the 90-Day Test

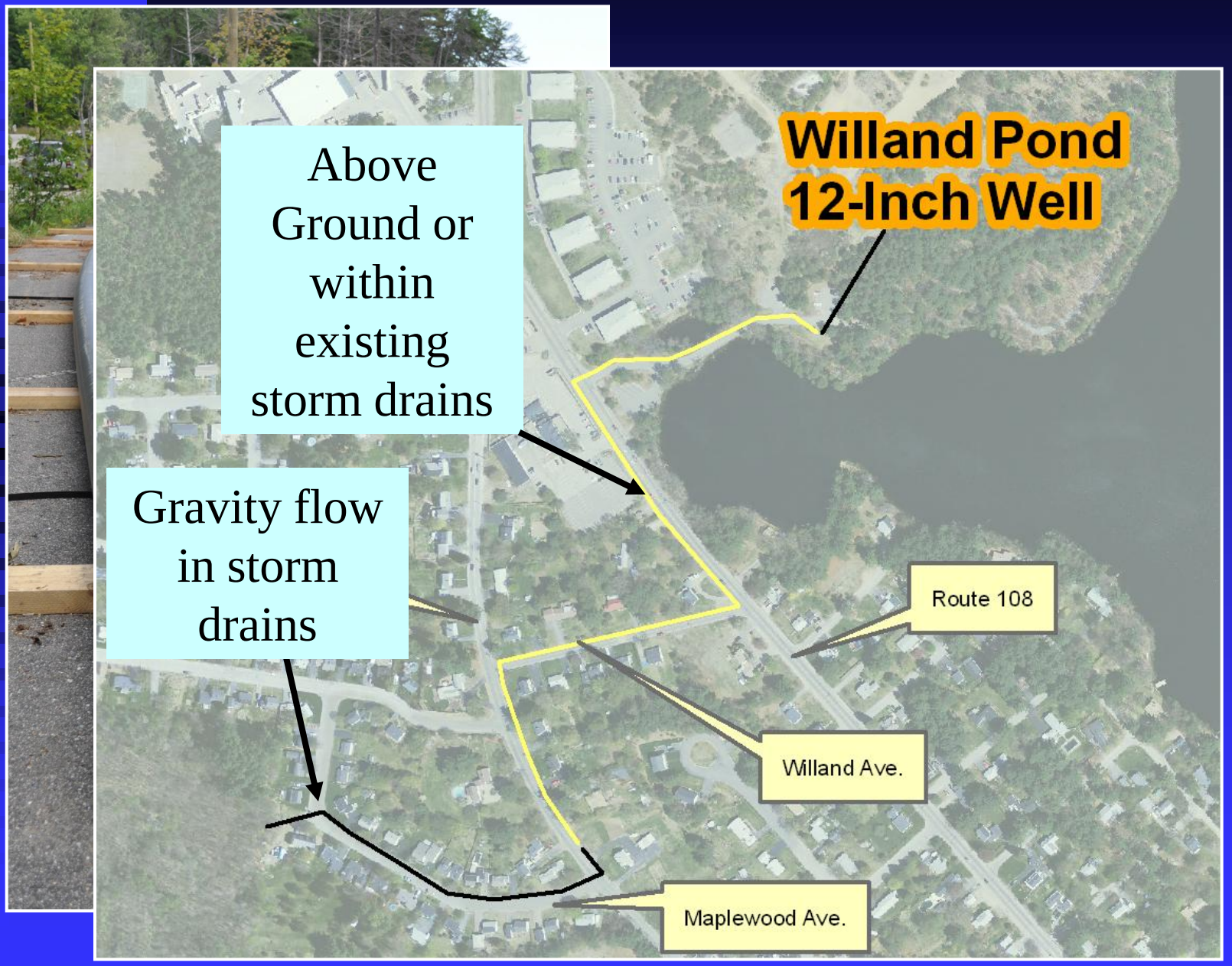
  (Performed by City)

- Permit Discharge

Groundwater Discharge

6-inch diameter HDPE flexible pipe used for discharge line

Groundwater Discharge



Groundwater Discharge

Phase III - Part II

- Conduct a 90-Day Pumping Test and Water Quality Assessment Program

Phase III - Part II

- **Pumping Test Program**

- Pumping Rate: 600 gpm.
- Pumping Period 90 Days:
  July 22, 2010 to October 20, 2010

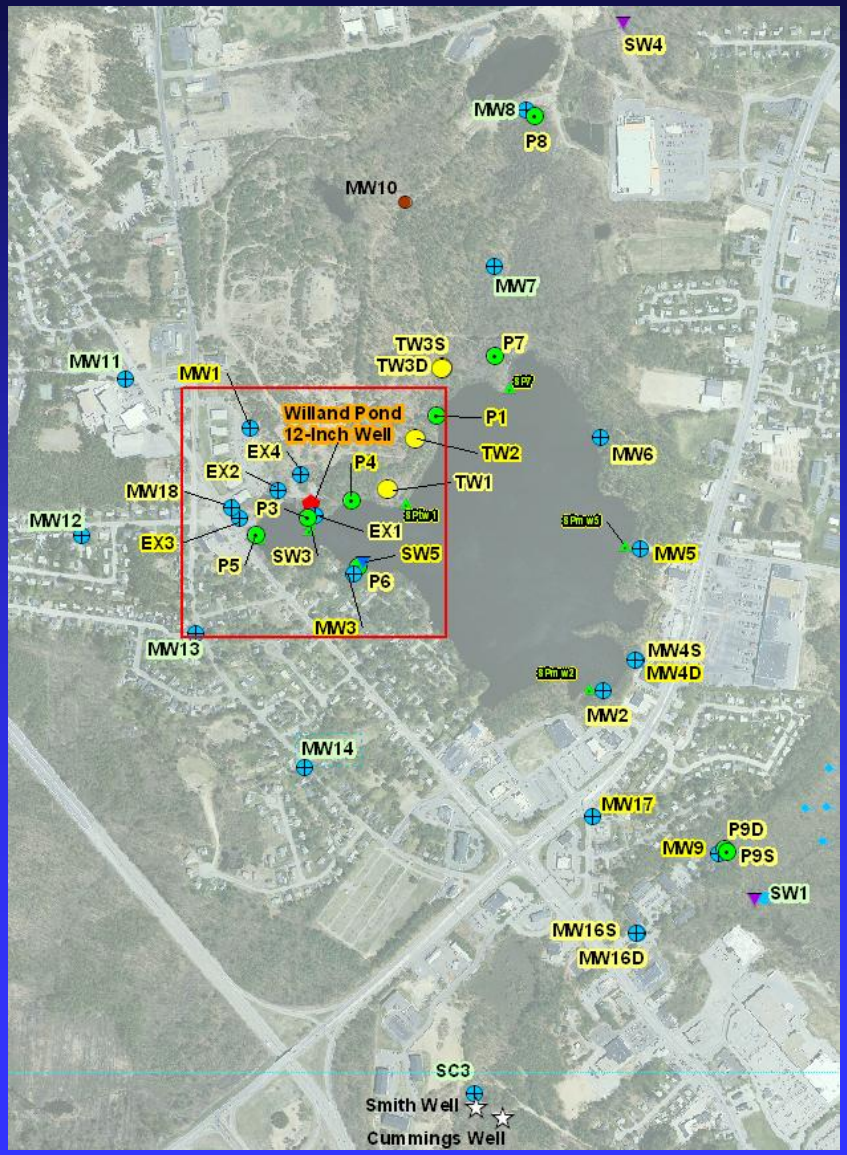
Phase III - Part II

- **Amount of Water Withdrawn from Aquifer During the Pumping Test**

  - Approximately 0.86 million gallons per day.
  - 77 million gallons during the 90-Day period.

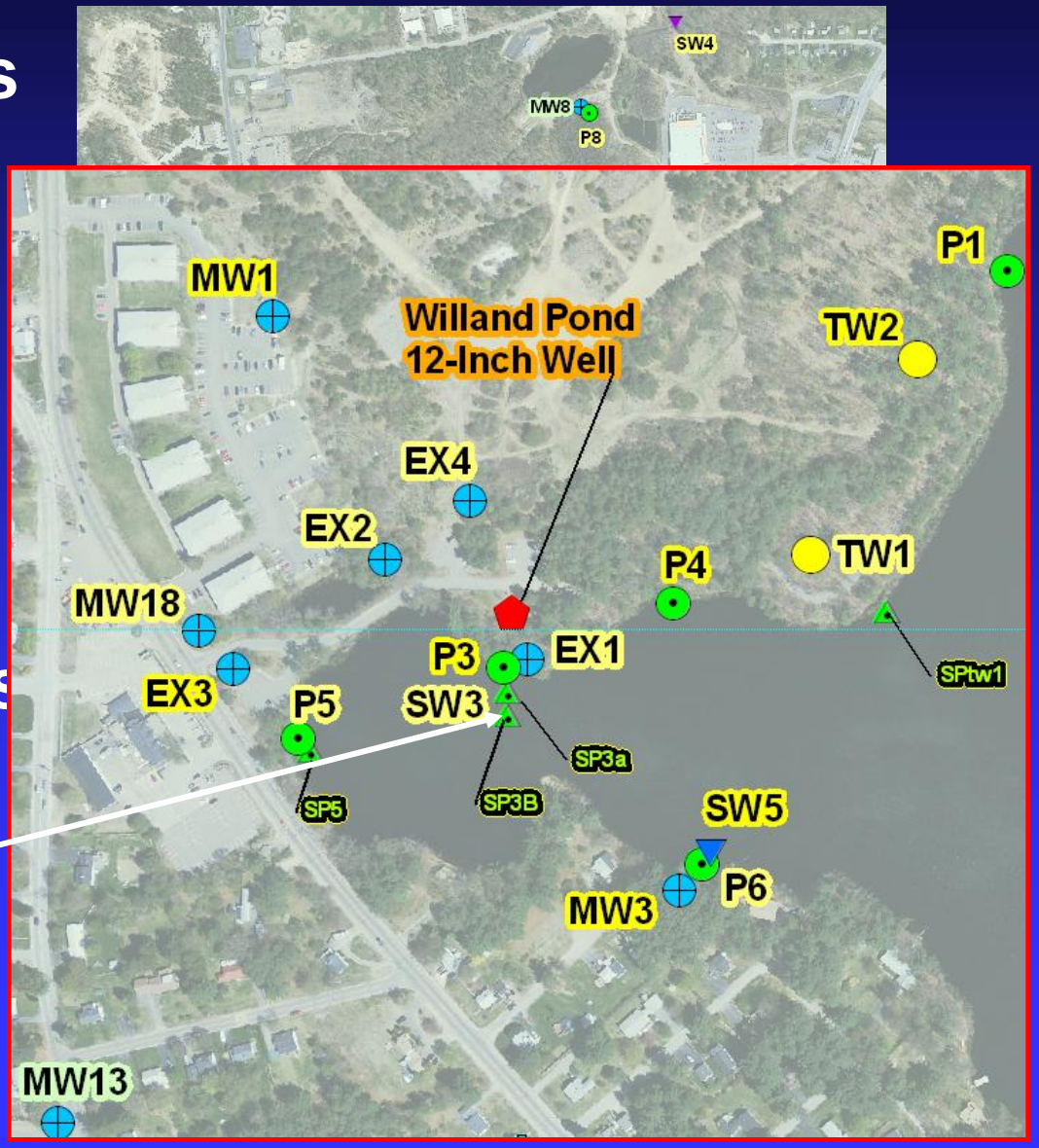
Monitoring Locations Used During Pumping Test

- 18 Monitoring Wells
- 8 Piezometers
- 4 Surface Water Stations
- 5 Existing Wells
- 4 Exploratory Wells



Monitoring Locations Used During Pumping Test

- 18 Monitoring Wells
- 8 Piezometers
- 4 Surface Water Stations
- 5 Existing Wells
- 4 Exploratory Wells
- 9 Seepage Meters



Phase III - Part II

- **Groundwater Monitoring Program**

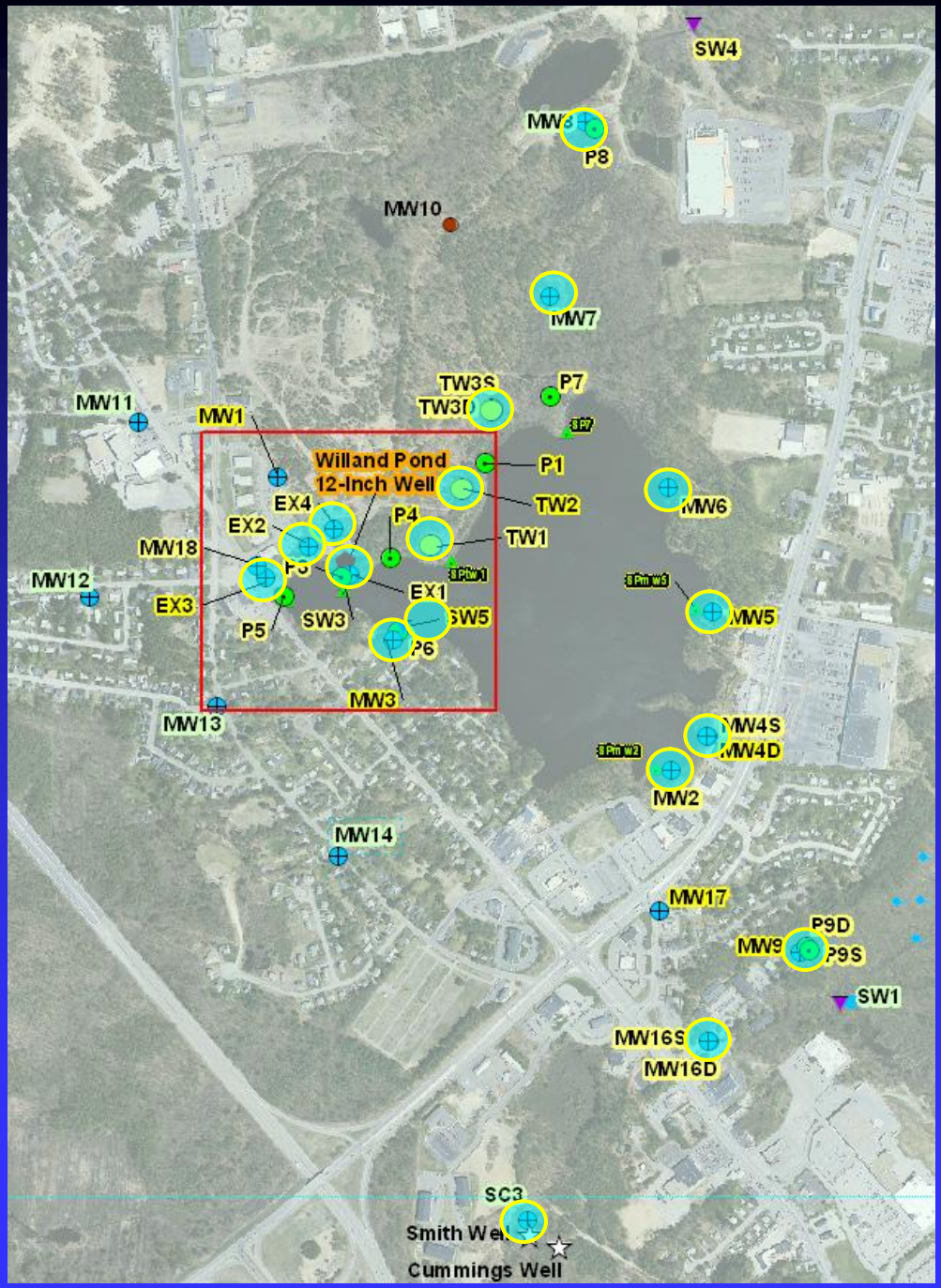
  - Water level data collected 60 ± days before and after the pumping period
  - Water level data collected during the 90-day pumping period

Supplemental Phase (EGGI Pro Bono Work)

- **Long-Term Monitoring Program**

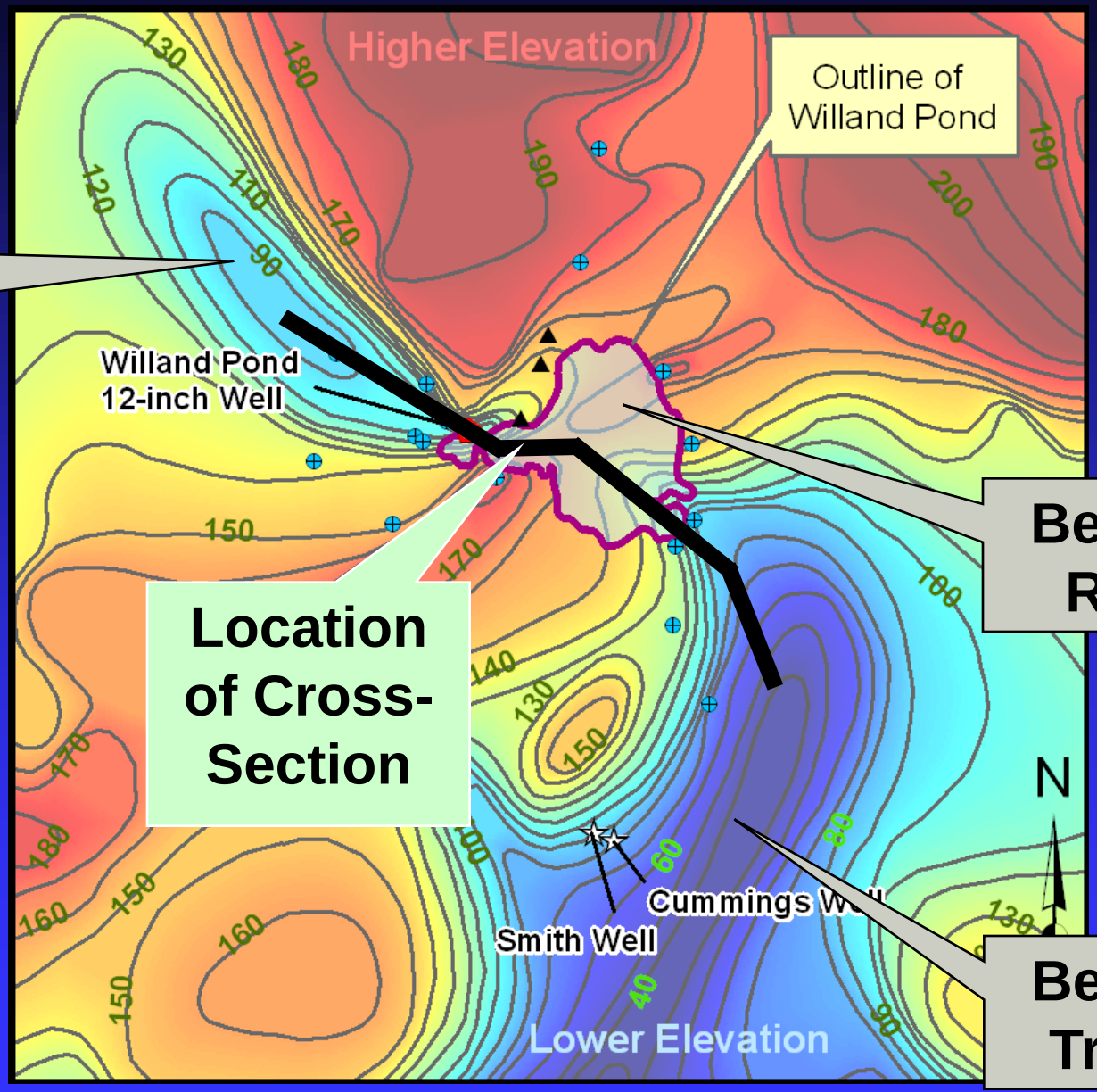
- Water Level Monitoring of 20 Selected Sites is ongoing:
  - 150 Days of post-pumping monitoring so far
  - Have collected a total 280-Days of water level data

Monitoring Locations Used During Long-Term Monitoring

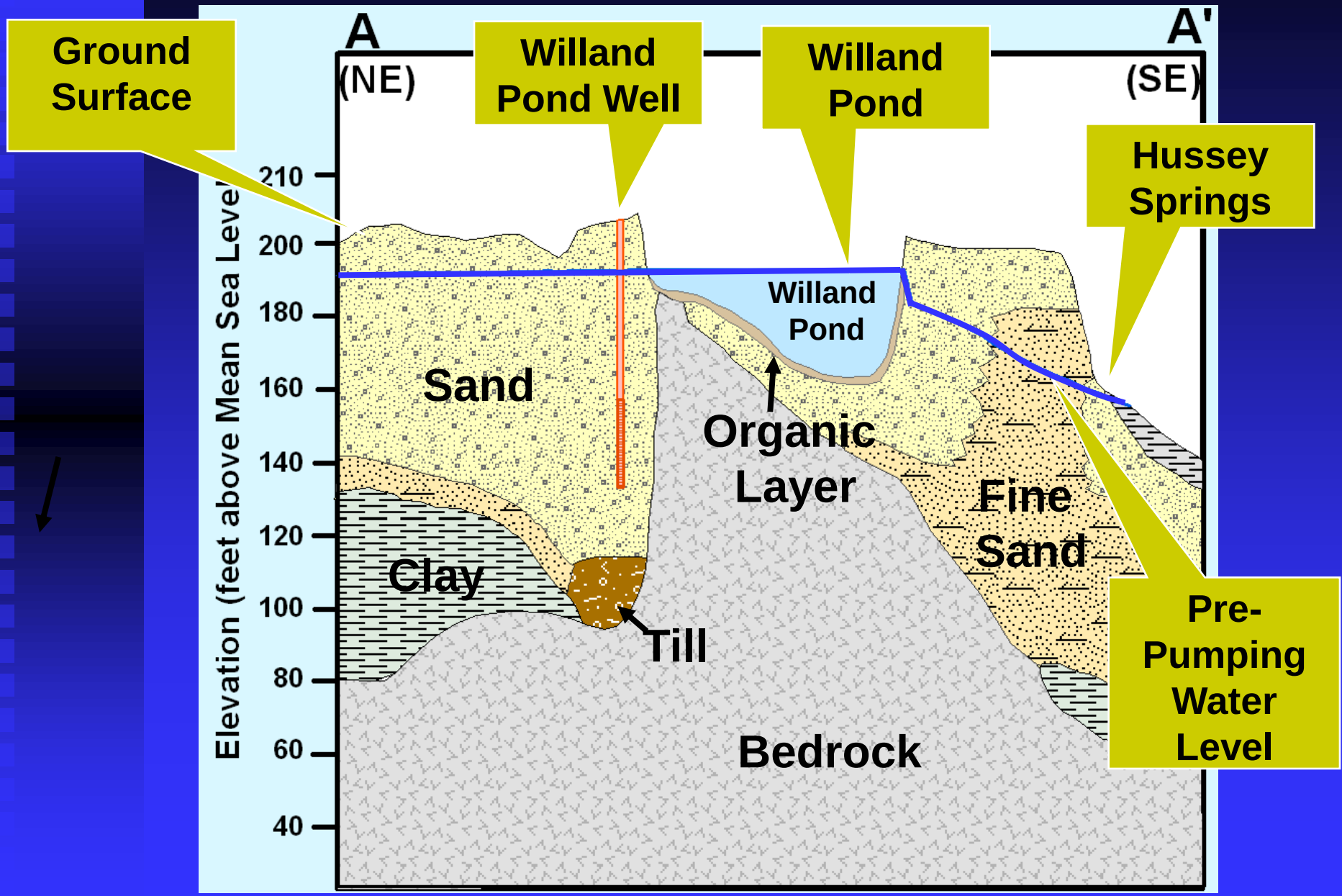


CONCEPTUAL MODEL OF WILLAND POND AQUIFER

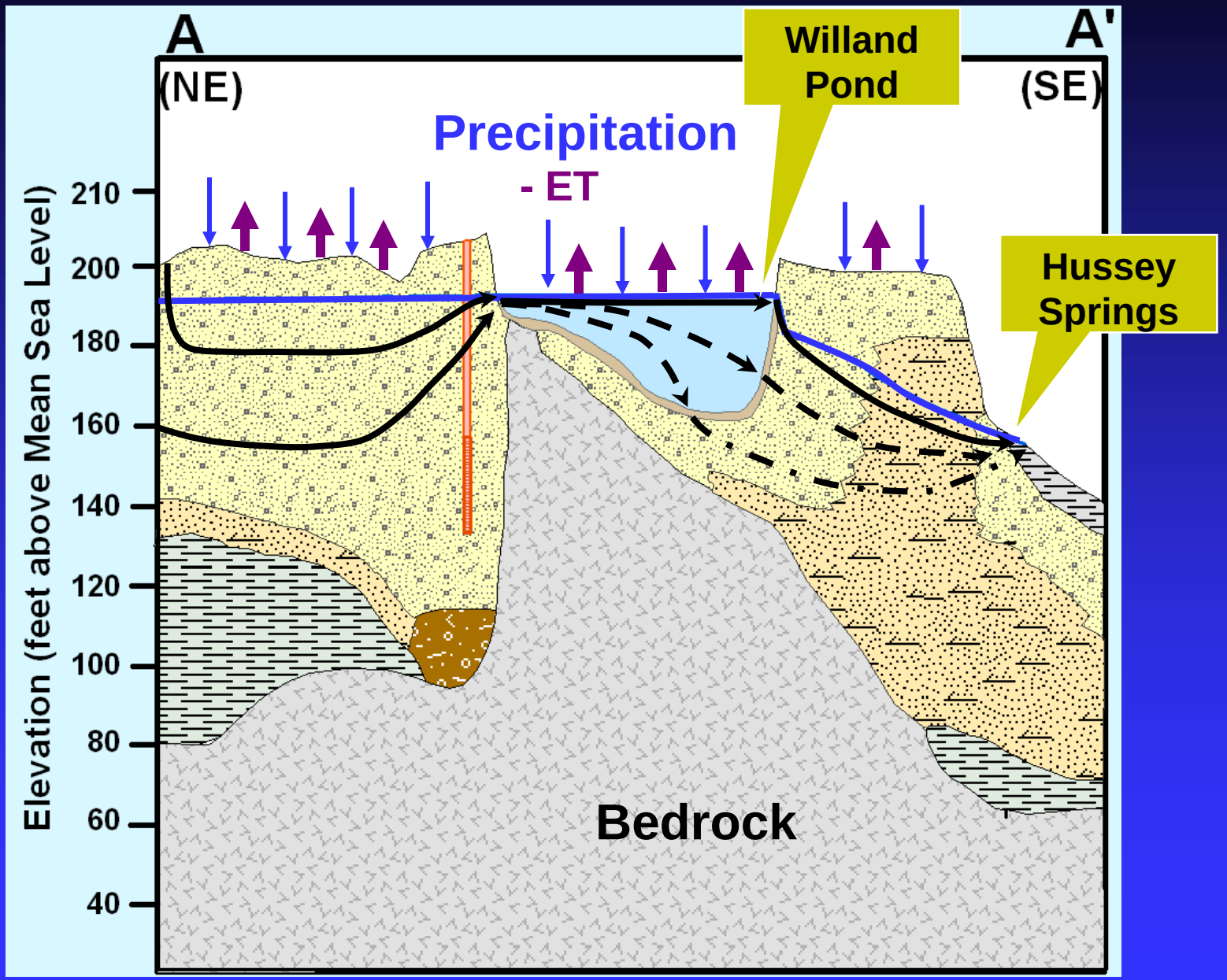
Bedrock Elevation Contour Map



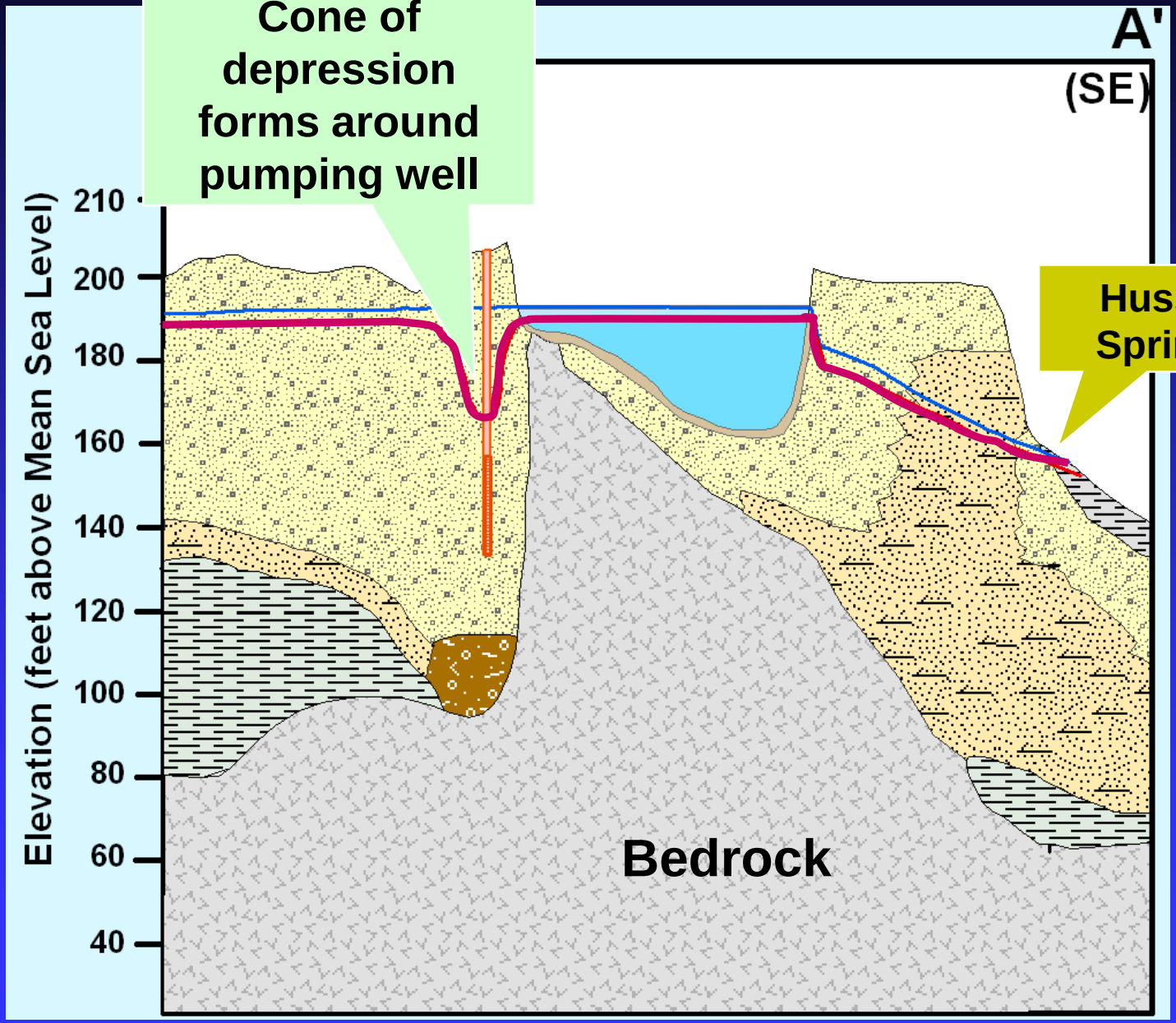
Bedrock Elevation Contour Map



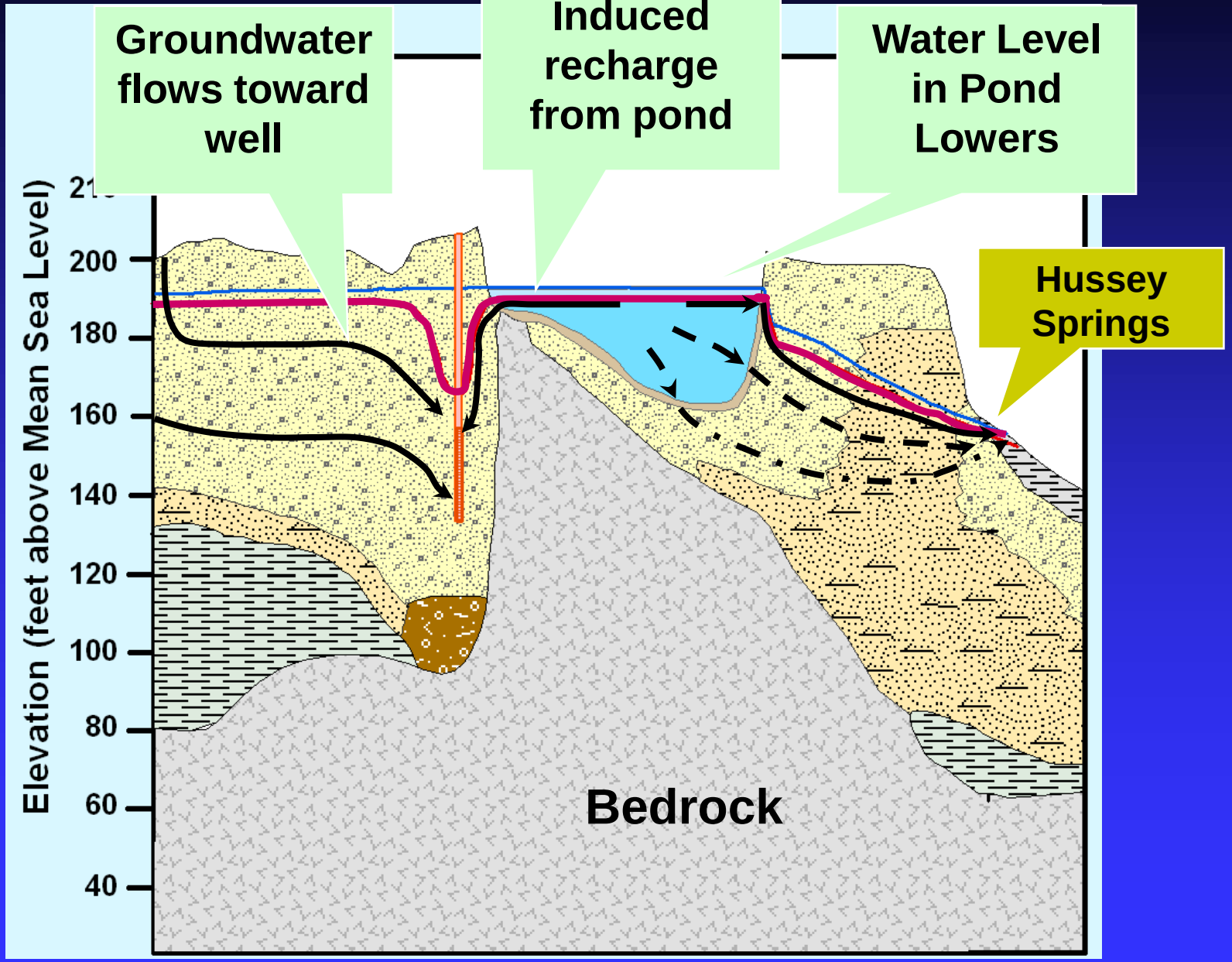
Hydrologic Cycle: Non-Pumping



Groundwater Flow: Pumping



Groundwater Flow: Pumping

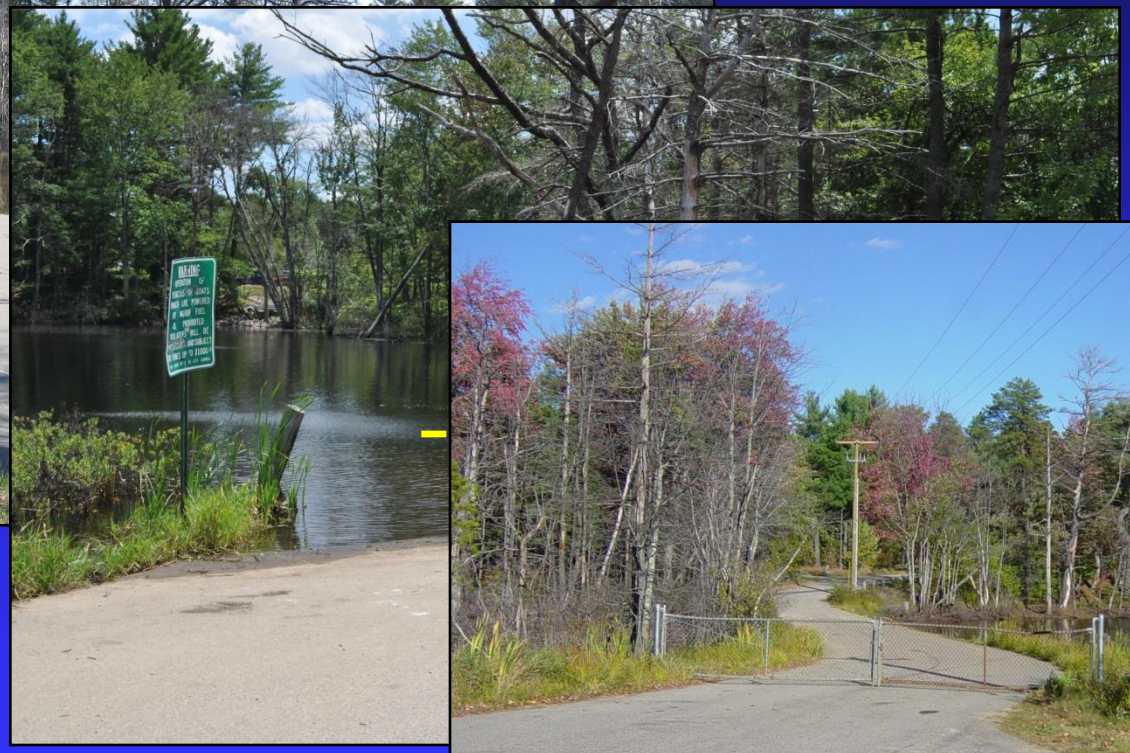


RESULTS OF 90-DAY PUMPING TEST AND 150-DAY RECOVERY MONITORING

Willand Pond Water Level Response to Pumping Willand Pond Well

Lowering of Willand Pond Water Level

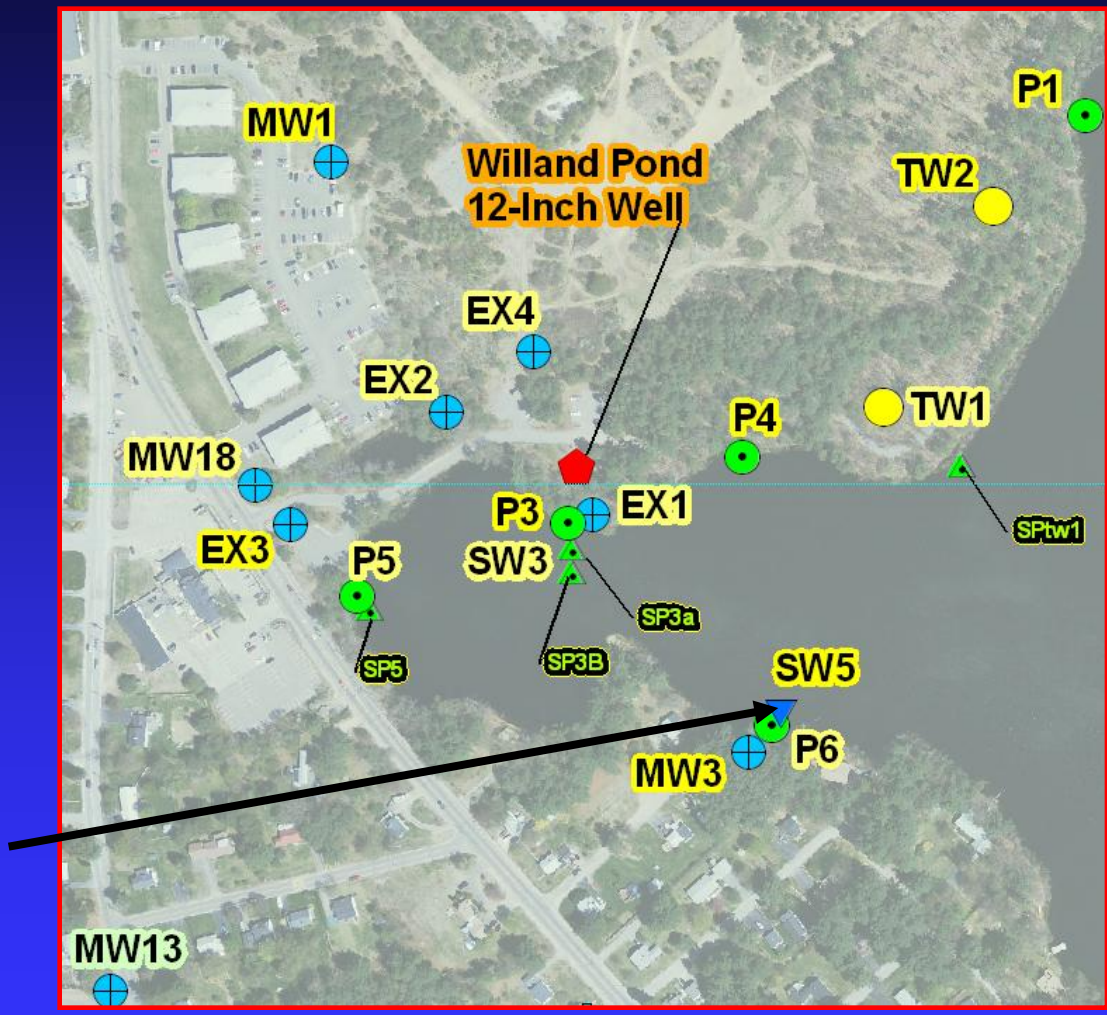
April 15th
194.19’



July 9th
192.6’

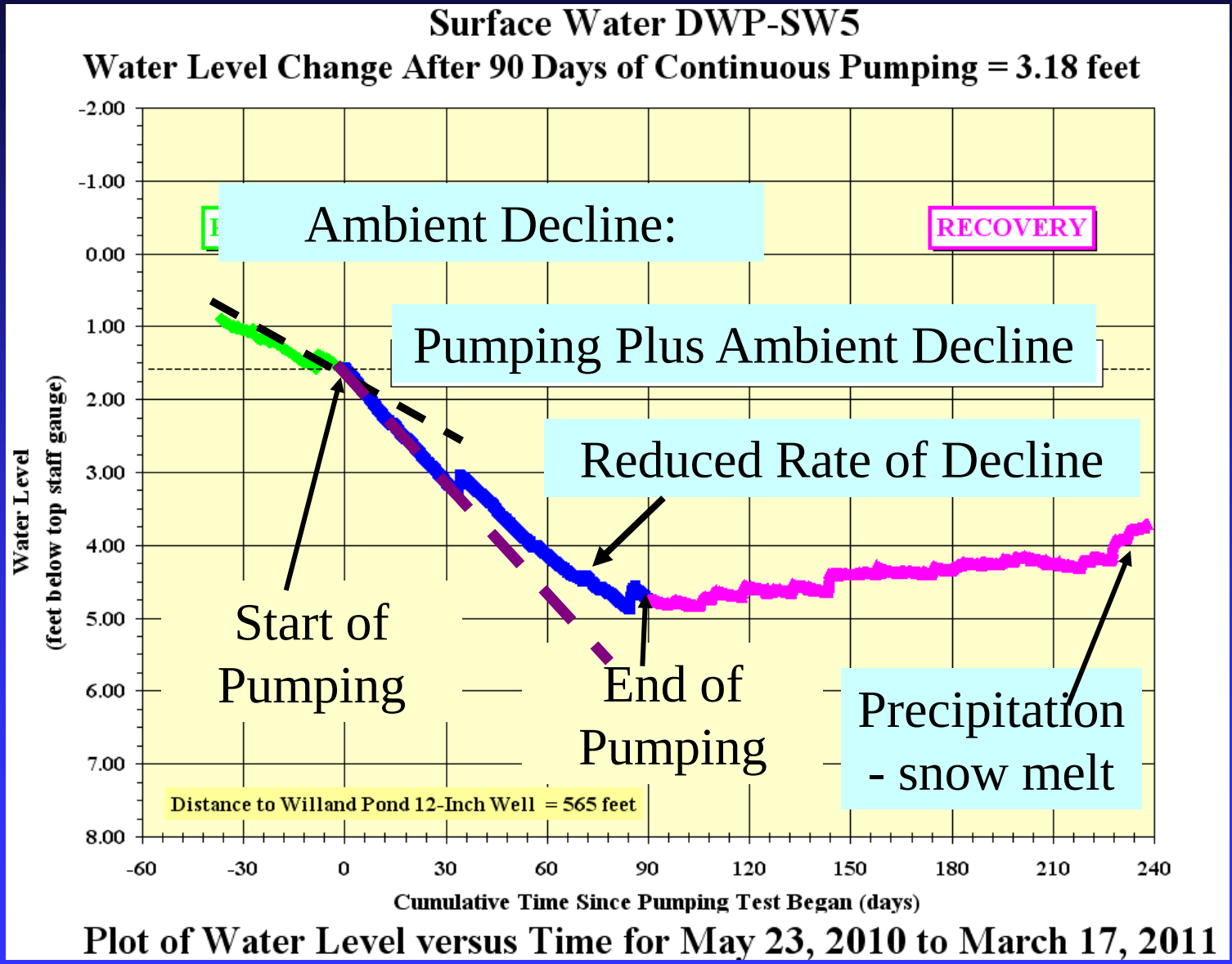
Oct. 8th
189.12’

Water Level Response during 280-Day Monitoring Period



Pond (SW5)

Long-Term Water Level in the Willand Pond



Phase III - Part II

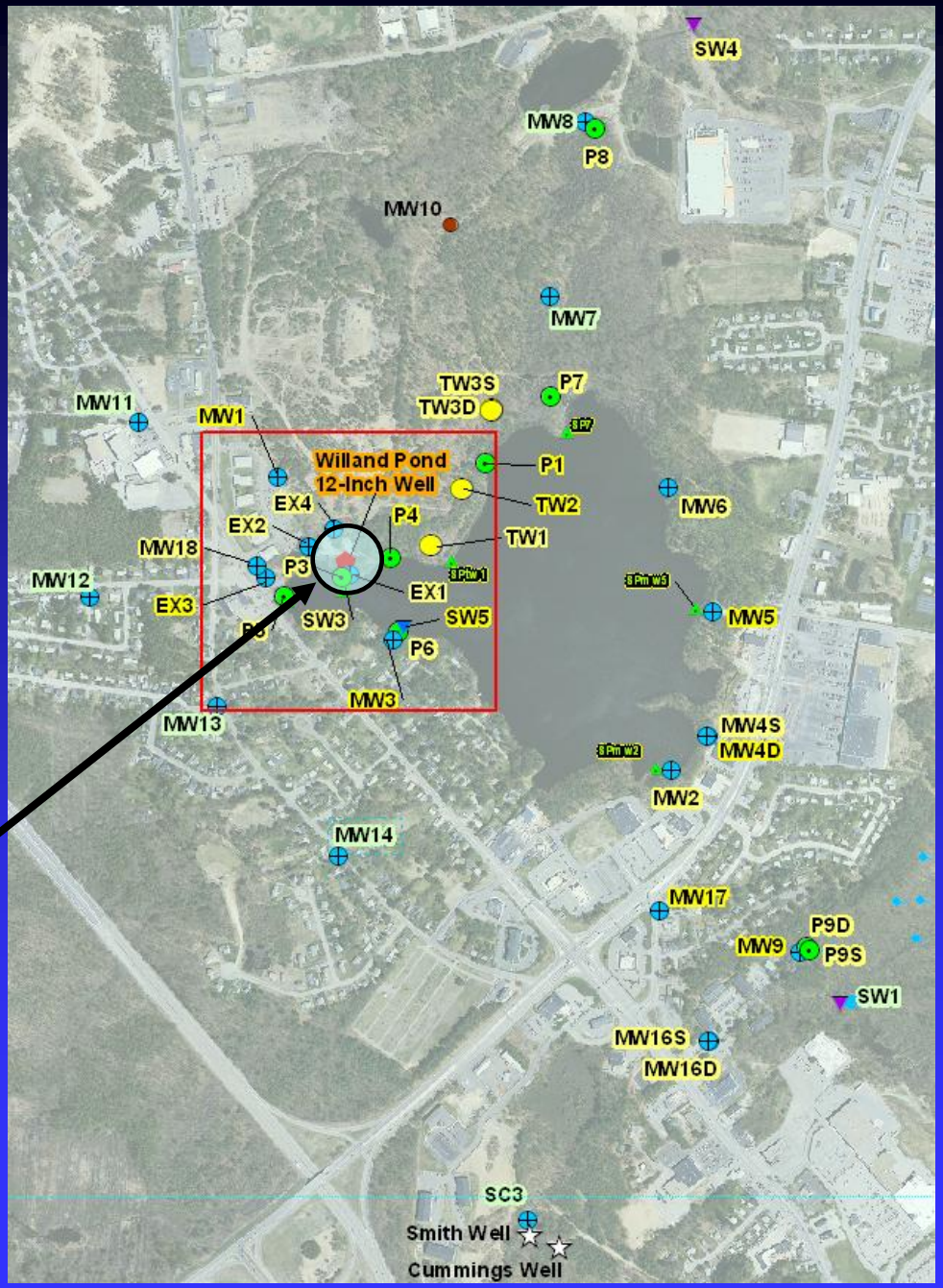
- 40% of the decline in the Pond water level observed during the testing was due to the Pumping of the Willand Pond Well

- Approximately 400 gpm, of the 600 gpm pumped from the Well, was induced from the Pond

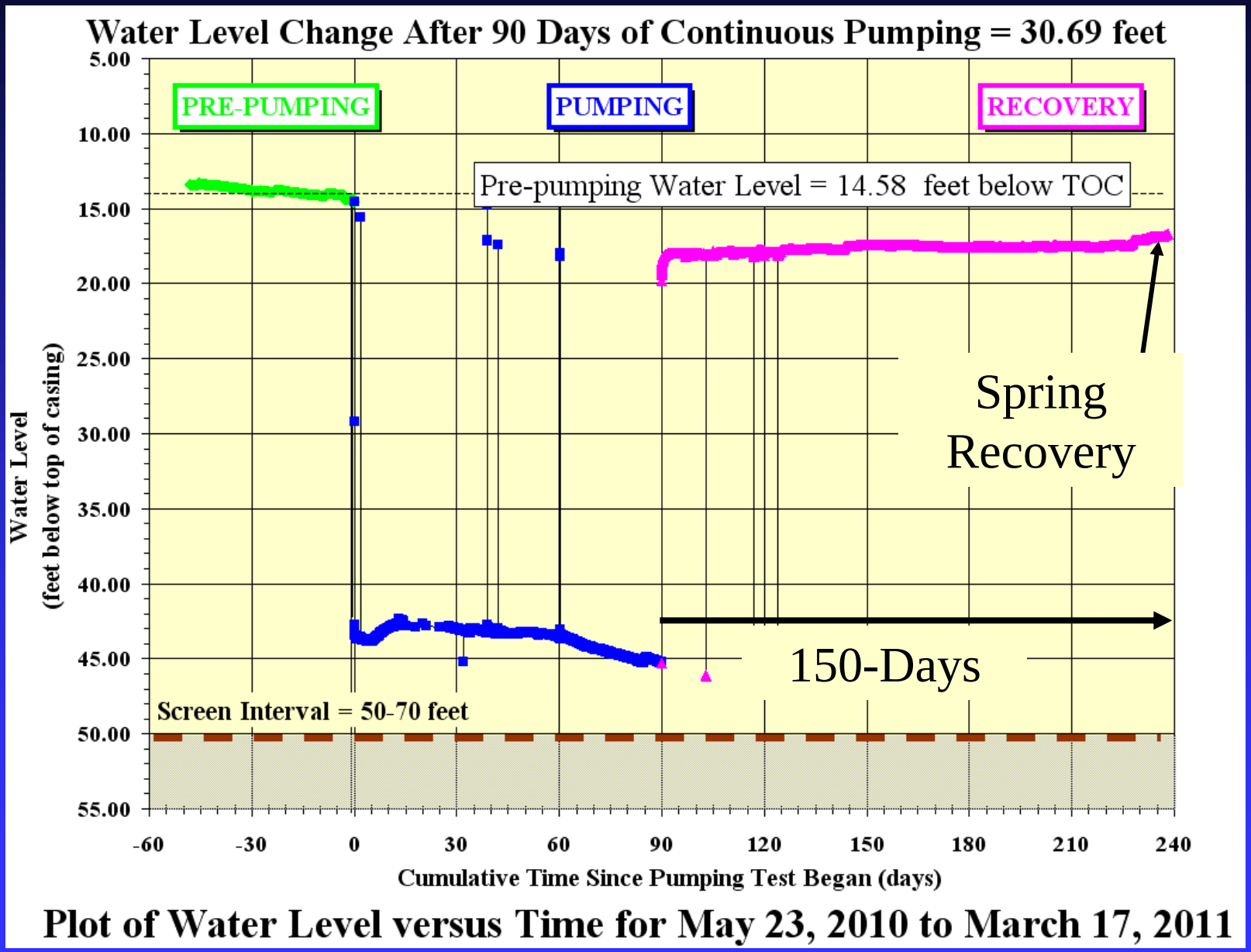
Groundwater Responses

Water Level Response during 280-day Monitoring Period

Willand Pond 12-Inch-Diameter Well

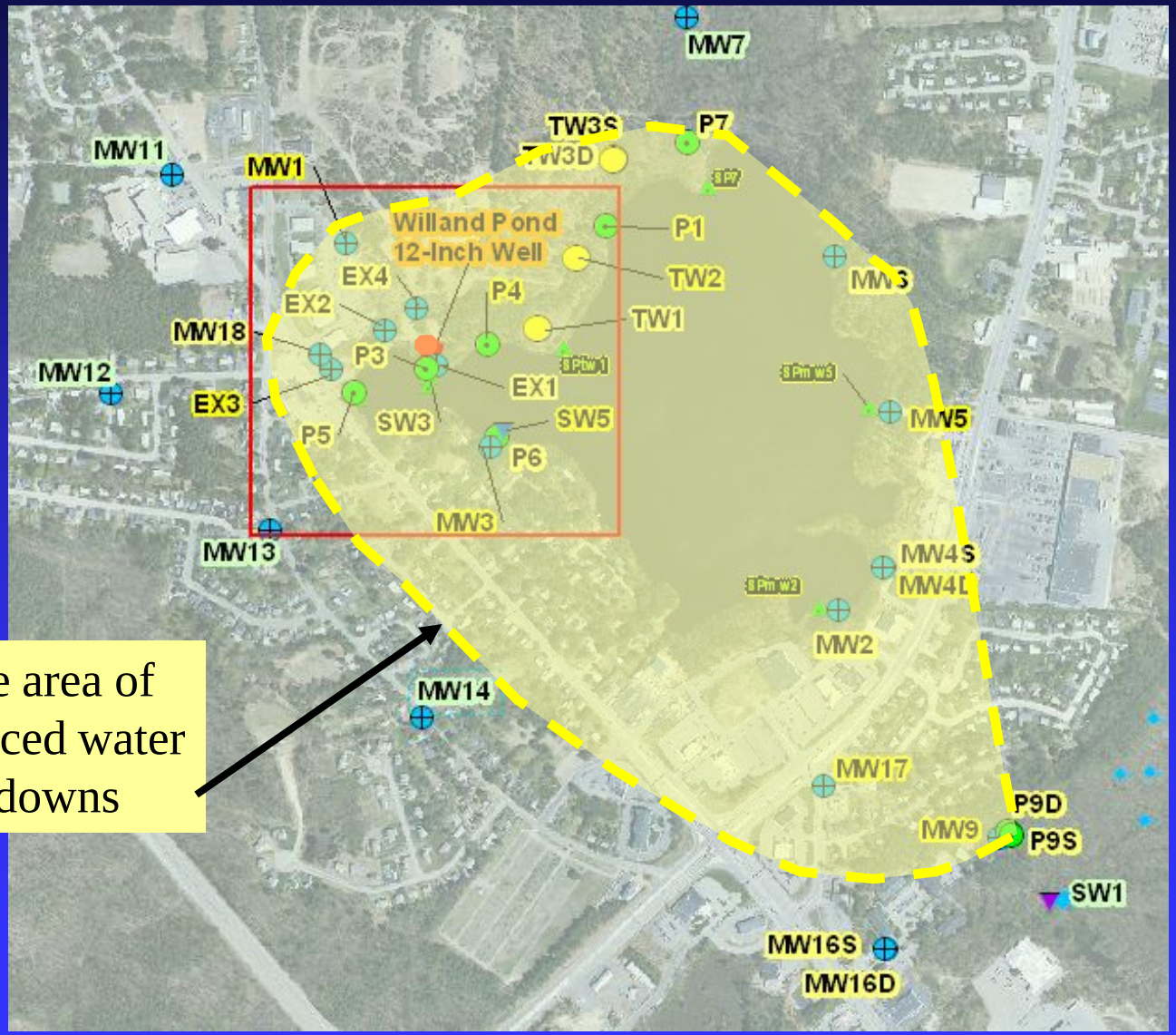


Long-Term Water Level in the Willand Pond Well



Plot of Water Level versus Time for May 23, 2010 to March 17, 2011

Area with Wells having Pumping-Induced Water Level Impacts



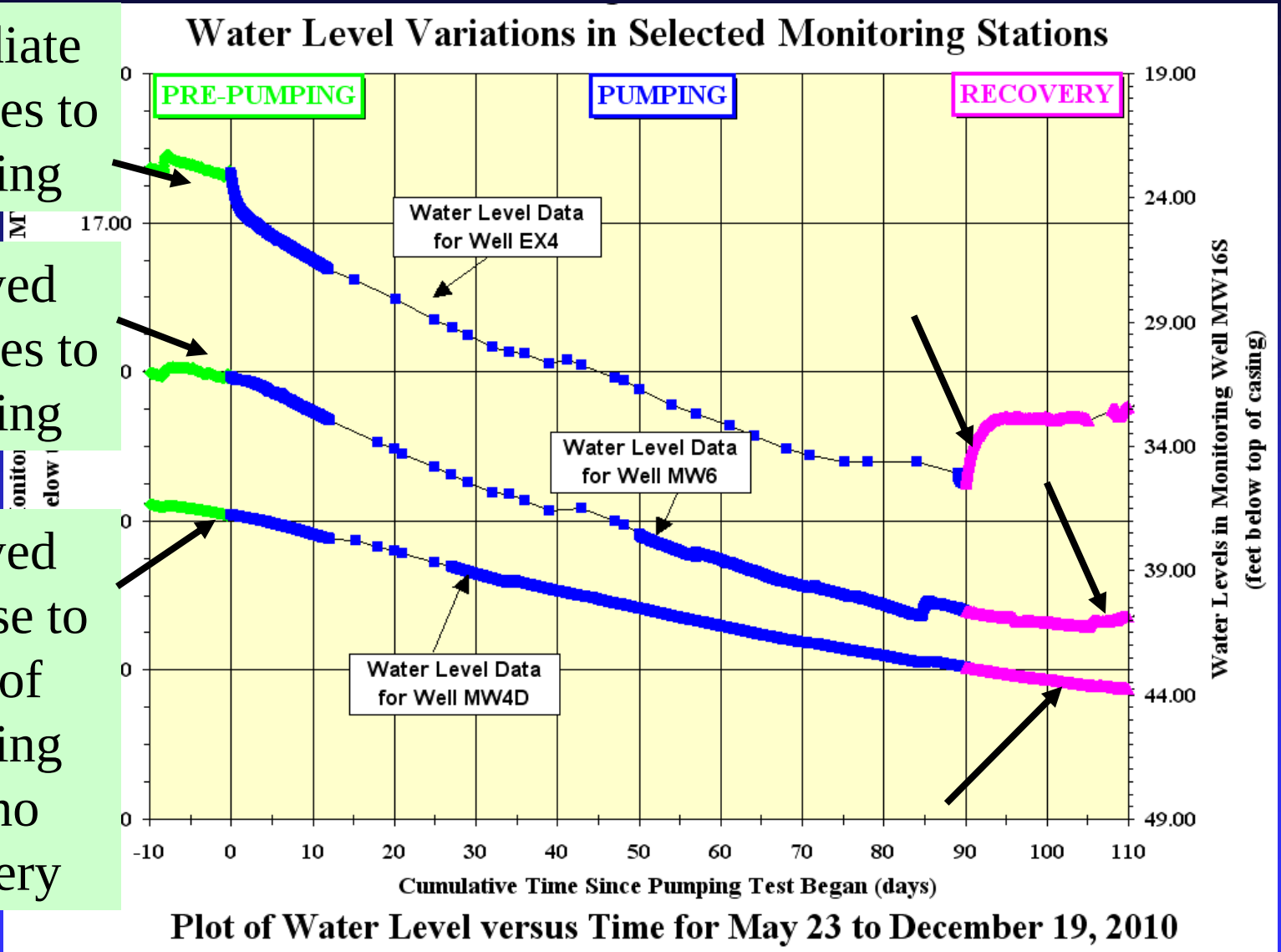
Approximate area of pumping-induced water level drawdowns

Variations in Pumping-Induced Water Level Impacts

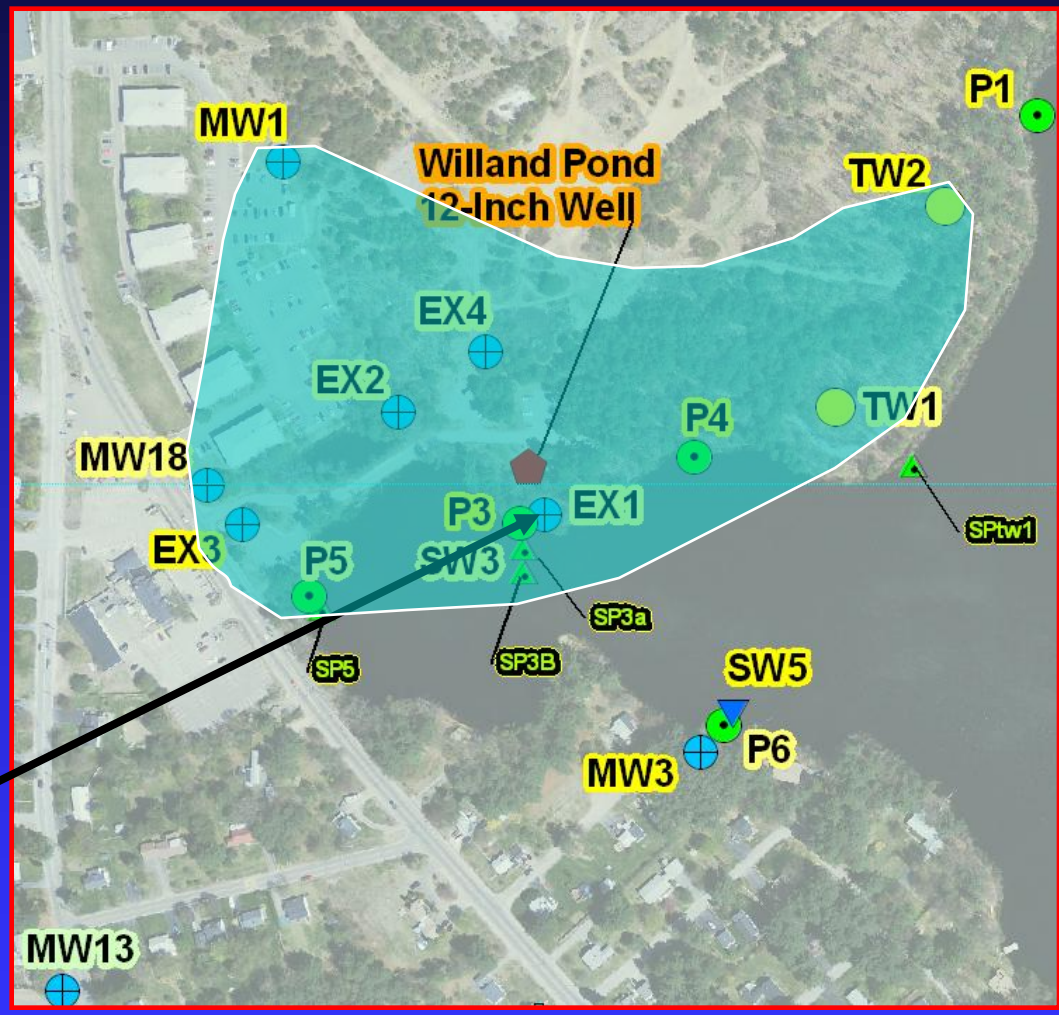
Immediate responses to pumping

Delayed responses to pumping

Delayed response to start of pumping and no recovery

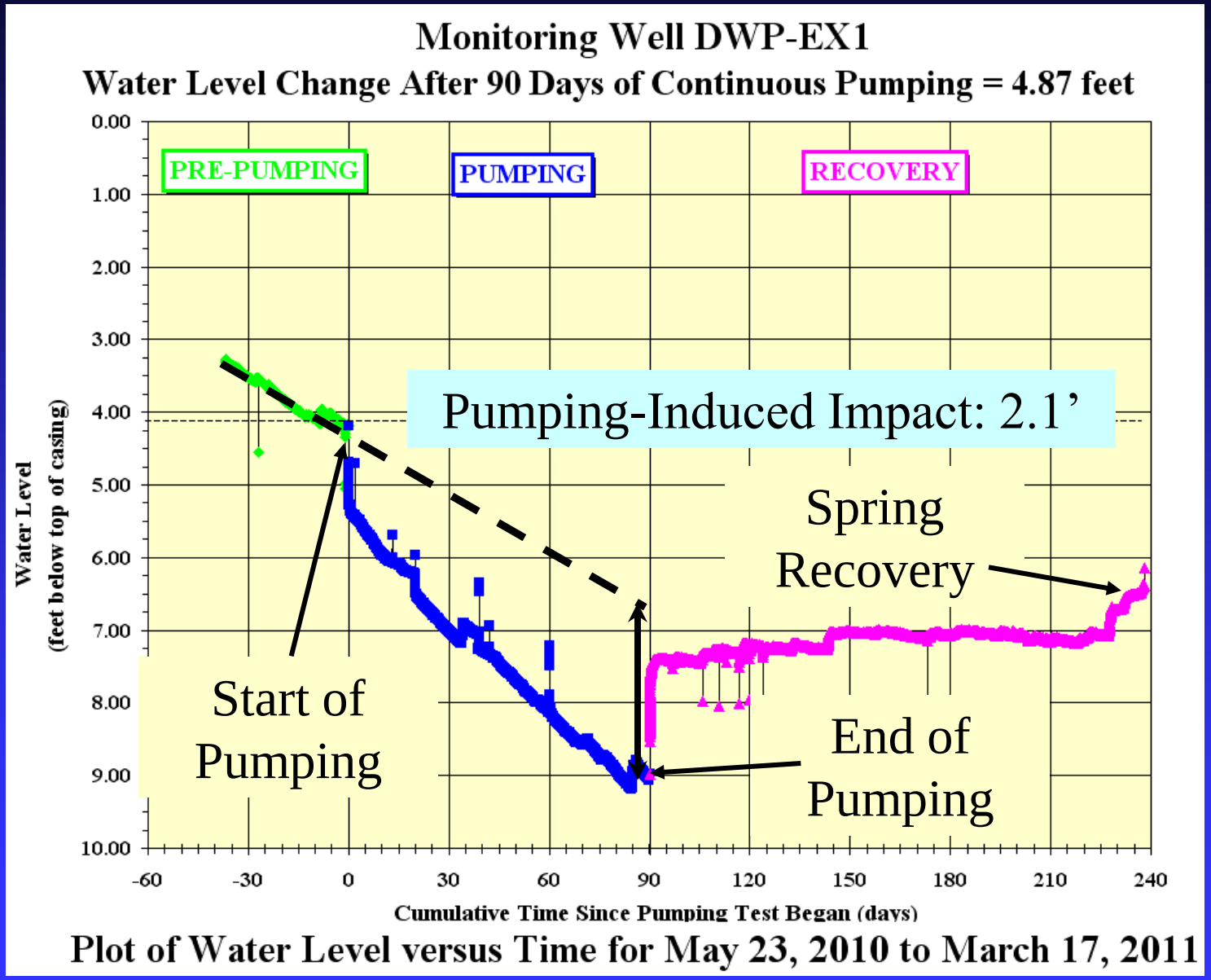


Water Level Response during 280-Day Monitoring Period



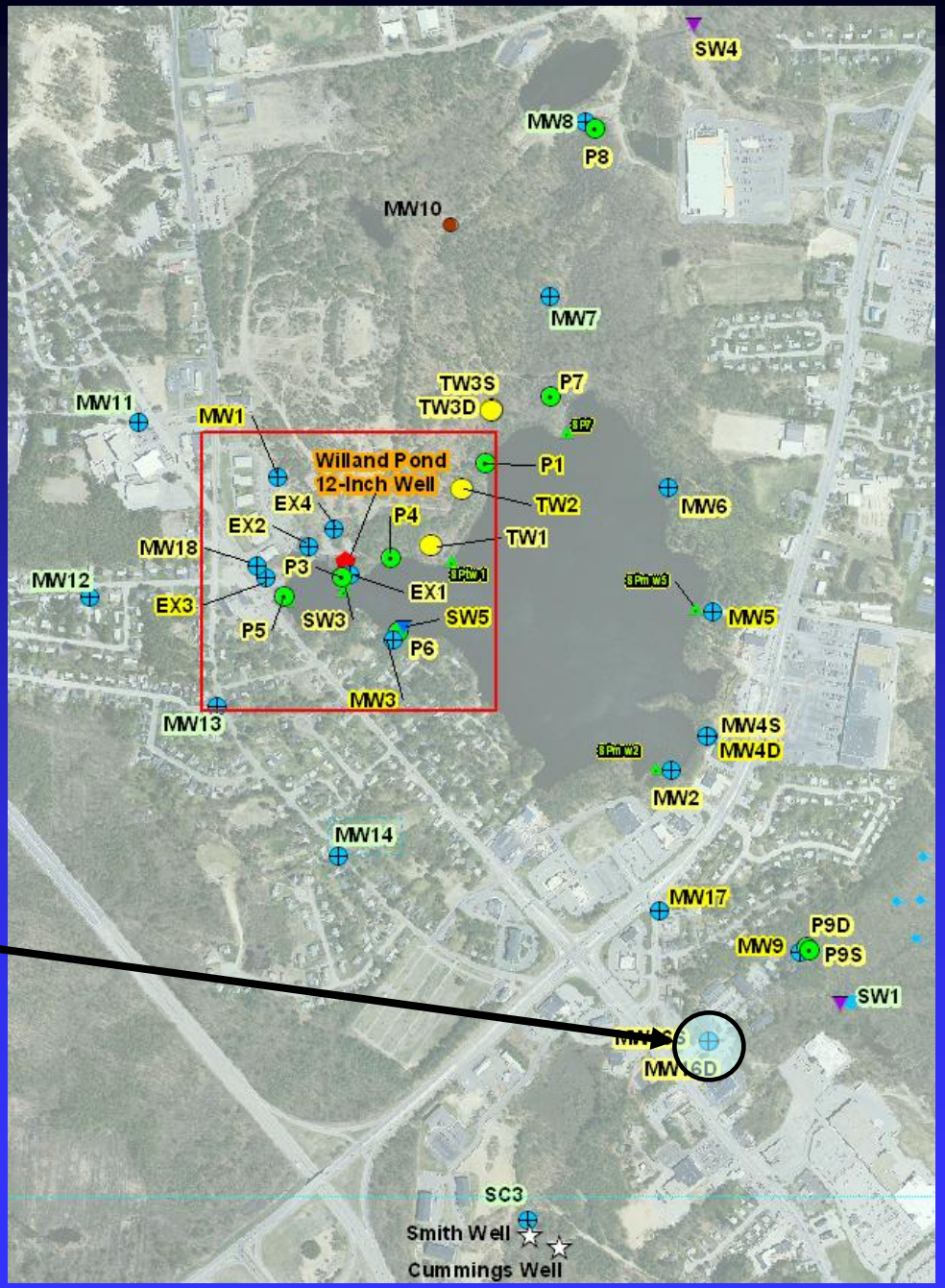
Well EX1

Long-Term Water Level Northwest End of Willand Pond

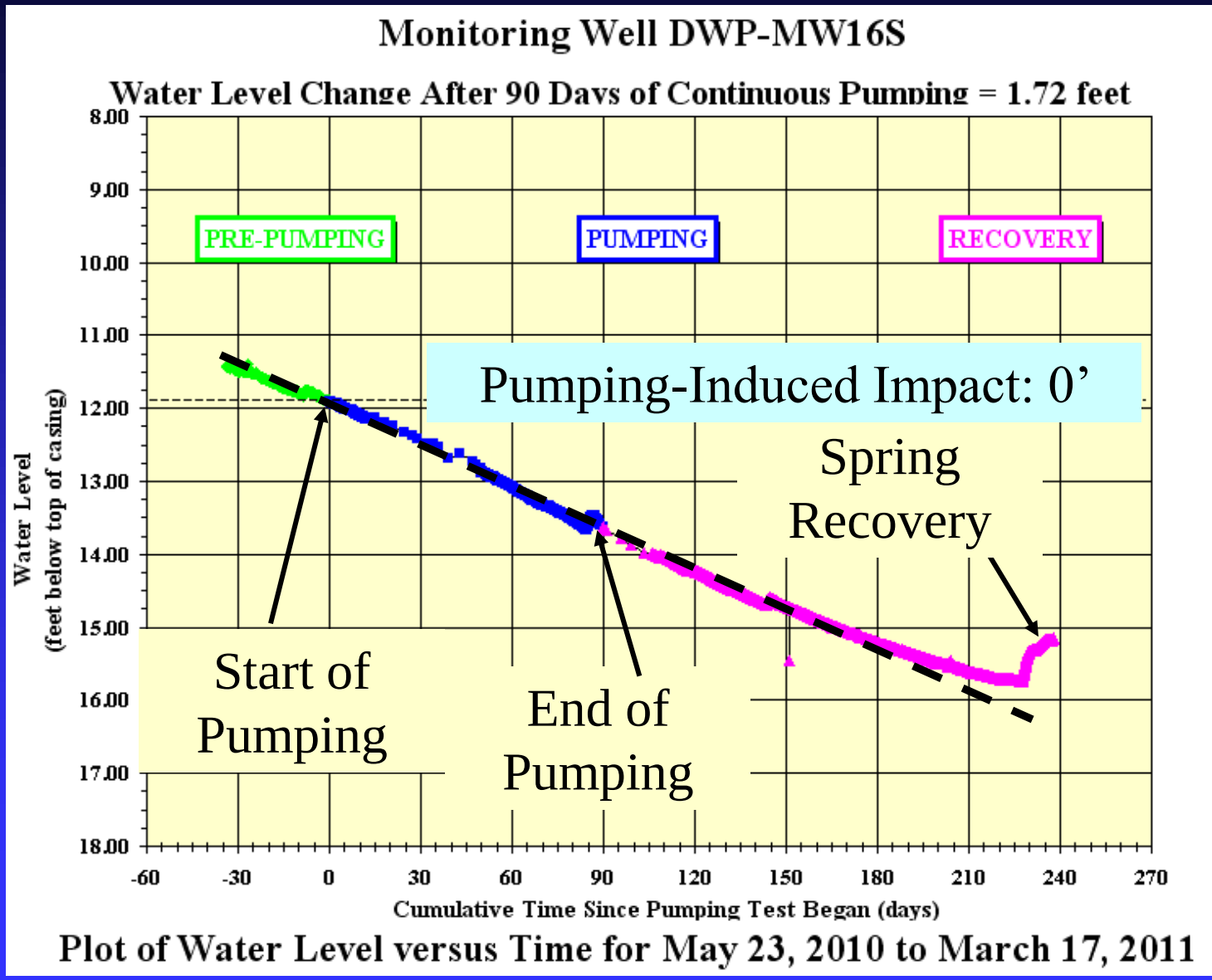


Water Level Response during 280-Day Monitoring Period

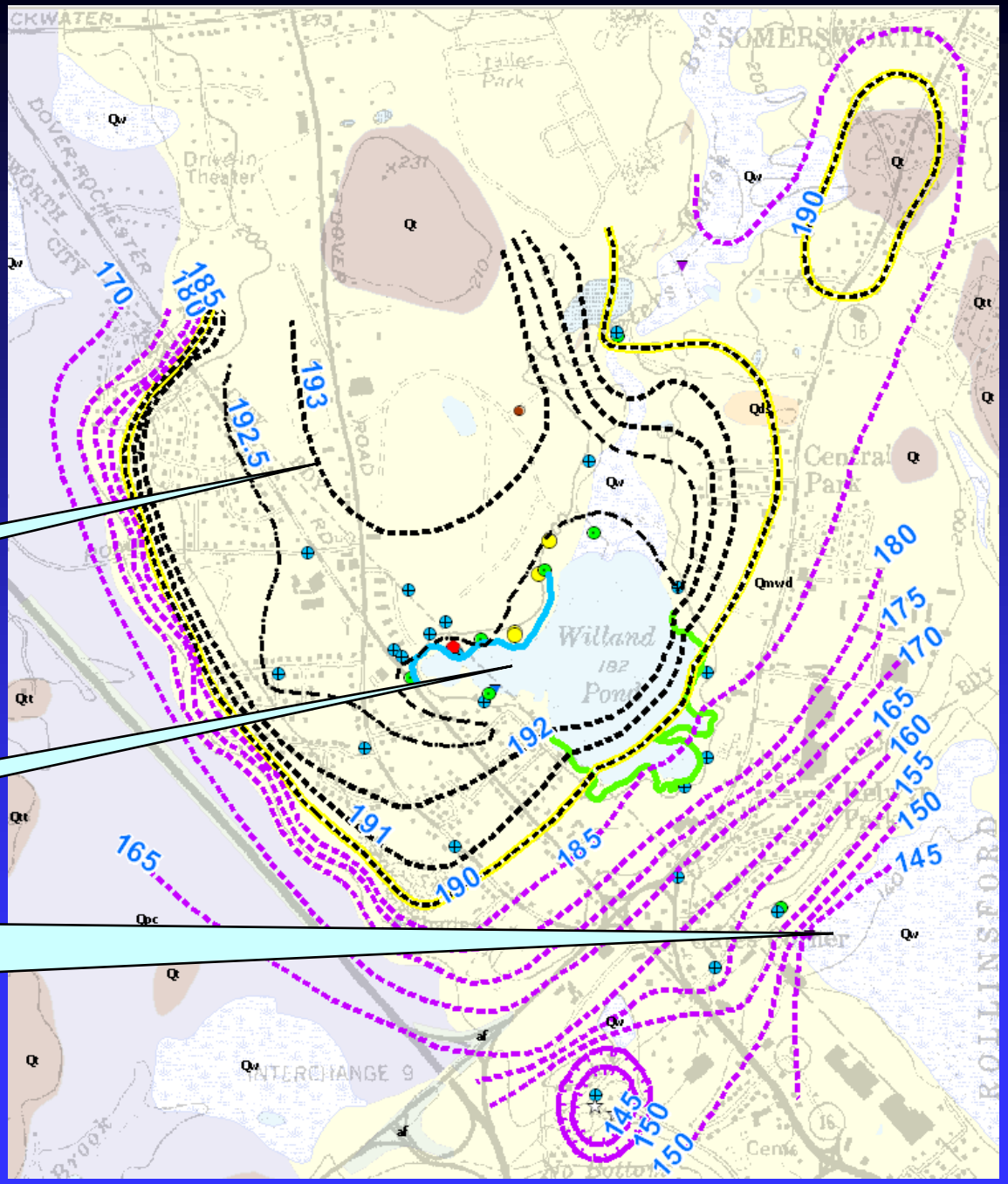
Well MW16S



Long-Term Water Level Near Hussey Spring



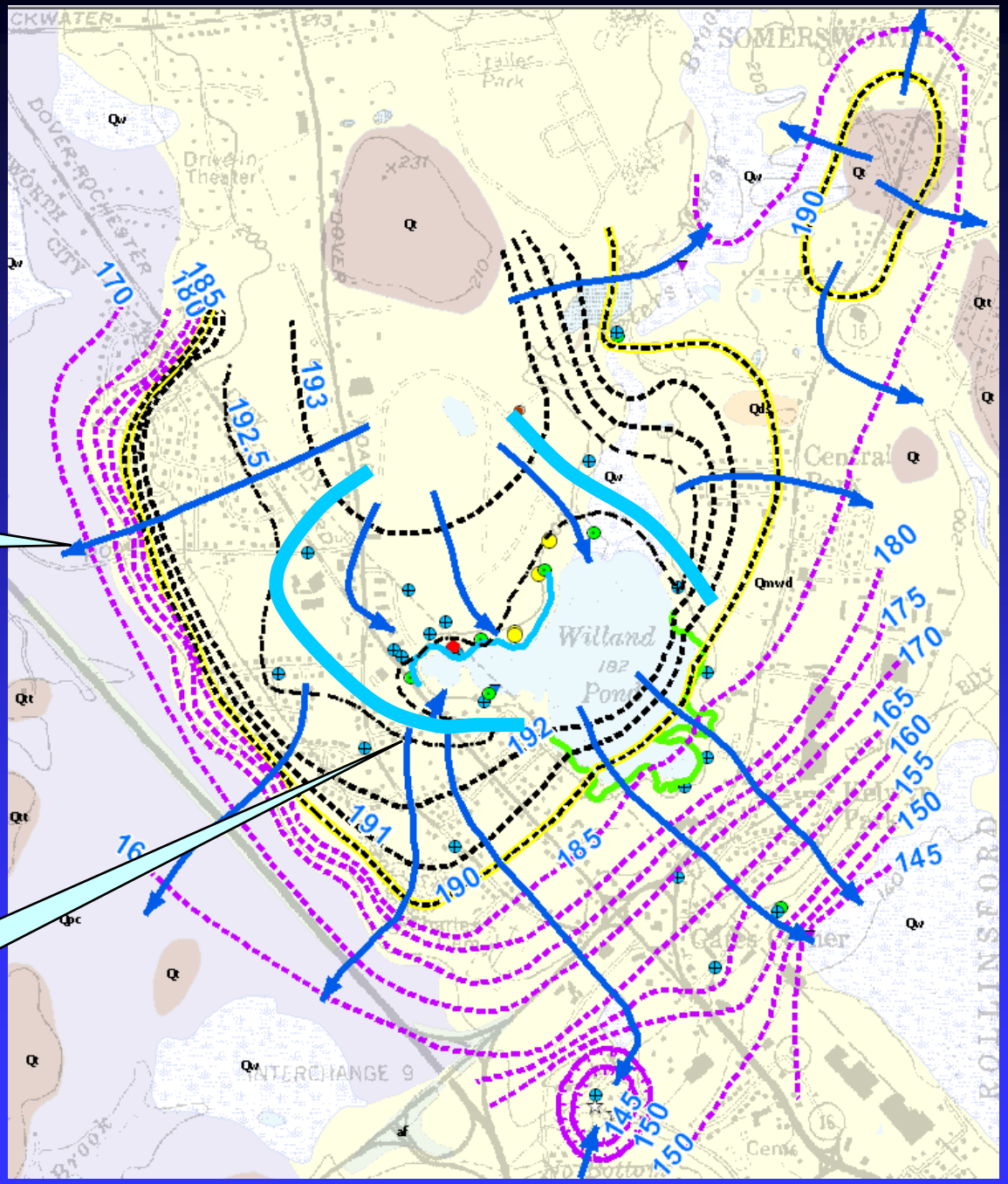
Pre-Pumping Groundwater Elevation Contours



Pre-Pumping Groundwater Elevation Contours

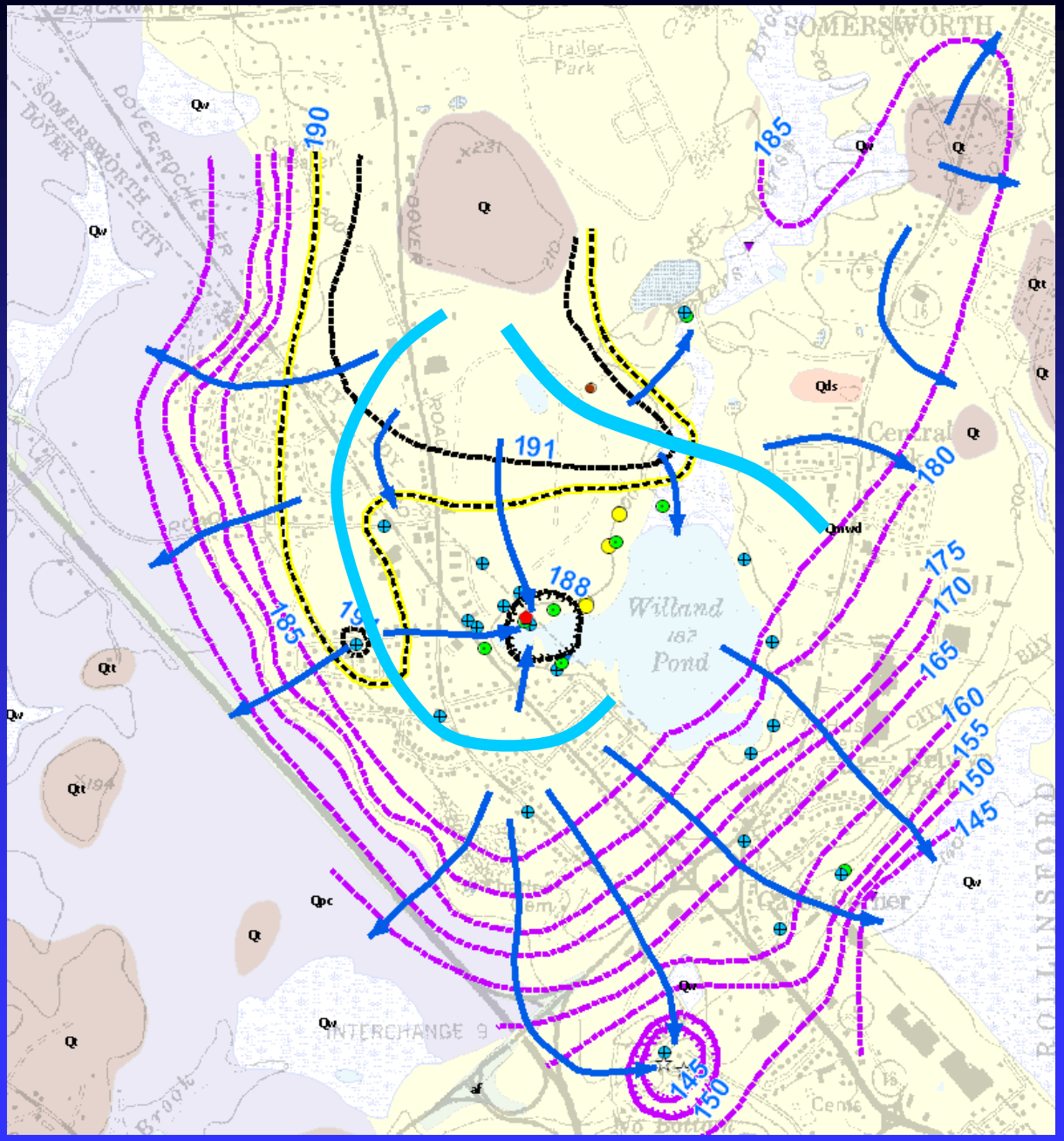
Groundwater flow lines

Groundwater Flow Divides

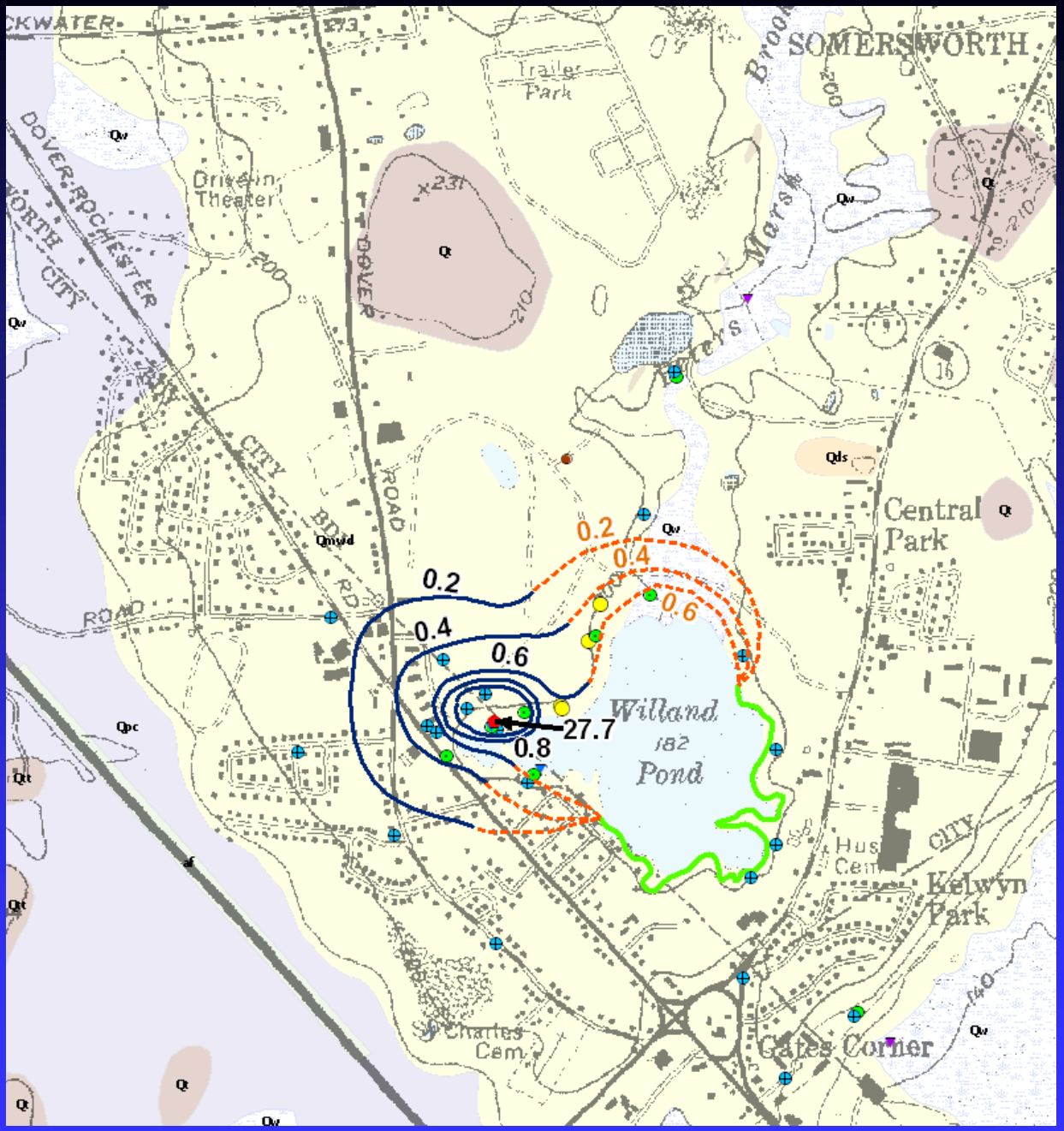


Groundwater Elevation Contours

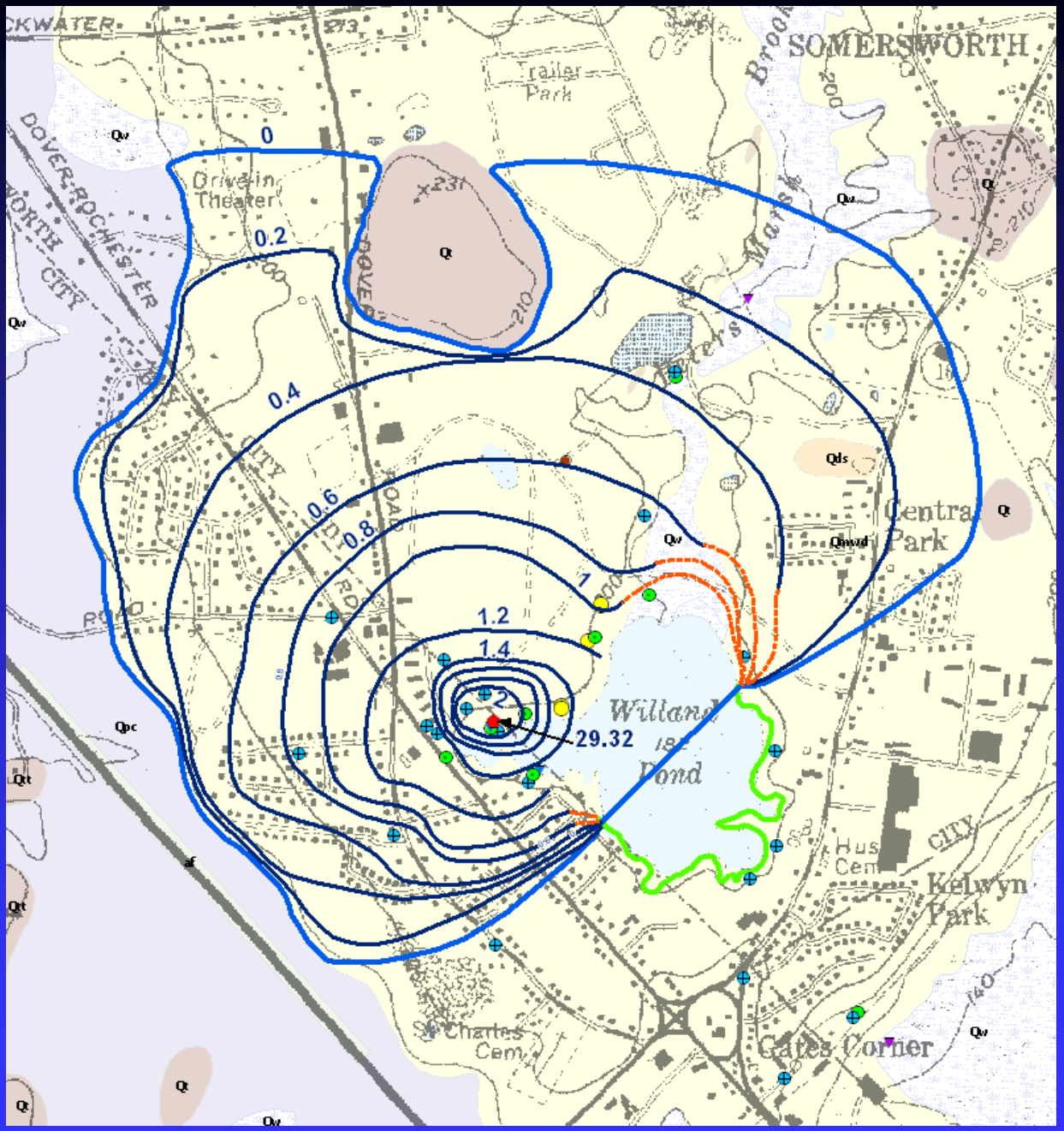
End of 90-Days of Pumping



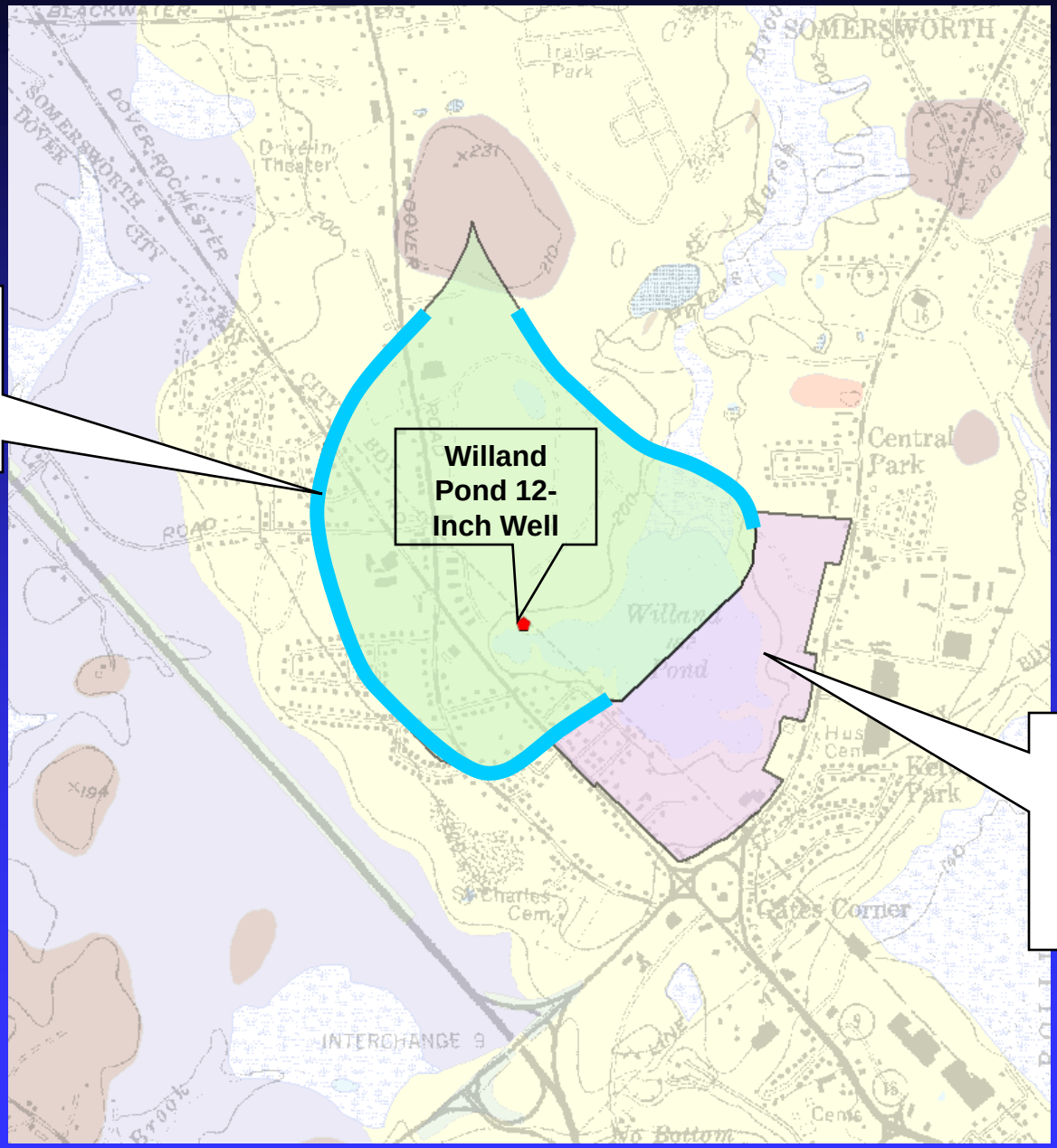
Pumping-Induced Drawdown After 34 Days of Pumping



Projected Pumping-Induced Drawdown after 180 Days of Pumping



Well Head Protection Areas



Phase III - Part II

Water Quality Analysis

- Full suite of drinking water parameters at start, middle, and end of pumping
- Weekly transient data
- Weekly bacteria analyses of Well water
- “Groundwater Under Surface Water Influence” Analyses

Water Quality Sampling and Field Analyses

Phase III - Part II

- Results of Water Quality Analysis

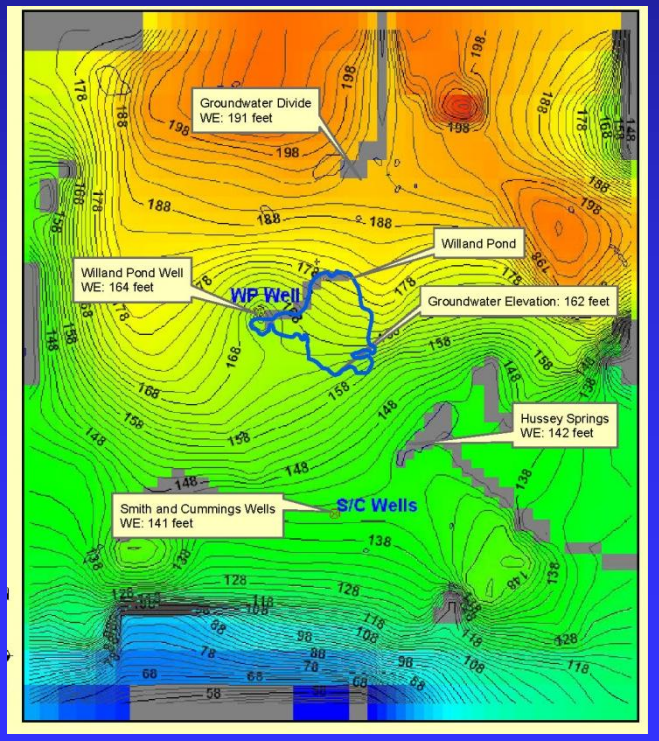
Phase III - Part II

Results of Water Quality Analysis

Phase III - Part III

The Numerical Model was Updated and Used to Investigate the utilization of the Willand Pond 12-Inch Well Under Varying Climatic Conditions to:

- **Supply Potable Water to the City of Dover and**
- **Dewater Willand Pond as Needed.**



Phase III - Part III

Example of Computer Model Simulations

Ten Years of Pumping

- Simulations are based upon using the last ten years of recorded precipitation and estimated evapotranspiration rates.

Phase III - Part III

Example of Computer Model Simulations

After the Past Ten Years of Pumping Under Known Climatologically Conditions

- Pumping 408 gpm; 8 hours/day; 365 days/year
  - (equal to 136 gpm for 24 hours/day)
  - Result: 2 feet of water level drawdown in Willand Pond

Phase III - Part III

Example of Computer Model Simulations

After the Past Ten Years of Pumping Under Known Climatologically Conditions

- Pumping 600 gpm; 8 hours/day; 365 days/year
  - Result: 3.5 feet of water level drawdown in Willand Pond

Phase III - Part III

Results of Data Analysis

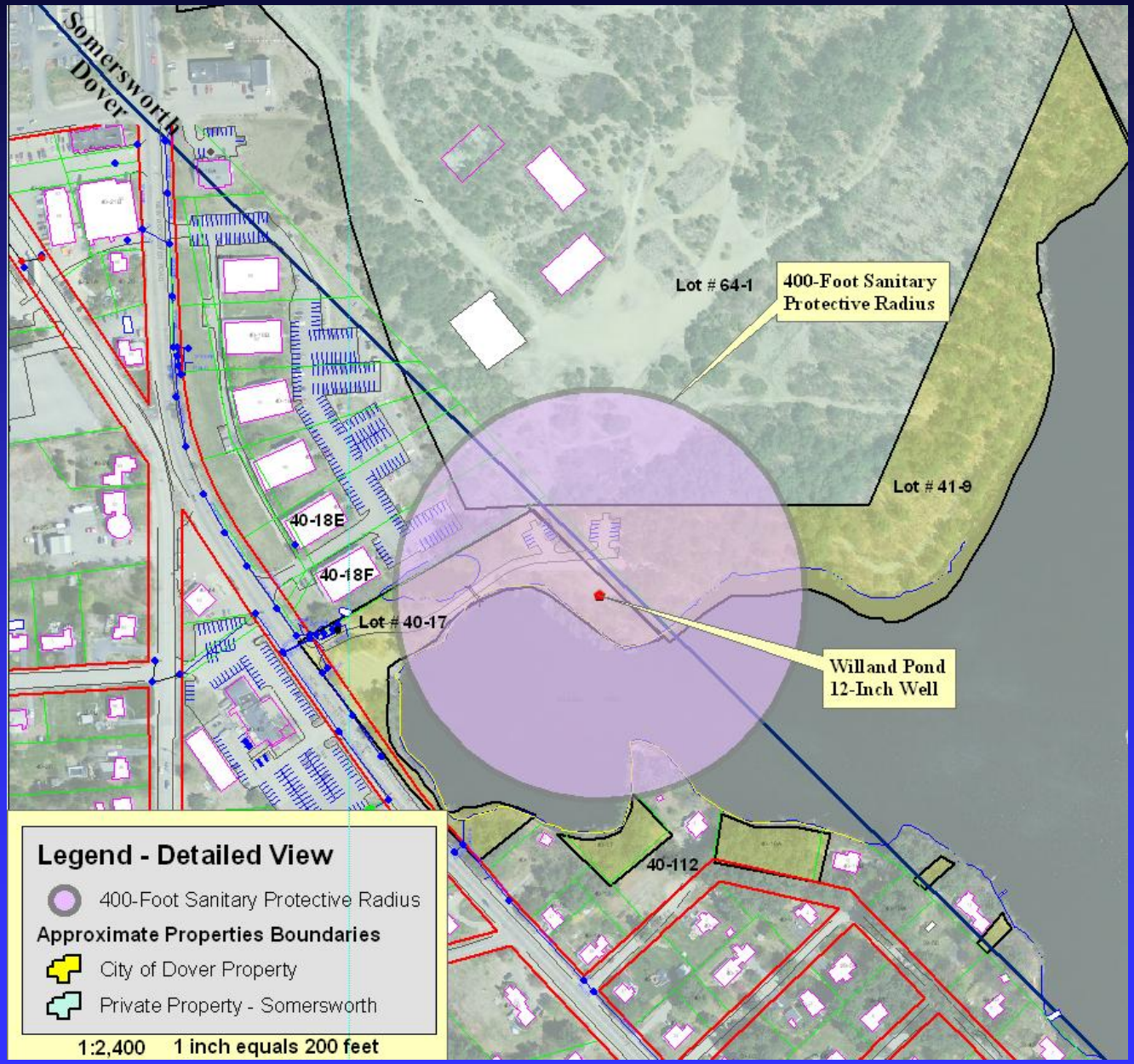
- **Groundwater withdrawals from the Willand Pond Aquifer, at a rate of 600 gpm, can be used to successfully manage and maintain desirable water levels in Willand Pond.**

Phase III - Part III

- Results of Data Analysis

- It is likely that the existing Willand Pond 12-Inch well can only be permitted for 408 gpm because a 400-foot protective radius can not be established around this well.

Phase III - Part III



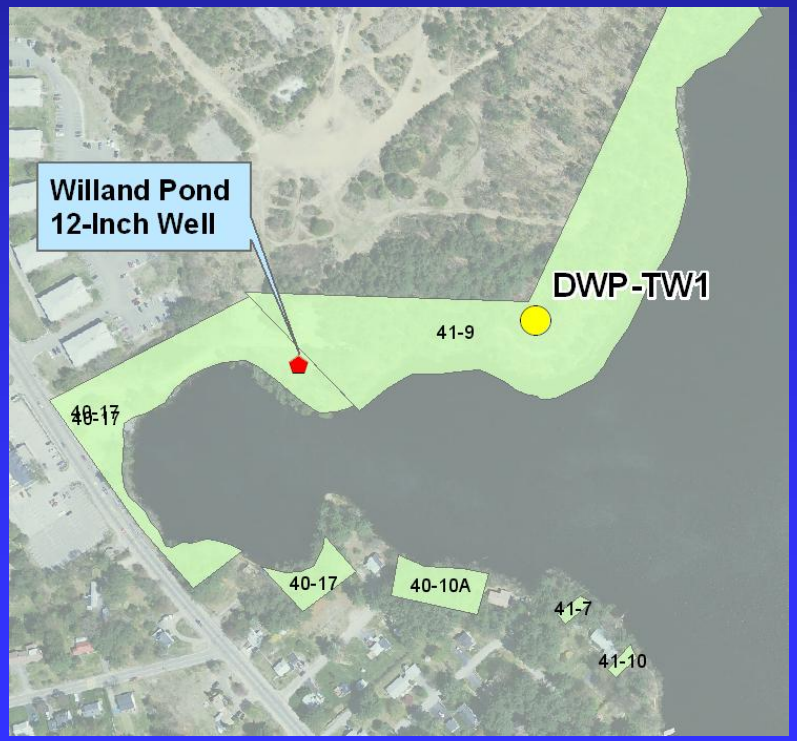
Phase III - Part III

- Results of Data Analysis

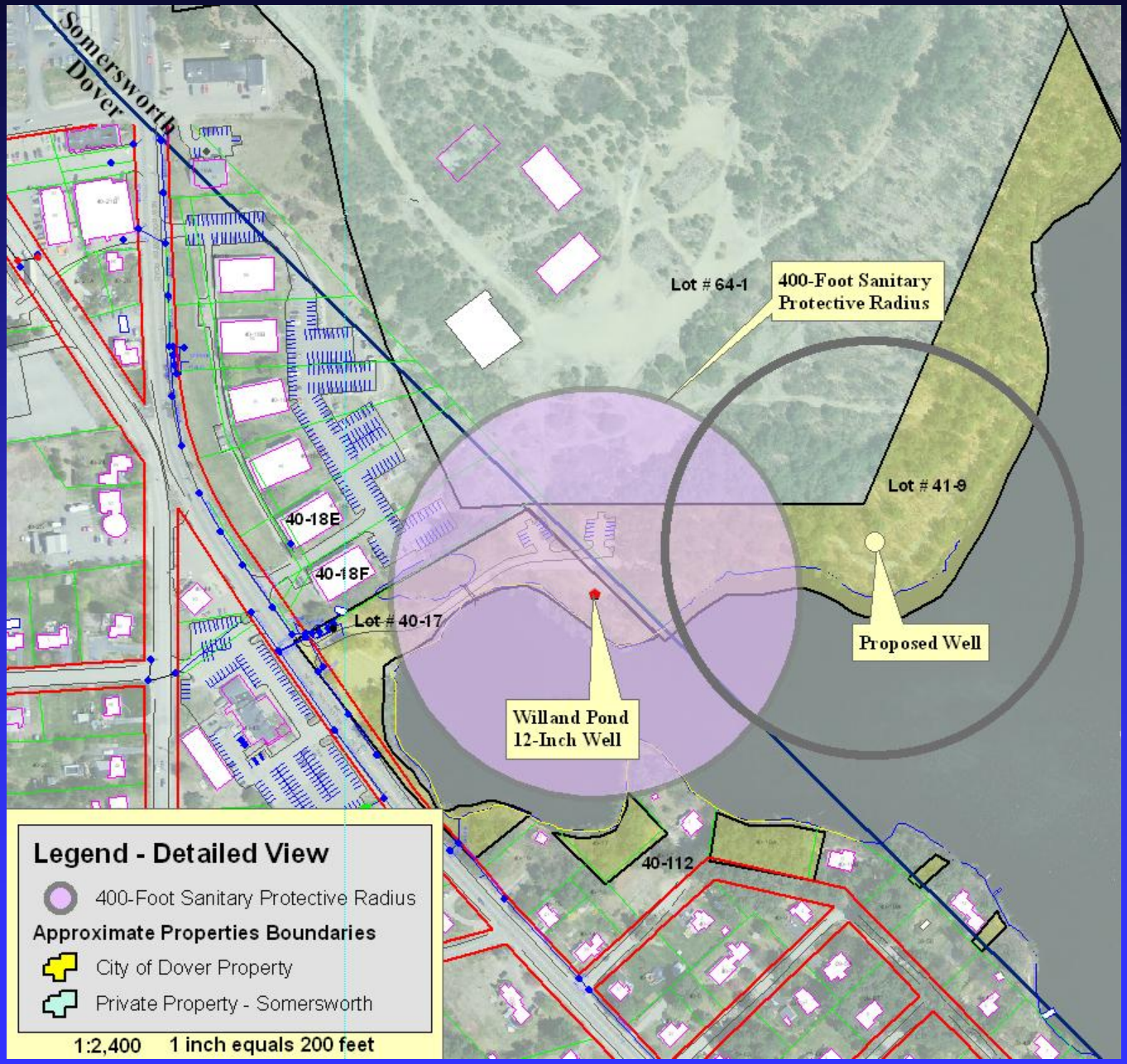
- Therefore, it will be desirable to develop a second production well in close proximity of the Willand Pond 12-Inch Well to maximize groundwater withdrawals such that water levels in Willand Pond can be managed effectively.

Phase III - Part III

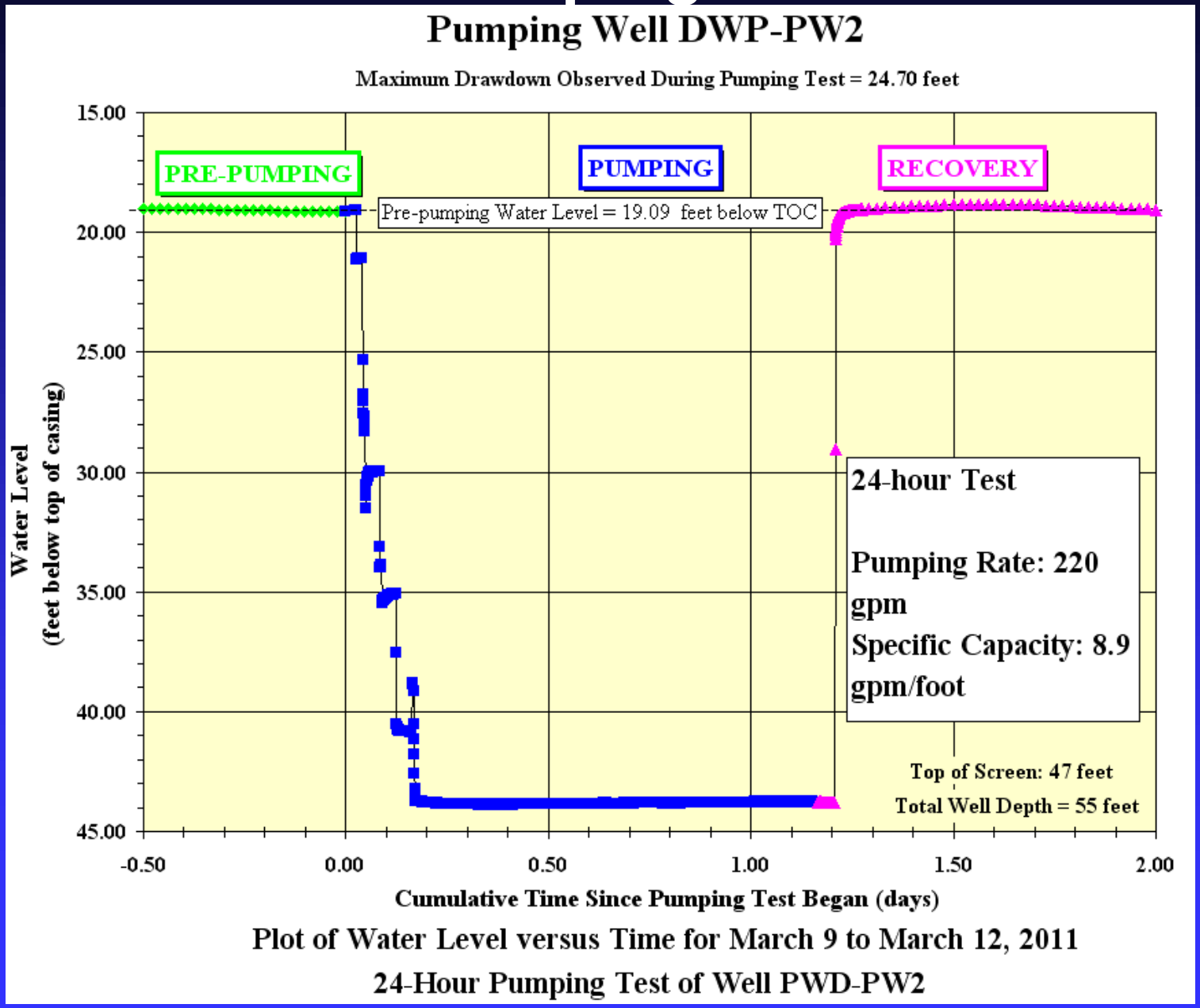
Assessment of the Potential for Developing an Additional Production Well on the North Shore of Willand Pond.



Phase III - Part III



24 hour Pumping Test Results



Phase III - Part III

Results of Testing New Proposed Production Well

- Potential yield of 225 gpm.
- Groundwater will require treatment for iron and manganese.
- Interference between new well and Willand Pond Well will be negligible.

Phase III - Part III

Assessment of Treatment Options for Willand Pond Well

Phase III - Part III

Treatment Assessment

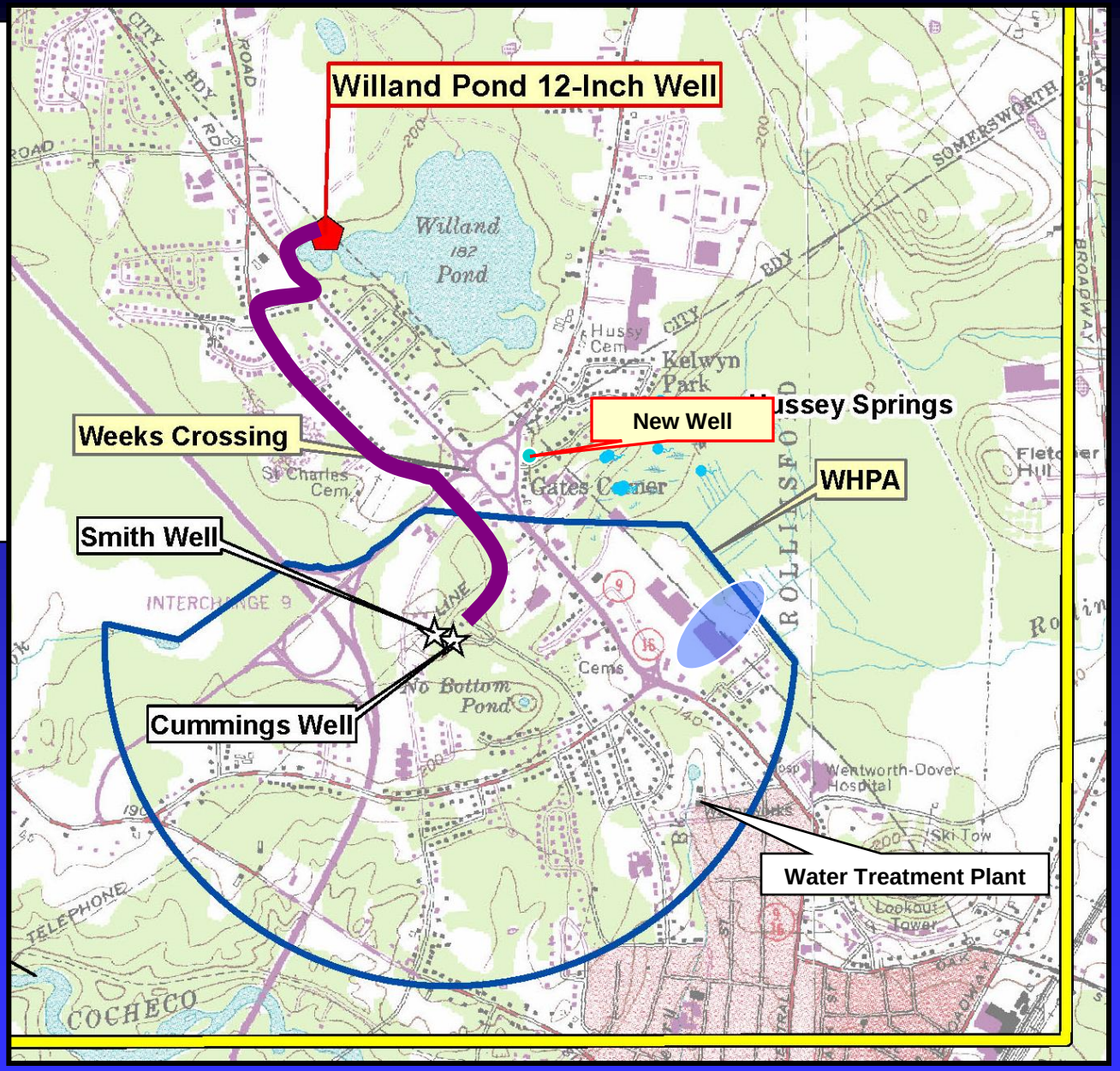
- Mixing of groundwater will not be sufficient to lower the iron and manganese levels
- Groundwater can be treated at the Lowell Ave Water Treatment Plant
- Approximately 600 gpm excess treatment capacity is available at the Plant

Phase III - Part III

Treatment Assessment

- Potential water line to be located along Old Rochester Road.
- Raw water to be discharged into existing raw water line between the Smith and Cummings Wells and Lowell Ave. Treatment Plant.

Potential Location of Water Line



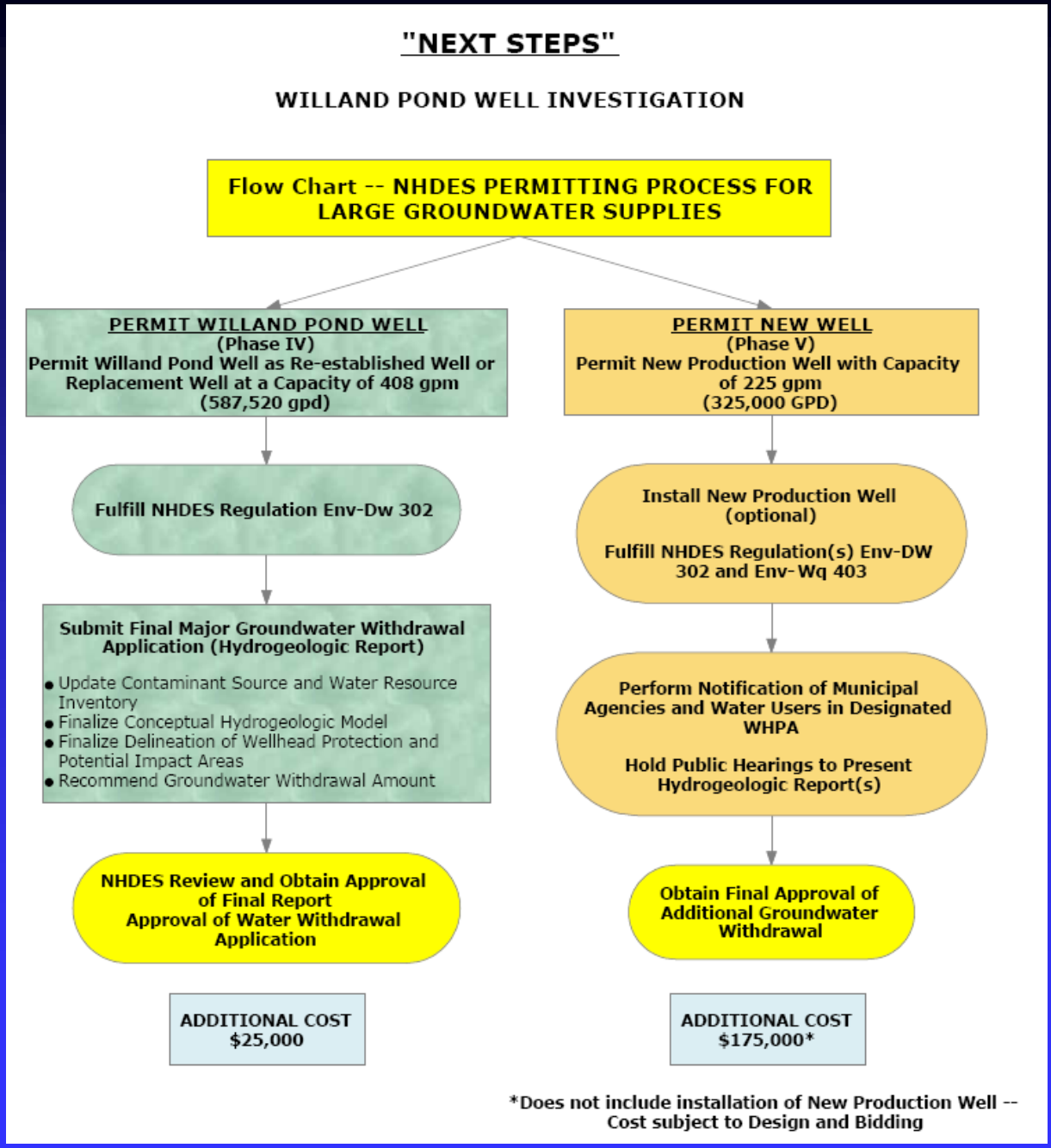
Recommended Next Steps

Phase III - Part III

- Obtain an approval from the NHDES for withdrawing groundwater from the existing Willand Pond 12-Inch Production Well (at 408 gpm); and
- Obtain a Groundwater Withdrawal Permit from the NHDES for a new groundwater supply well on the north shore of Willand Pond (at 225 gpm).

Recommended Next Steps - Continued

Phase III- Part III



End of Presentation