Advanced Technologies For Stripper Gas Well Enhancement

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Presentation Outline

- Project Objectives
- Project Background
- Database Construction
- Stripper Well Remediation Methodology (SWARM) Software

Presentation Outline (continued)

- Additional Objectives
- Software Demonstration
- Example of Candidates Identified
- Conclusions
- Recommendations

Project Objectives

- Create a methodology able to identify underperforming natural gas stripper-wells
  - Easily, effectively, and inexpensively
- Utilize this methodology to recognize remediation candidates in an operating, stripper-gas, field
  - +/- 700 wells operated by Great Lakes Energy Company, and Belden & Blake Corporation have been evaluated
  - Field located in northwestern Pennsylvania

Project Background

Operators Frequently Face a Dilemma in Maximizing Production From Low-productivity Wells

- Hundreds of stripper wells covering thousands of acres
- Difficult for an operator to identify marginal wells easily and efficiently

In Most Fields There Are Wells That Do Not Perform As Expected

- May be due to:
  - Reservoir characteristics
  - Inadequate completions
  - Operational constraints
  - Mechanical problems

In Most Fields There Are Wells That Do Not Perform As Expected (Continued)

- Negative influence upon:
  - Overall field production
  - Economics
- Magnitude of reviewing vast amounts of data
  - Burden upon available work force
  - Strains corporate financial resources

First Step Is to Identify the Underperformers

- We recognized that operators can use an easier and faster method to identify suspect wells. Need to be able to:
  - Screen stripper wells within their field
  - Spot candidate wells that may need remediation

Assumptions

- General localized production trends exist within a field.
- Any abrupt change exhibited by an individual well, relative to an established trend in its vicinity, identifies that well as a potential remediation/restimulation candidate

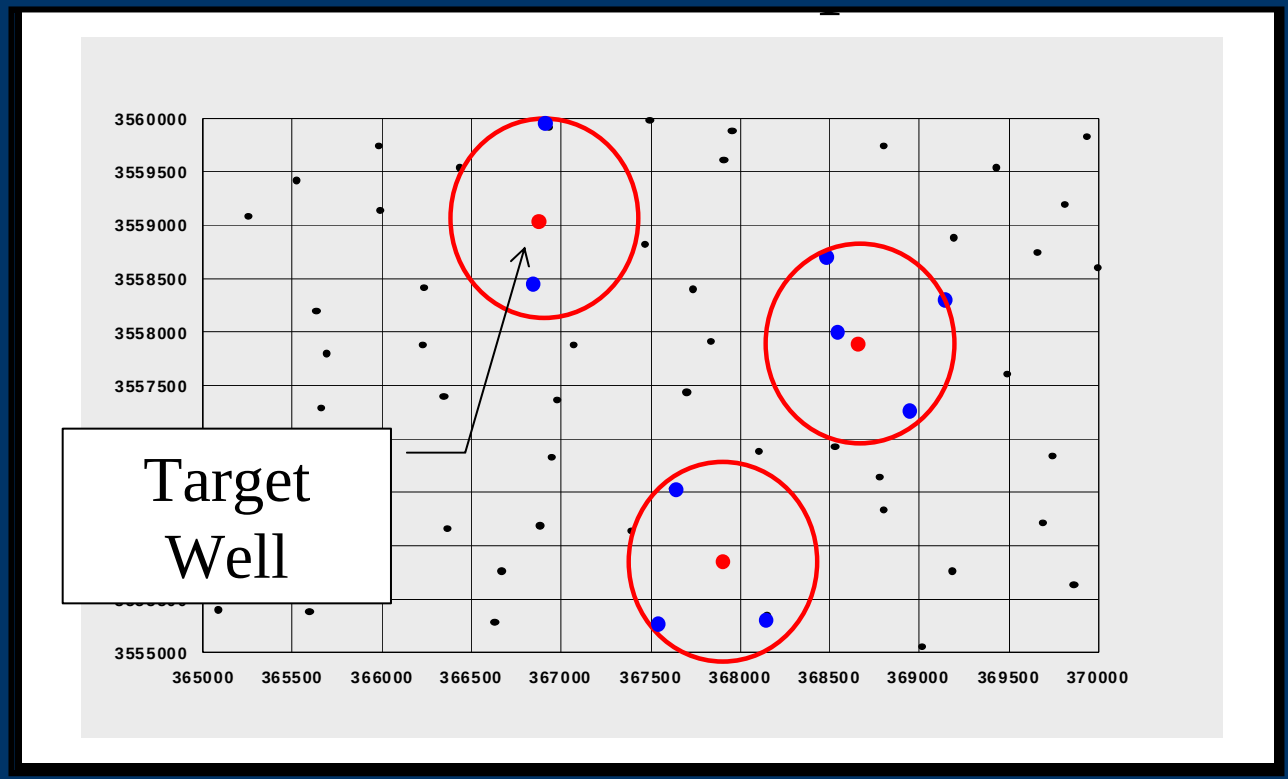
Database Construction

- Production history, location, and well data was provided to us by Great Lakes Energy Company and Belden & Blake
- This information was incorporated into various Microsoft Access databases and Excel files designed to facilitate our analyses

Fundamentals of SWARM
(***S**tripper **W**ell **R**emediation **M**ethodology*)

- Calculates appropriate production indicators
  - Representative of a target well's production history over a chosen interval
    - (e.g. 4-Year Cum, 5-Year Cum, 7- Year Cum etc.)
    - Normalized rate = average monthly rate for the last year of the desired production period
- Compares an individual target well's production profile to its offsets
- Streamlines identification process

A Target Well and Its Offsets Make up a Domain



SWARM
(***S**tripper **W**ell **R**emediation **M**ethodology*)

- The Software compares the cumulative production of a target well over a user-specified time span, with all offsets within a fixed distance
- Depletion is taken into account by considering the date of first production (DOFP) versus a desired production-indicator (PI)
  - Lower PI's over time
- Streamlines identification process

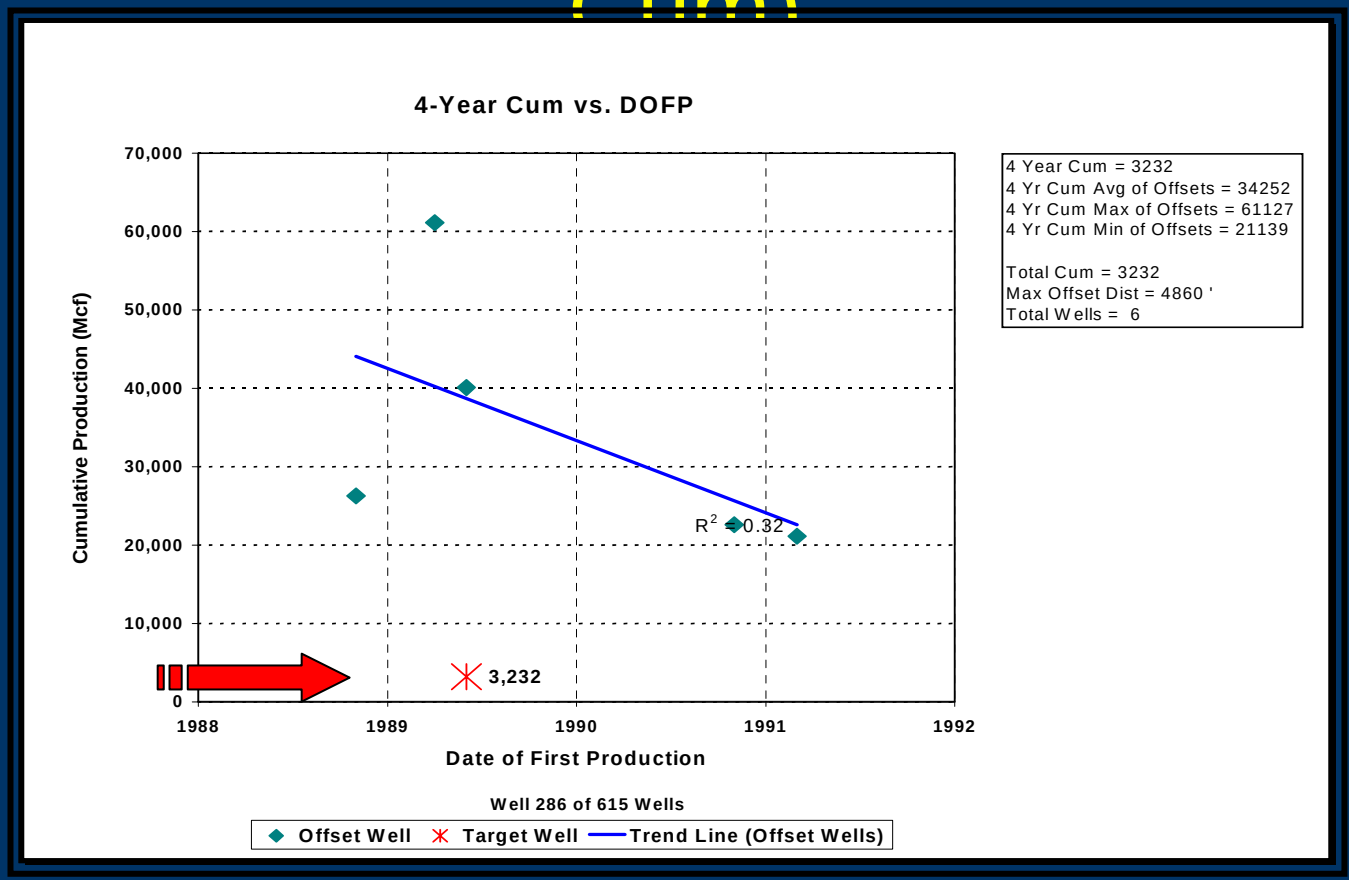
SWARM
(***S**tripper **W**ell **R**emediation **M**ethodology*)

- If the PI of a Target well is lower than a given percentage (e.g 50%, 70% etc.) it is flagged for additional review
- The entire list of wells is processed and all Target wells that meet the desired criteria are identified
- This is an efficient and rapid method of identifying potential remediation candidates

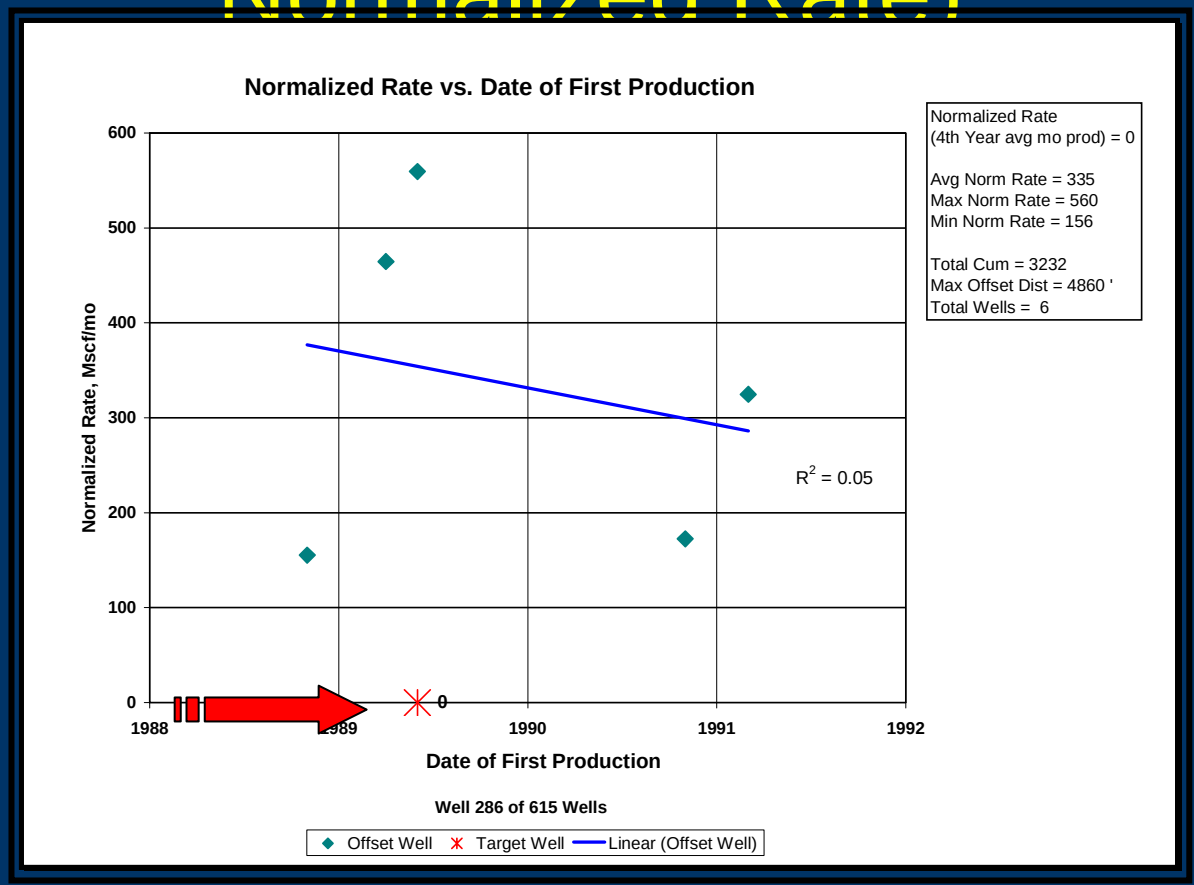
SWARM
(***S**tripper **W**ell **R**emediation **M**ethodology*)

- After the first pass is completed, a review of each candidates completion data, geologic information, production history, and operating environment should be conducted

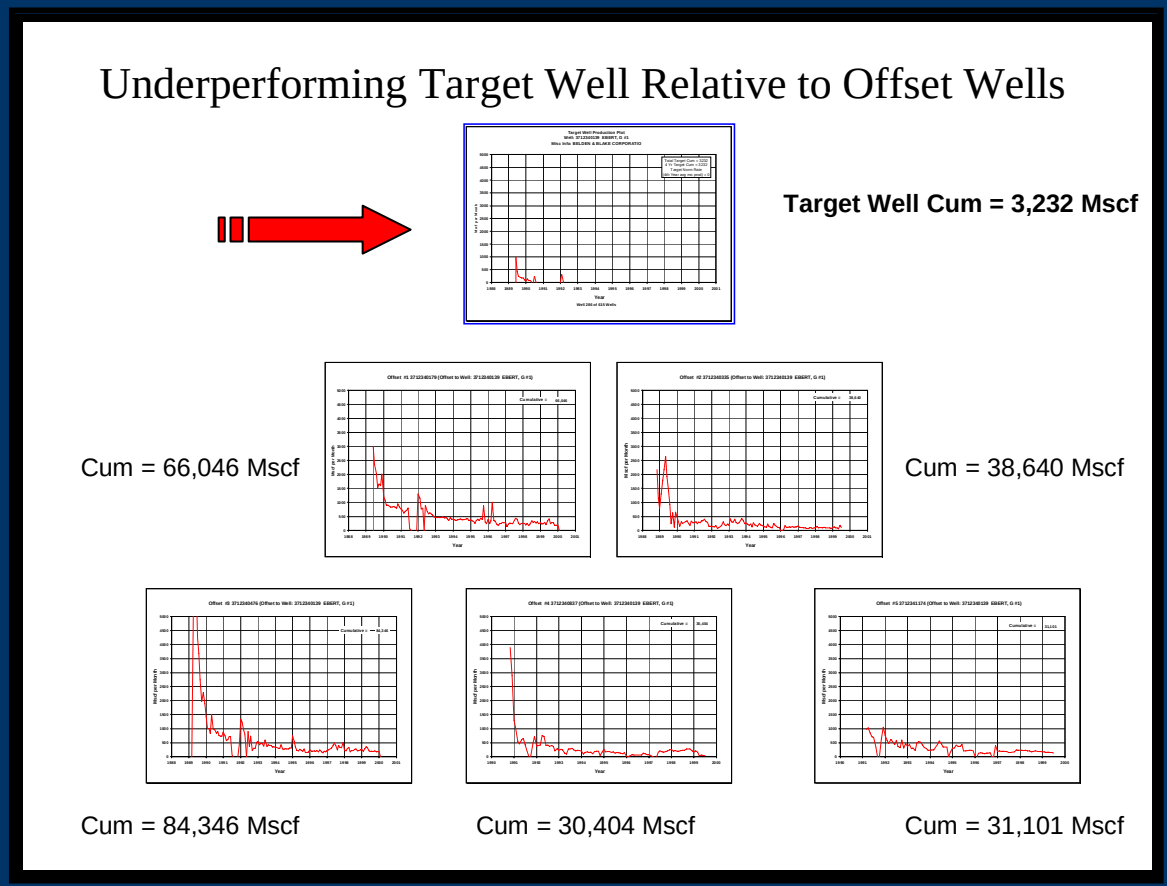
Example of a Target Well Performing Significantly Worse Than Its Offsets (Based Upon 4-year Cum)



Example of a Target Well Performing Significantly Worse Than Its Offsets (Based Upon Normalized Rate)



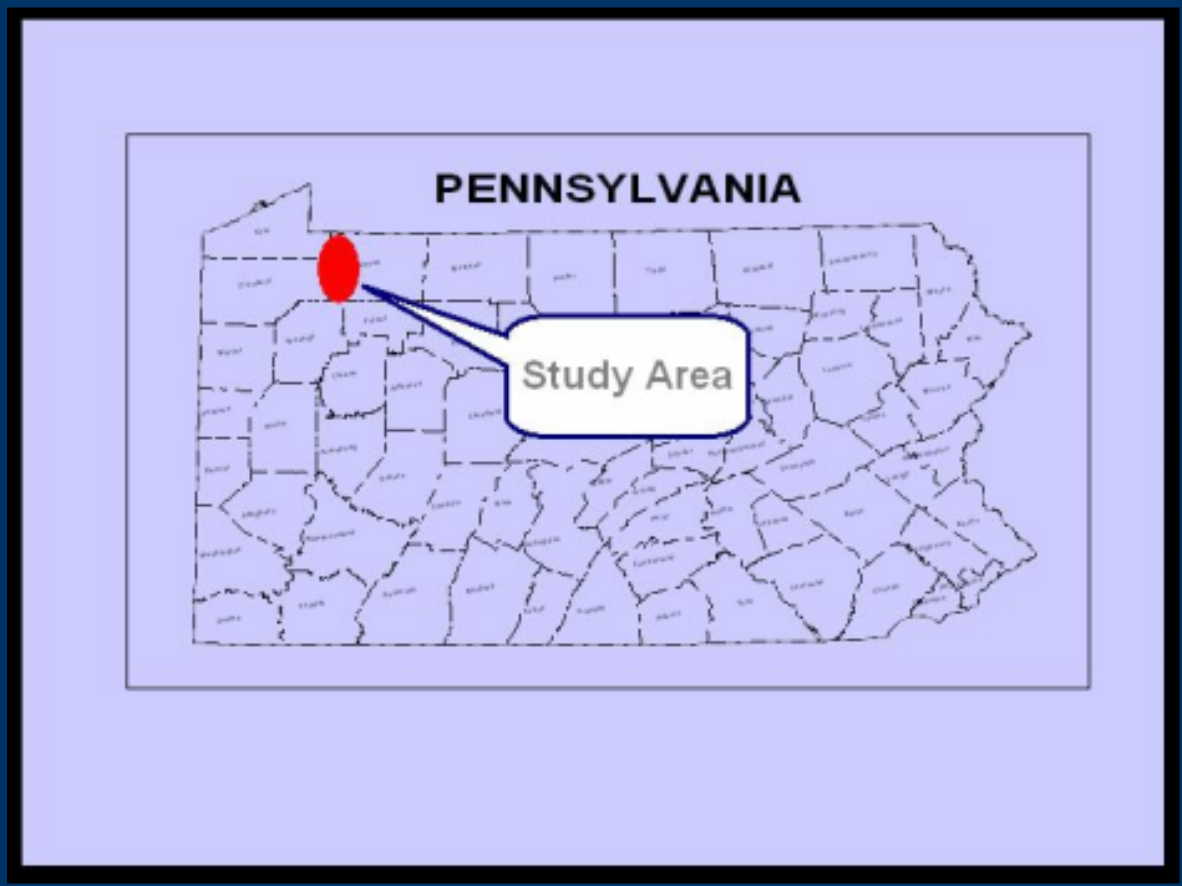
Underperforming Target Well Relative to Offsets



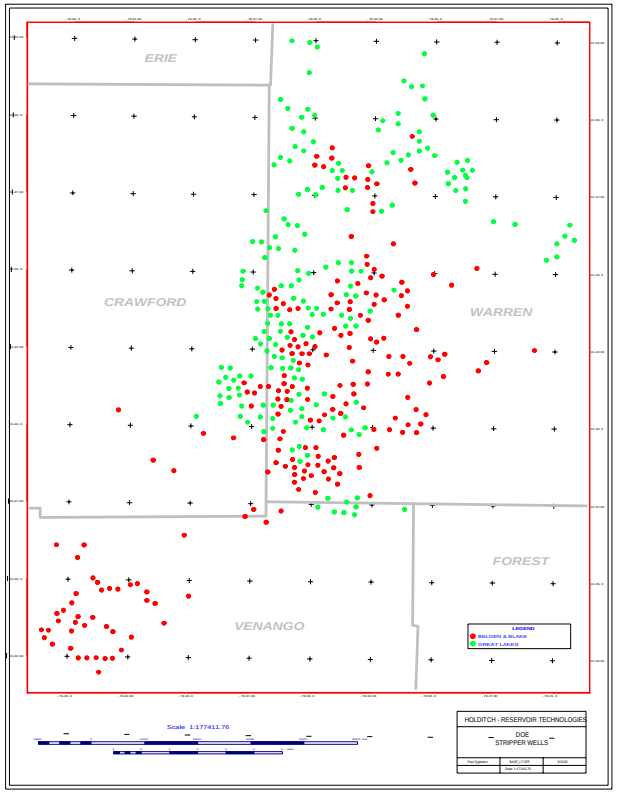
Additional Objectives of This Project

- Evaluate workover/recompletion potential of the Whirlpool/Medina Formation in western Pennsylvania
- Objective included quantifying the number of remediation candidates and their geographic location
- Great Lakes Energy Company (Great Lakes), and Belden & Blake provided information for more than 700 wells

Location Map of Study Area



Location Map Showing Wells



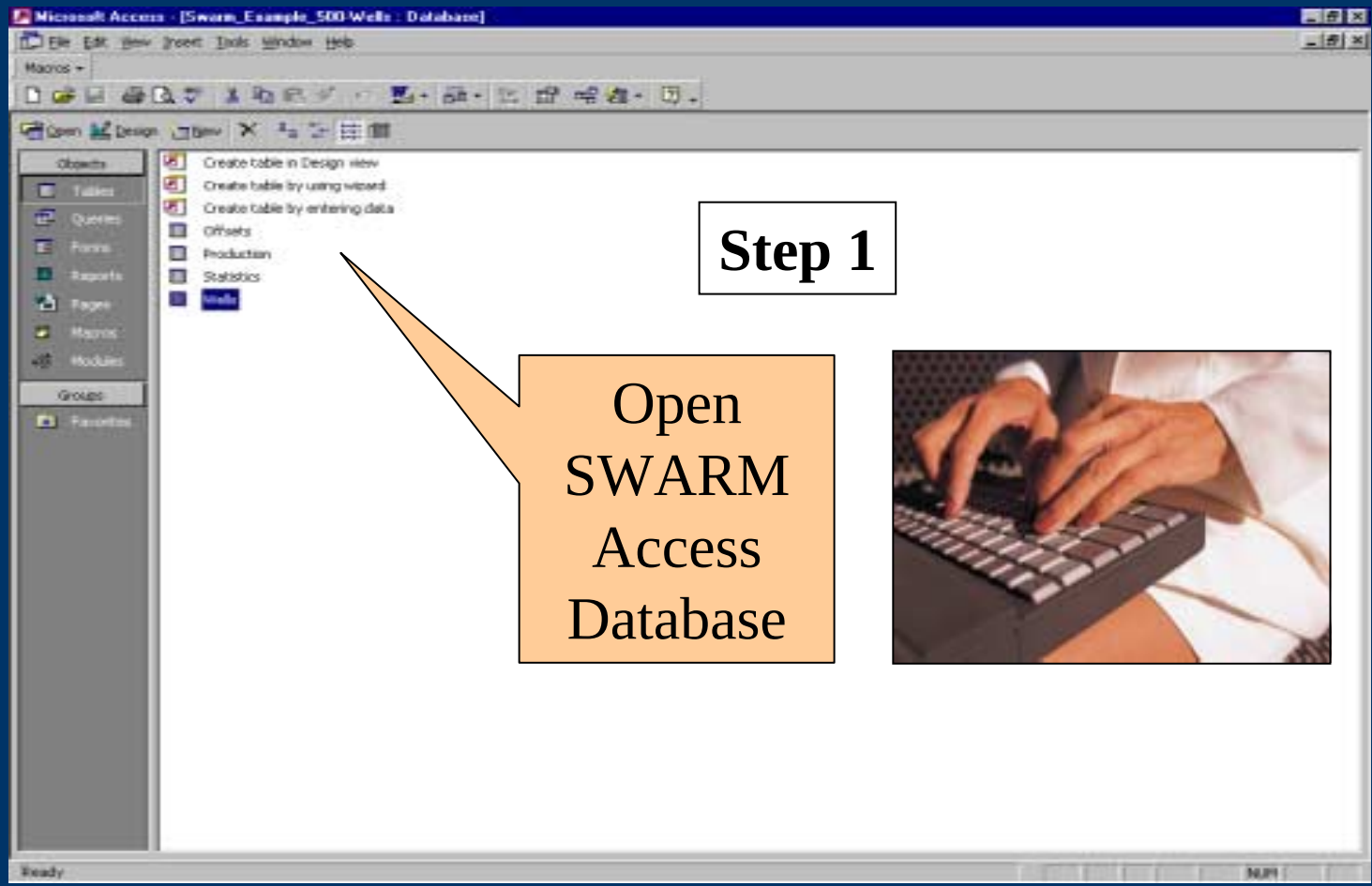
Location Map of Study Area Wells

Crawford, Venango and Warren Counties, Pennsylvania

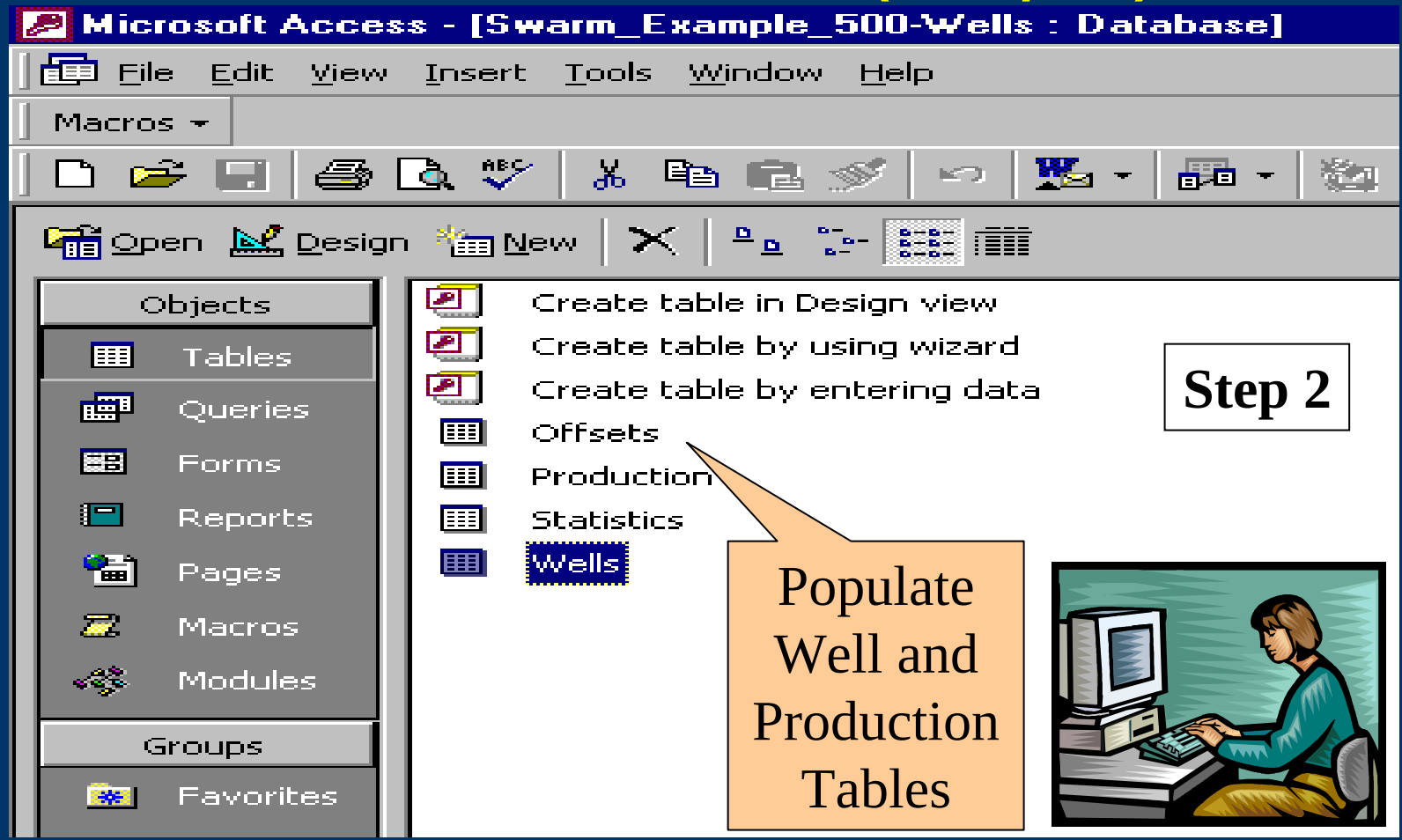
~700 wells

SWARM Software

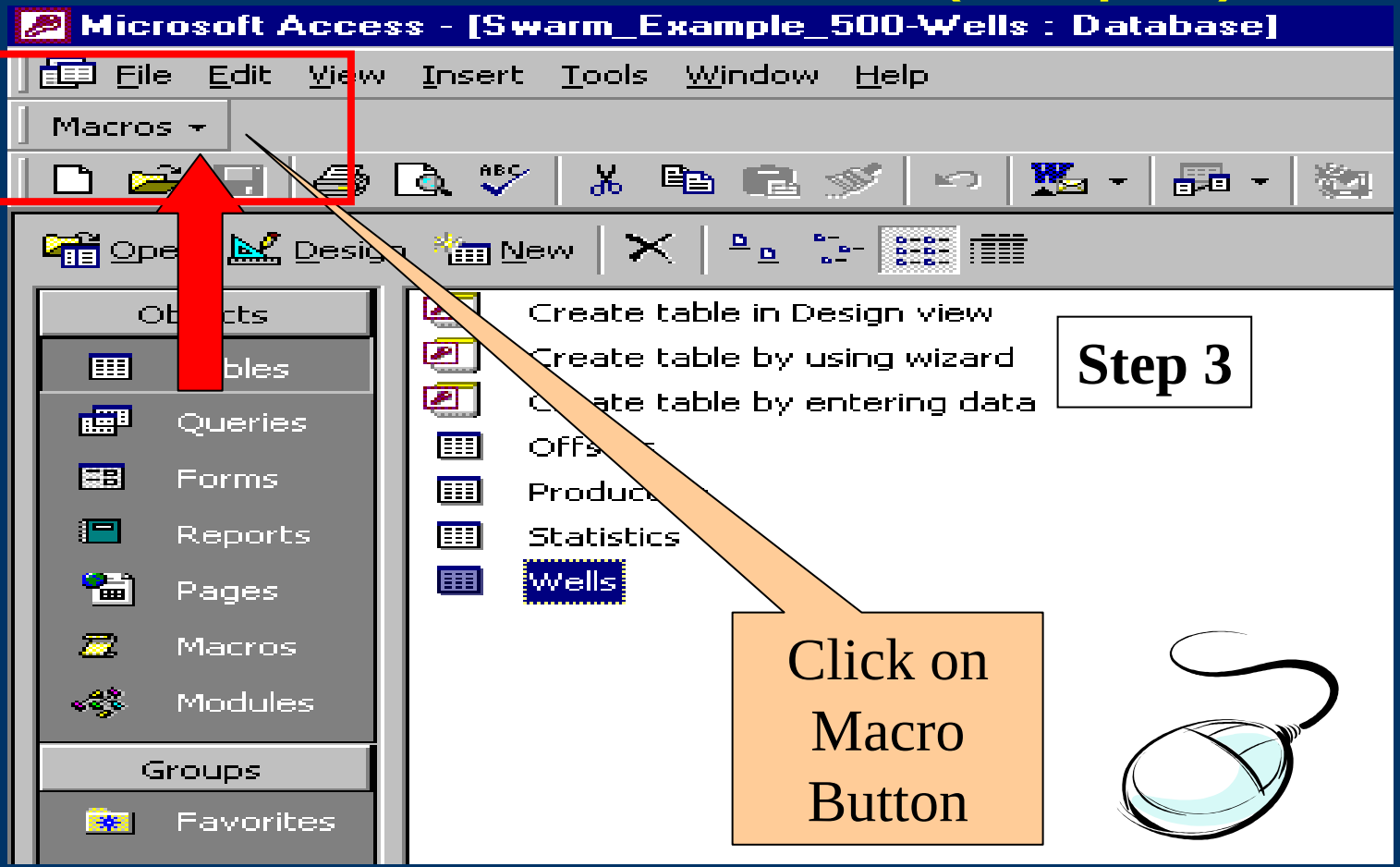
Example Screen Shots of SWARM Microsoft™ Access Database



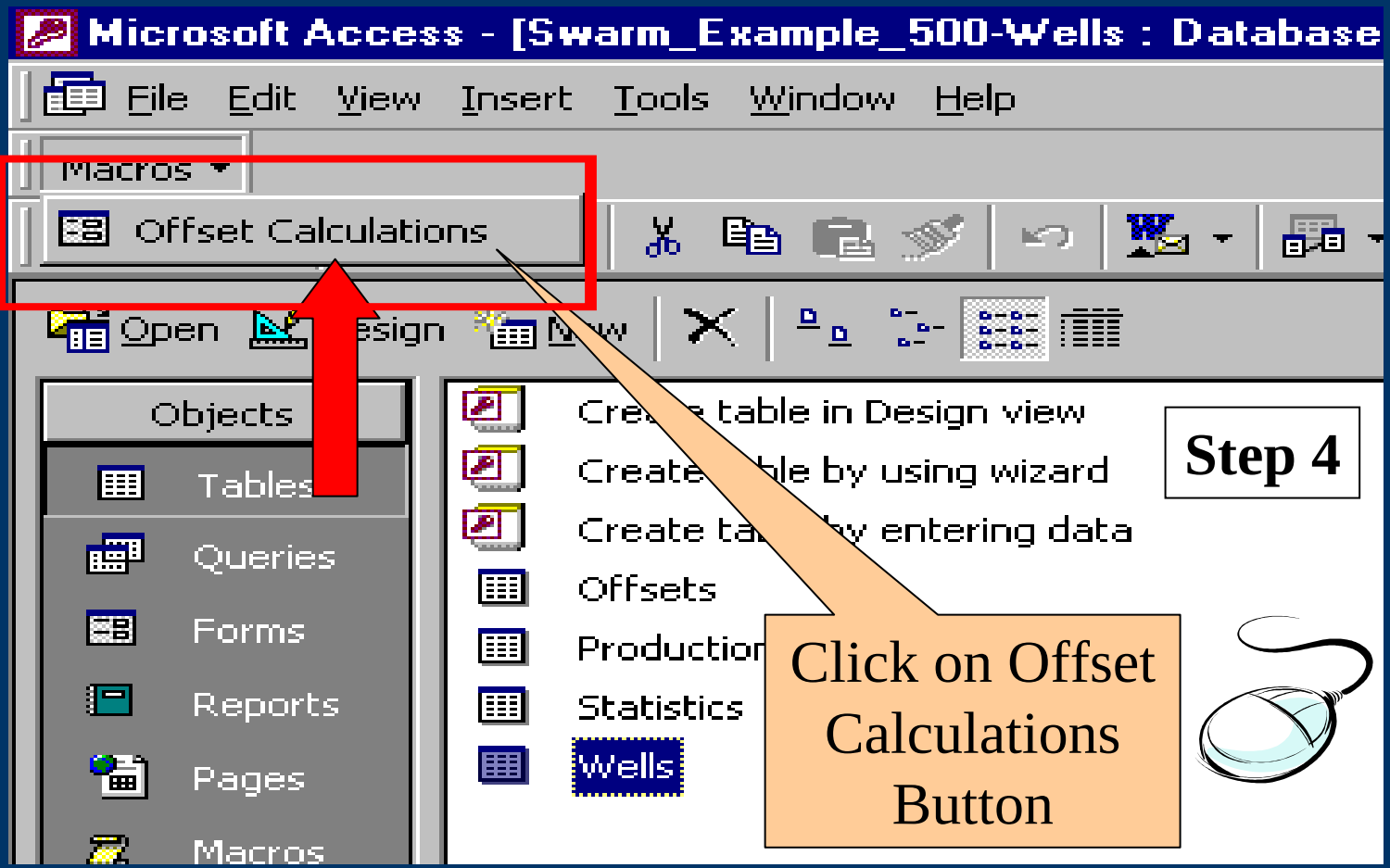
Screen Shot of SWARM Access Database (Step 2)



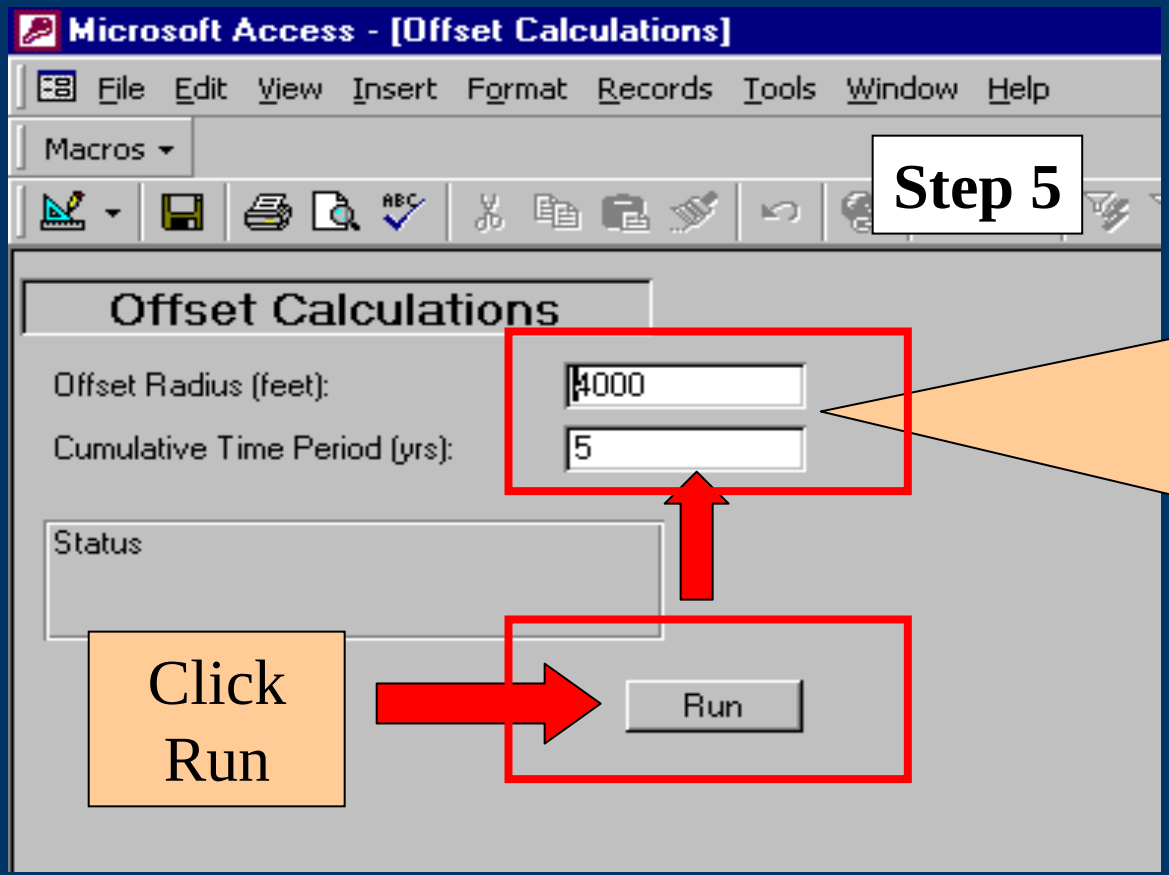
Screen Shot of SWARM Access Database (Step 3)



Screen Shot of SWARM Access Database (Step 4)



Screen Shot of SWARM Access Database (Step 5)

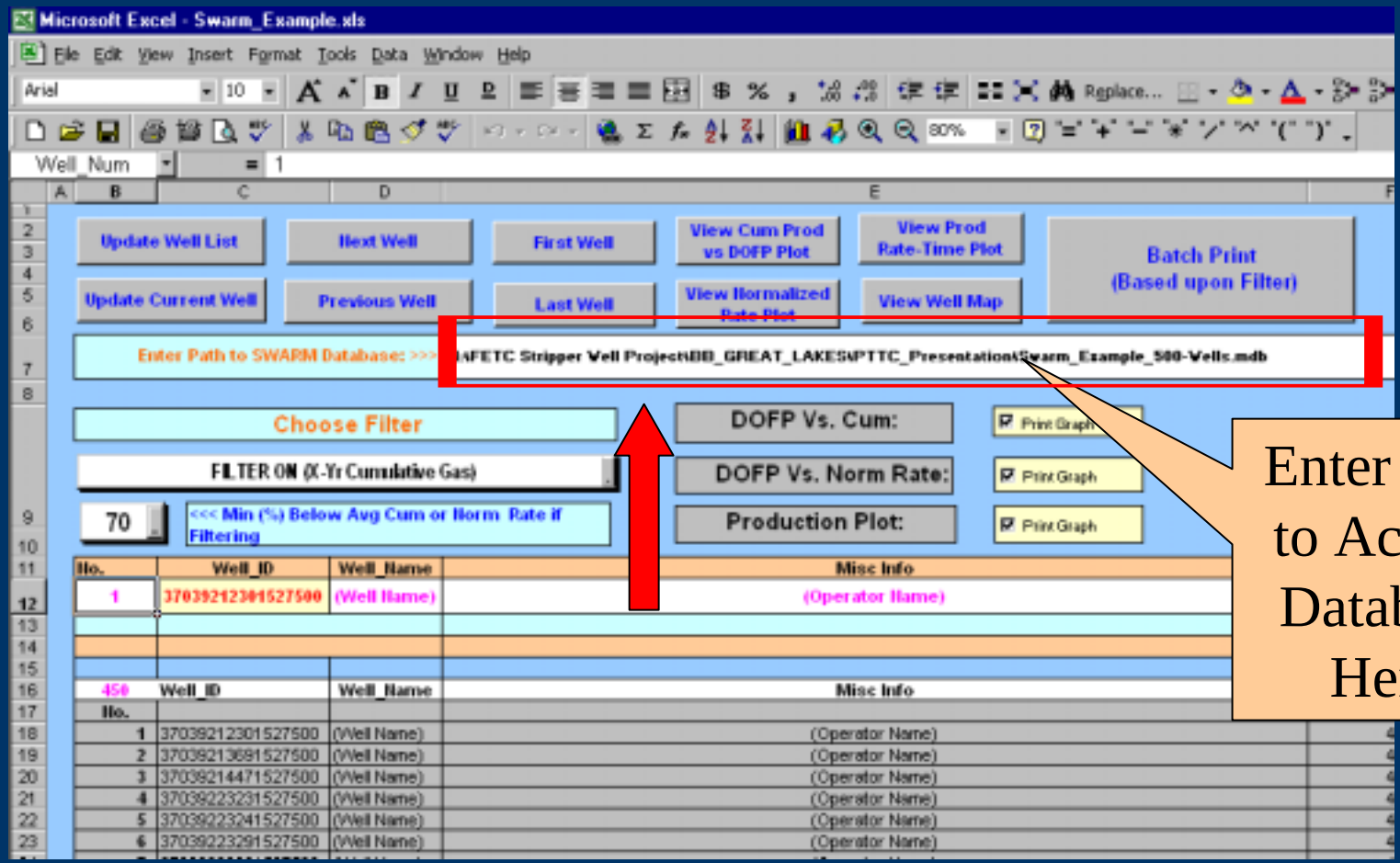


Enter Maximum Radius Desired For Target Well to Offset Analysis and Input Cumulative Time Period for Production Indicator

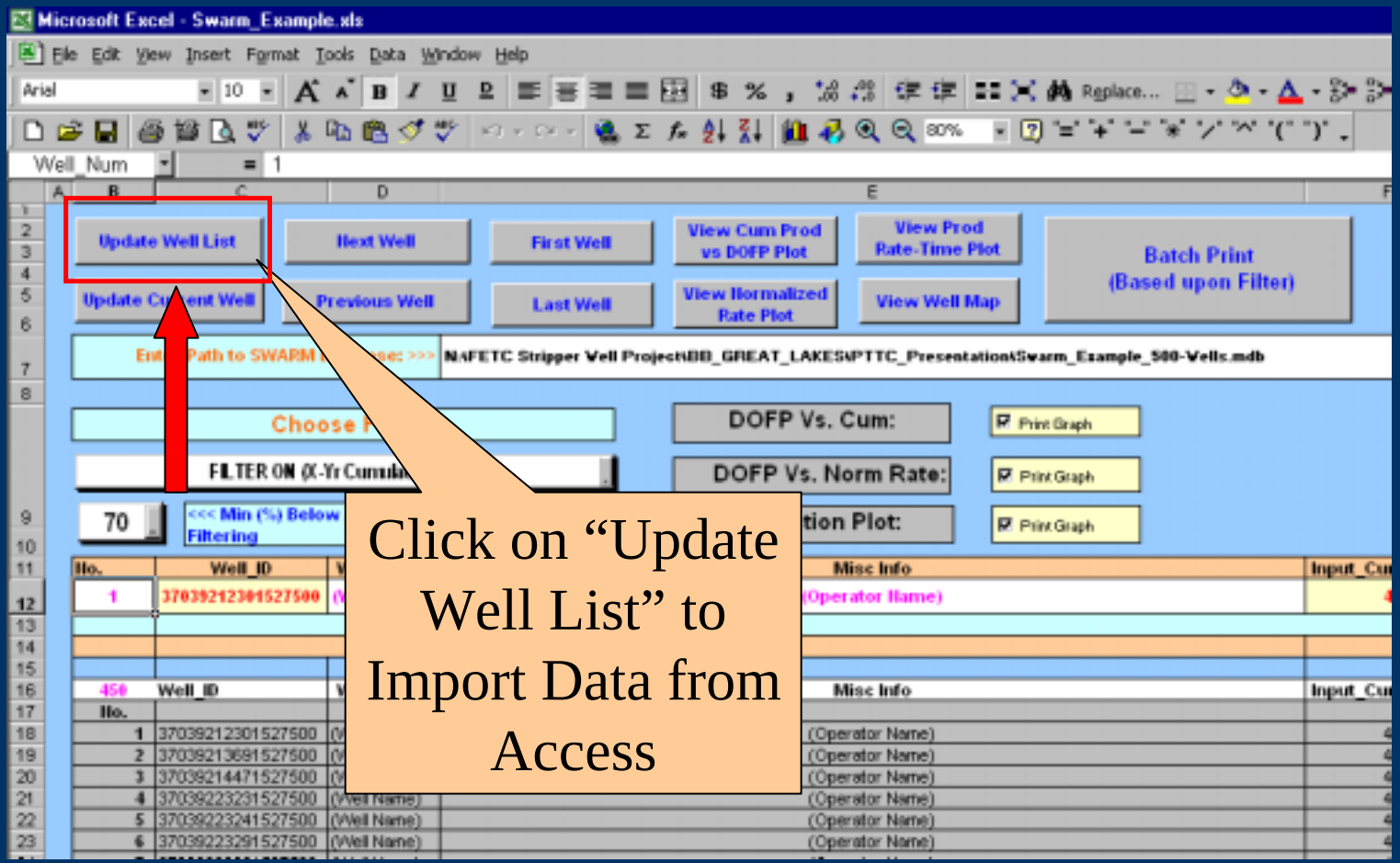
Access File Ready for Excel Processing

- Our Access file is now ready for processing by a SWARM Microsoft Excel™ spreadsheet.
- Note imaginary well names and locations.

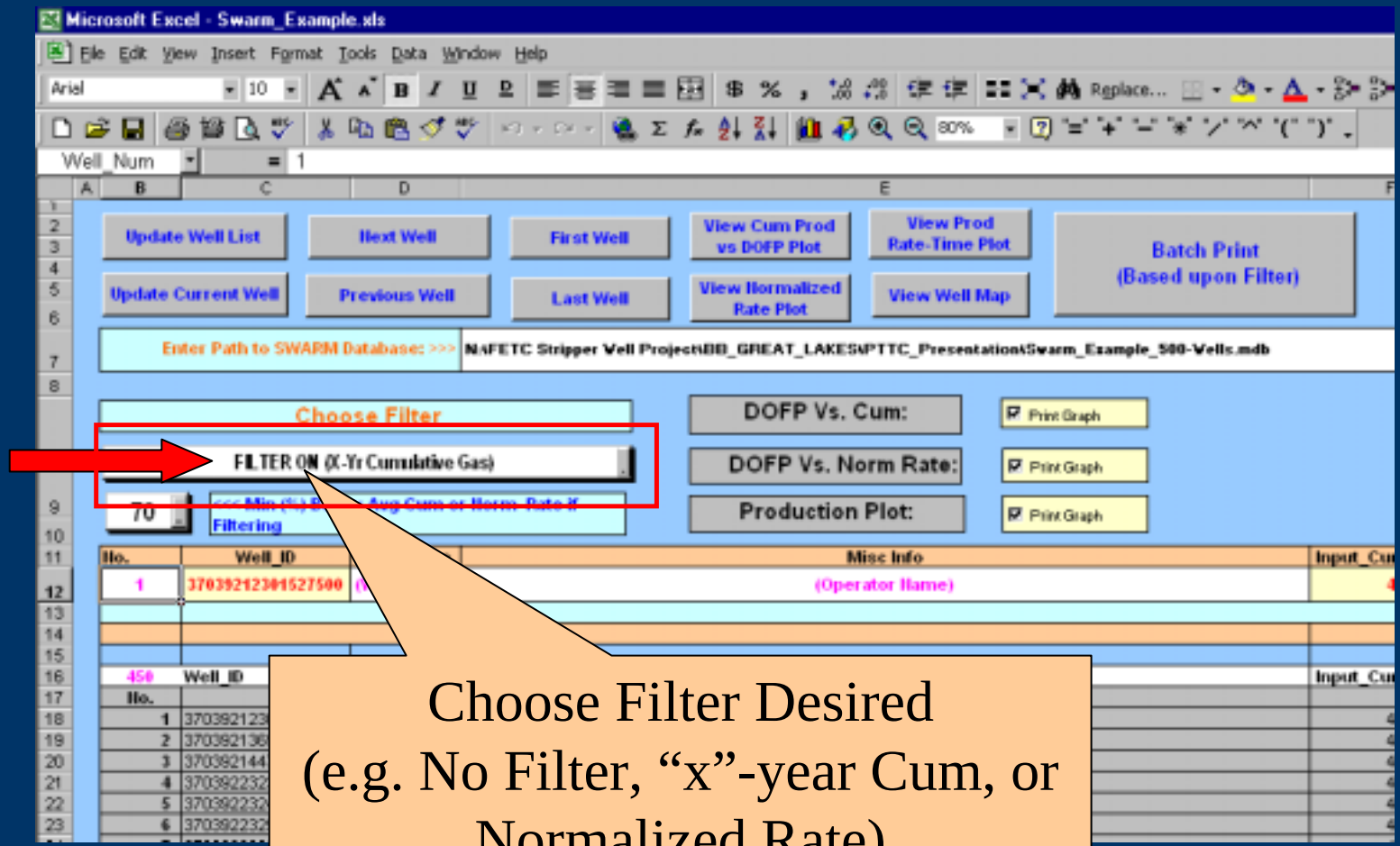
Screen Shot of SWARM Excel Spreadsheet (Step 1)



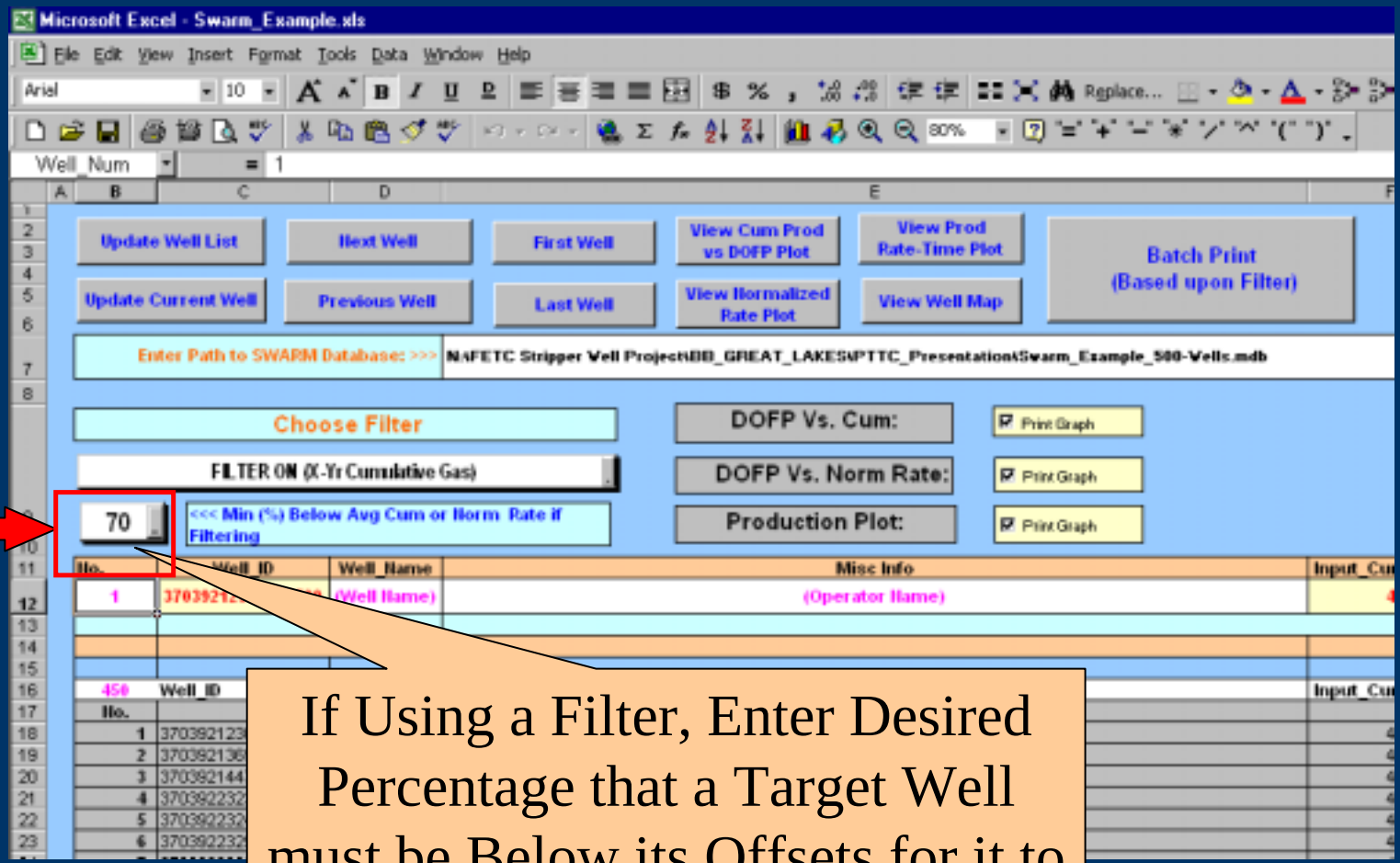
Screen Shot of SWARM Excel Spreadsheet (Step 2)



Screen Shot of SWARM Excel Spreadsheet (Step 3)

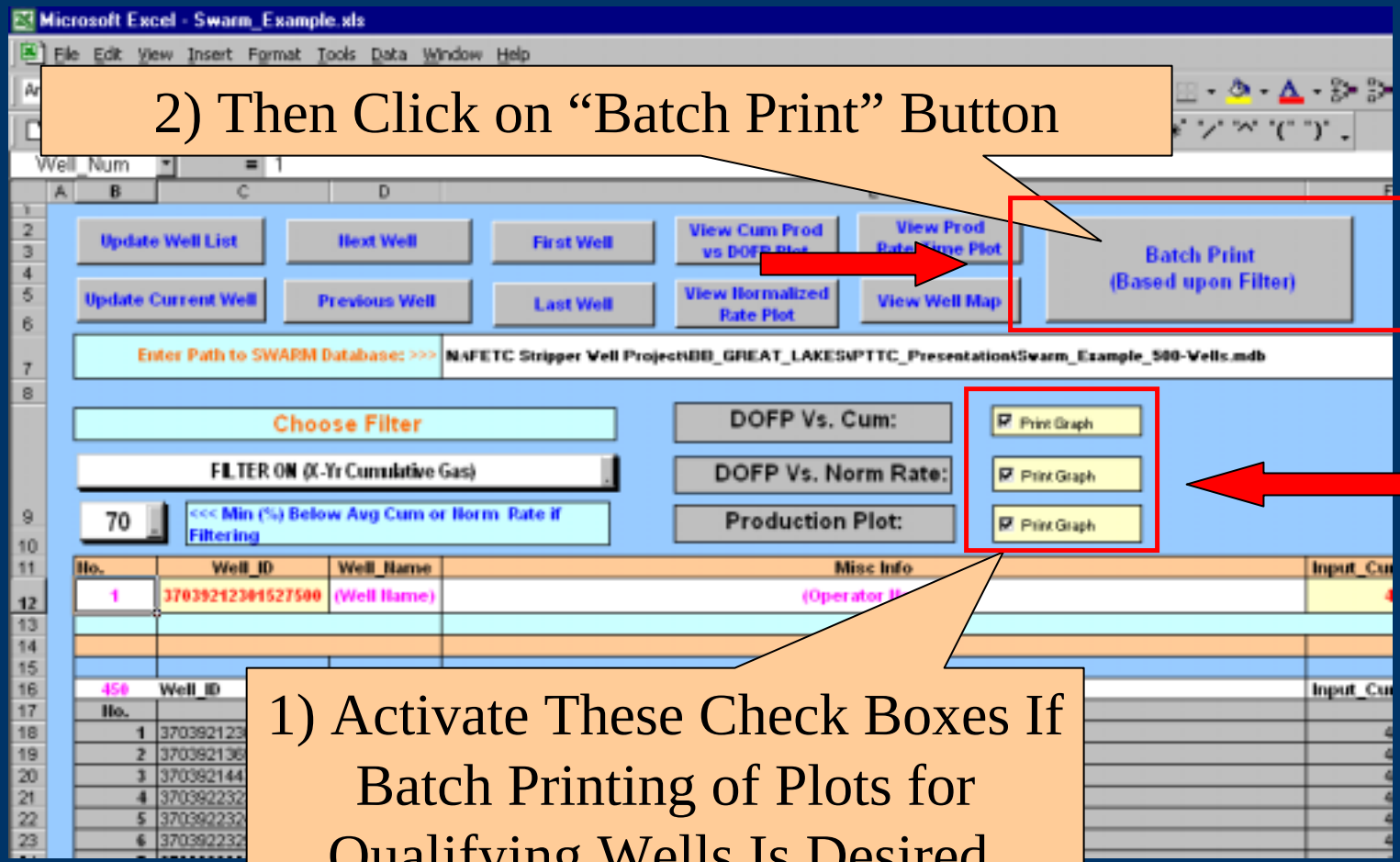


Screen Shot of SWARM Excel Spreadsheet (Step 4)



If Using a Filter, Enter Desired Percentage that a Target Well must be Below its Offsets for it to be Flagged

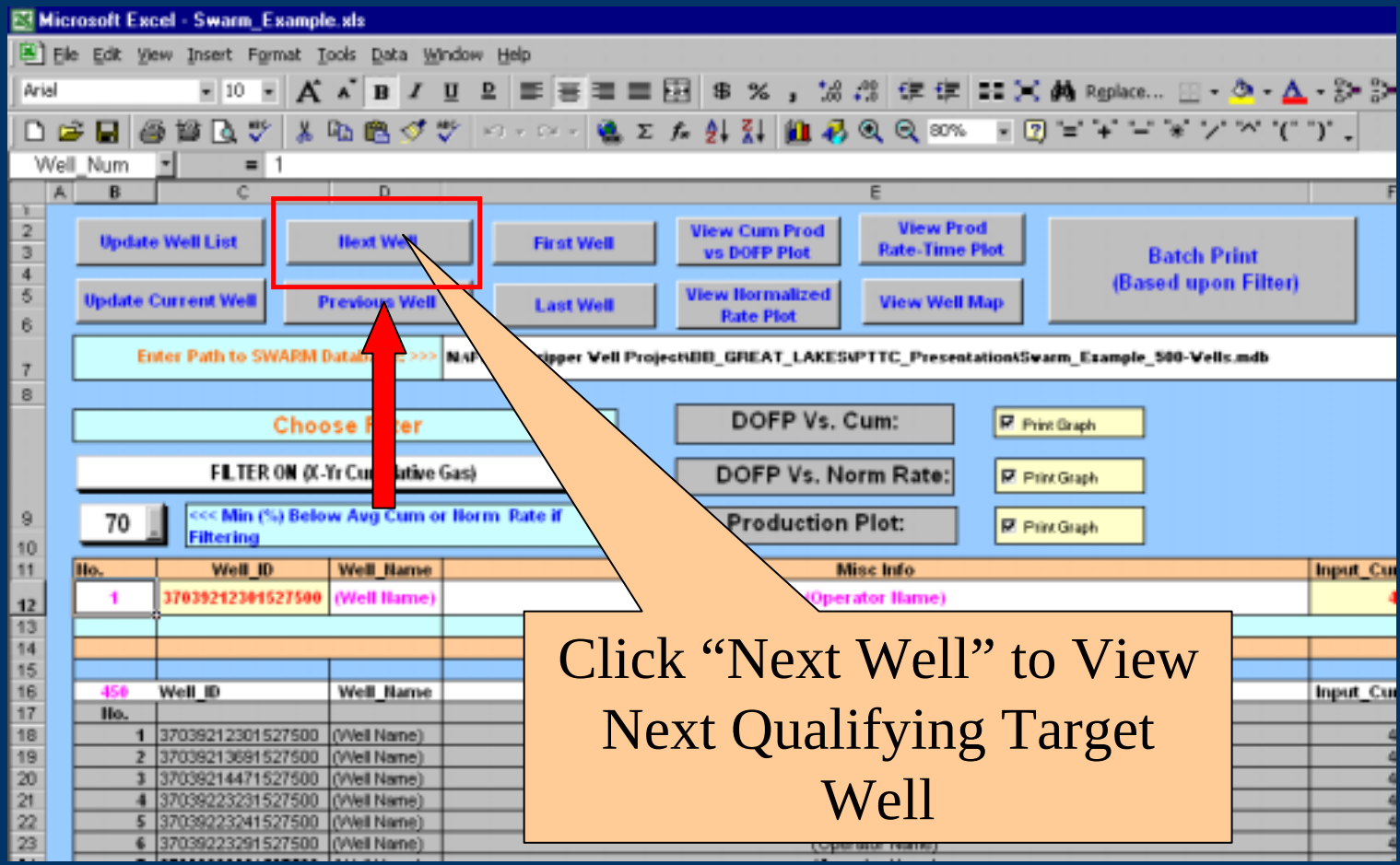
Screen Shot of SWARM Excel Spreadsheet (Step 5)



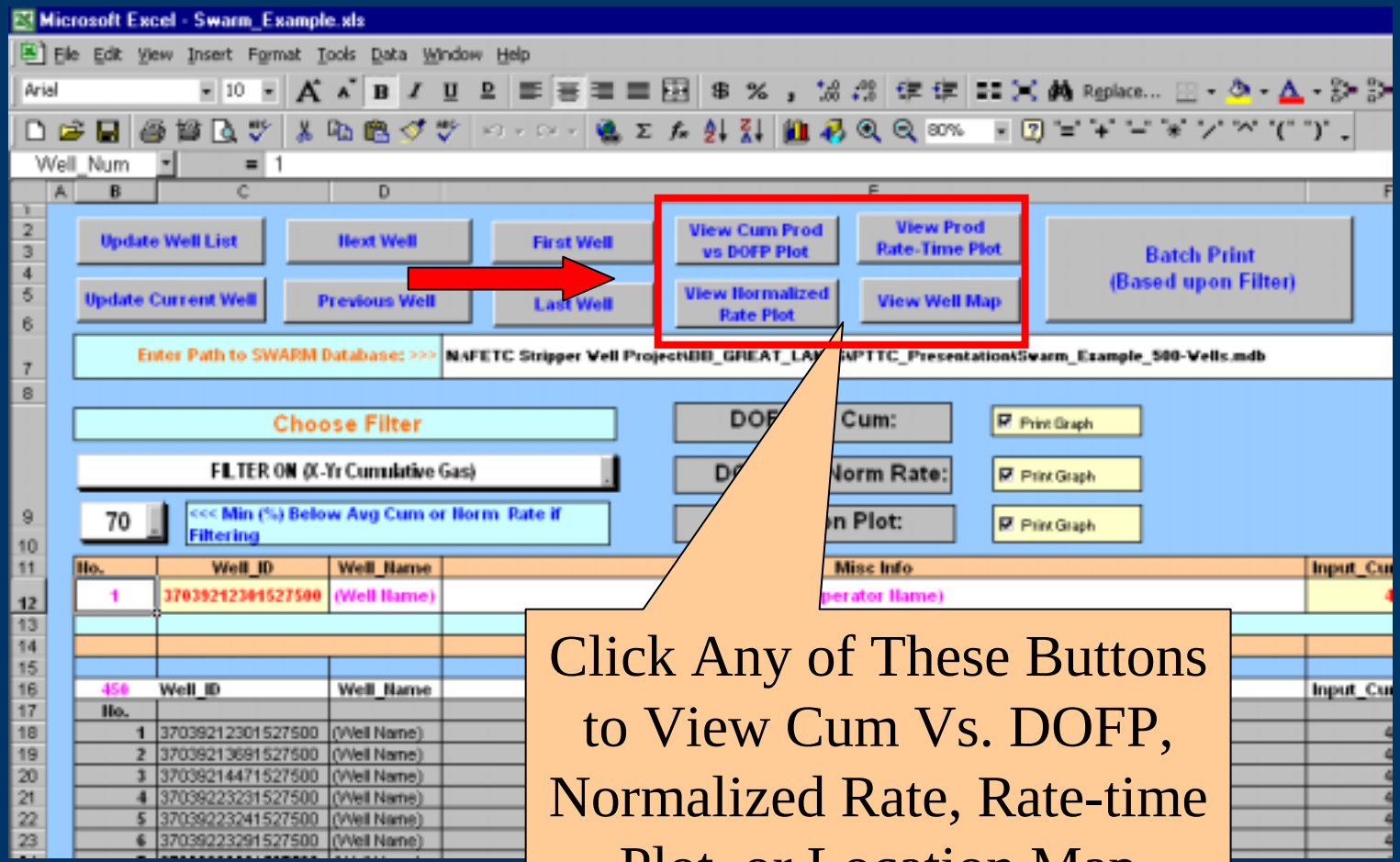
2) Then Click on “Batch Print” Button

1) Activate These Check Boxes If Batch Printing of Plots for Qualifying Wells Is Desired,

Screen Shot of SWARM Excel Spreadsheet (Step 6)

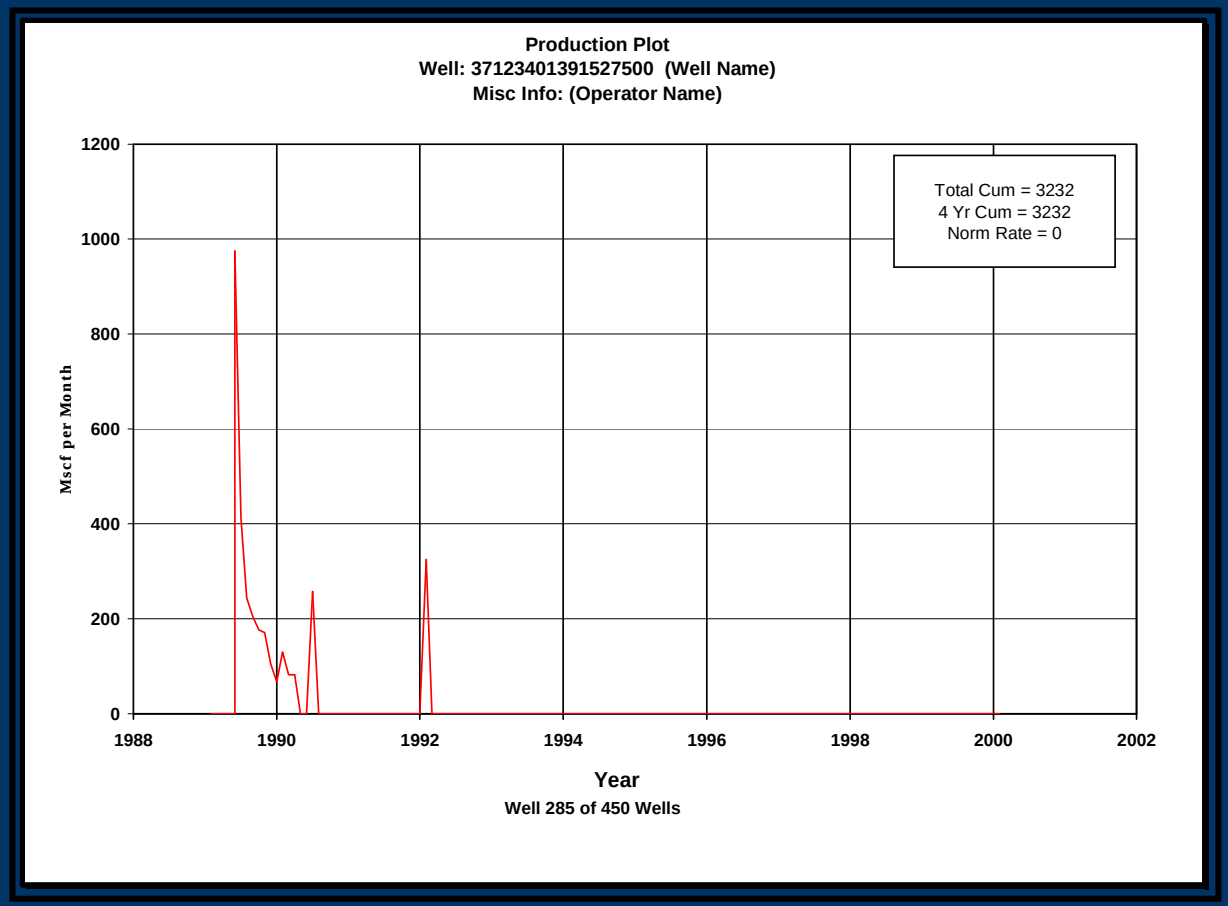


Screen Shot of SWARM Excel Spreadsheet (Step 7)

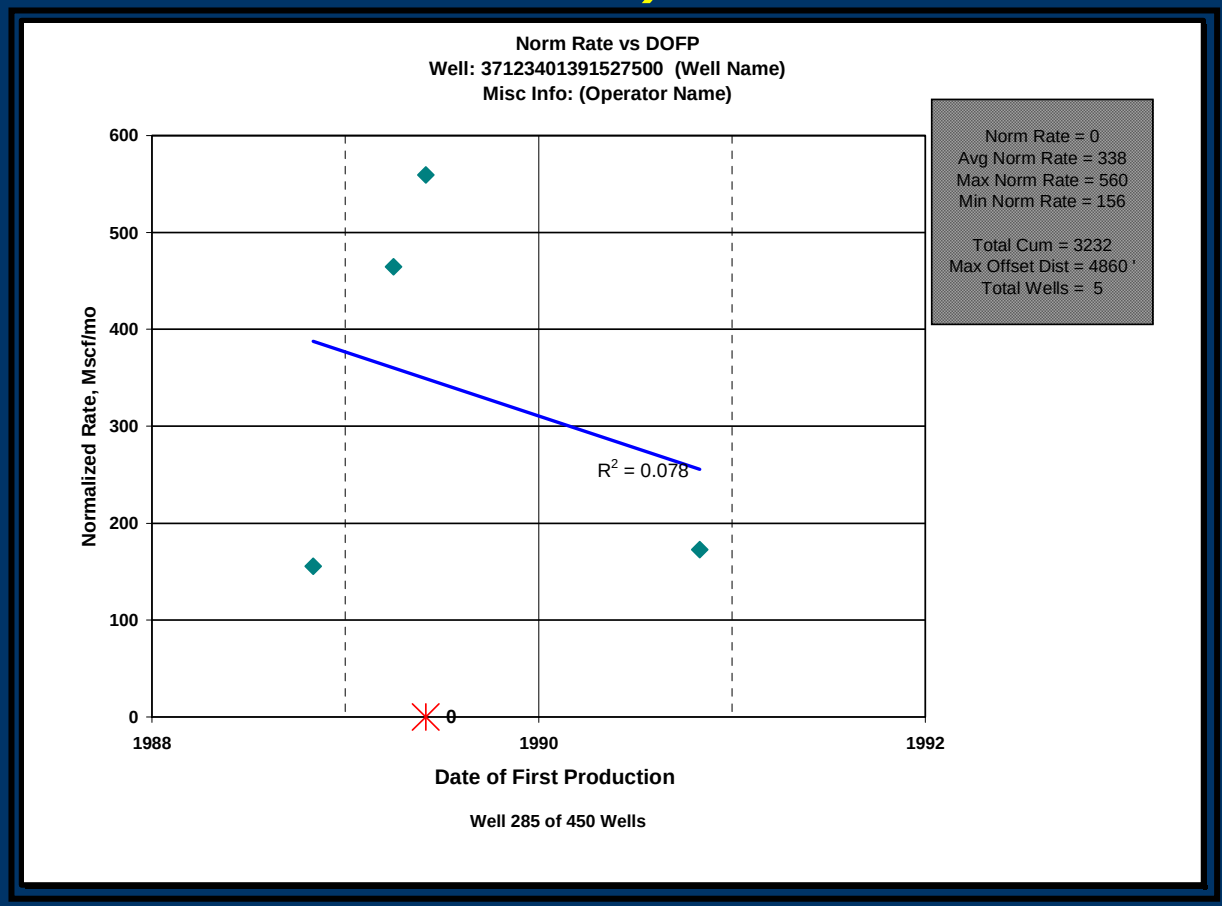


Click Any of These Buttons to View Cum Vs. DOFP, Normalized Rate, Rate-time Plot, or Location Map

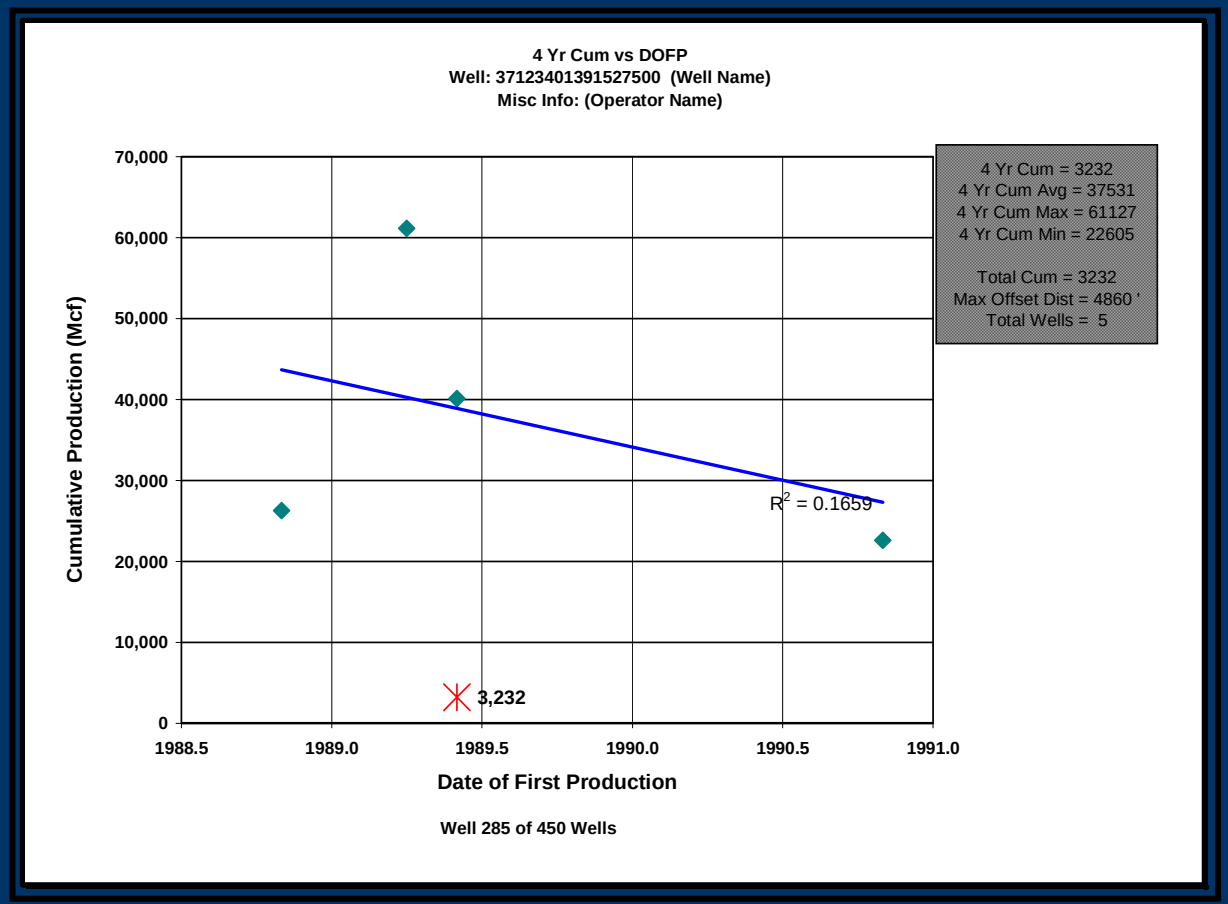
Screen Shot of SWARM Excel Spreadsheet (Rate-Time Plot)



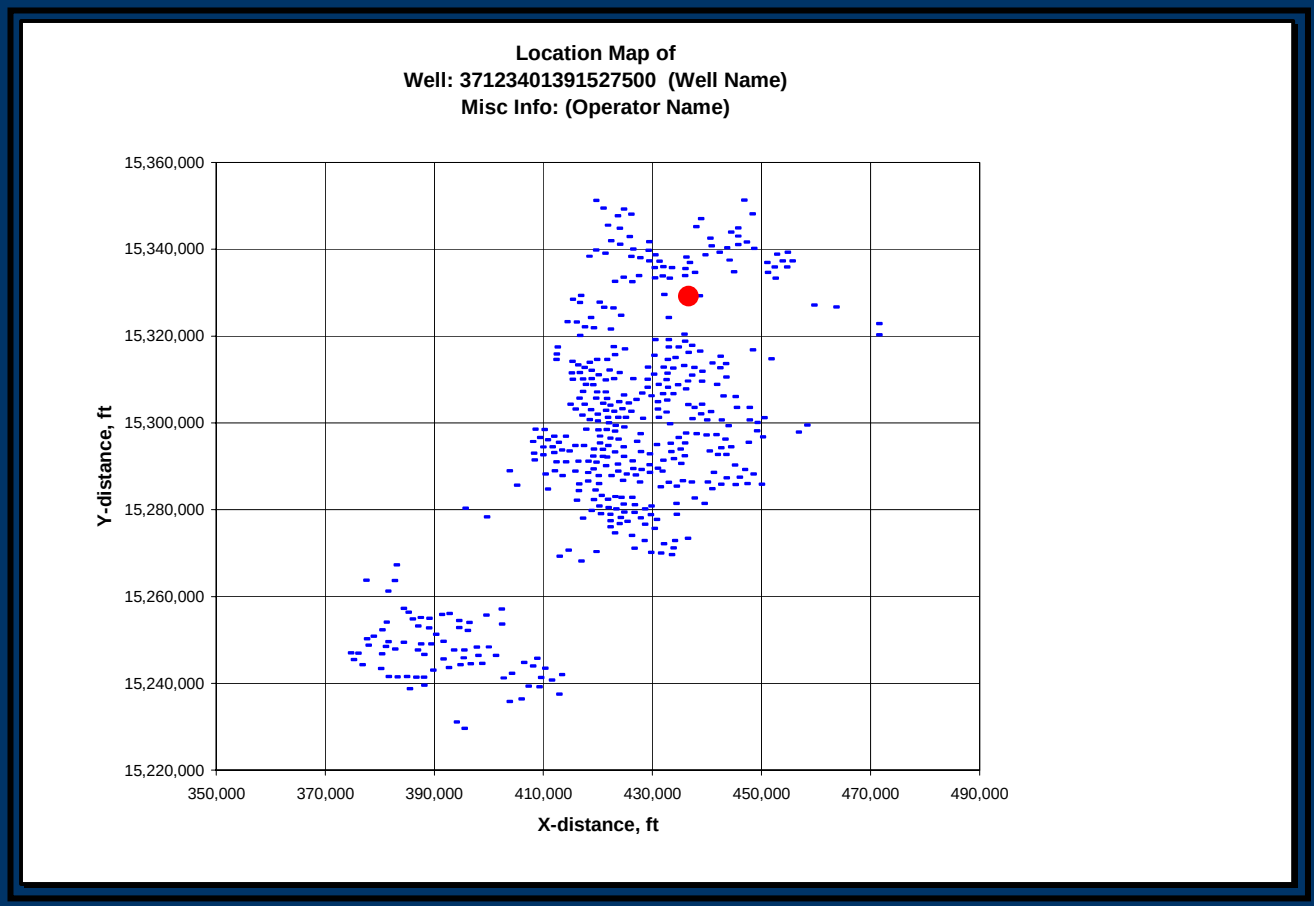
Screen Shot of SWARM Excel Spreadsheet (Normalized Rate Plot)



Screen Shot of SWARM Excel Spreadsheet ("x"-Year Cum vs. DOFP Plot)



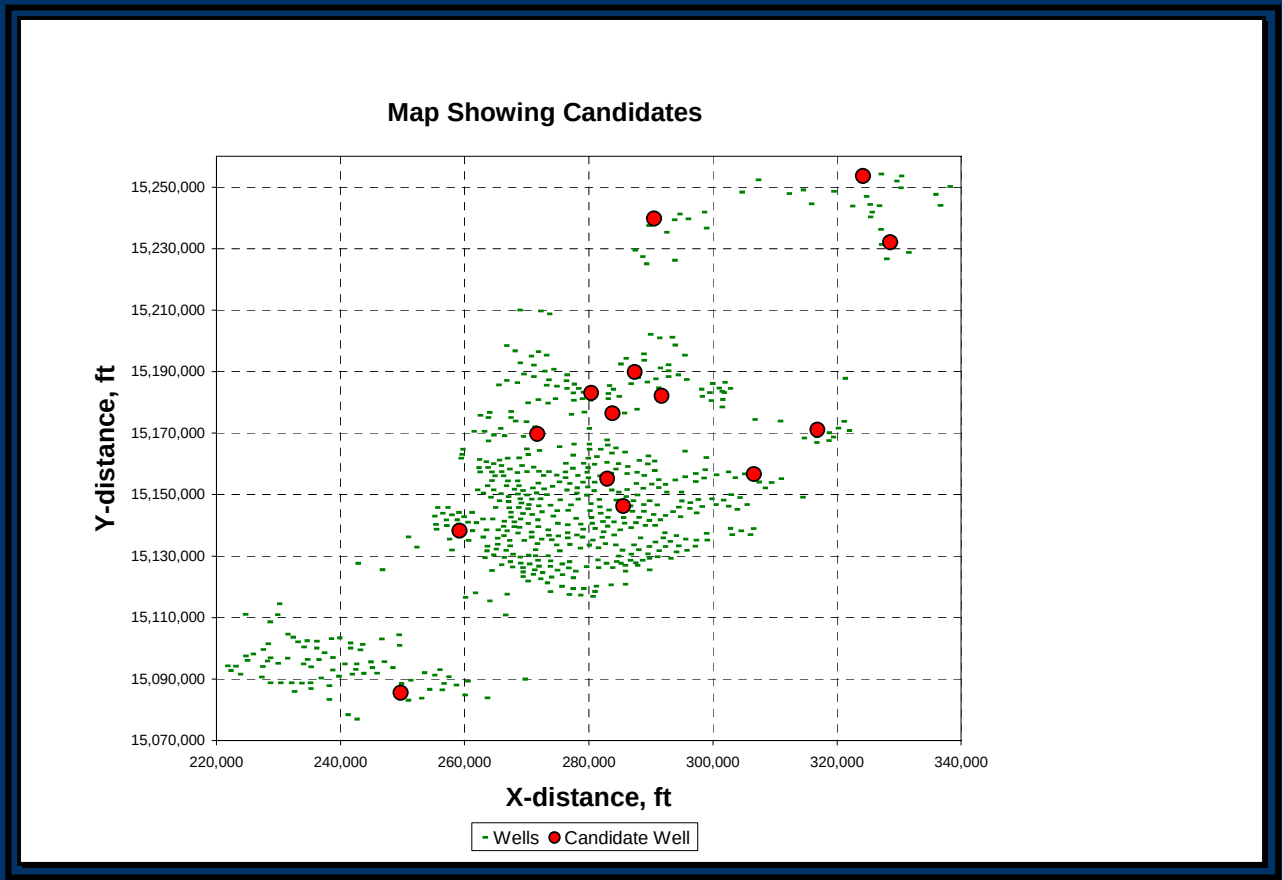
Screen Shot of SWARM Excel Spreadsheet (Location Map)



Recommendations (Continued)

- List of candidates should be high-graded for economic viability based upon recompletion and workover potential

Map of Remediation Candidates



Conclusions

- A PC-based, Stripper Well Remediation Methodology (SWARM) software package capable of quickly and easily identifying underperforming gas stripper-wells has been designed, built, and tested.
- We identified candidates to be reviewed for possible inadequate completions, operational constraints, and/or mechanical problems.

Recommendations

- Rework candidates should be evaluated for geologic, completion, and operational factors that may have led to underperformance.
- Contributing factors should be corrected if possible (e.g. Line pressure, well tending, pipeline constraints etc.).

Recommendations (Continued)

- List of candidates should be high-graded for economic viability based upon recompletion and workover potential

SWARM Program Review

- Easier process for operators to examine their wells
  - Life is much simpler now