

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 (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

(Stripper Well Remediation Methodology)

- 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

SWARM

(Stripper Well Remediation Methodology)

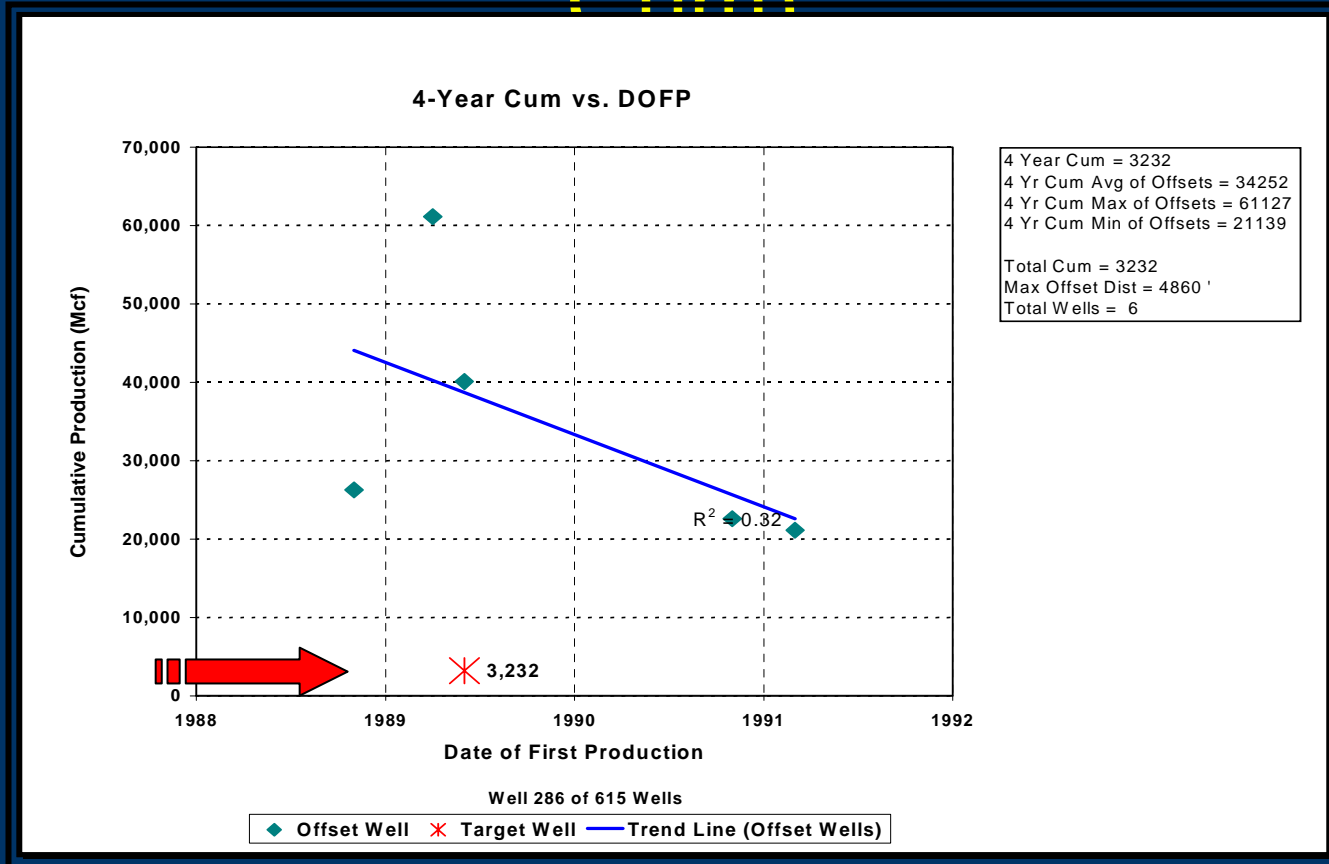
- The Software compares the cumulative production of a target well over a user-specified time span, with all offsets within a fixed distance
- Depletion is taken into account by considering the date of first production (DOFP) versus a desired production-indicator (PI)
 - Lower PI's over time
- Streamlines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

SWARM

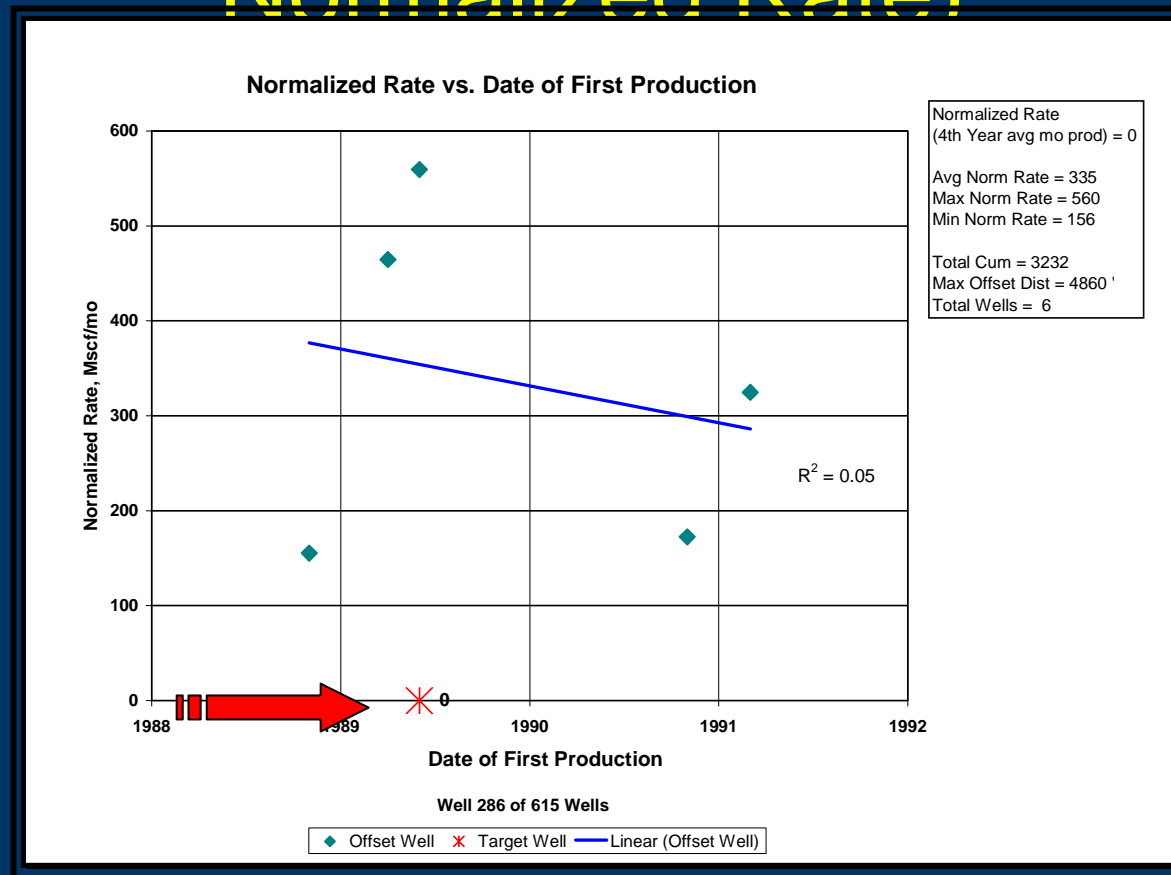
(Stripper Well Remediation Methodology)

- 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

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

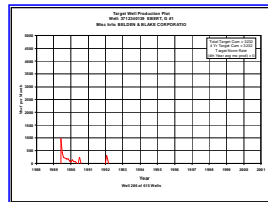


Example of a Target Well Performing Significantly Worse Than Its Offsets (Based Upon Normalized Rate)



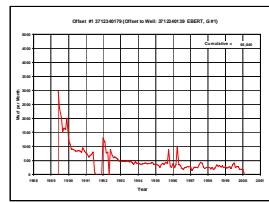
Underperforming Target Well Relative to Offsets

Underperforming Target Well Relative to Offset Wells

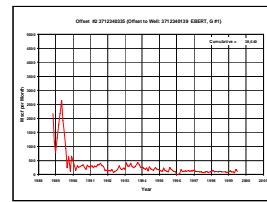


Target Well Cum = 3,232 Mscf

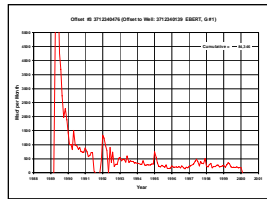
Cum = 66,046 Mscf



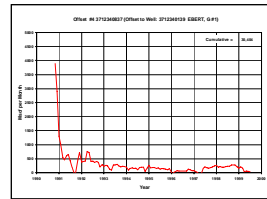
Cum = 38,640 Mscf



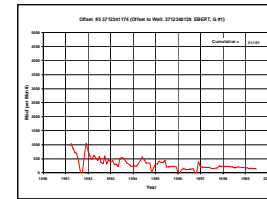
Cum = 84,346 Mscf



Cum = 30,404 Mscf



Cum = 31,101 Mscf



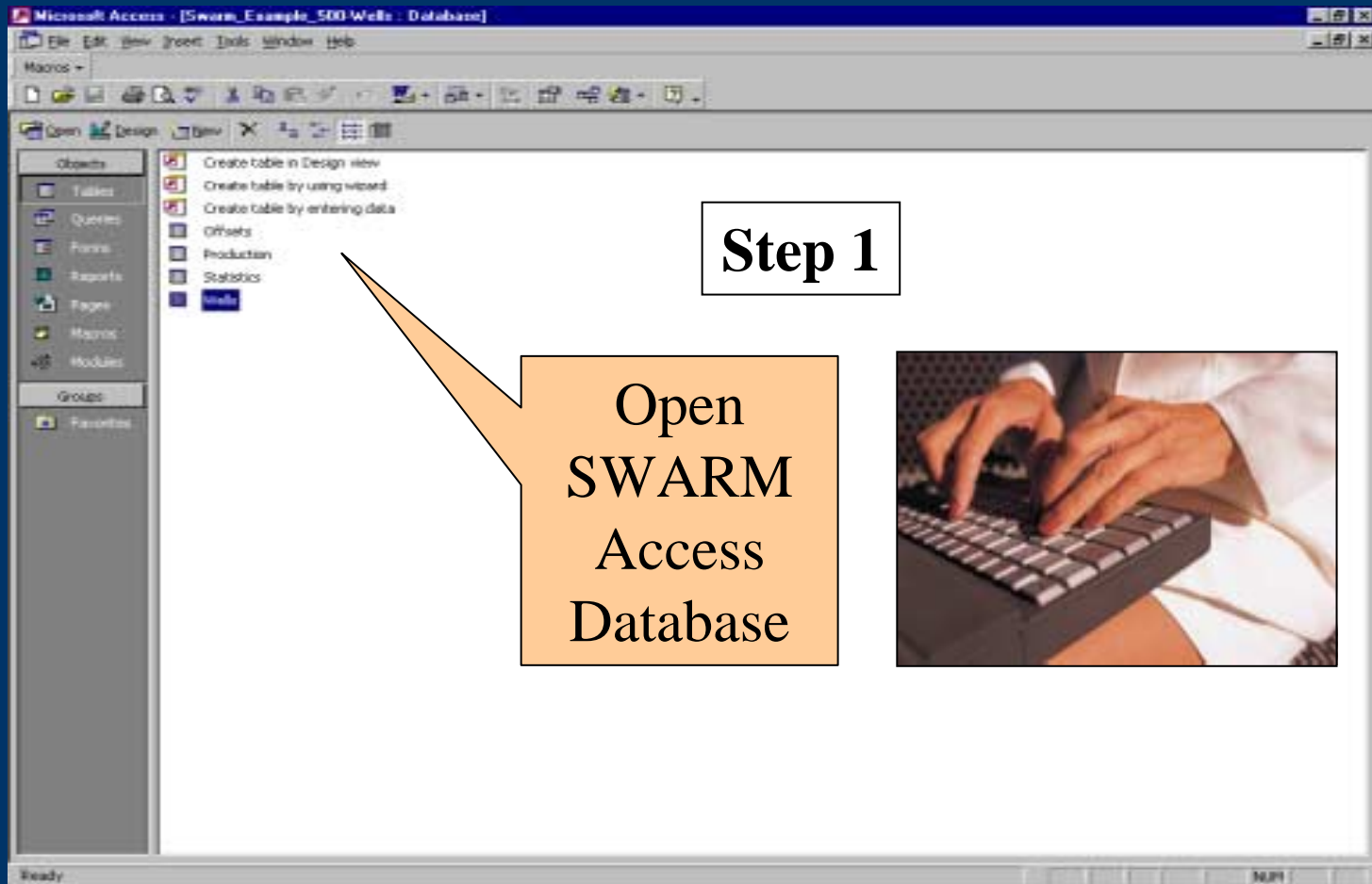
Additional Objectives of This Project

- 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

SWARM Software



Example Screen Shots of SWARM Microsoft™ Access Database



Screen Shot of SWARM Access Database (Step 2)

The screenshot shows the Microsoft Access interface for a database named 'Swarm_Example_500-Wells'. The 'New' menu is open, and the 'Wells' option is selected. A callout box points to 'Wells' with the text 'Populate Well and Production Tables'. A box labeled 'Step 2' is also present.

Microsoft Access - [Swarm_Example_500-Wells : Database]

File Edit View Insert Tools Window Help

Macros

Open Design New

Objects

- Tables
- Queries
- Forms
- Reports
- Pages
- Macros
- Modules

Groups

- Favorites

Create table in Design view

Create table by using wizard

Create table by entering data

Offsets


Production

Statistics

Wells

Step 2

Populate Well and Production Tables



Screen Shot of SWARM Access Database (Step 3)

The screenshot displays the Microsoft Access application window titled "Microsoft Access - [Swarm_Example_500-Wells : Database]". The menu bar includes File, Edit, View, Insert, Tools, Window, and Help. The "Macros" menu is highlighted with a red box, and a red arrow points to the "Macros" button in the ribbon. The ribbon shows the "Design" view, and the "Wells" table is selected in the "Tables" group. A text box labeled "Step 3" is positioned near the "Wells" table. An orange callout box with the text "Click on Macro Button" and a mouse cursor icon points to the "Macros" button in the ribbon.

Microsoft Access - [Swarm_Example_500-Wells : Database]

File Edit View Insert Tools Window Help

Macros

Open Design New

Objects

- Tables
- Queries
- Forms
- Reports
- Pages
- Macros
- Modules

Groups

- Favorites

Create table in Design view

Create table by using wizard

Create table by entering data

Offs...

Produc...

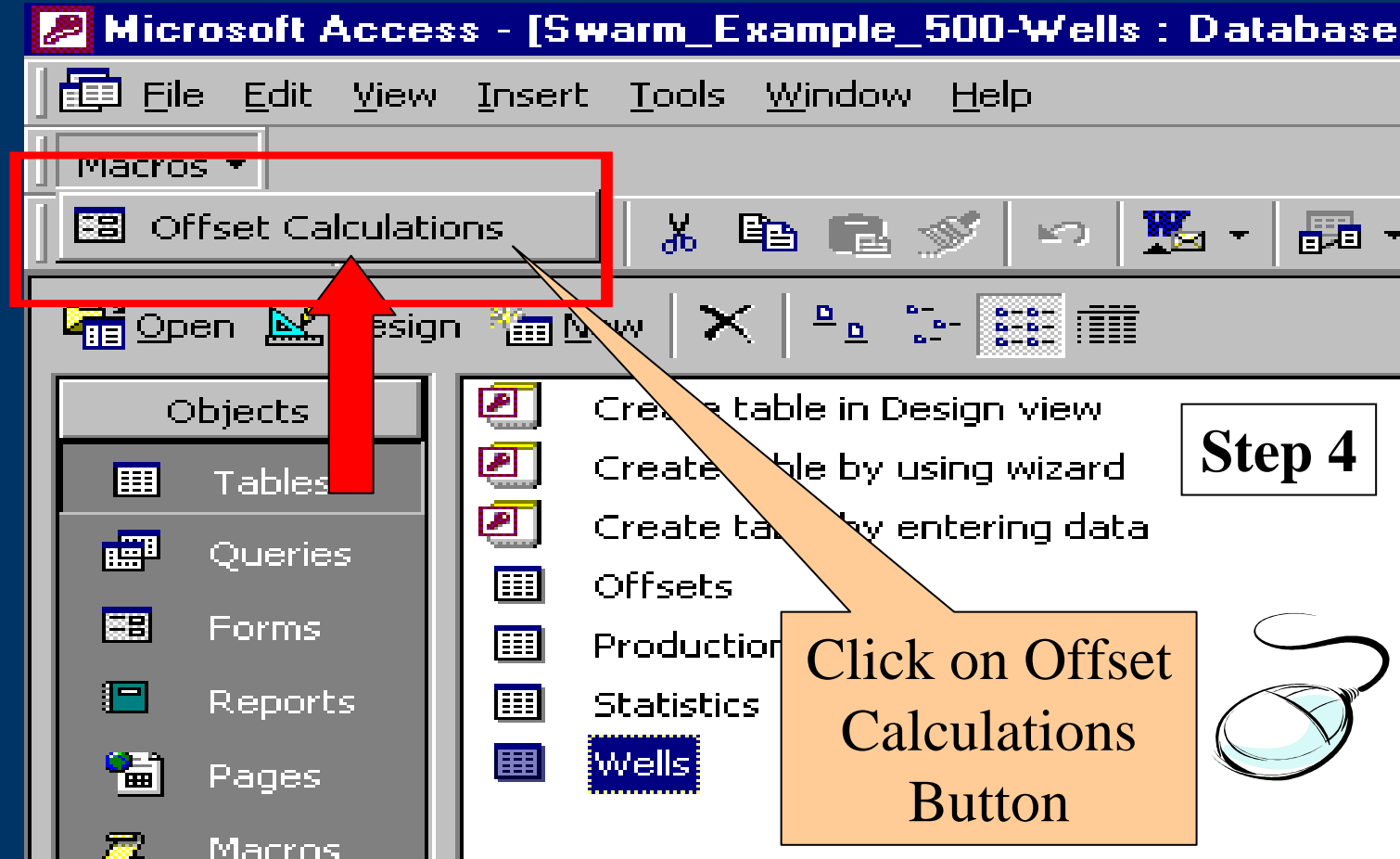
Statistics

Wells

Step 3

Click on Macro Button

Screen Shot of SWARM Access Database (Step 4)



Screen Shot of SWARM Access Database (Step 5)

Microsoft Access - [Offset Calculations]

File Edit View Insert Format Records Tools Window Help

Macros

Step 5

Offset Calculations

Offset Radius (feet): 4000

Cumulative Time Period (yrs): 5

Status

Click Run

Run

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)

Microsoft Excel - Swarm_Example.xls

File Edit View Insert Format Tools Data Window Help

Well Num = 1

Update Well List Next Well First Well View Cum Prod vs DOFP Plot View Prod Rate-Time Plot Batch Print (Based upon Filter)

Update Current Well Previous Well Last Well View Normalized Rate Plot View Well Map

Enter Path to SWARM Database: >>> AFETC Stripper Well Project\BB_GREAT_LAKES\PTTC_Presentation\Swarm_Example_500- Wells.mdb

Choose Filter

FILTER ON (X-Yr Cumulative Gas)

70 <<< Min (%) Below Avg Cum or Norm Rate if Filtering

DOFP Vs. Cum: Print Graph

DOFP Vs. Norm Rate: Print Graph

Production Plot: Print Graph

No.	Well_ID	Well_Name	Misc Info
1	37039212301527500	(Well Name)	(Operator Name)
450	Well_ID	Well_Name	Misc Info
No.			
1	37039212301527500	(Well Name)	(Operator Name)
2	37039213681527500	(Well Name)	(Operator Name)
3	37039214471527500	(Well Name)	(Operator Name)
4	37039223231527500	(Well Name)	(Operator Name)
5	37039223241527500	(Well Name)	(Operator Name)
6	37039223291527500	(Well Name)	(Operator Name)

Enter Path to Access Database Here

Screen Shot of SWARM Excel Spreadsheet (Step 2)

Microsoft Excel - Swarm_Example.xls

File Edit View Insert Format Tools Data Window Help

Arial 10

Well_Num = 1

Update Well List Next Well First Well View Cum Prod vs DOFP Plot View Prod Rate-Time Plot Batch Print (Based upon Filter)

Update Current Well Previous Well Last Well View Normalized Rate Plot View Well Map

Enter Path to SWARM Database: >>> NAFETC Stripper Well Project\BDD_GREAT_LAKES\PTTC_Presentation\Swarm_Example_500-Wellc.mdb

Choose Filter

DOFP Vs. Cum: Print Graph

DOFP Vs. Norm Rate: Print Graph

70 <<< Min (%) Below Filtering

No.	Well ID	Well Name	Misc Info	Input_Cum
1	37039212301527500	(Well Name)	(Operator Name)	4
2	37039213681527500	(Well Name)	(Operator Name)	4
3	37039214471527500	(Well Name)	(Operator Name)	4
4	37039223231527500	(Well Name)	(Operator Name)	4
5	37039223241527500	(Well Name)	(Operator Name)	4
6	37039223291527500	(Well Name)	(Operator Name)	4

Screen Shot of SWARM Excel Spreadsheet (Step 3)

Microsoft Excel - Swarm_Example.xls

File Edit View Insert Format Tools Data Window Help

Arial 10

Well Num = 1

Update Well List Next Well First Well View Cum Prod vs DOFP Plot View Prod Rate-Time Plot Batch Print (Based upon Filter)

Update Current Well Previous Well Last Well View Normalized Rate Plot View Well Map

Enter Path to SWARM Database: >>> NAFETC Stripper Well Project\BB_GREAT_LAKES\PTTC_Presentation\Swarm_Example_500-Wellc.mdb

Choose Filter

FILTER ON (X-Yr Cumulative Gas)

70 Filtering

DOFP Vs. Cum: Print Graph

DOFP Vs. Norm Rate: Print Graph

Production Plot: Print Graph

No.	Well_ID	Misc Info	Input_Cu
1	37039212301527590	(Operator Name)	
450	Well_ID		
No.			
1	370392123		
2	370392136		
3	370392144		
4	370392232		
5	370392232		
6	370392232		

Choose Filter Desired
(e.g. No Filter, "x"-year Cum, or
Normalized Rate)

Screen Shot of SWARM Excel Spreadsheet (Step 4)

The screenshot displays the Microsoft Excel interface for the 'Swarm_Example.xls' file. The menu bar includes File, Edit, View, Insert, Format, Tools, Data, Window, and Help. The toolbar contains various icons for file operations and data manipulation. The spreadsheet area shows a table with columns for Well No., Well ID, Well Name, Misc Info, and Input_Cum. A red arrow points to a text box containing the number '70', which is highlighted by a red box. A callout box points to this text box with the following text: 'If Using a Filter, Enter Desired Percentage that a Target Well must be Below its Offsets for it to be Flagged'. The interface also features several buttons for navigation and data processing, such as 'Update Well List', 'Next Well', 'First Well', 'View Cum Prod vs DOFP Plot', 'View Prod Rate-Time Plot', 'Batch Print (Based upon Filter)', 'Update Current Well', 'Previous Well', 'Last Well', 'View Normalized Rate Plot', and 'View Well Map'. A text box labeled 'Enter Path to SWARM Database: >>>' contains the path 'NAFETC Stripper Well Project\BB_GREAT_LAKES\PTTC_Presentation\Swarm_Example_500-Wellc.mdb'. Below this, there are sections for 'Choose Filter' and 'FILTER ON (X-Yr Cumulative Gas)', along with checkboxes for 'DOFP Vs. Cum:', 'DOFP Vs. Norm Rate:', and 'Production Plot:', each with a 'Print Graph' button.

Well No.	Well ID	Well Name	Misc Info	Input_Cum
1	370392123	(Well Name)	(Operator Name)	
450	Well ID			
1	370392123			
2	370392136			
3	370392144			
4	370392232			
5	370392232			
6	370392232			

Screen Shot of SWARM Excel Spreadsheet (Step 5)

2) Then Click on "Batch Print" Button

Batch Print (Based upon Filter)

Choose Filter

DOFP Vs. Cum: Print Graph

DOFP Vs. Norm Rate: Print Graph

Production Plot: Print Graph

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

No.	Well_ID	Well_Name	Misc Info	Input_Cu
1	37039212301527590	(Well Name)	(Operator #)	
450	Well_ID			
No.				
1	370392123			
2	370392136			
3	370392144			
4	370392232			
5	370392232			
6	370392232			

Screen Shot of SWARM Excel Spreadsheet (Step 6)

Microsoft Excel - Swarm_Example.xls

File Edit View Insert Format Tools Data Window Help

Arial 10

Well_Num = 1

Update Well List **Next Well** First Well View Cum Prod vs DOFP Plot View Prod Rate-Time Plot Batch Print (Based upon Filter)

Update Current Well Previous Well Last Well View Normalized Rate Plot View Well Map

Enter Path to SWARM Database: >>> N:\Projects\Swarm\Project001\GREAT_LAKES\PTTC_Presentation\Swarm_Example_500-Wellc.mdb

Choose Filter

DOFP Vs. Cum: Print Graph

DOFP Vs. Norm Rate: Print Graph

Production Plot: Print Graph

70 <<< Min (%) Below Avg Cum or Norm Rate if Filtering

No.	Well_ID	Well_Name	Misc Info	Input_Cu
1	37039212301527500	(Well Name)	(Operator Name)	
450	Well_ID	Well_Name		Input_Cu
No.	Well_ID	Well_Name		Input_Cu
1	37039212301527500	(Well Name)		
2	37039213681527500	(Well Name)		
3	37039214471527500	(Well Name)		
4	37039223231527500	(Well Name)		
5	37039223241527500	(Well Name)		
6	37039223291527500	(Well Name)		

Click "Next Well" to View Next Qualifying Target Well

Screen Shot of SWARM Excel Spreadsheet (Step 7)

Microsoft Excel - Swarm_Example.xls

File Edit View Insert Format Tools Data Window Help

Arial 10

Well Num = 1

Update Well List Next Well First Well View Cum Prod vs DOFP Plot View Prod Rate-Time Plot Batch Print (Based upon Filter)

Update Current Well Previous Well Last Well View Normalized Rate Plot View Well Map

Enter Path to SWARM Database: >>> NAFETC Stripper Well Project\BB_GREAT_LAKES\NPTTC_Presentation\Swarm_Example_500-Wellc.mdb

Choose Filter

DOFP Cum: Print Graph

Filter ON (X-Yr Cumulative Gas)

DOFP Norm Rate: Print Graph

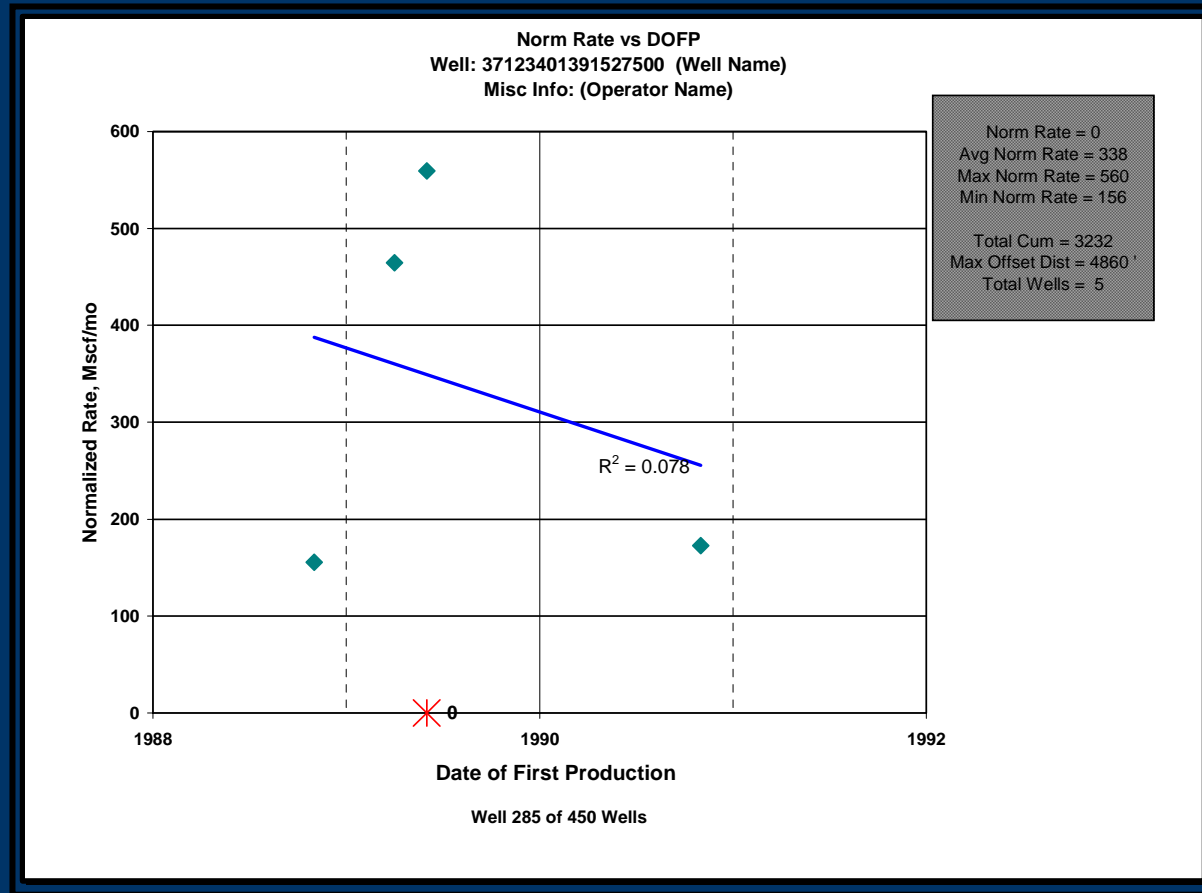
70 <<< Min (%) Below Avg Cum or Norm Rate if Filtering

on Plot: Print Graph

No.	Well_ID	Well_Name	Misc Info	Input_Cur
1	37039212301527500	(Well Name)	operator Name)	
450				
No.	Well_ID	Well_Name	Misc Info	Input_Cur
1	37039212301527500	(Well Name)		
2	37039213681527500	(Well Name)		
3	37039214471527500	(Well Name)		
4	37039223231527500	(Well Name)		
5	37039223241527500	(Well Name)		
6	37039223291527500	(Well Name)		

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

Screen Shot of SWARM Excel Spreadsheet (Normalized Rate Plot)



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.).

