Decline Curve Analysis for Estimating EUR's (and OOIP's)

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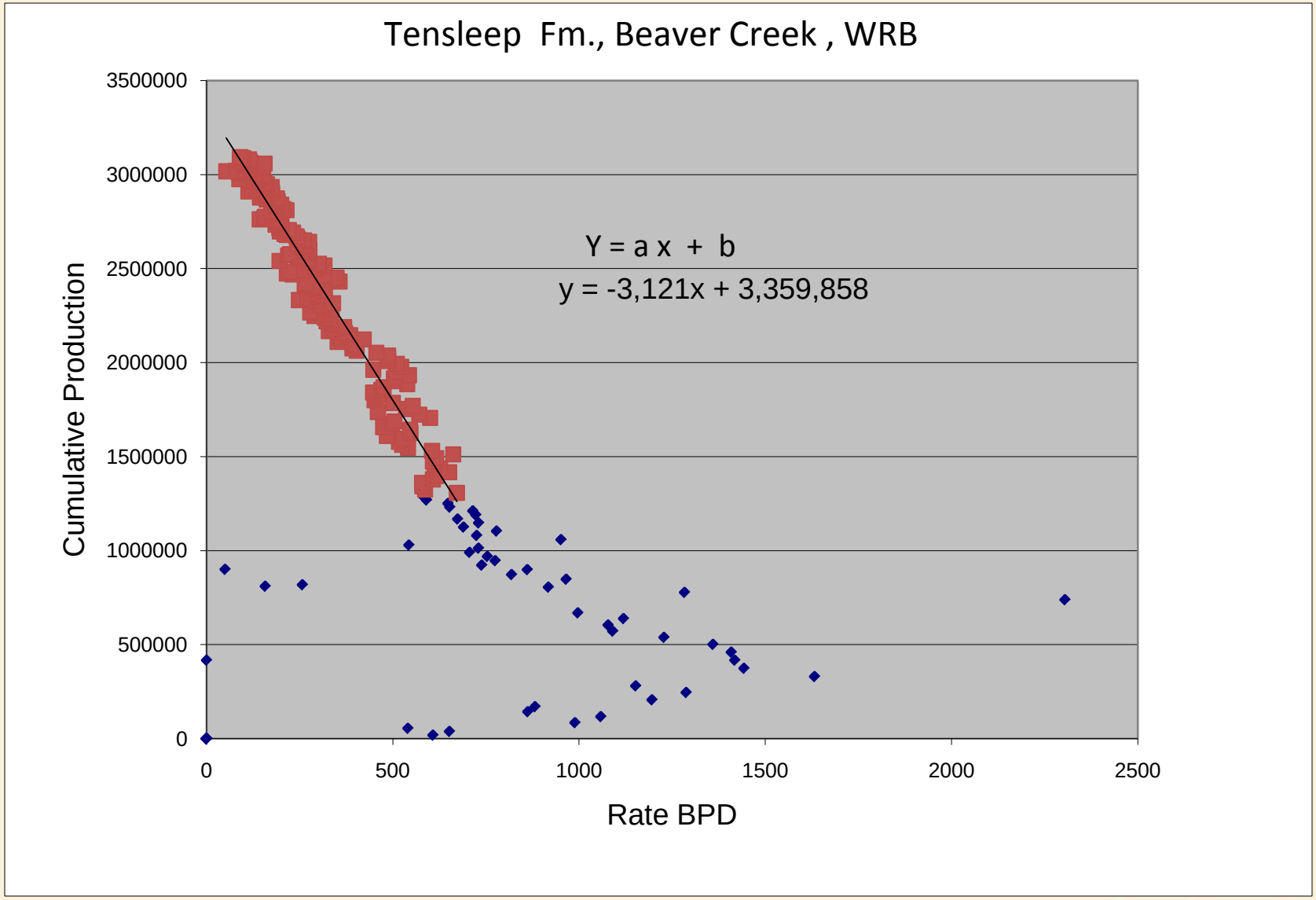
Decline Curve Analysis

- Three basic decline curve equations

- All of the equations give you the ability to predict cumulative production or production rate at some point in time.

We are not concerned with time

- To estimate OOIP we need to know the **E**stimated **U**ltimate **R**ecovery (EUR) and the Recovery Factor
  - We can get **EUR** directly from a graph
  - We use a standardized average **recovery factor** of 35% for all reservoirs undergoing secondary recovery. (Not applied to Tertiary Recovery)

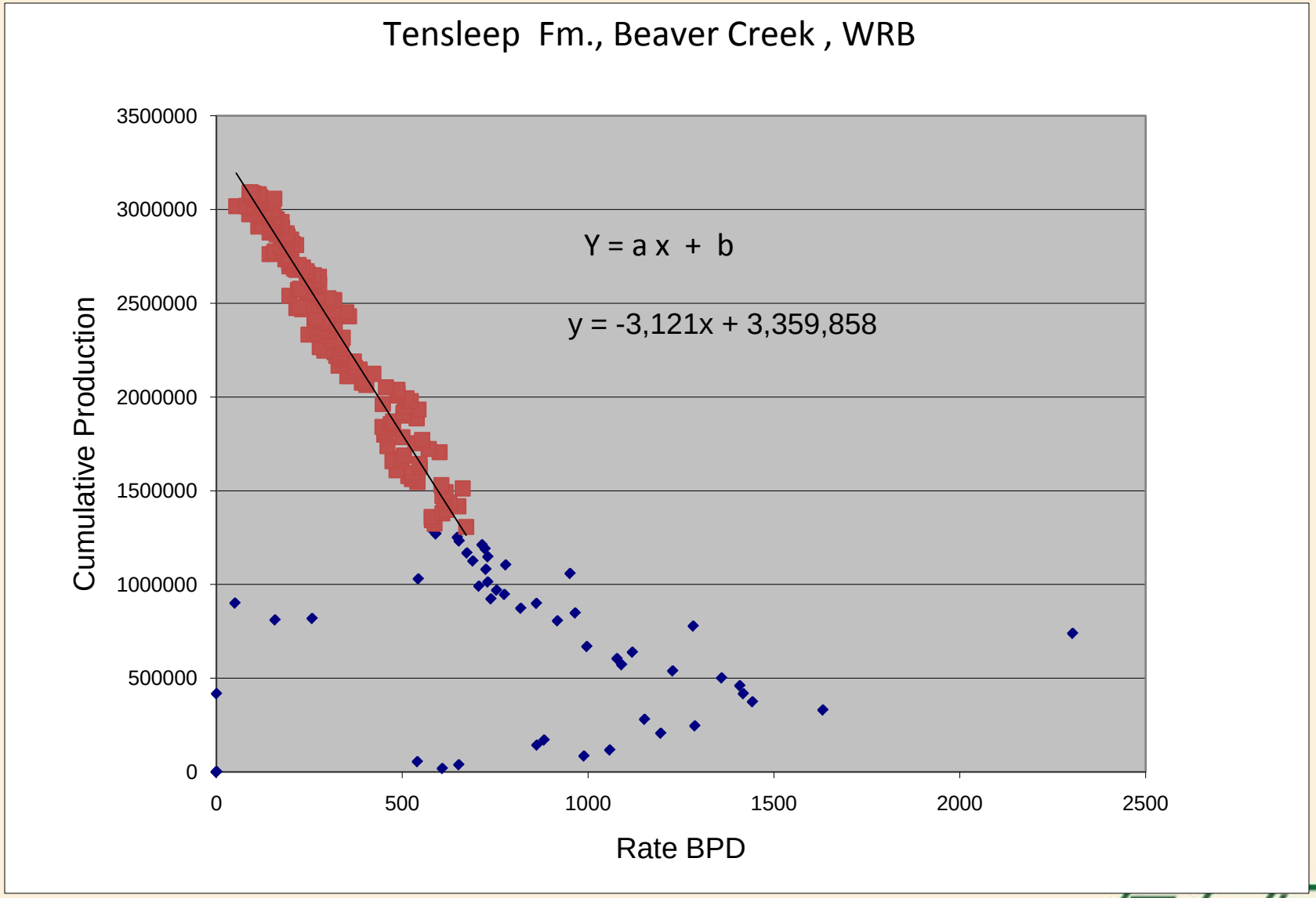

Tensleep Fm., Beaver Creek , WRB
Y = a x + b
y = -3,121x + 3,359,858
Cumulative Production
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
0
500
1000
1500
2000
2500
Rate BPD

VOILA

- $Y = a x + b$
- $b = EUR$
- EUR / recovery factor = OOIP

Complications

- **Lack WOGCC reservoir production data prior to 1978**
- Engineering changes after a pseudo-steady state decline
- Secondary vs. Tertiary recovery
- Poor (or nonexistent) decline
- Terminology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Two basic solutions

- Find individual reservoir production from sources other than WOGCC

- Estimate the pre 1978 production based on available WOGCC data.

Other comprehensive sources of information

- WGA Symposiums - They usually published reservoir cums for the year in which the symposium was published

- IHS - Although the production data is reported by well - by recombining the data it gives both the total reservoir production and the **reservoir production prior to 1978**

Poor match with field cums

(Basin)	Field	WOGCC Total Field Cum	IHS Total Field Cum
GGRB	BIRCH CREEK	90,423,491	11,516,555
GGRB	ARCH (PATRICK DRAW)	19,057,196	2,447,684
GGRB	GREEN RIVER BEND	13,739,093	6,227,030
PRB	FIDDLER CREEK EAST	11,327,391	612,322
GGRB	HOGSBACK	8,911,019	1,548,950
GGRB	PATRICK DRAW	9,548,258	58,344,237
PRB	CLARETON	6,409,638	27,160,863
PRB	FIDDLER CREEK	5,861,157	26,807,558
PRB	LITTLE BUCK CREEK	120,372	9,425,596
PRB	SEMLEK SOUTHWEST	412,727	4,184,979

Poor match with reservoirs

Field	Formation	WOGCC **Reservoir** 1978-2009	IHS **Reservoir** 1978-2009
FOURBEAR	DARWIN-MADISON	1,207,599	425,237
FOURBEAR	DINWOODY	1,257,573	337,115
FOURBEAR	DINWOODY-PHOSPHORIA-TENSLEEP	15,635	24,322
FOURBEAR	DINWOODY-PHOSPHORIA	47	
FOURBEAR	DINWOODY-PHOSPHORIA-TENSLEEP-DARWIN-MADISON	3,160,816	3,023,756
FOURBEAR	MADISON	6,065	
FOURBEAR	PHOSPHORIA	276,290	410,854
FOURBEAR	TENSLEEP	349,972	1,897,764
FOURBEAR	TENSLEEP-DARWIN-MADISON	0	183,800

When sources don't match

- When 2 of the 3 agree I generally use one of the two agreeing sources

- When there is no agreement - I use WOGCC -- it is the publically available data source

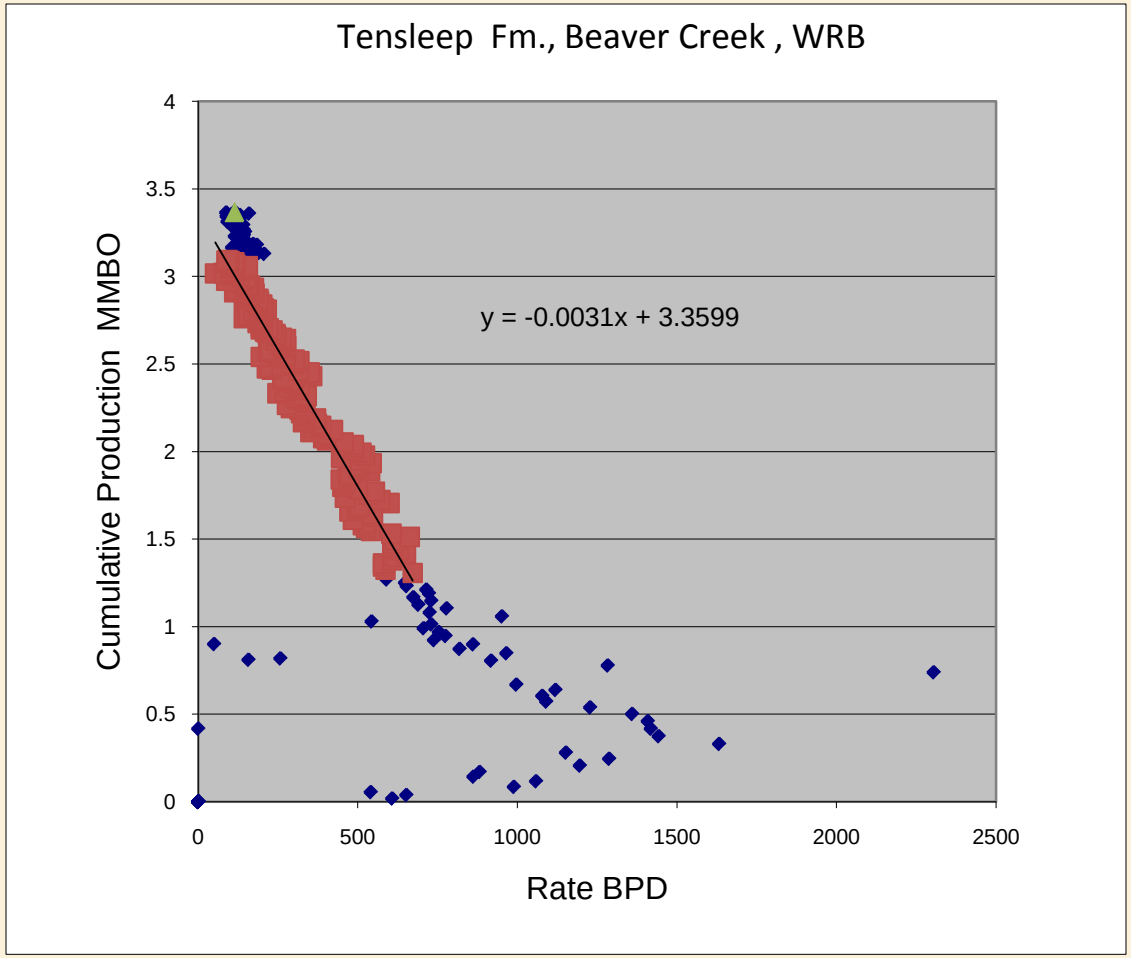
  To do this:

  – Assume relative amounts of production amongst reservoirs has remained constant.
  – Back calculate reservoir cums using proportional amounts of pre 1978 field cum.

Complications

- Lack of pre 1978 WOGCC reservoir data
- **Engineering changes after a "steady state" decline**
- Secondary vs. Tertiary recovery
- Poor (or nonexistent) decline
- Terminology

Late change in decline after long "steady state"



ULTIMATE RECOVERY	USING SLOPE
slope =	-0.0031
x (last rate) =	112.8
y (last cum MMBO) =	3.367973
	y=ax+b
	y-(slope*x) = b
(MMBO)	3.717743
Ultimate by slope	**3,717,743**

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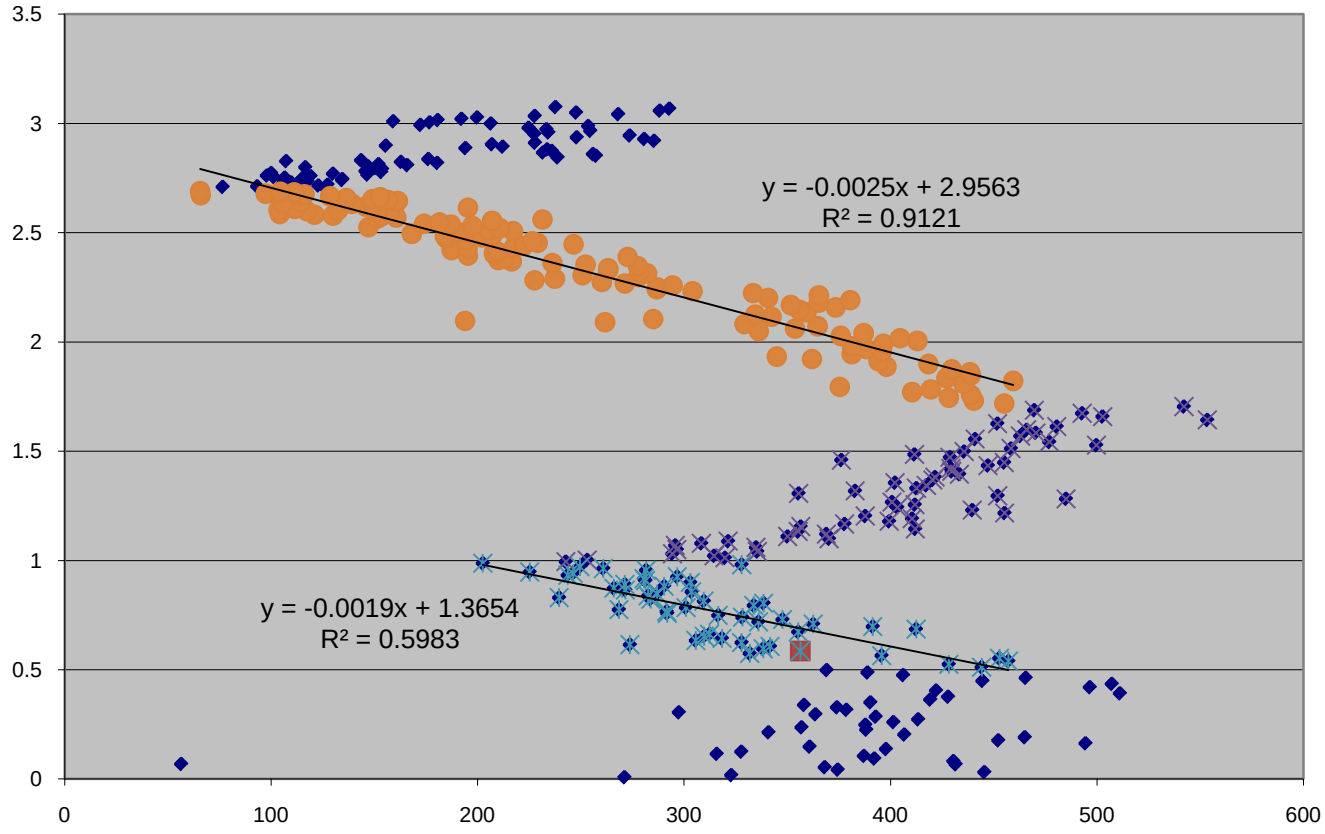
Secondary vs. Tertiary Recovery



Tertiary recovery
EUR = 3,666,852 BO
(Trend tacked on to last data point)

Secondary recovery
EUR = 1,365,400 BO

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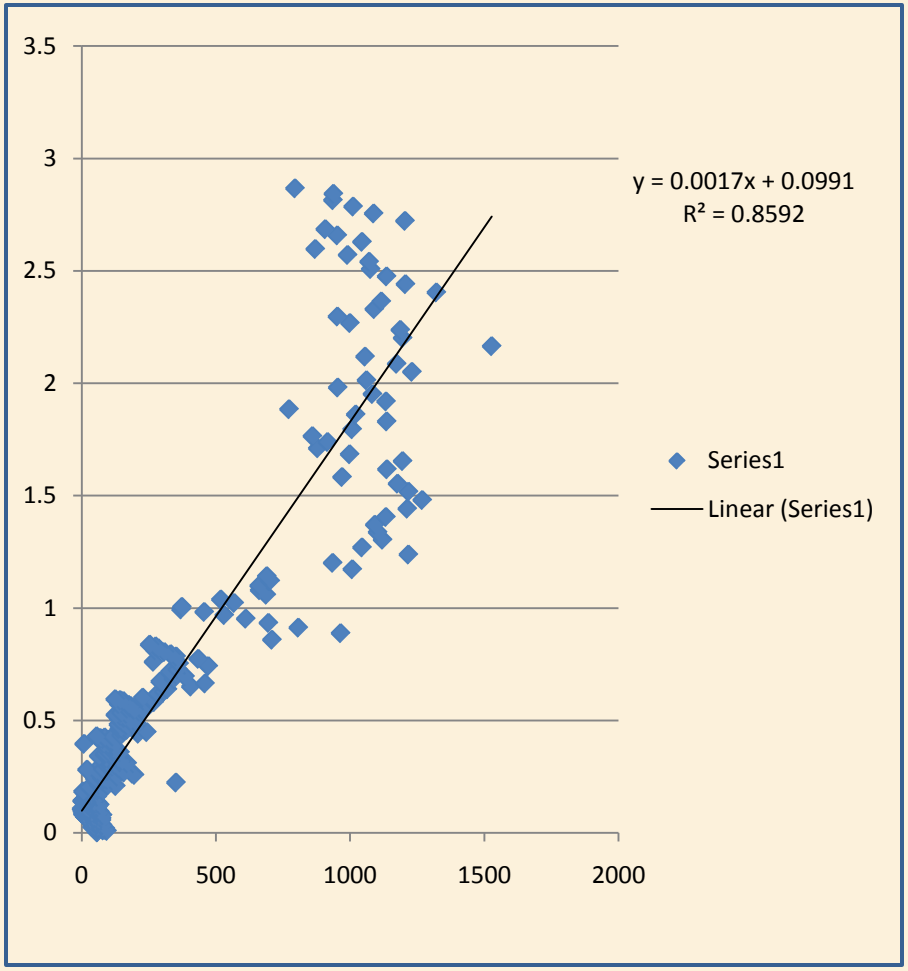
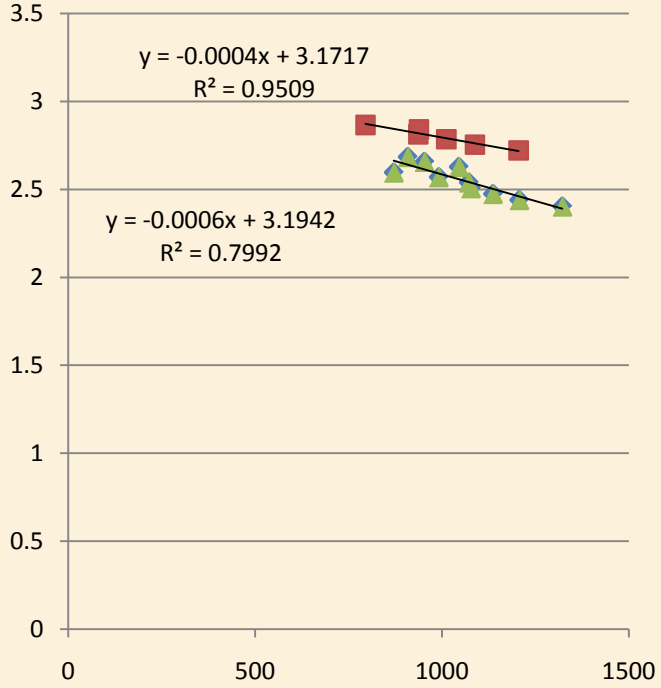
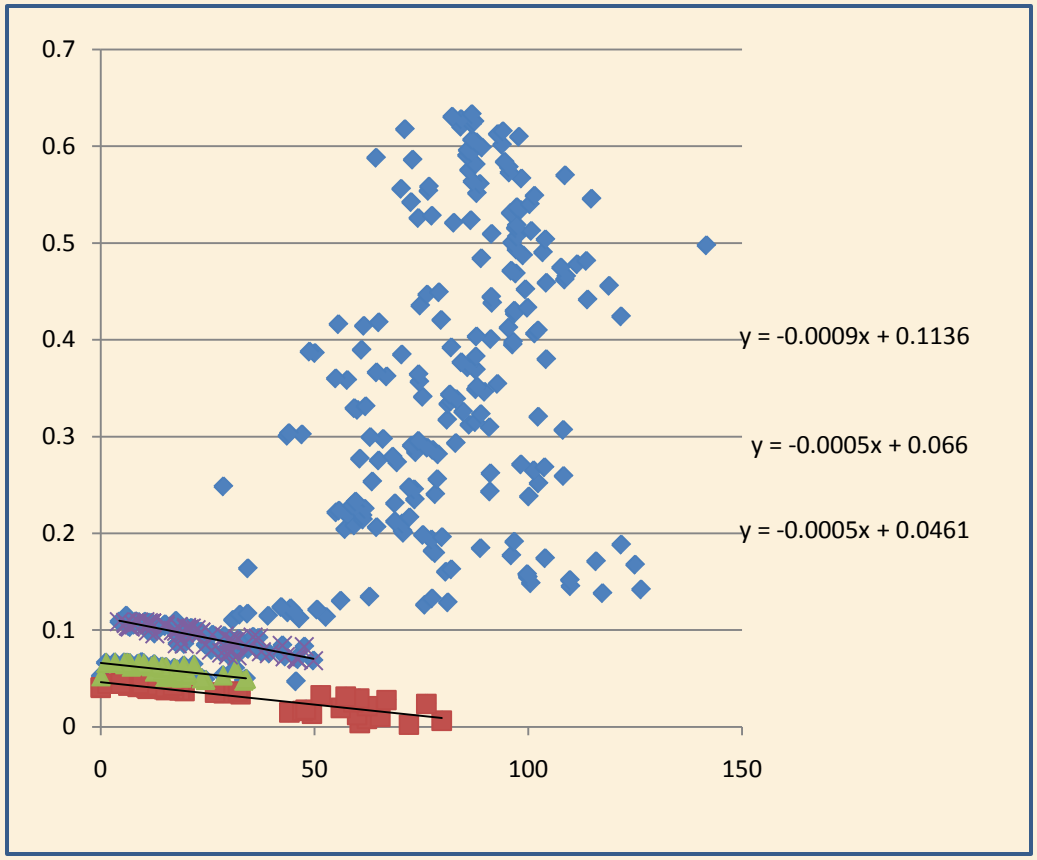
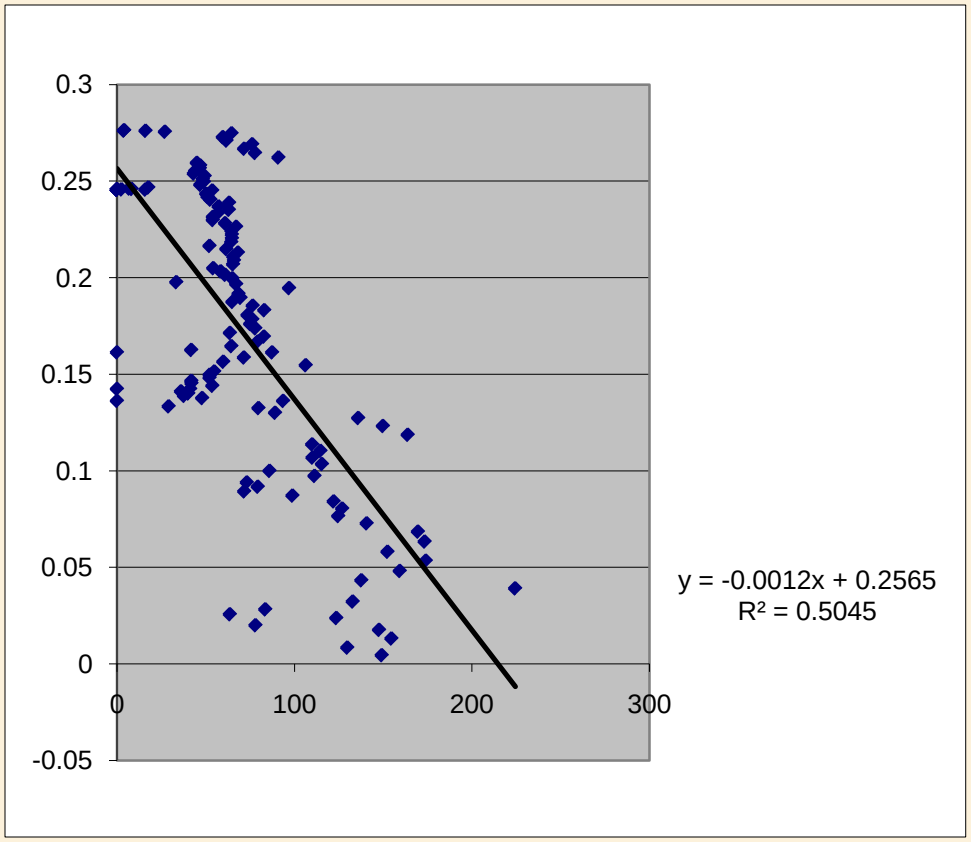




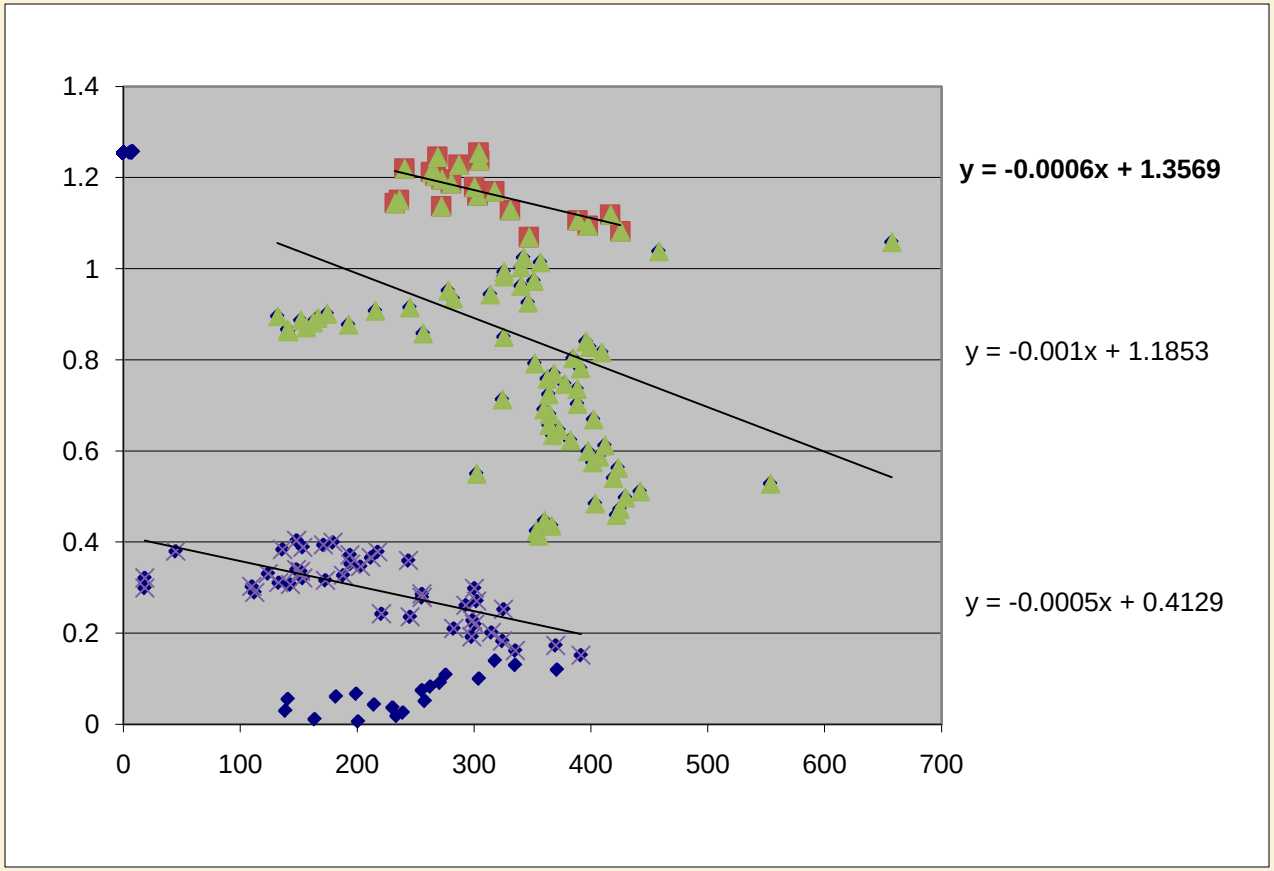
ULTIMATE RECOVERY USING SLOPE		
	slope =	-0.0005
x (rate) =		1090.649123
y (cum MMBLS) =		2.721578
	y=ax+b	
	y-(slope*x) = b	
		3.266903
Ultimate by slope		**3,266,903**



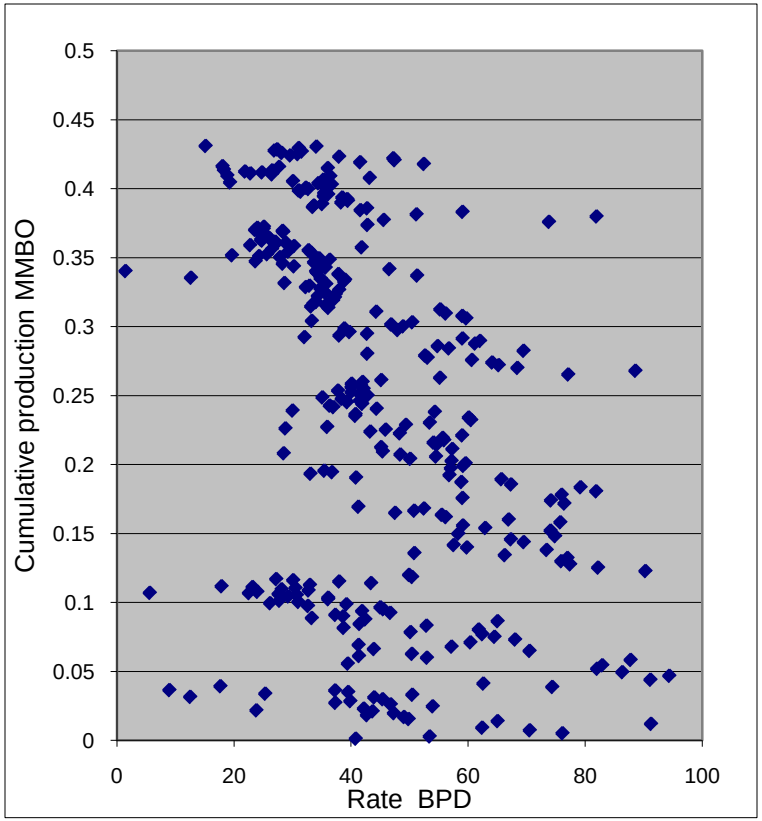
ULTIMATE RECOVERY USING SLOPE	
slope =	-0.0006
x (rate) =	85
y (cum MMBLS) =	0.620213
	y=ax+b
	y-(slope*x) = b
	0.662713
Ultimate by slope	**662,713**



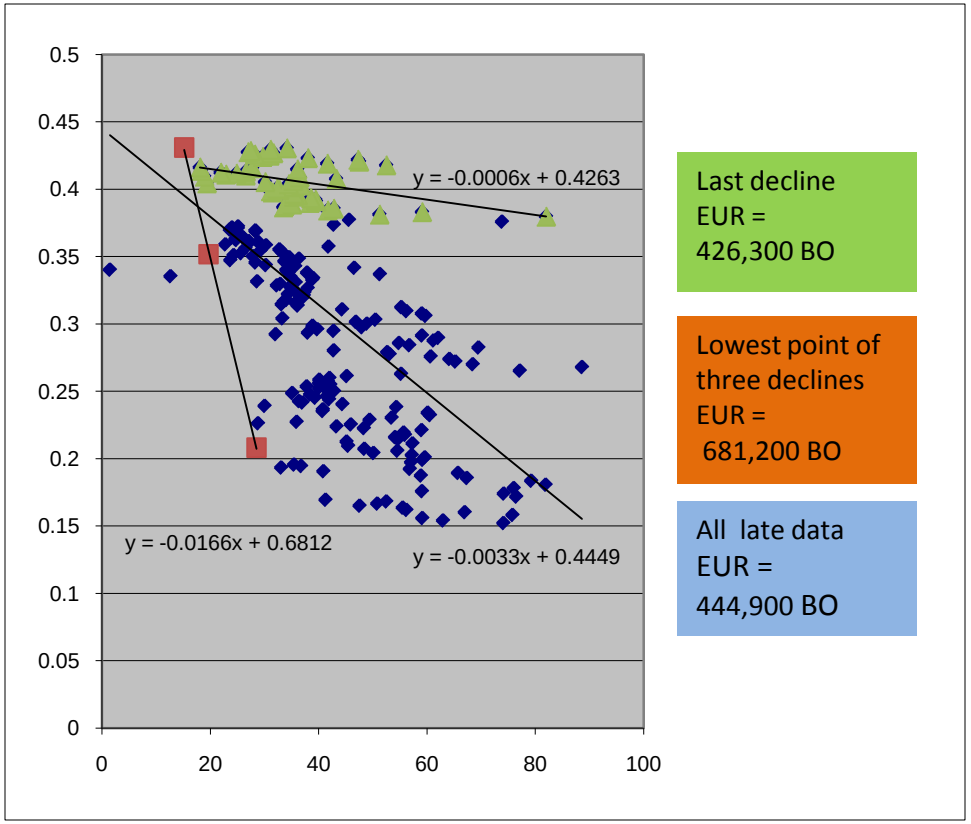
ULTIMATE RECOVERY USING SLOPE		
	slope =	-0.0012
x (rate) =		45
y (cum MMBLS) =		0.276290
	y=ax+b	
	y-(slope*x) = b	
		0.330290
Ultimate by slope		330,290


1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
500
600
700
y = -0.0006x + 1.3569
y = -0.001x + 1.1853
y = -0.0005x + 0.4129

All data (1978 to 2009)



Possible declines



Complications

- Lack of pre 1978 WOGCC reservoir data
- Engineering changes after a pseudo-steady state decline
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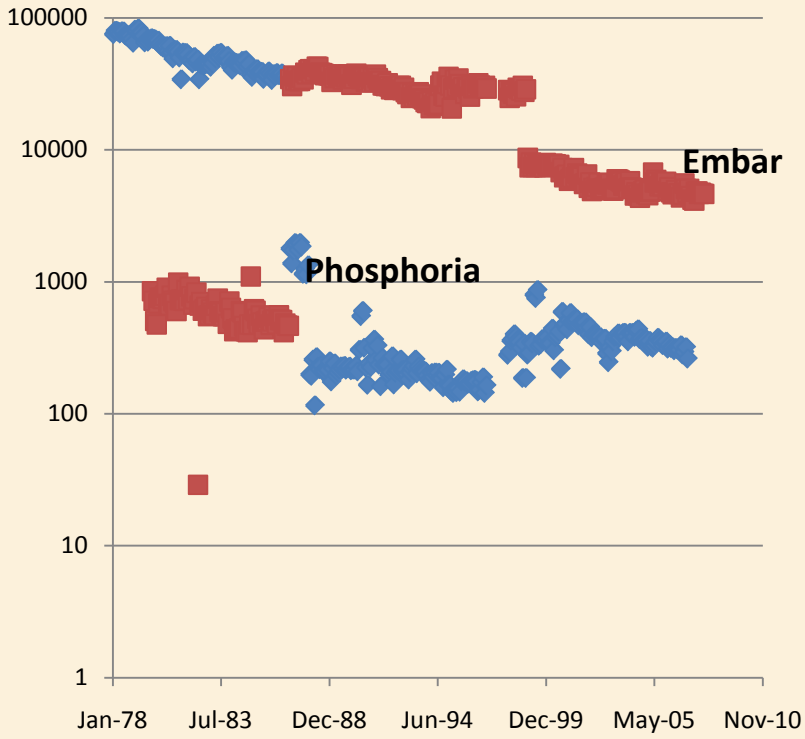
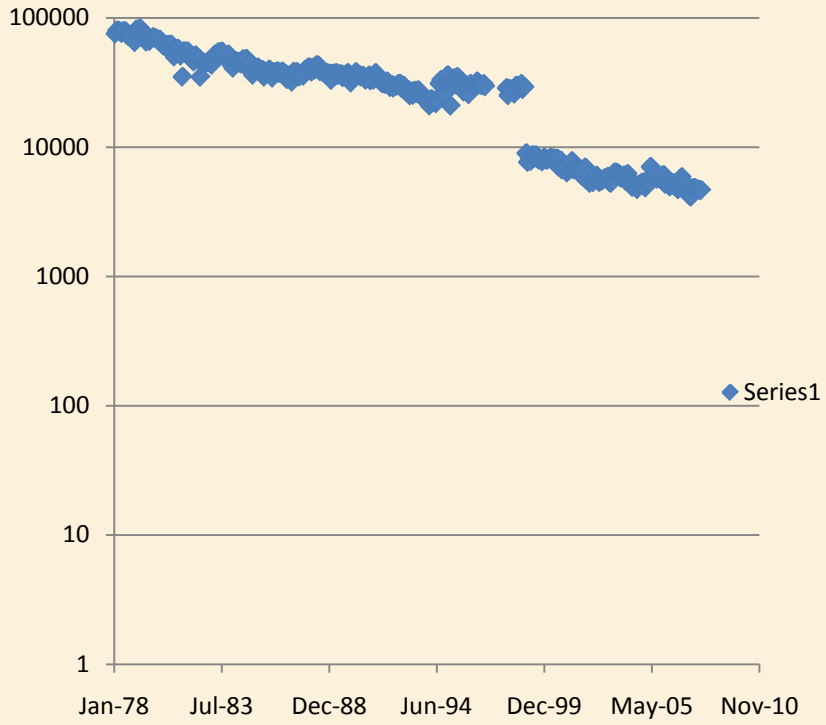
- Poor (or nonexistent) decline
- **Changes in Terminology**

Terminology
(production vs. time)

Reservoirs reported individually



Combined reservoir data



Summary

- Graph the available WOGCC data
- Choose a section of the graph that seems to represent a natural “pseudo-steady state” decline.
- Derive the partial EUR from the graph.
- Determine the amount of prior production and add that to the partial EUR for the actual Estimated Ultimate Recovery.
- Calculate OOIP using 35% recovery factor
- If the reservoir has undergone Tertiary Recovery – then also determine the Tertiary EUR