

Continuation of the discussion from last class: Probabilistic estimation of reserves

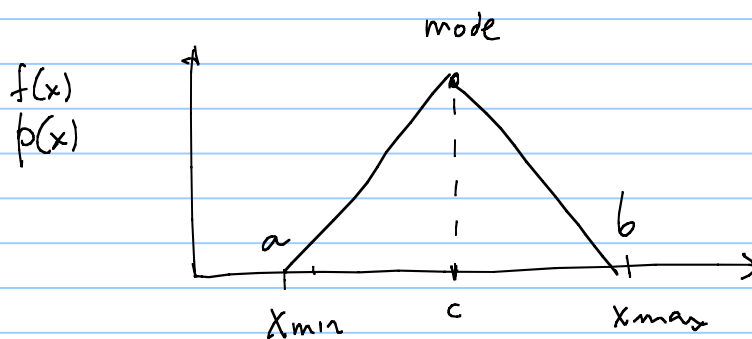
max ↑ P90 the quantity for which there is a 90% probability that the quantities actually recovered will equal or exceed the estimate.

median ↓ P50 the quantity for which there is a 50% probability that the quantities actually recovered will equal or exceed the estimate.

min ↓ P10 the quantity for which there is a 10% probability that the quantities actually recovered will equal or exceed the estimate.

typically triangular or uniform probability distributions are used during early stages of the planning phase.

triangle distribution



$$0 \leq u \leq 1$$

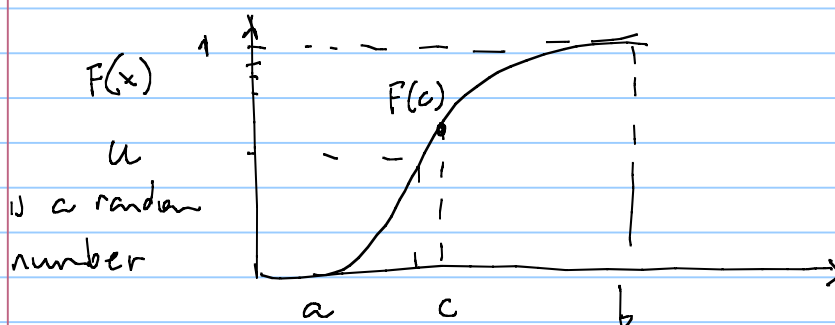
function (u, a, b, c)

for $0 < u < F(c)$

$$x = a + \sqrt{u(b-a)(c-a)}$$

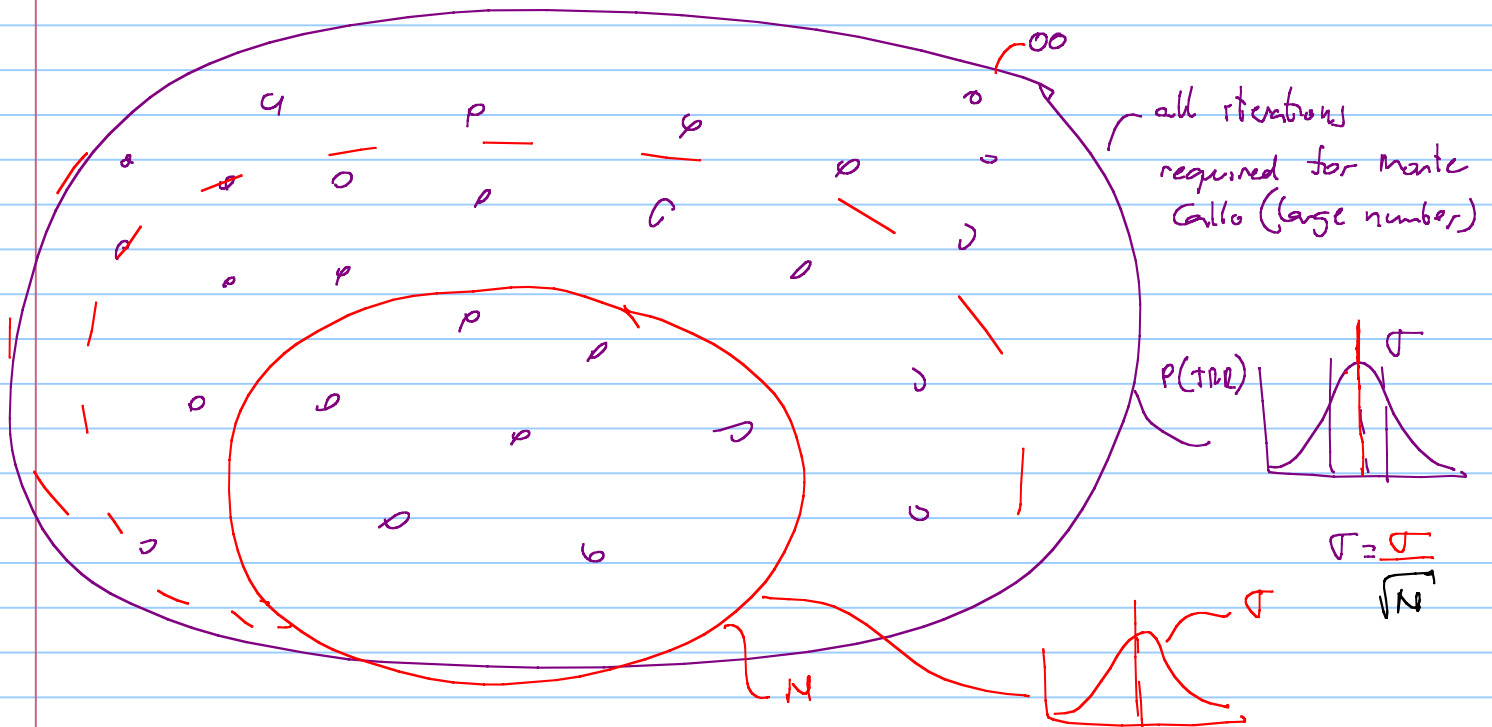
for $1 > u > F(c)$

$$x = b - \sqrt{(1-u)(b-a)(b-c)}$$



$$F(c) = \frac{(c-a)}{(b-a)}$$

How many iterations are required in Monte-Carlo?



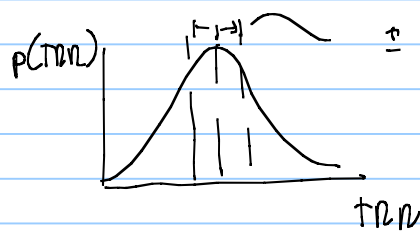
Estimating confidence interval. Estimating number of samples
number of iterations

$$N = \left(\frac{\sigma}{E} \right)^2$$

confidence level associated with
the error range

95%, 98%, 99%

E is the desired error of
the most probable value



function in excel

$$Z = \text{NORM.S.INV}(\text{confidence range in fraction})$$

0.95
0.98
0.998

σ standard deviation of
the population.

so it is necessary to assume
an initial number of iterations
and calculate N .

$$Z = 3$$

$$N = \left(\frac{3 \sigma}{E} \right)^2 \quad \% \text{ of the average.}$$

2% Average $\pm$ 2% (average)

Some engineers don't estimate beforehand the required number of iterations, just run increasing the number of iterations until the results don't change much

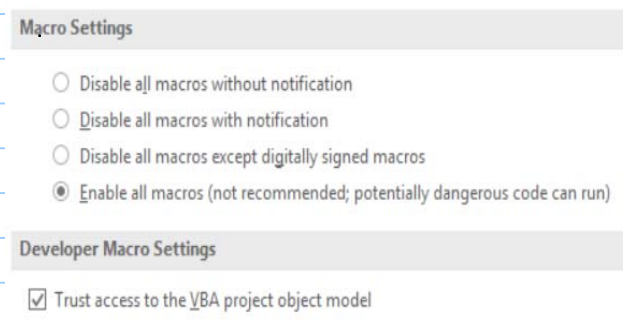
pol
cd 1%
0.5%
3%

Excel practices in petroleum engineering

• initial setup:

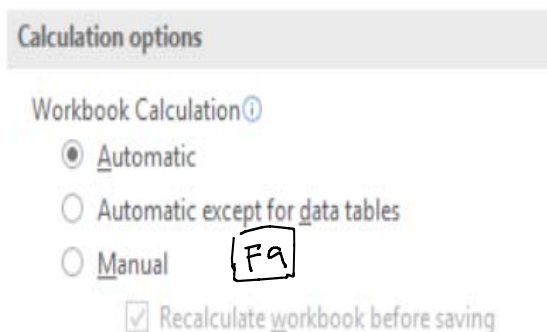
- Reduce macro security: to be able to run macros

options → trust center → macro setting



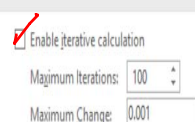
- Automatic cell calculation

options → formula



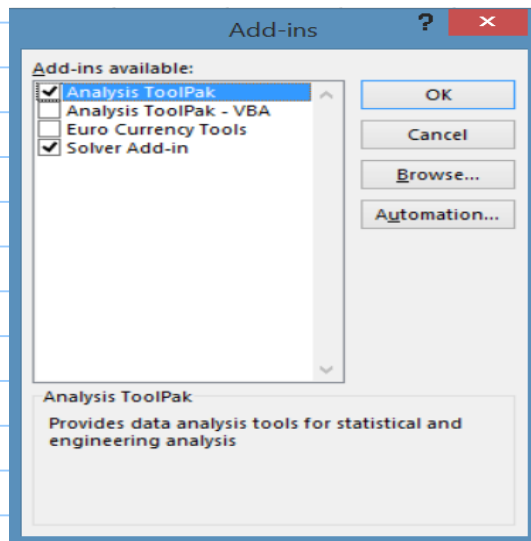
- activate circular references.

general - formula



- Enable solver add-in and analysis toolpack

options → add-in → "go"
(bottom window)



- Etiquette:

- IO sheet

	A	B	C	D	E	F
1	Milan Stanko, 20170124, Probabilistic estimation of reserves					
2						
3	name	date	title			
4		yyyy-mm-dd				

- Color convention for cell info

Red for user input

blue for calculated cells, in long columns we use black

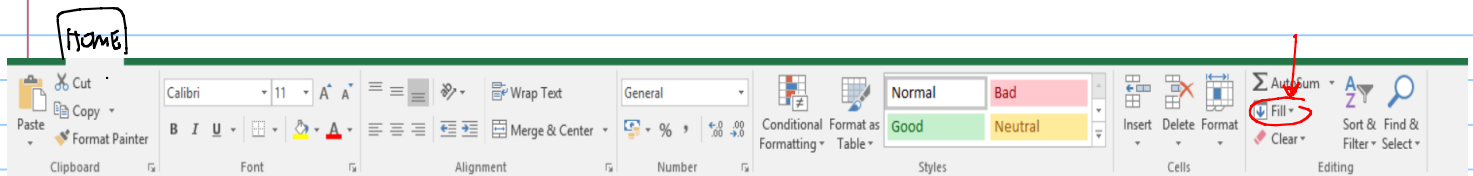
- figures should be in a separate sheet

- for each column: variable name, variable symbol, units in brackets

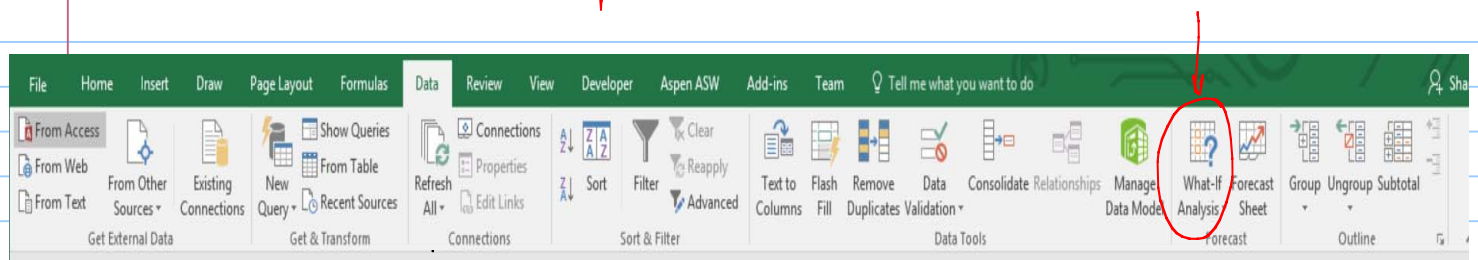
porosity, ϕ
 ↳ [-]
 ↳ fraction.

- Use common sense imagine that another person will use your excel sheet

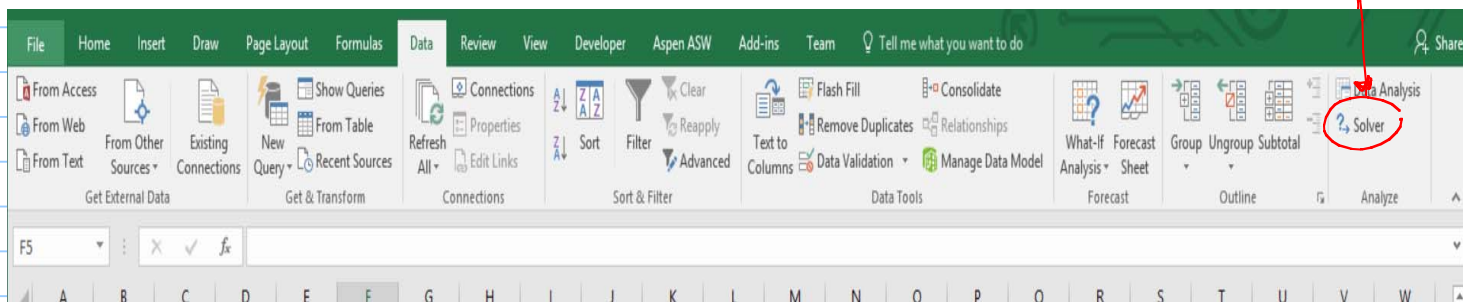
- built functions and utilities → apply on a cell (group of cells) → use the upper menu
- fill → apply values to many cell (rows columns)



- Goalseek (solver but simplified)

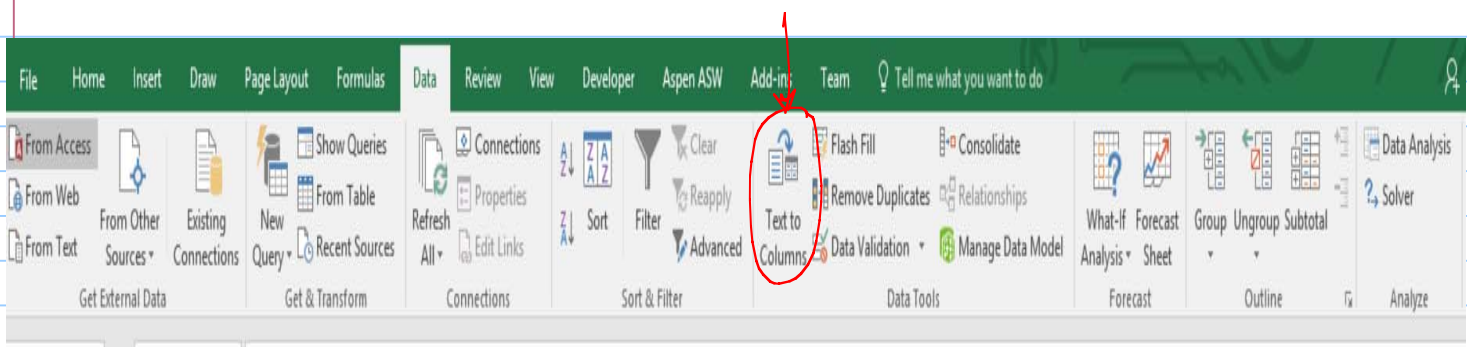


- Solver



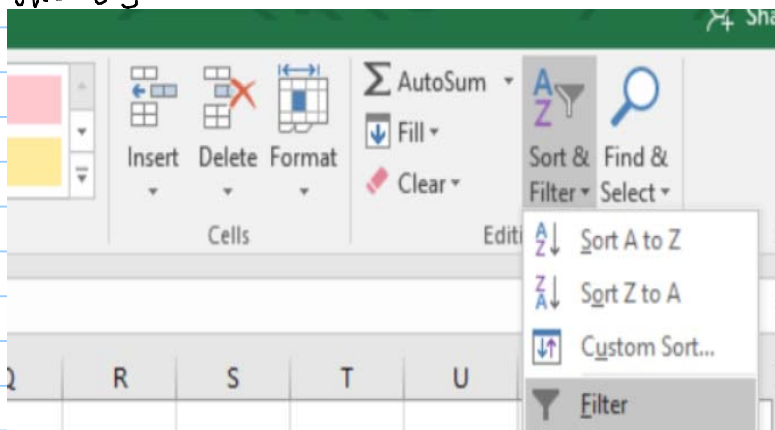
- making frequency table (frequency function) matrixial function
apply function with data + data + enter.

- Paste text in excel



- Sorting, filtering cells

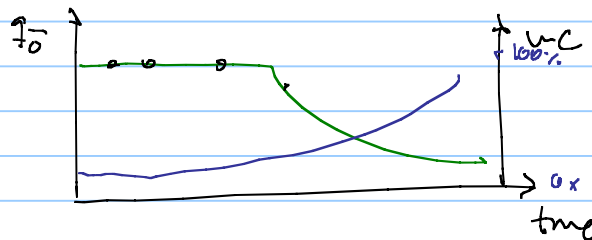
[Home]



• Plotting

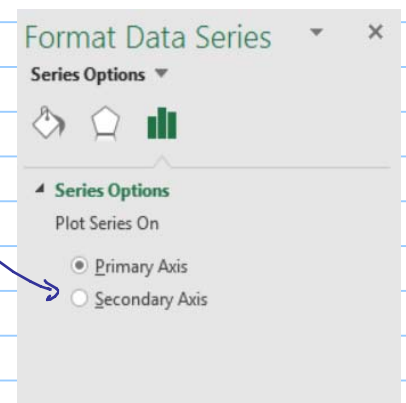
- in its own sheet
- appearance: font size (14-18), bold. Add line data point. point size should be visible (4-6). White background. outside tick marks on the axis, vertical grid. change color on vertical and horizontal axis to black. Adjust data range (min max)

optional to plot another variable that has significantly different values
secondary vertical axis.



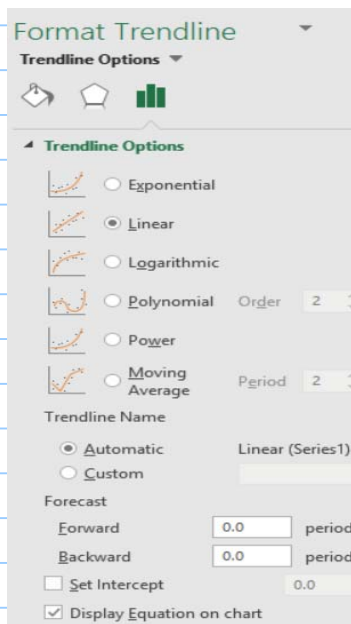
select series right click → properties data series

use log scale when required



- types of plots ~ scatter with lines
 ↳ bar (no gap between the bars)

- trendline



• Programming in Excel

• Accessing VBA environment - `Alt + F11`

• UDF — user defined function, Remember to comment $\rightarrow$ purpose
 ↳ input, units
 ↳ clarify an action if necessary
 ↳ apostrophe before
 * _ _ _

• Key shortcuts

ctrl + shift + enter apply matrix functions

ctrl + shift + down / up
 right / left brings to the end of the column, row

CLASS EXERCISE

• in Windows there are two options to save the file :

1997-2003 excel file .xls $\left\{ \begin{array}{l} \text{save both the} \\ \text{sheet and} \\ \text{the macro} \end{array} \right.$

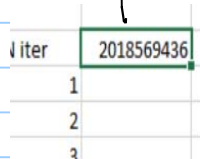
if you want to use the latest format then

$\rightarrow$.xlsx $\sim$ only sheets

.xlsm $\sim$ sheets + macro

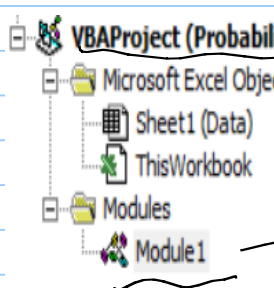
freeze n column
freeze n row
X-uniform (\$B\$5, B6)

two extra tricks → fill: to fill n iter column from 1-1000 and double
click on the right bottom corner to apply automatically until the end



Observations / sources of error:

- Some computers use ; for separator in function arguments
f(a, b, c) or f(a; b; c) be careful!
- in computers with norwegian language rand() is frlfteldig()
- Once you create the UDF, save it!
- module 1 should be located in the excel sheet where you are working



your excel file

this is where your macro should be!

random has a volatile behavior any change a new number will be generated

if after some iterations the value doesn't change. I recommend
to put rand inside vba function

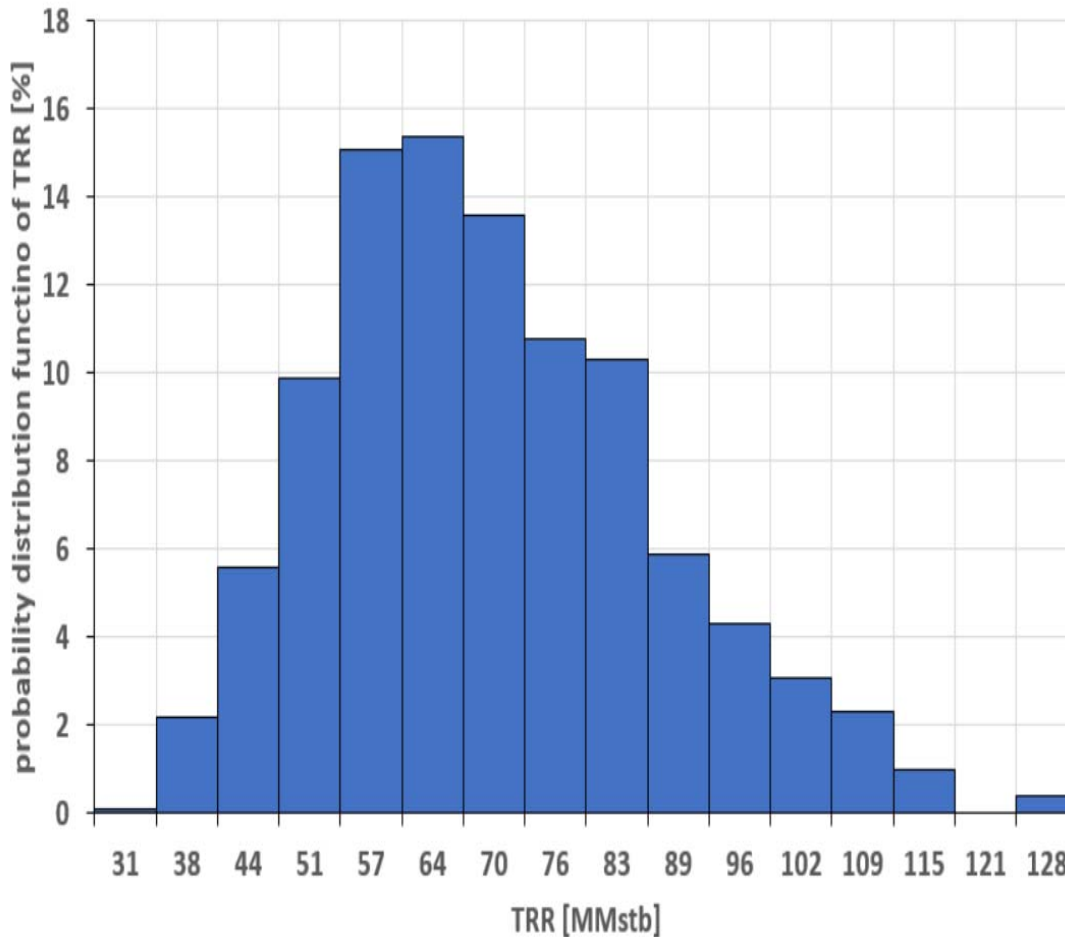
Function X_uniform(a, b) ·
 'value of the variable X for a uniform probability distribution
 'a is the minimum value of X
 'b is the maximum value of X
 Application.volatile(true)
 U=Rnd()
 $X_{\text{uniform}} = a + (b - a) * U$
 End Function

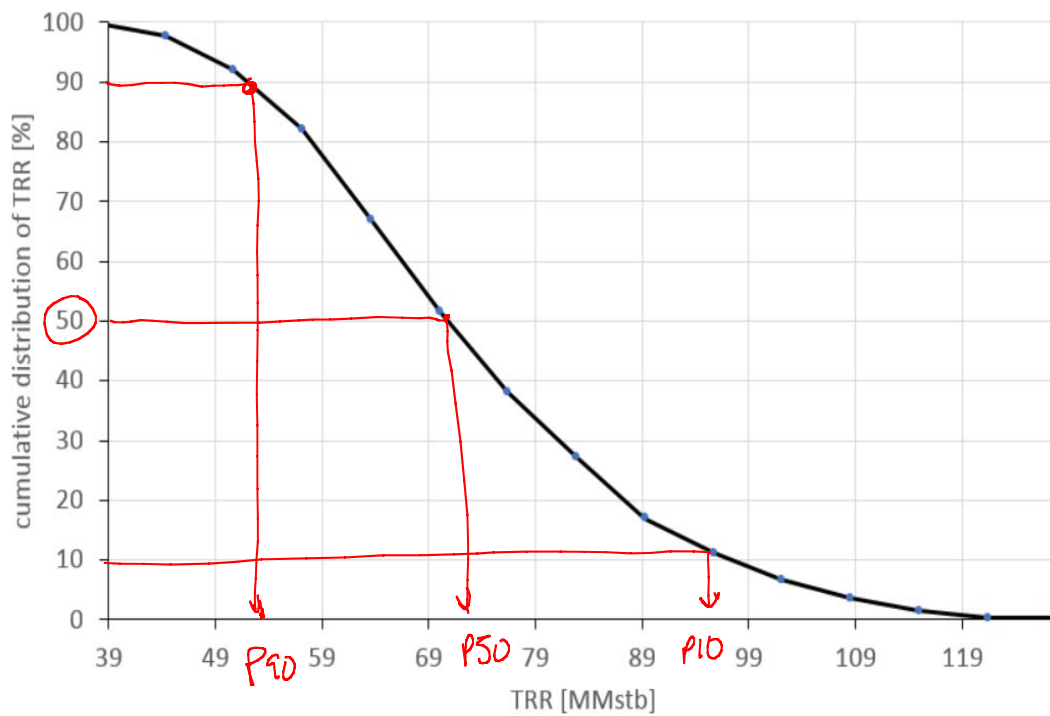
TRR	count	relative freq	cumulative freq
[MMstb]		%	{%}
31	1	0.1	100
38	22	2.2	99.9
44	56	5.6	97.7
y ₁ 51	99	9.9	x ₁ 92.1
y ₂ 57	151	15.1	x ₂ 82.2
64	154	15.4	67.1
70	136	13.6	51.7
76	108	10.8	38.1

p90

$\sim 90\% \quad x_3 \rightarrow y_3$

$$\frac{y_2 - y_1}{x_2 - x_1} \approx \frac{y_2 - y_3}{x_2 - x_3}$$





$$N = \left(\frac{z \cdot \sigma}{E} \right)^2$$

sigma	[MMStb]	17
average	[MMStb]	66
E (2% of average)	[MMStb]	1
Z factor (for 98% confidence)		2
Required N		693

σ (Popul)

~ Average (Col)

2 ~ 99.9%

2% of the average

$$\frac{2\sigma - \text{Average}}{100} = E$$