Simple Spreadsheet Models for Interpretation of Fractured Media Tracer Tests

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Gas Phase Partitioning Tracer Test FR_x

- ◆ To support soil / groundwater remediation
  - » Detect NAPL
  - » Fractured clay, 90% water content

- ◆ Four tracer types
  - » Noble gases, Light alkanes, Perflorides, Halons

- ◆ Project components
  - » Measure K_H and K_i
  - » Design field parameters and protocols

  - » *Transport Analysis*

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Tracer Concepts

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- Partitioning and sorption retard movement
- Diffusion / dispersion alter concentration profiles

$$\frac{\partial C(t,x)}{\partial t} \quad = \quad -u\frac{\partial C(t,x)}{\partial x} \quad + \quad D\frac{\partial^2 C(t,x)}{\partial x^2} + \quad D\frac{\partial^2 C(t,x)}{\partial y^2}$$

accumulation   *advection*   *diffusion*

- Tracer response can be attributed to any of several physical models.

Homogeneous Model

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- ◆ 1-D Cartesian

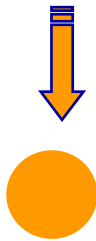- ◆ Pulse of tracer in, observe at distance

- ◆ Solution by Sauty (1980)

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Homogeneous Model -2D

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- ◆ 2-D 2° term, 1-D advection

- ◆ Pulse of tracer in, observe portion at distance
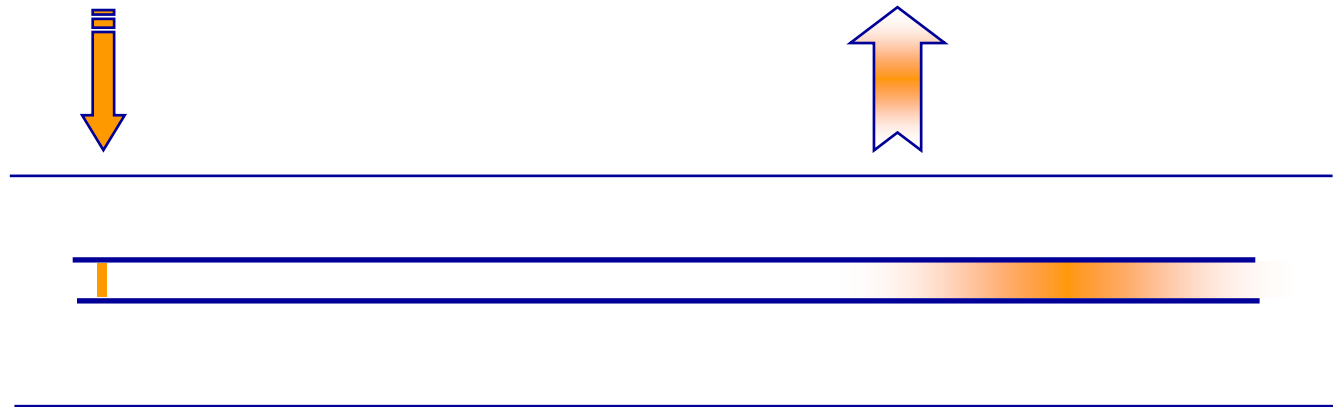
- ◆ Solution also by Sauty (1980)
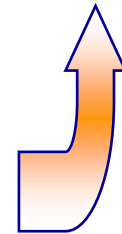
Single Fracture Model

*FR*x

- ◆ Similar to 1D Homogeneous
- ◆ Solution by Bullivant & O'Sullivan (1980)

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Multi-Fracture Model

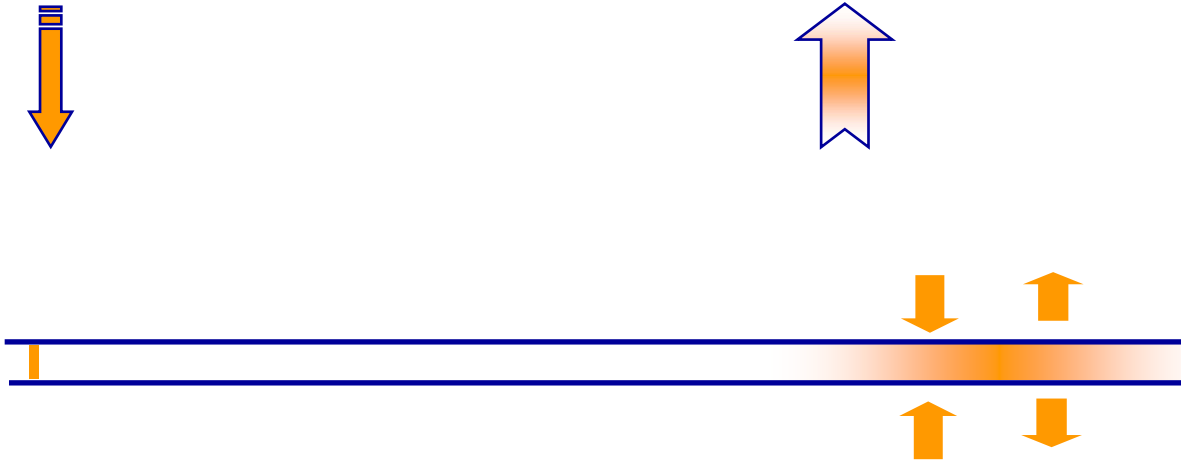◆ Summation of a triplet of Single Facture Models
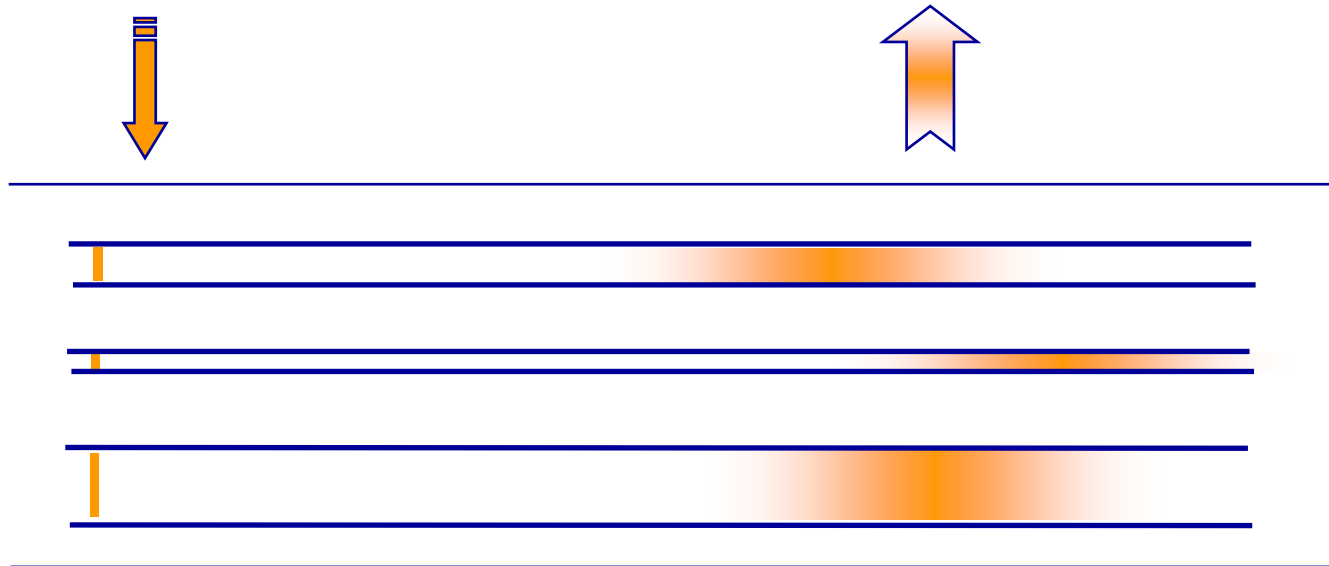
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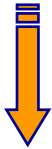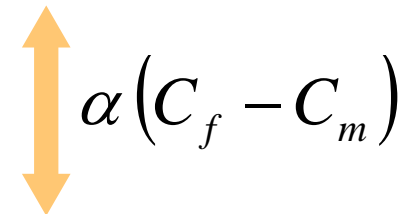
Fracture-Matrix Model

◆ Solution by Bullivant & O'Sullivan (1980)

Pseudo Steady State

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♦ Dual porosity:

   » A fracture

   superimposed on

   » Matrix

$$\alpha\left(C_f - C_m\right)$$

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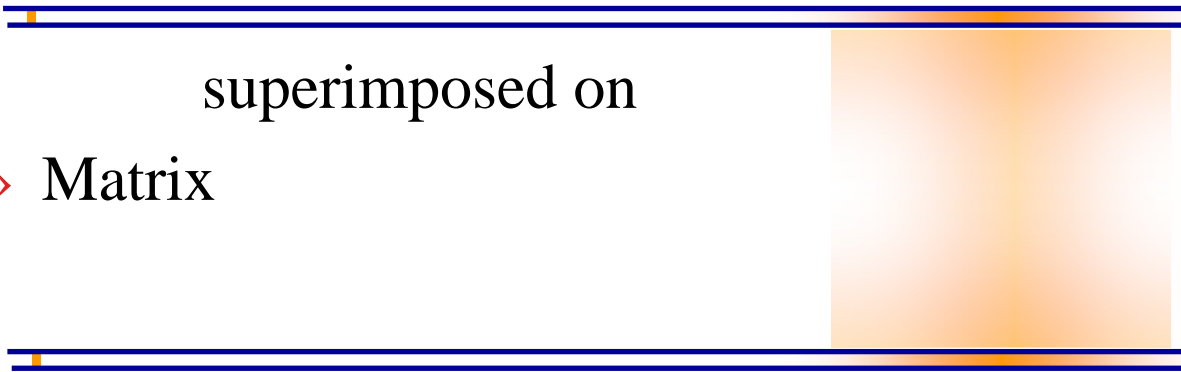
Slab Model

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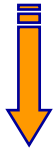
◆ Also dual porosity:
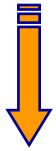
» Fractures

superimposed on

» Matrix

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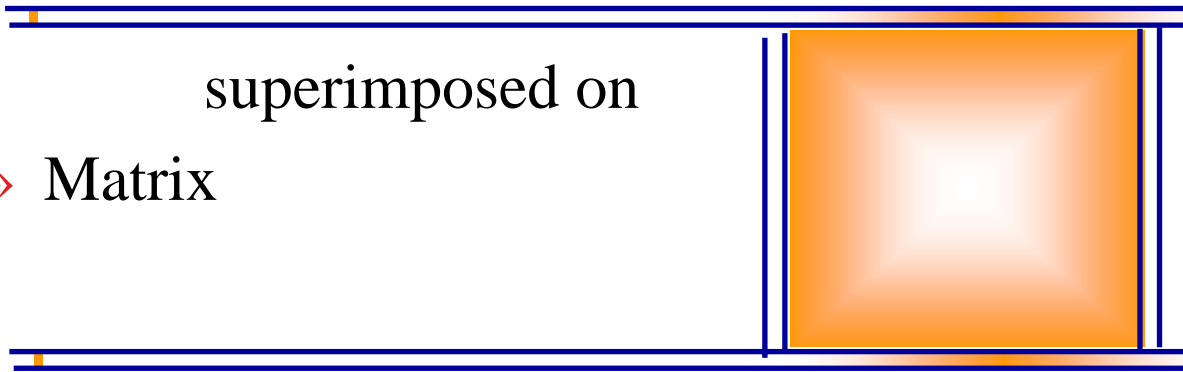
Cube Model

◆ Also dual porosity:

  » Fractures

  superimposed on

  » Matrix
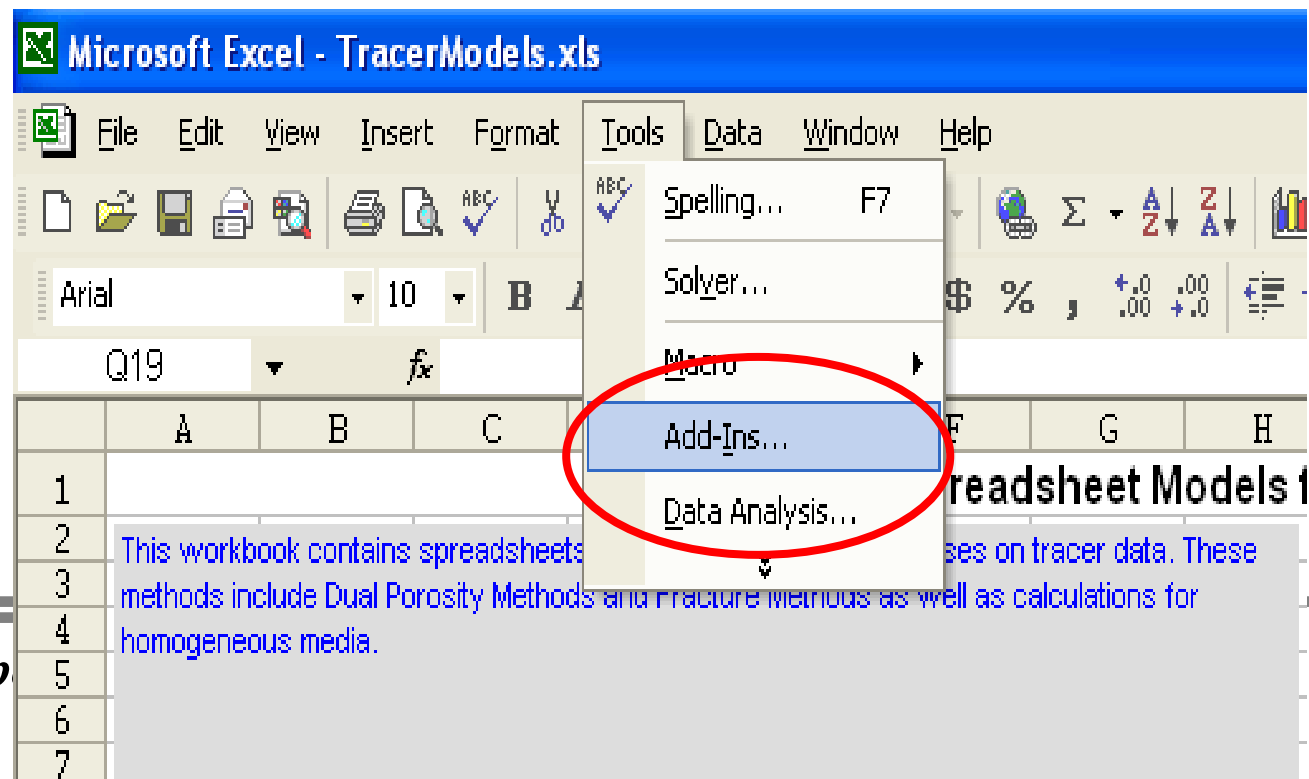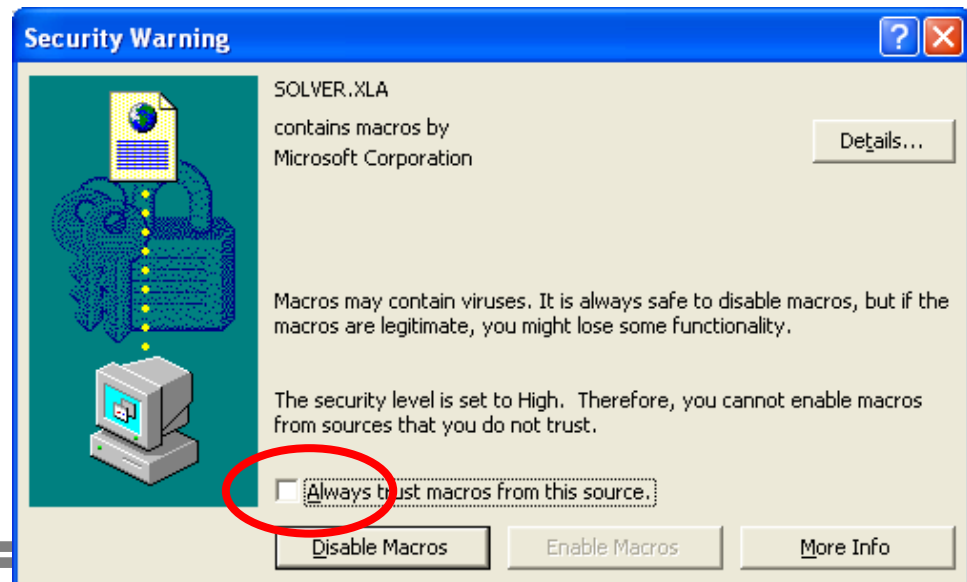
Excel Functionality

- SOLVER Add-In required
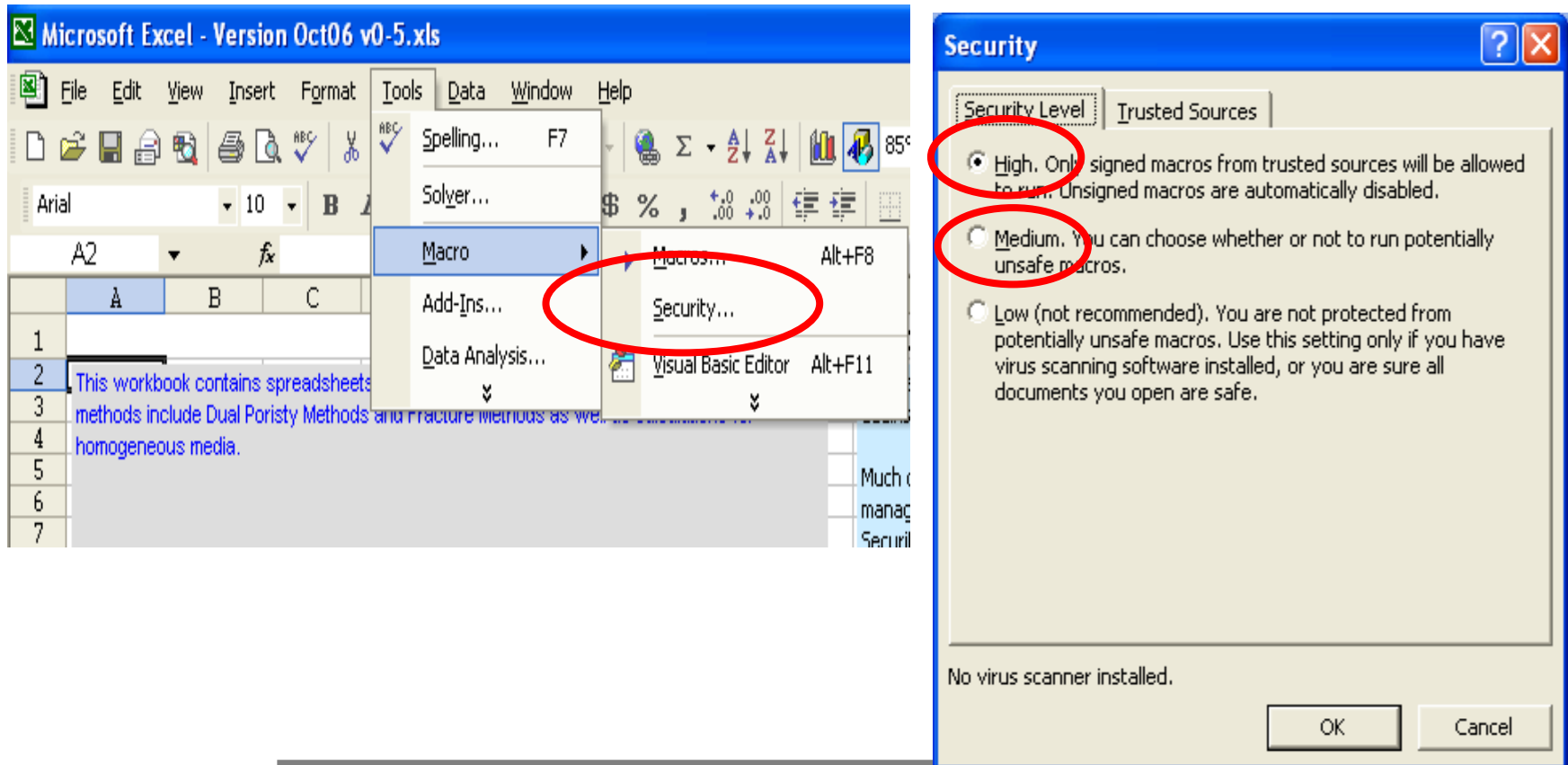- ANALYSIS ToolPak required

Excel Macros

- ◆ Pros and cons of macros

- ◆ Enable macros
  - » Change security settings to MEDIUM
  - » Use selfcert.exe

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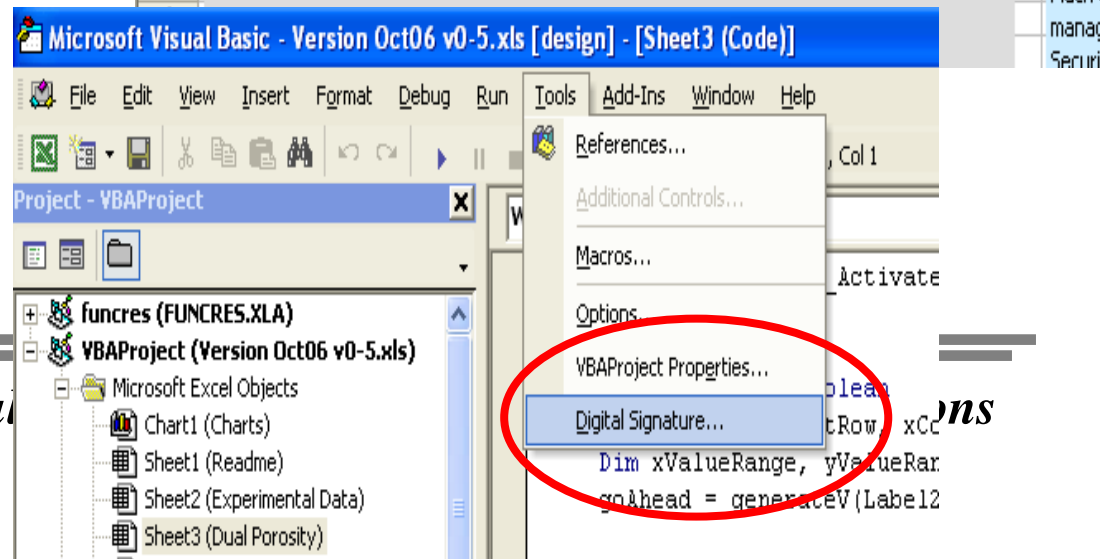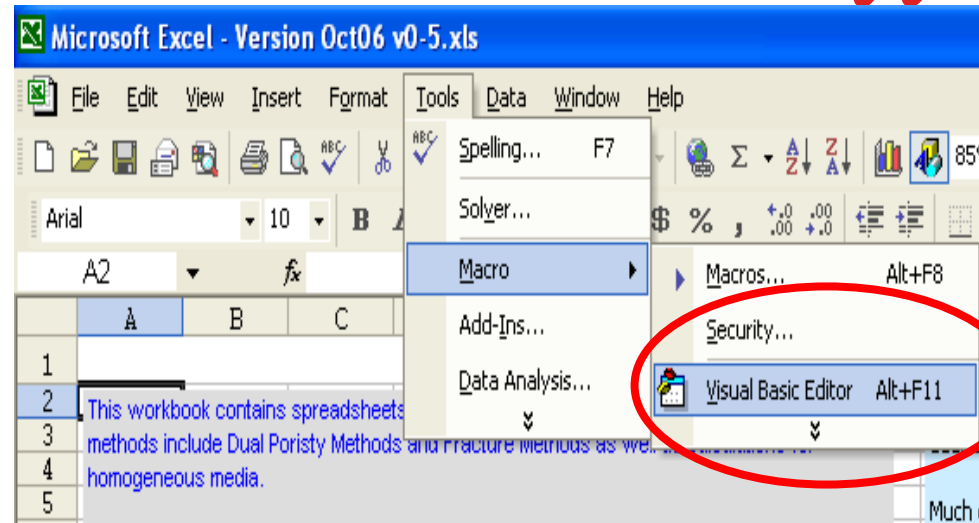
Changing Security Levels

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Self certifying

- Commercial certificate - Verisign
- IT administrator

- Run selfcert.exe
- Then apply your certificate

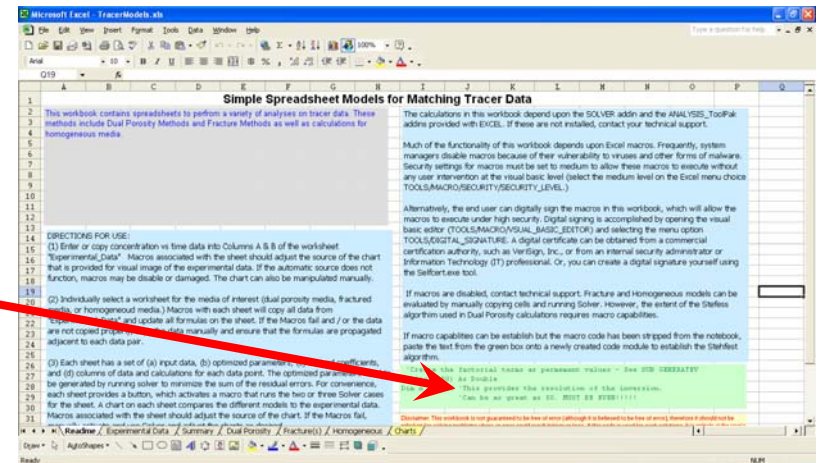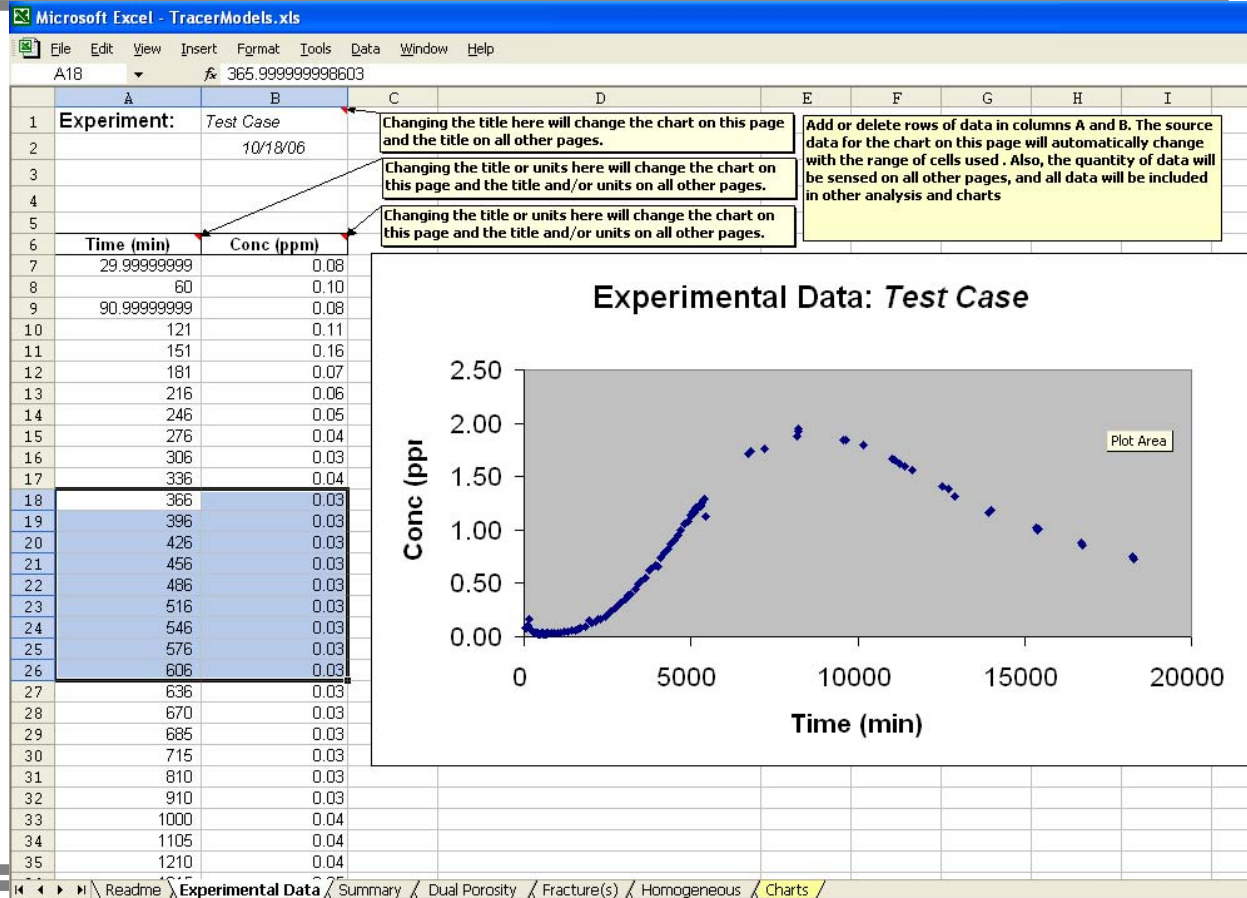*developers of hydrau... ...ons*

Still No Macros?

- Contact IT Support

- Copy cells manually (Homogeneous & Fracture models only)

- Copy macro code from green textbox on ReadMe page

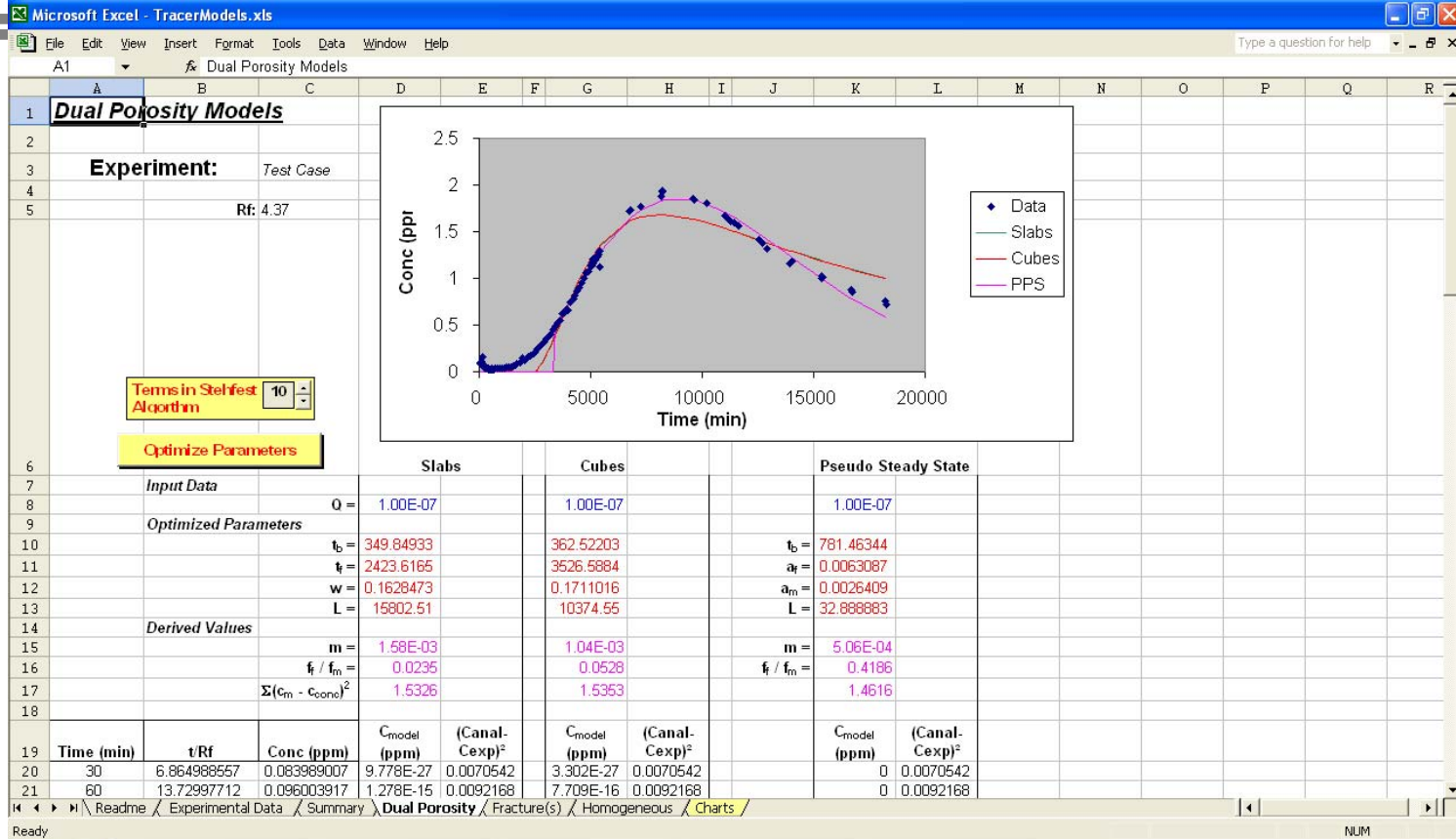*developers of hydraulic fracturing and other subsurface innovations*

Entering Data

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Dual Porosity Models
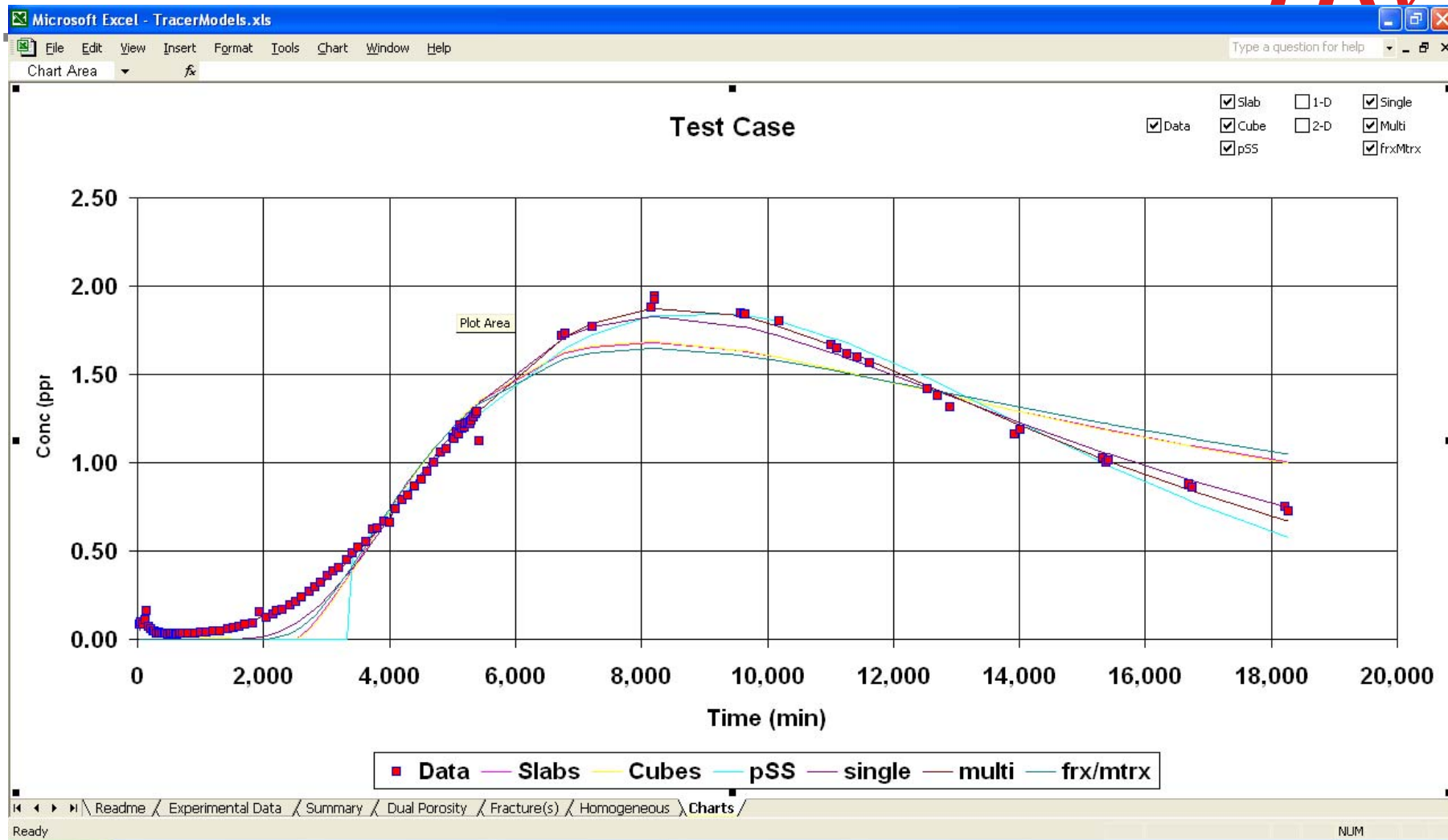

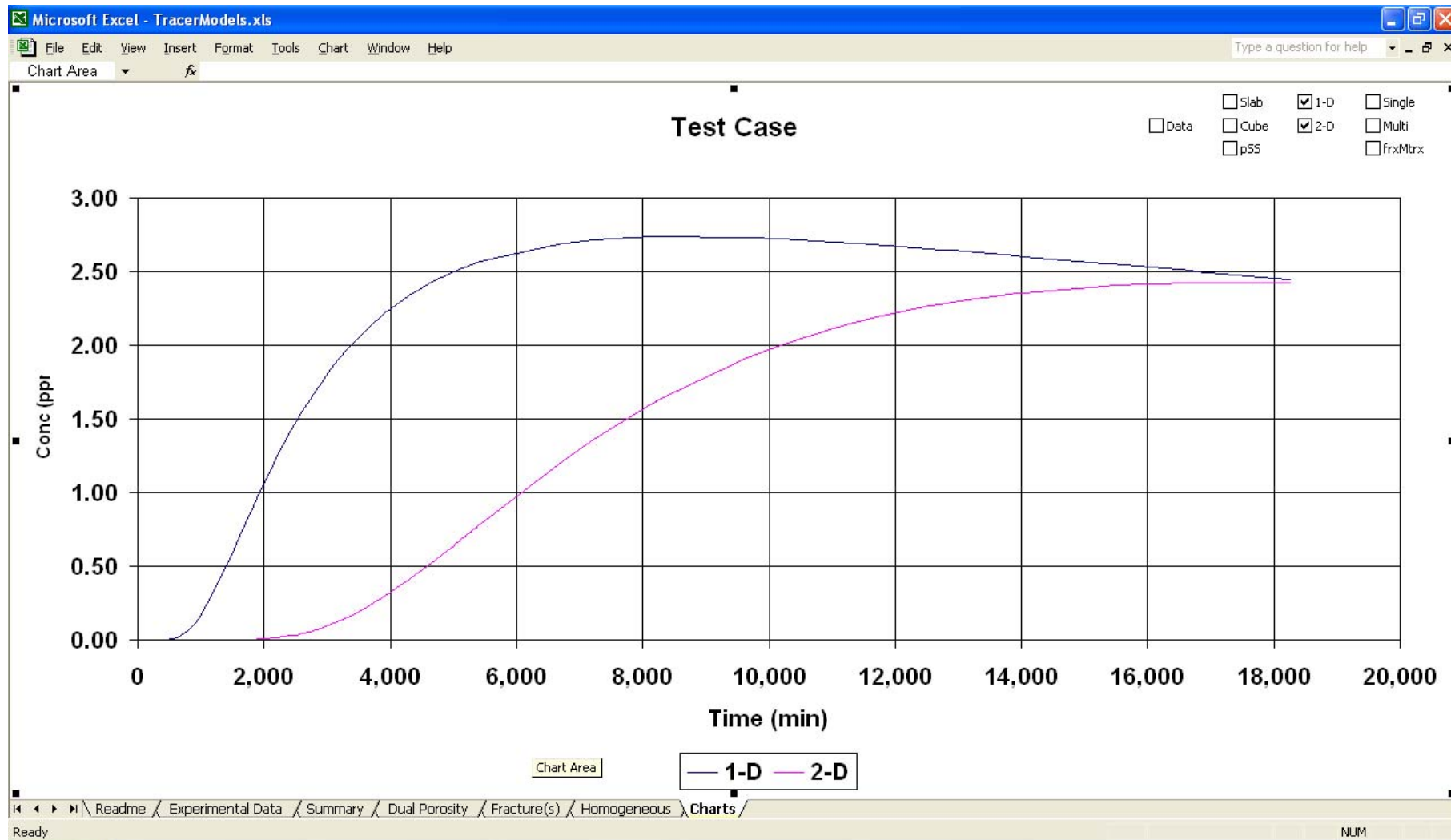*developers of hydraulic fracturing and other subsurface innovations*

Charts of Results

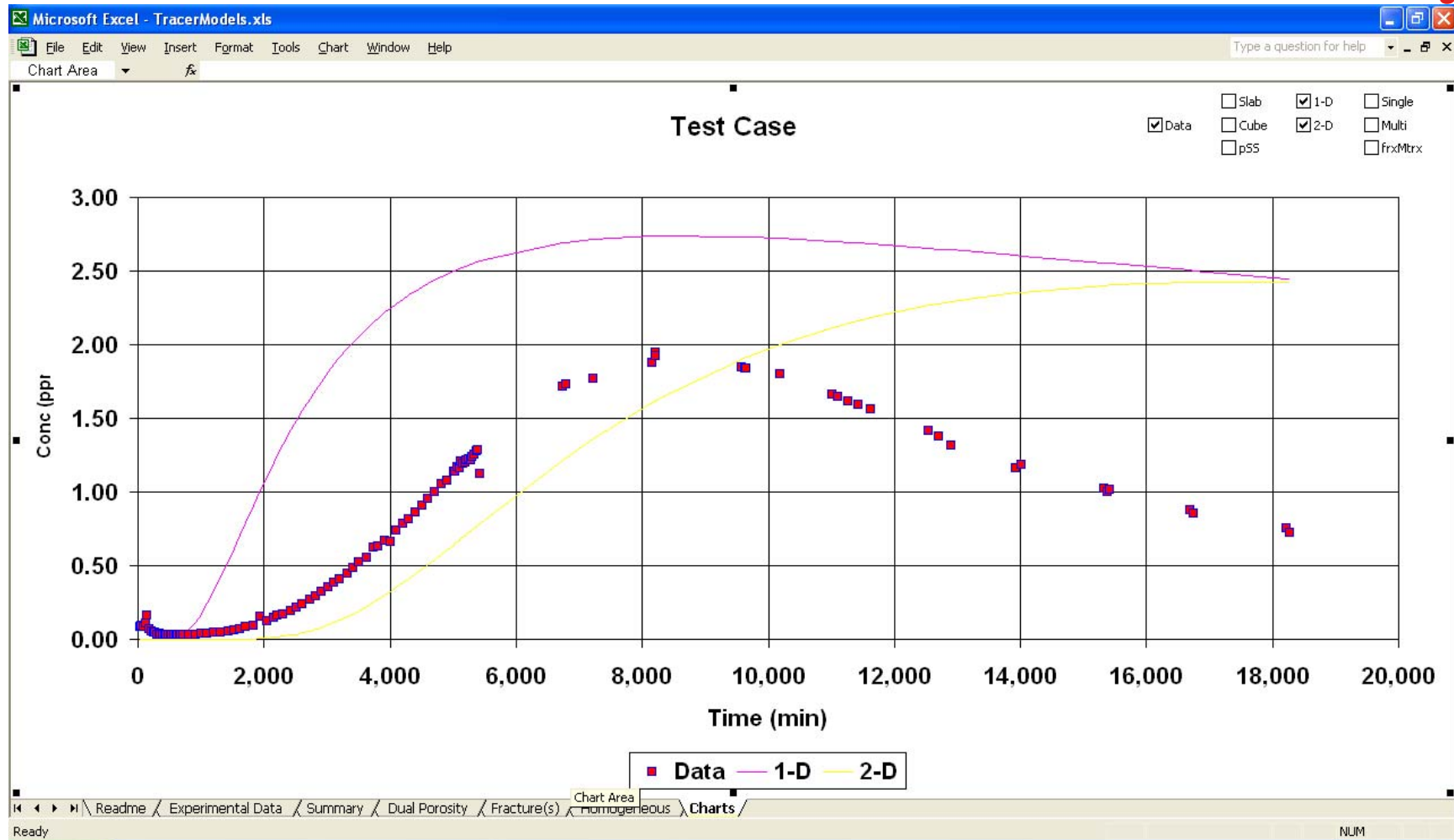# Nine Mouse Clicks Later

One More Click

Where and Who

FR_x

- http://frx-inc.com/TracerModels.xls
- simon.michelle@epa.gov
- wslack@frx-inc.com

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Conclusions

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- ◆ Simple models can be implemented easily
- ◆ Multiple models lends broader perspective
- ◆ Integrate package offers side-by-side comparisons