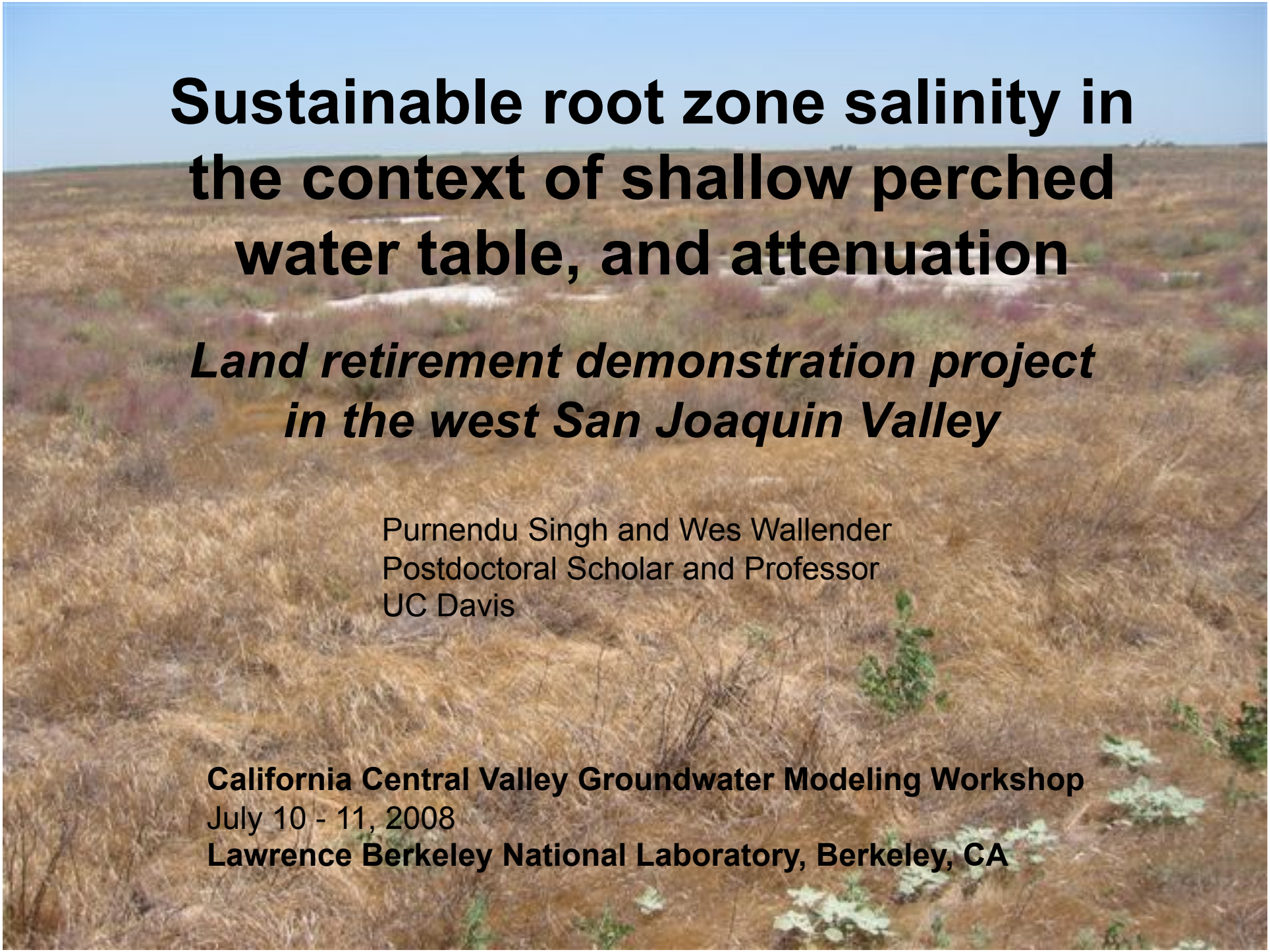


Sustainable root zone salinity in the context of shallow perched water table, and attenuation

Land retirement demonstration project in the west San Joaquin Valley

Purnendu Singh and Wes Wallender
Postdoctoral Scholar and Professor
UC Davis

California Central Valley Groundwater Modeling Workshop
July 10 - 11, 2008
Lawrence Berkeley National Laboratory, Berkeley, CA

Outline

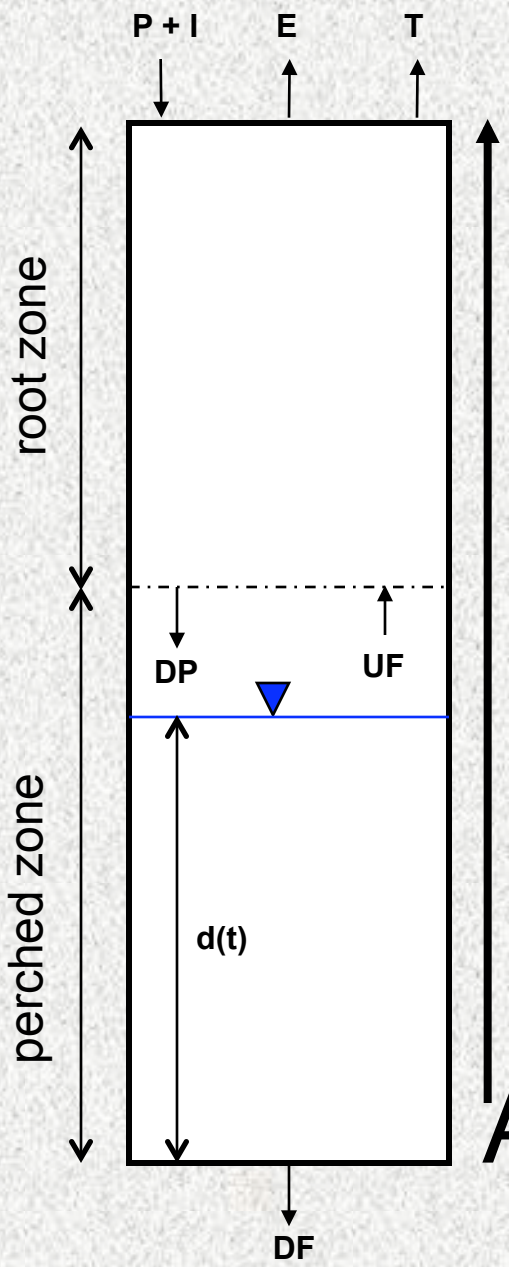
- **Introduction**
- Land retirement demonstration project
- Field data and modeling framework
- Calibration
- Water and salt balance
- Sustainability and groundwater attenuation

Introduction

- Use long term field data in conjunction with numerical modeling framework to understand the dynamics of water and salt movement in vadose zone under land retirement.

- Pathway to and final shallow water table depth to maintain root zone salinity balance for sustainability.

- A bottom up approach.



$DP > UF$ and salt balance

DP = deep percolation
UF = upward flux
(DP – UF)= net deep percolation

$DF \geq (DP - UF)$

DF(d(t)) = downward flux below perched zone

A bottom up approach

Site selection?

Habitat management for sustainability?

Outline

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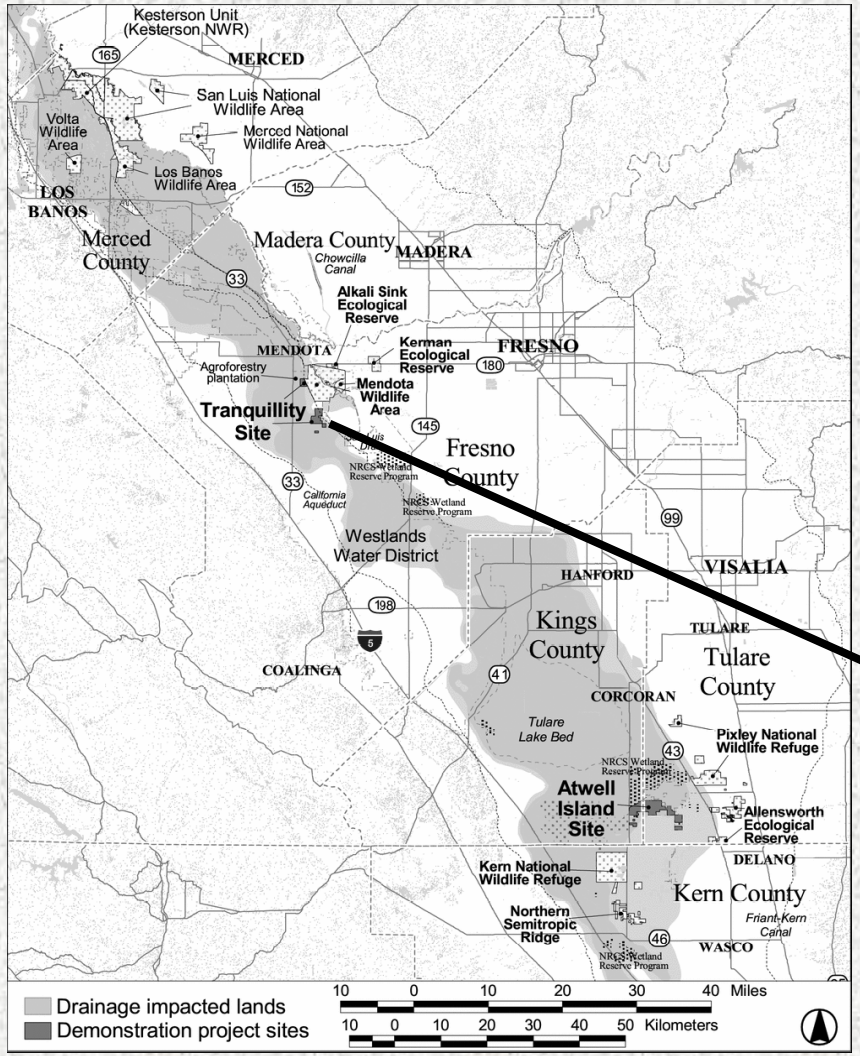
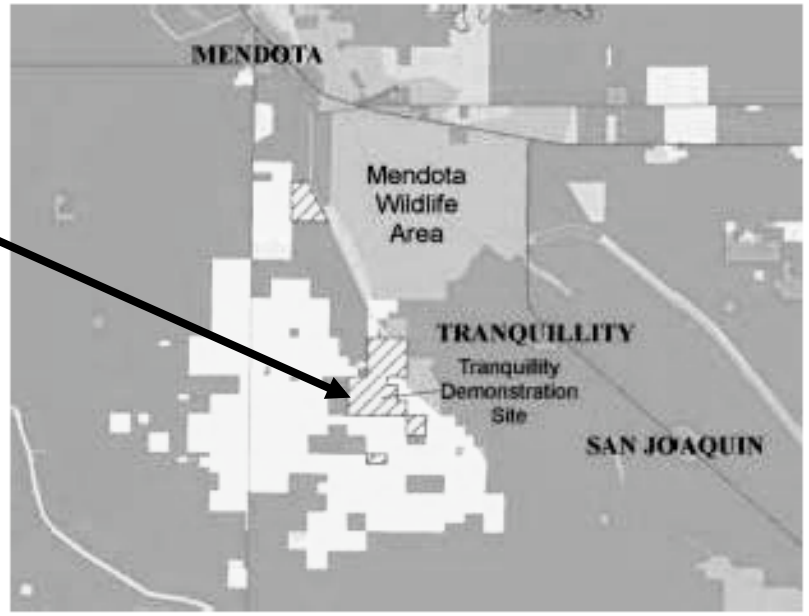
- Calibration
- Water and salt balance
- Sustainability and groundwater attenuation

Land Retirement Demonstration Project (LRDP)



Data on changes in vadose zone salinity levels as measured by electrical conductivity, groundwater quality with major ion chemistry, and shallow groundwater levels as compared to the base year of 1999. Precipitation and irrigation data for the period is available.



Tranquillity demonstration site http://esrp.csustan.edu/projects/lrdp/restdata/

Outline

- Introduction
- Land retirement demonstration project
- **Field data and modeling framework**
- Calibration
- Water and salt balance
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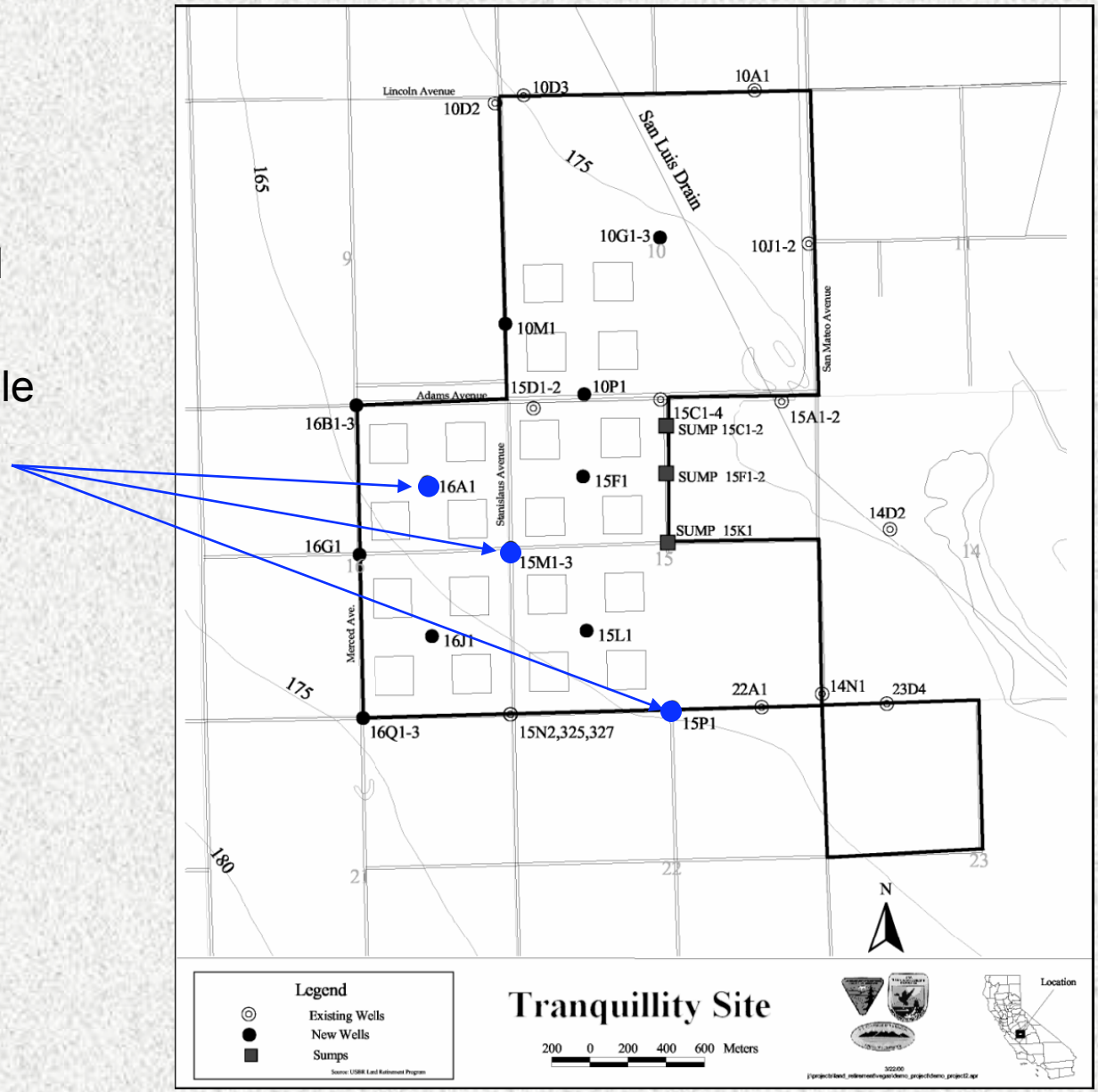
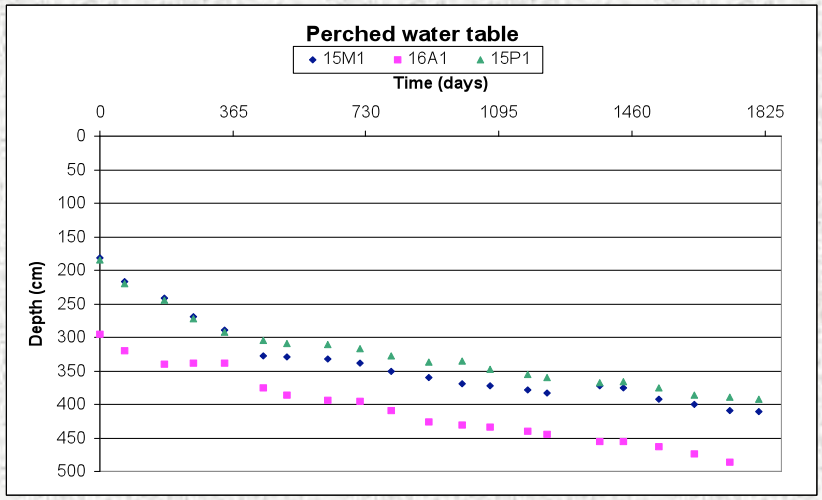
Land Retirement Demonstration Project (LRDP)

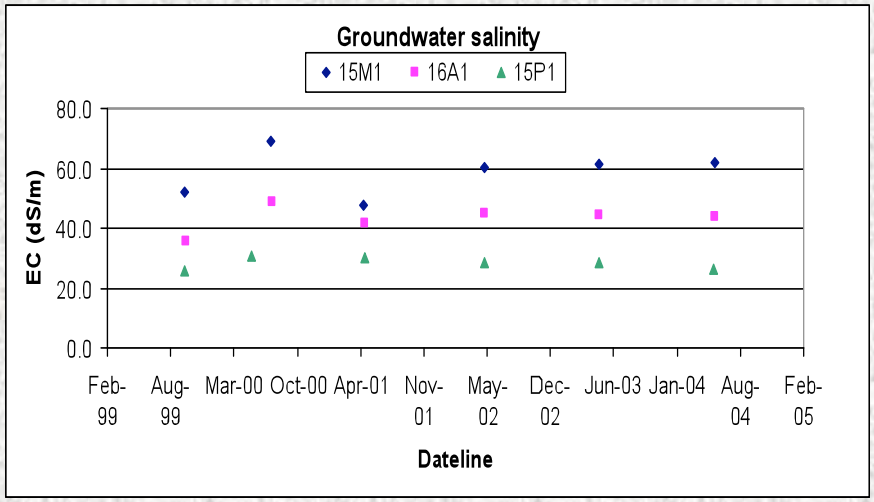
Time series of depth and quality of shallow groundwater as well as root zone salinity available at three sites.

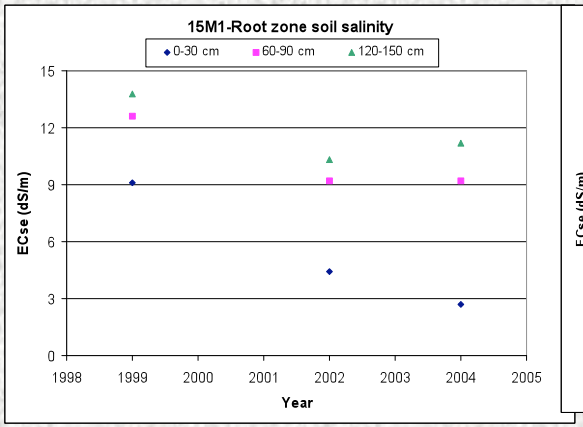


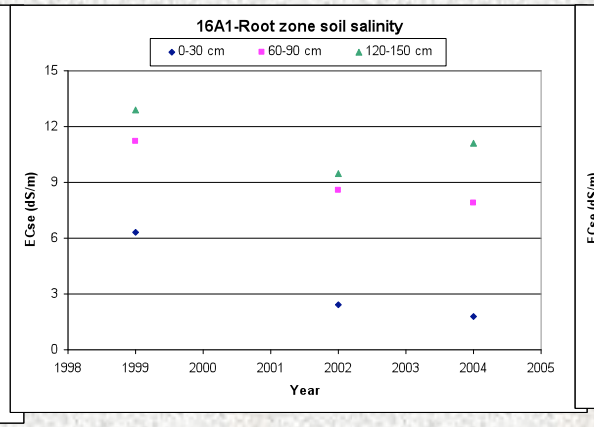
Land Retirement Demonstration Project (LRDP)

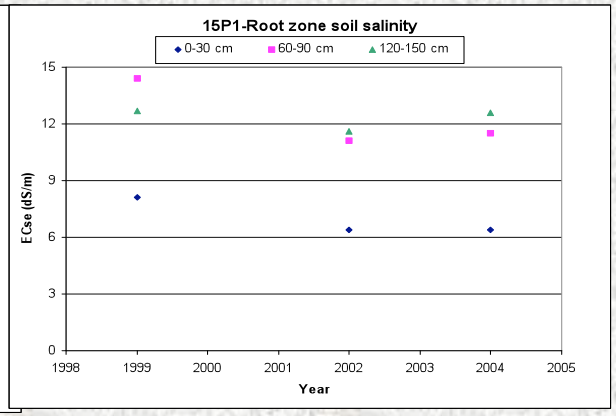
Time series of depth and quality of perched groundwater as well as root zone salinity available at three sites.





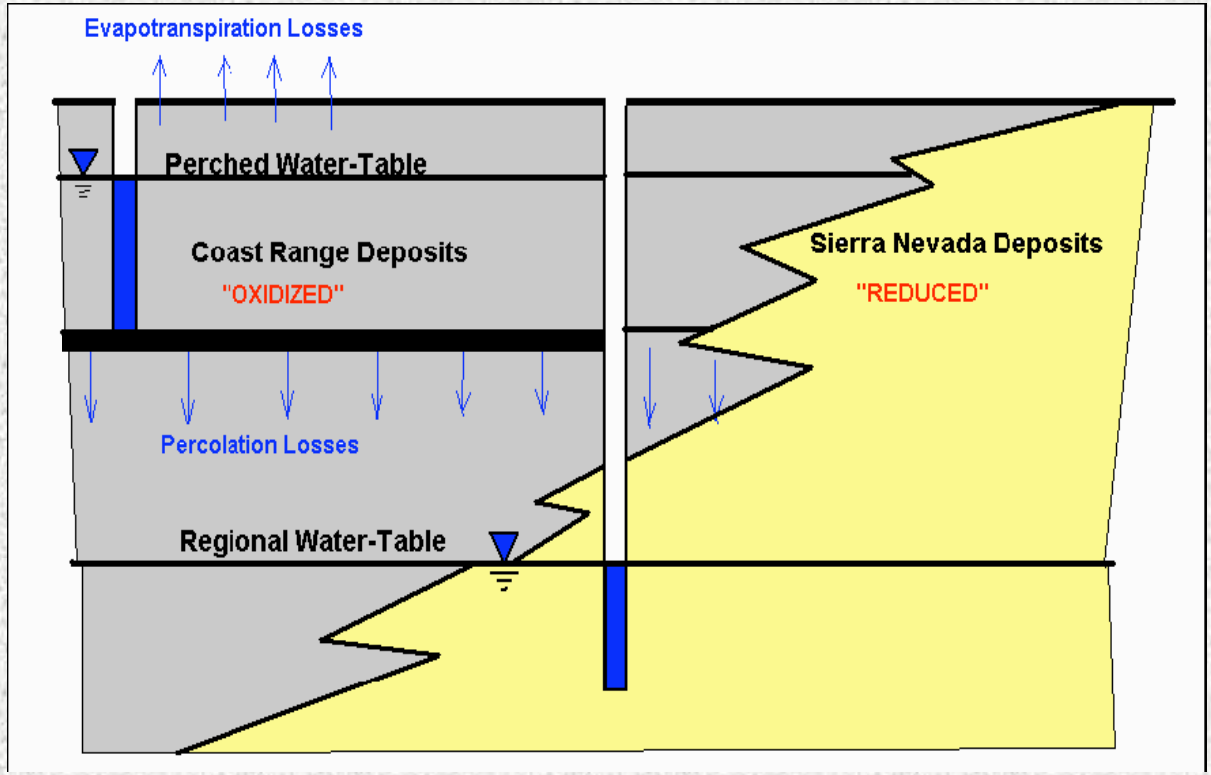




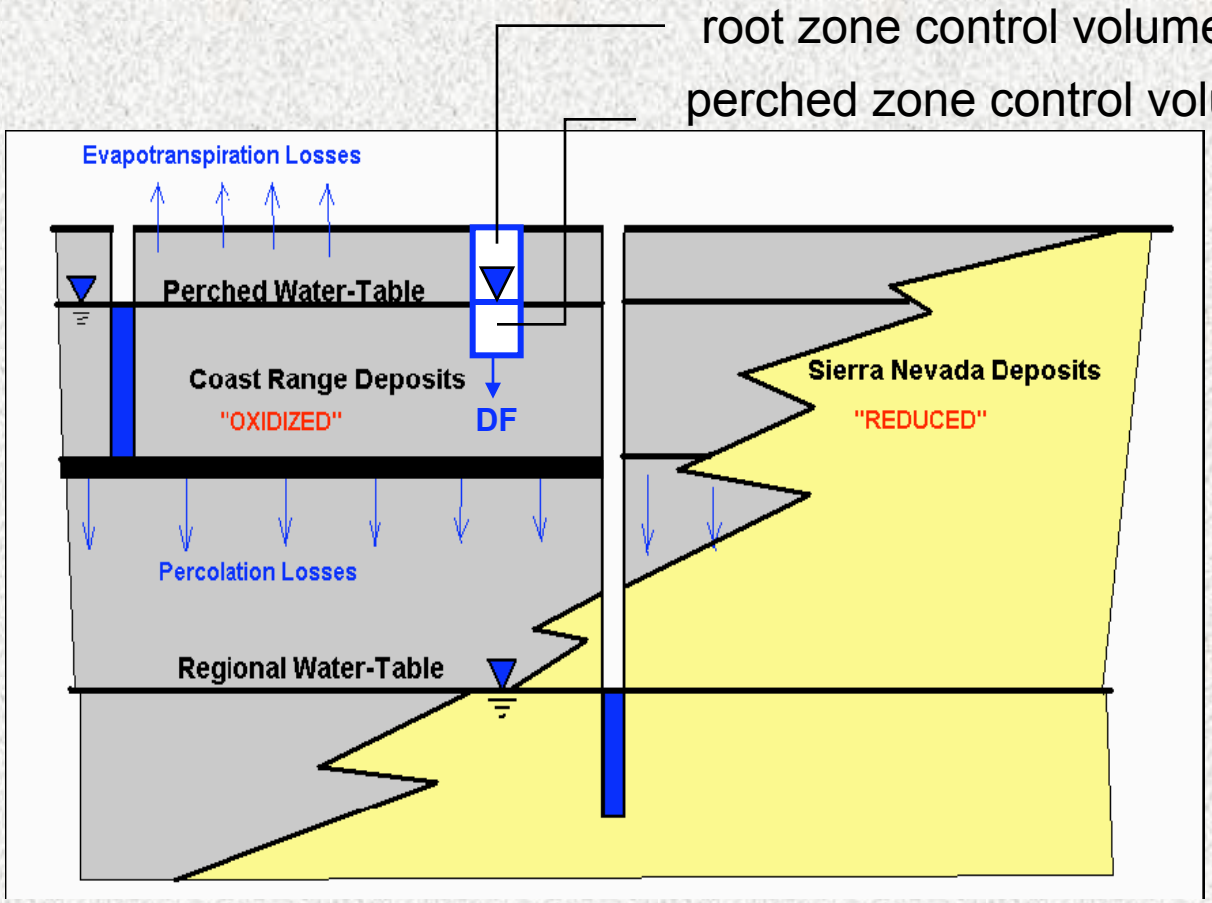


Hydrology

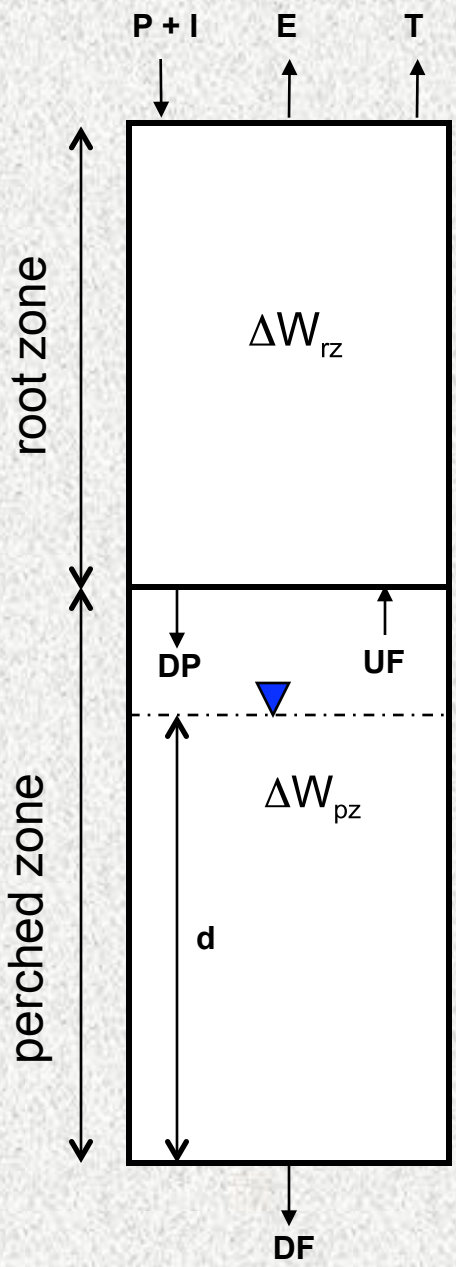
Barrier layer



Conceptual model



Barrier layer



P = precipitation
I = irrigation
E = evaporation ?
T = transpiration ?
DP = deep percolation ?
UF = upward flux ?
ΔW_{rz} = change in root zone water storage?

d = depth of saturated soil in perched zone
DF = downward flux below perched zone ?
ΔW_{pz} = change in perched zone water storage?

? Simulate water and salt content and flow

Modeling tools

Šimůnek, J., M. Th. Van Genuchten, M. Šejna. 2005. The HYDRUS-1D software package for simulating one-dimensional movement of water, heat, and multiple solutes in variably saturated media, Version 3.0. U.S. Salinity Laboratory, USDA, ARS, Riverside, California.

Suarez, D. R. and P. Taber. 2007. Numerical software package for estimating changes in solution composition due to changes in soil water content. U.S. Salinity Laboratory, USDA, ARS, Riverside, California.

Doherty J., L. Brebber, P. Whyte. 2004. PEST: model independent parameter estimation. Watermark Computing Trademarks, Australian.

Initial and boundary conditions

Duration of simulation: 1827 days (5 years)

Start date: Oct. 1999

Time step: daily

Total depth: 500-600 cm

Depth step: cm

Initial conditions: Water and solute profiles

Water flow boundary conditions:
Precipitation and irrigation, ET barley cover crop (root depth 0.107 m, 181 days) with minimum irrigation first two years and no irrigation thereafter, variable flux at bottom

Solute transport boundary conditions:
Top concentration flux, bottom zero concentration gradient

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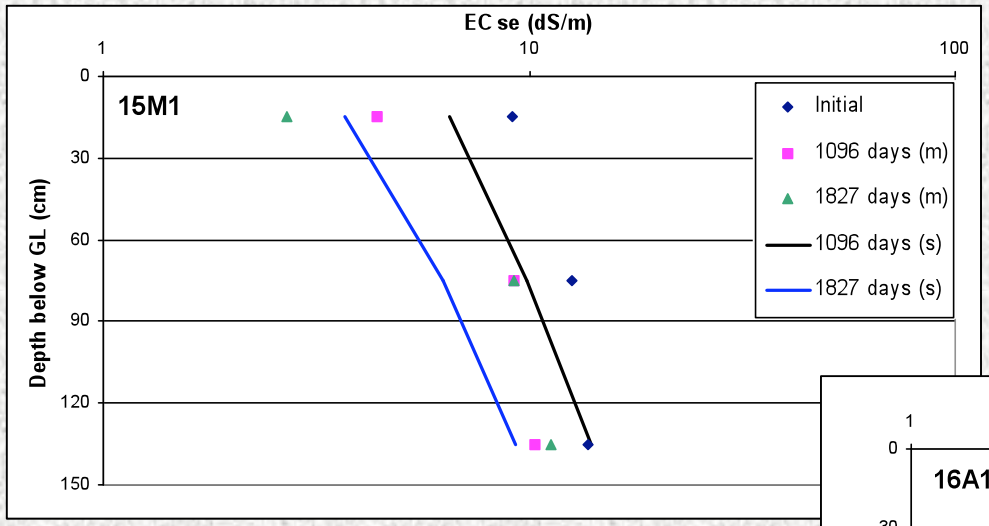
PEST

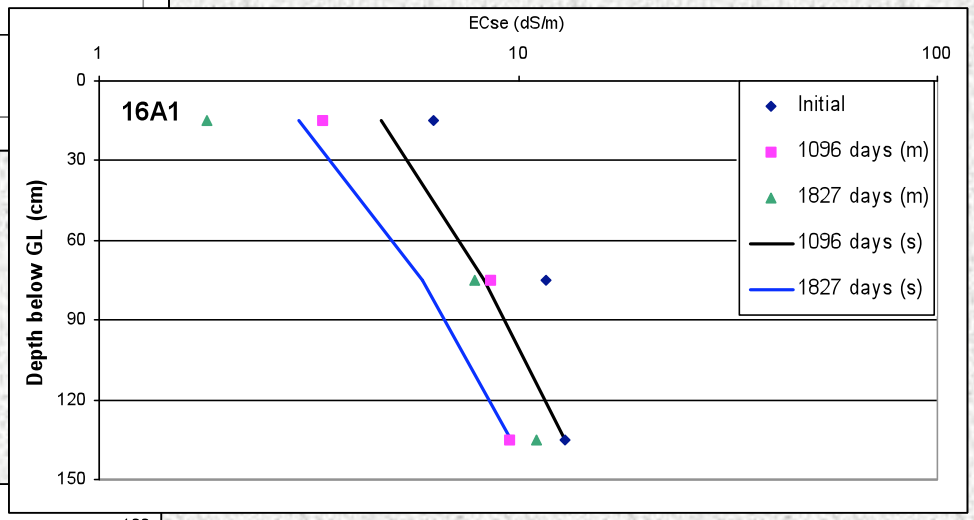
Observations:
Salinity profiles
Depth to groundwater

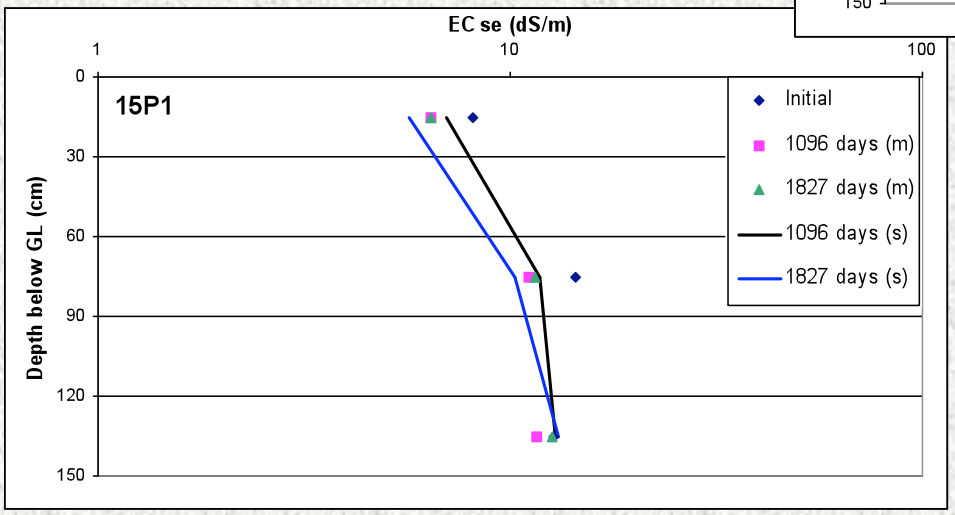
Parameters:
Soil hydraulic functions
Solute transport functions
Bottom water flux

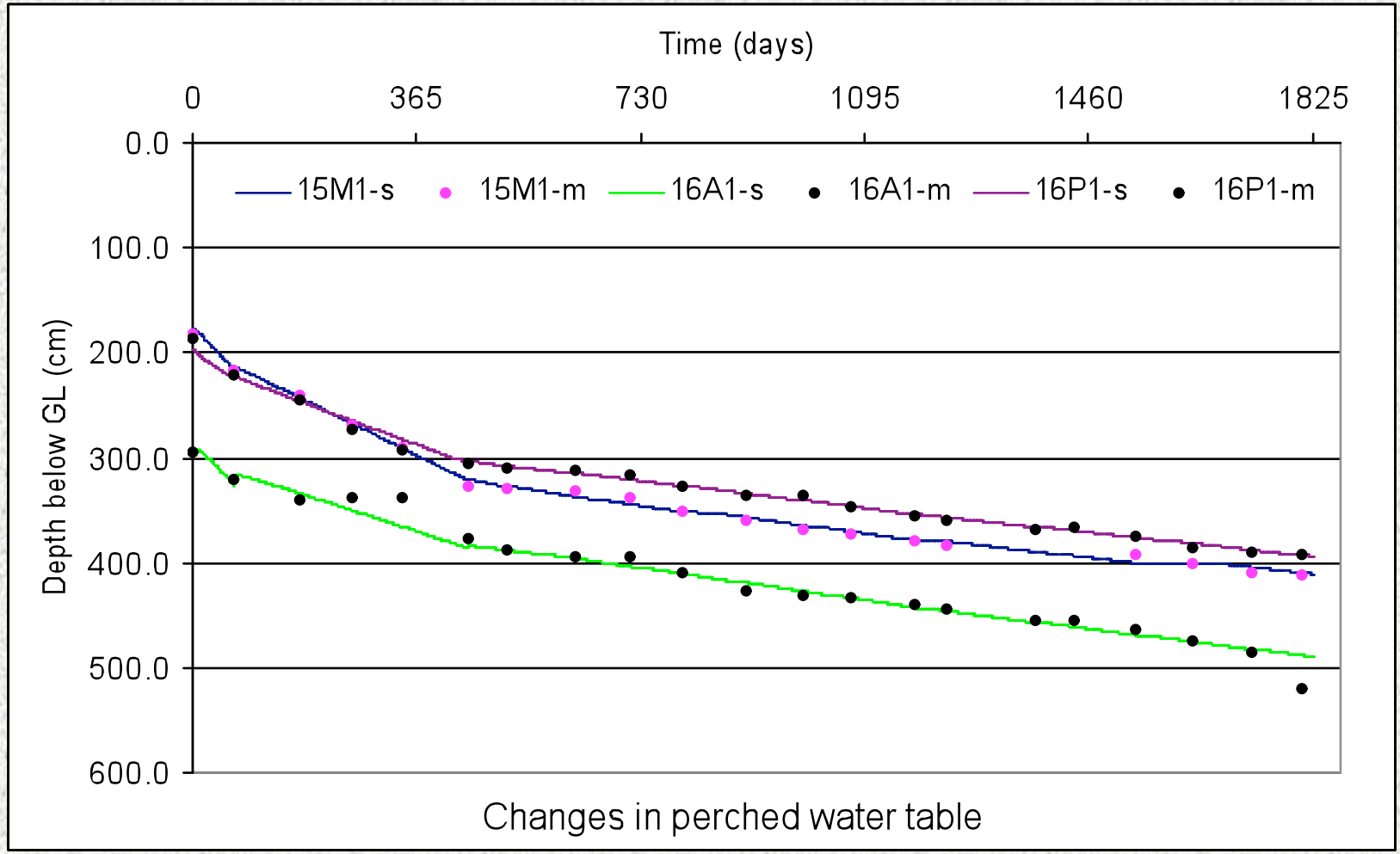
Inverse solution converged to narrow range of parameters.

PEST


EC se (dS/m)
1
10
100
0
30
60
90
120
150
Depth below GL (cm)
15M1
Initial
1096 days (m)
1827 days (m)
1096 days (s)
1827 days (s)


ECse (dS/m)
1
10
100
0
30
60
90
120
150
Depth below GL (cm)
16A1
Initial
1096 days (m)
1827 days (m)
1096 days (s)
1827 days (s)


EC se (dS/m)
1
10
100
0
30
60
90
120
150
Depth below GL (cm)
15P1
Initial
1096 days (m)
1827 days (m)
1096 days (s)
1827 days (s)


Time (days)
0
365
730
1095
1460
1825
0.0
100.0
200.0
300.0
400.0
500.0
600.0
Depth below GL (cm)
15M1-s
15M1-m
16A1-s
16A1-m
16P1-s
16P1-m
Changes in perched water table

Outline

- Introduction
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- **Water and salt balance**
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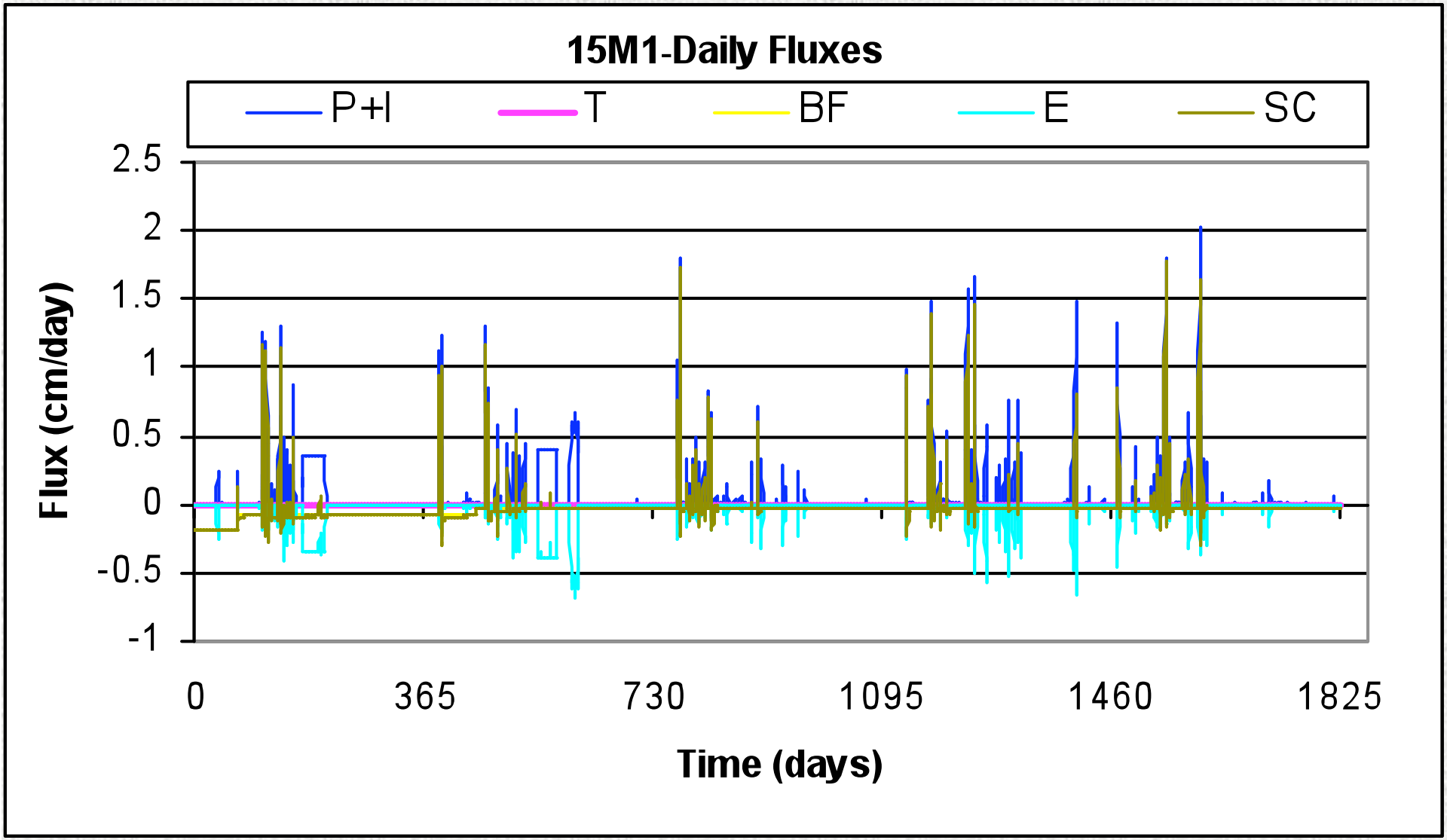
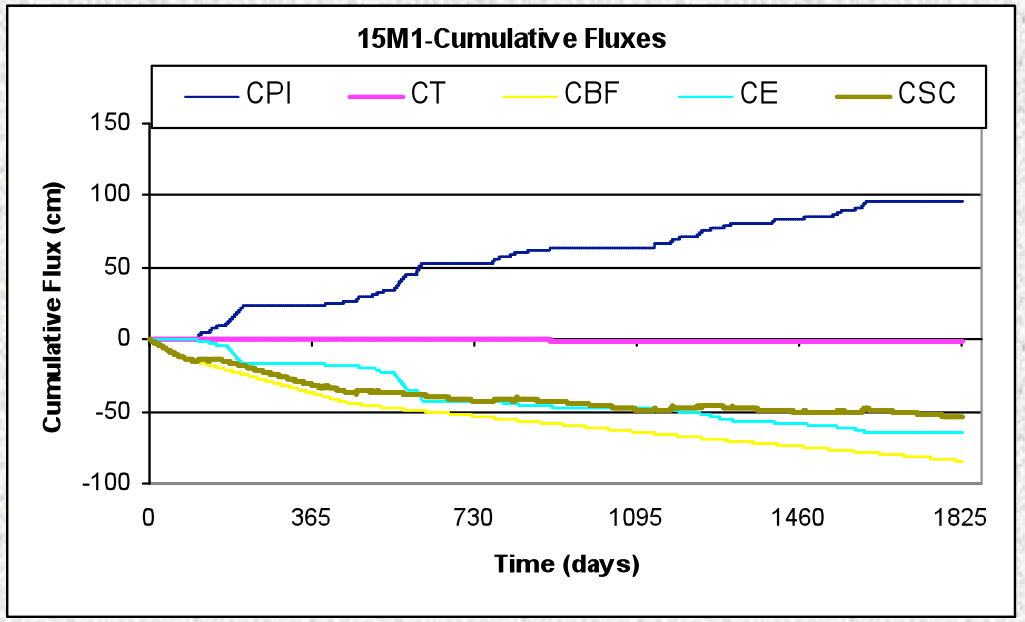
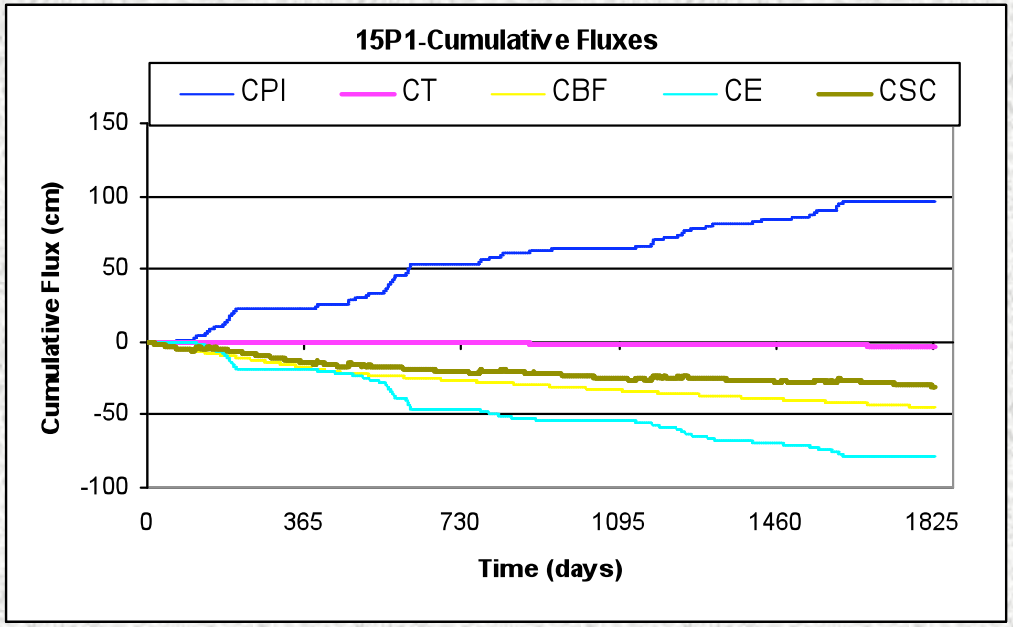
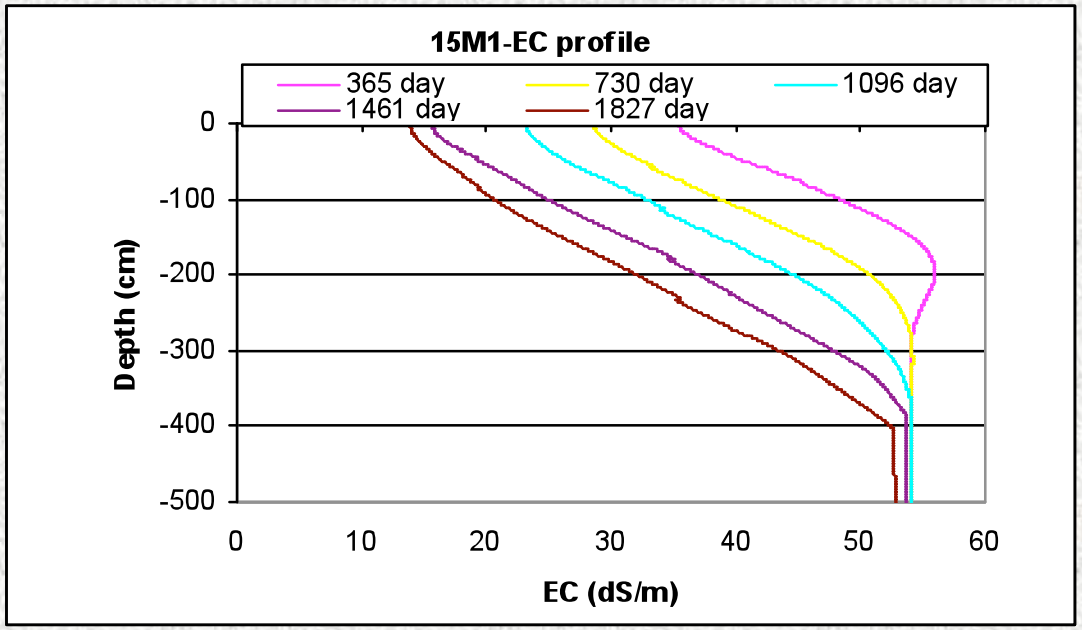
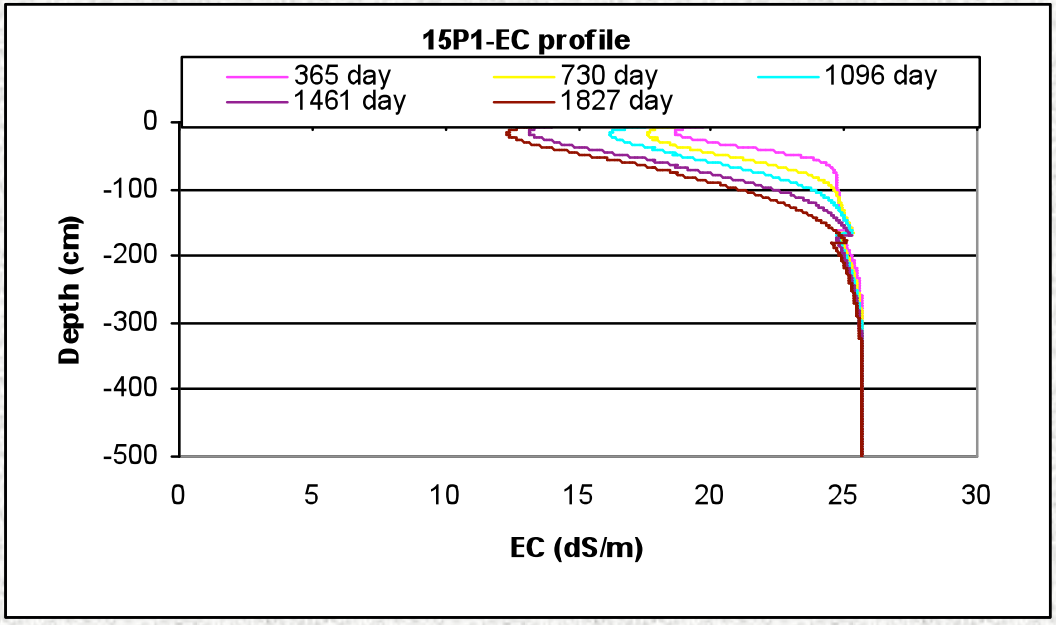
Total control volume

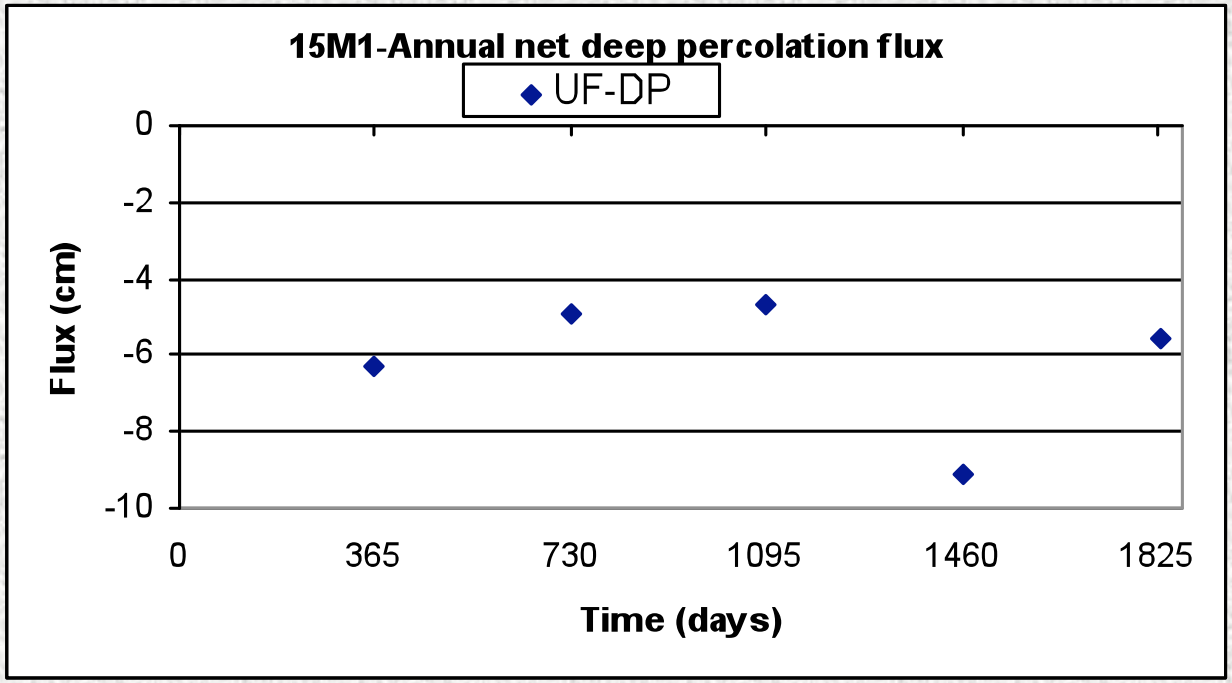


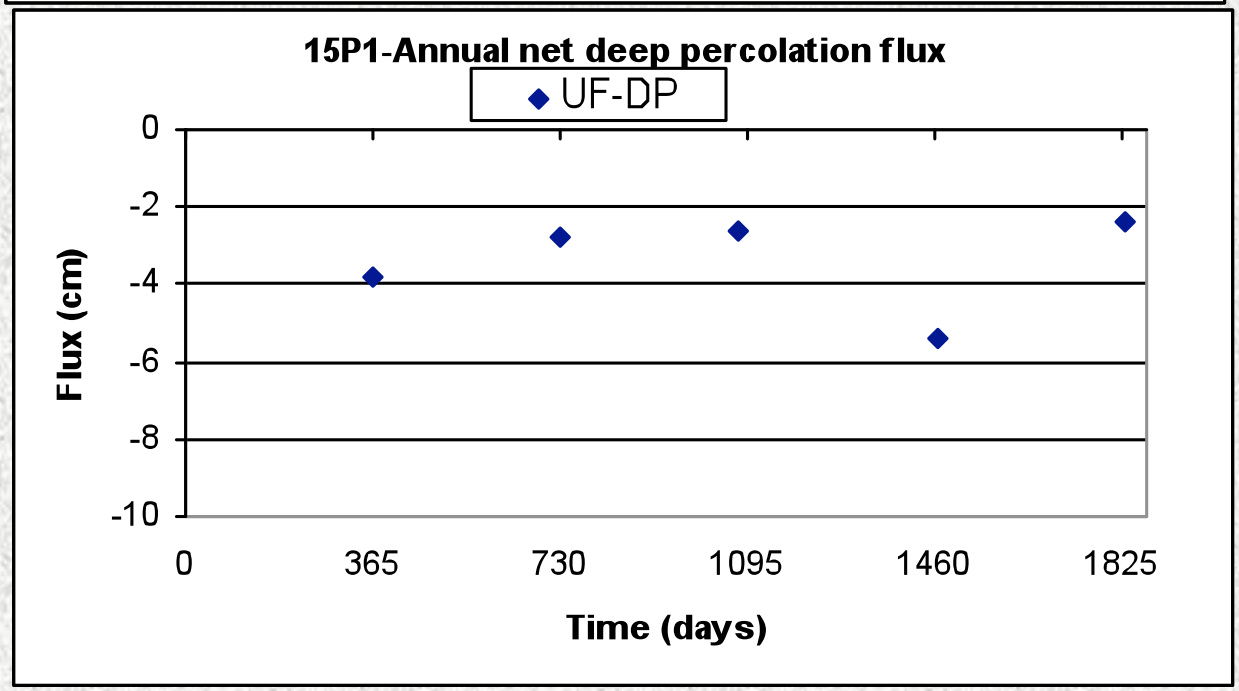

15M1-Cumulative Fluxes
CPI
CT
CBF
CE
CSC
150
100
50
0
-50
-100
Cumulative Flux (cm)
0
365
730
1095
1460
1825
Time (days)


15P1-Cumulative Fluxes
CPI
CT
CBF
CE
CSC
150
100
50
0
-50
-100
Cumulative Flux (cm)
0
365
730
1095
1460
1825
Time (days)

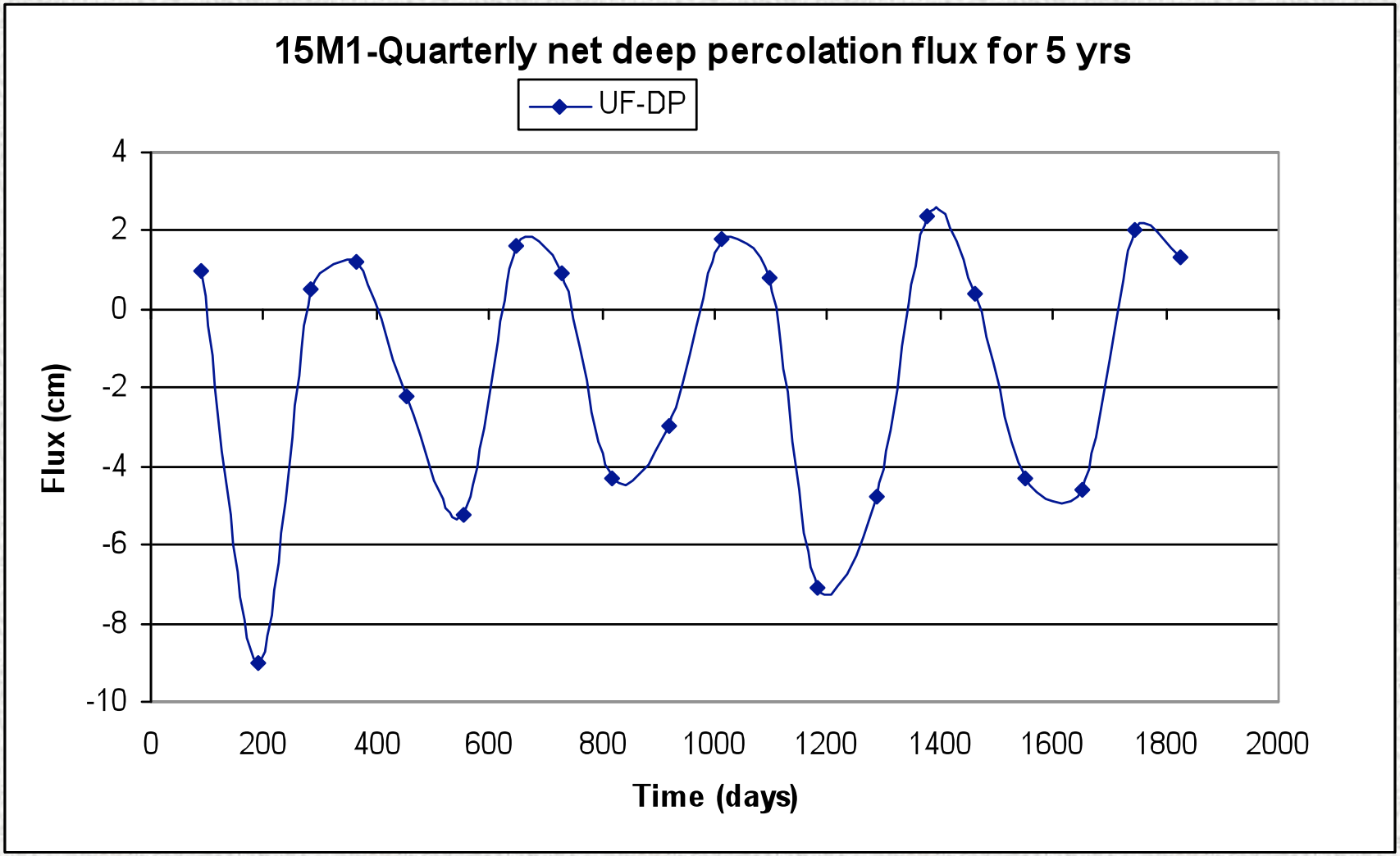

15M1-EC profile
365 day
730 day
1096 day
1461 day
1827 day
0
-100
-200
-300
-400
-500
Depth (cm)
0
10
20
30
40
50
60
EC (dS/m)

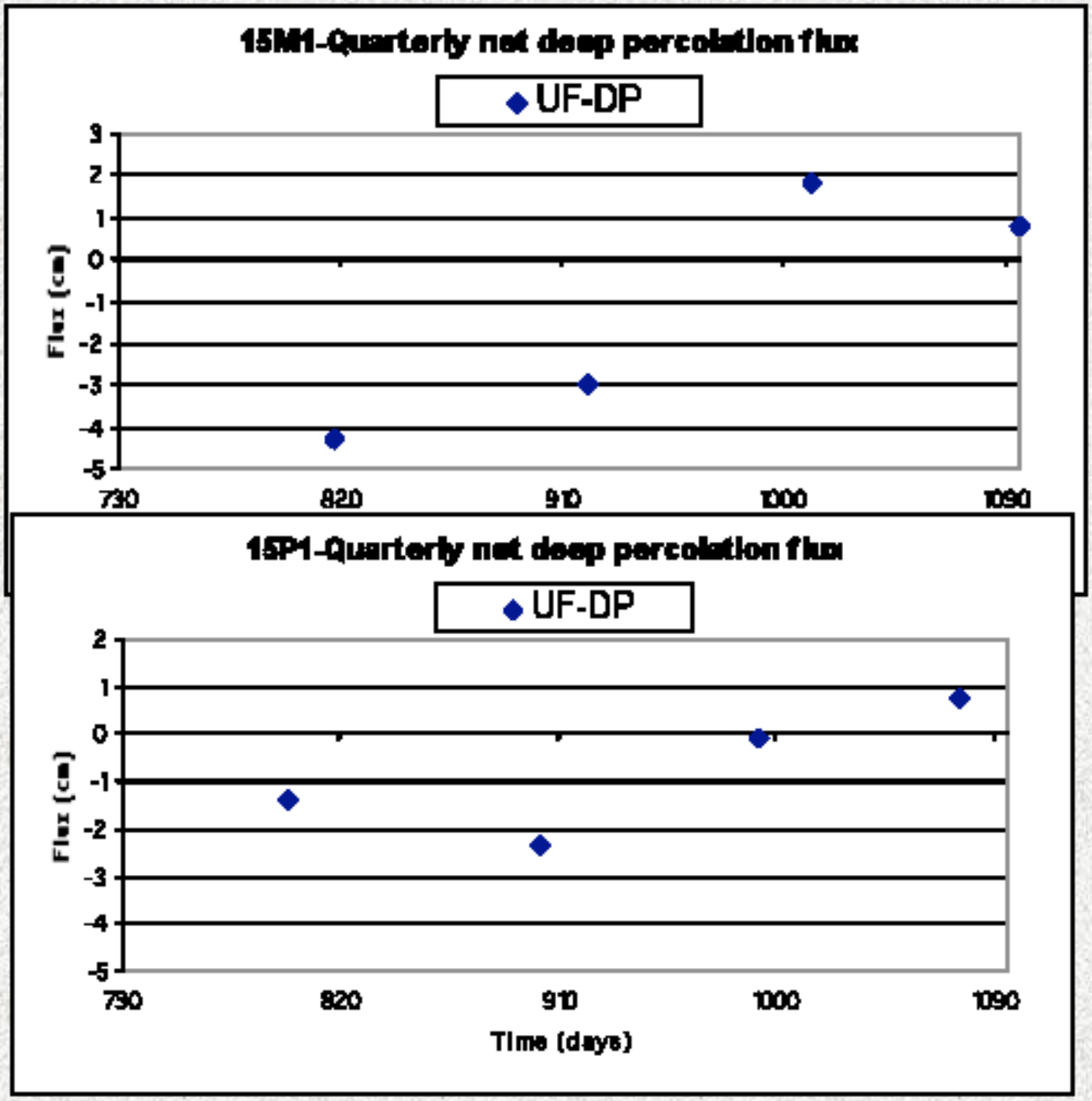

15P1-EC profile
365 day
730 day
1096 day
1461 day
1827 day
0
-100
-200
-300
-400
-500
Depth (cm)
0
5
10
15
20
25
30
EC (dS/m)

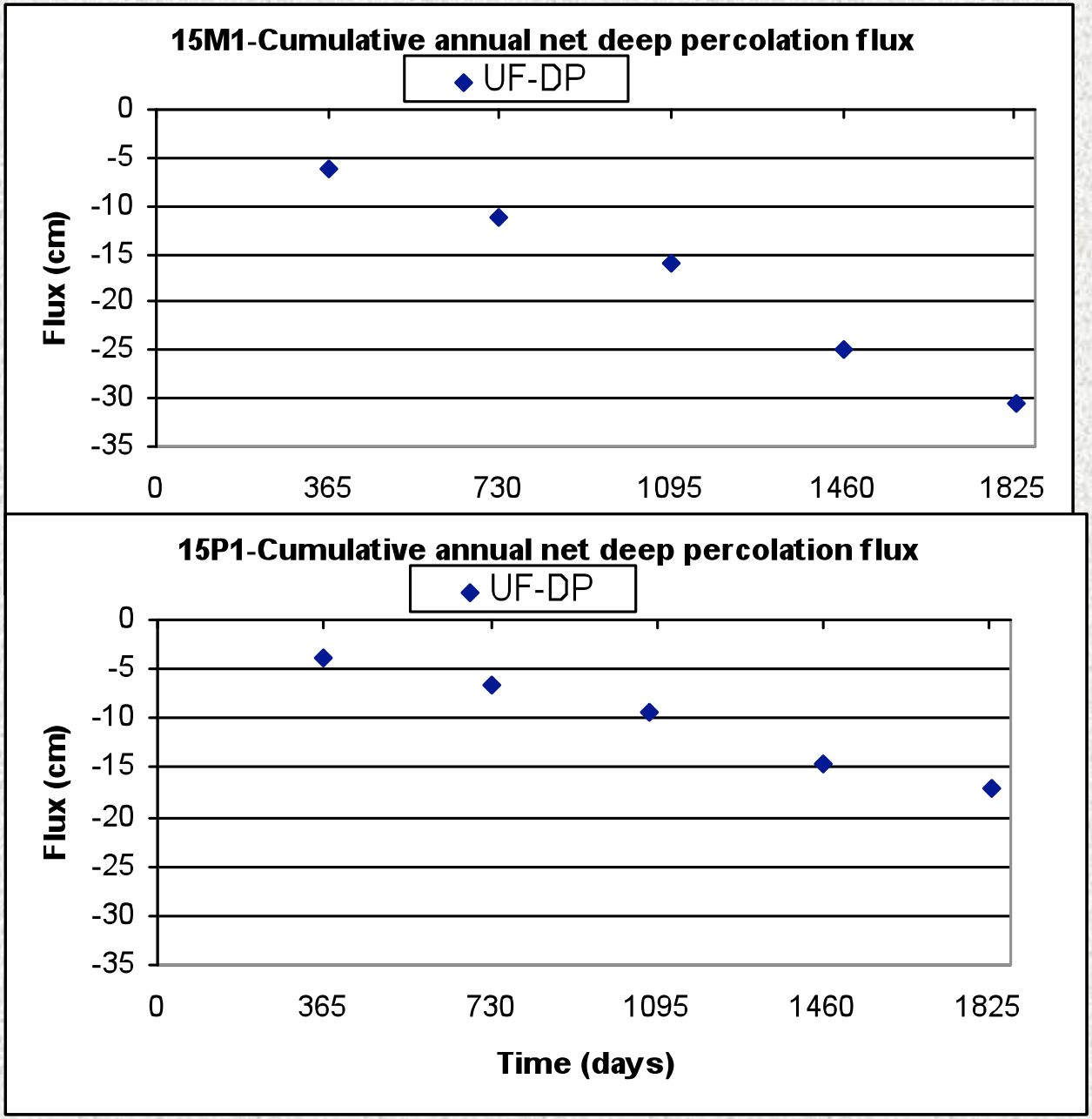

15M1-Annual net deep percolation flux
UF-DP
0
-2
-4
-6
-8
-10
Flux (cm)
0
365
730
1095
1460
1825
Time (days)


15P1-Annual net deep percolation flux
UF-DP
0
-2
-4
-6
-8
-10
Flux (cm)
0
365
730
1095
1460
1825
Time (days)

Root zone control volume




15M1-Quarterly net deep percolation flux
UF-DP
Flux (cm)
3
2
1
0
-1
-2
-3
-4
-5
730
820
910
1000
1090
15P1-Quarterly net deep percolation flux
UF-DP
Flux (cm)
2
1
0
-1
-2
-3
-4
-5
730
820
910
1000
1090
Time (days)


15M1-Cumulative annual net deep percolation flux
UF-DP
Flux (cm)
0
-5
-10
-15
-20
-25
-30
-35
0
365
730
1095
1460
1825
15P1-Cumulative annual net deep percolation flux
UF-DP
Flux (cm)
0
-5
-10
-15
-20
-25
-30
-35
0
365
730
1095
1460
1825
Time (days)

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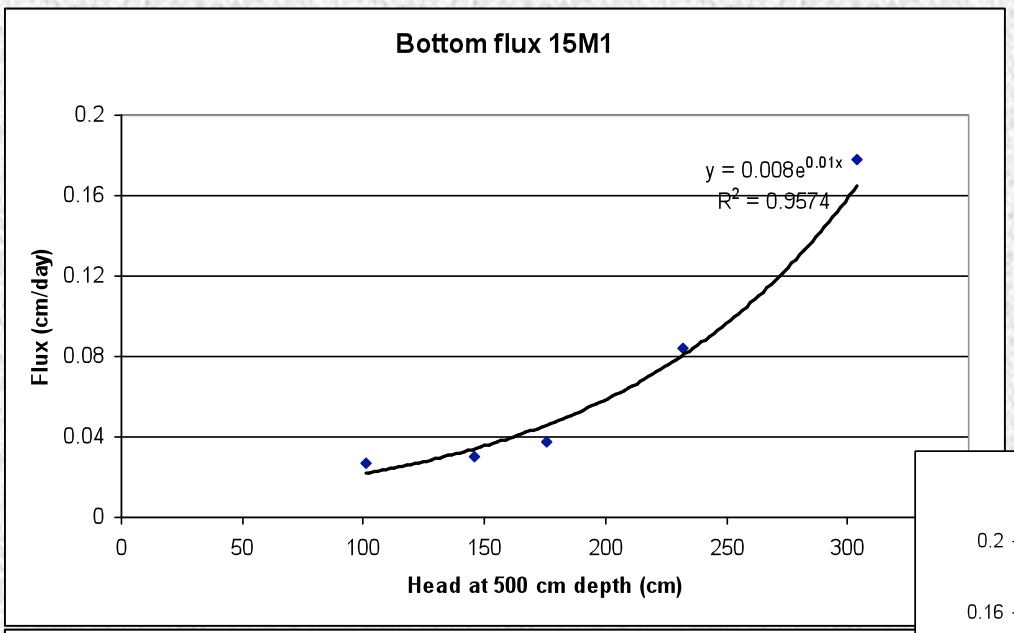
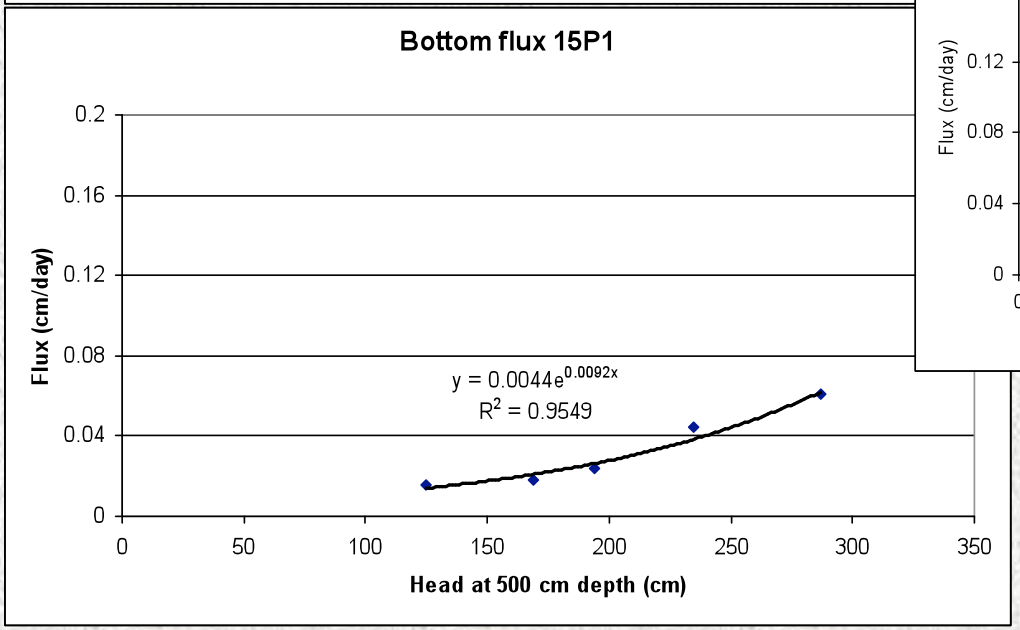
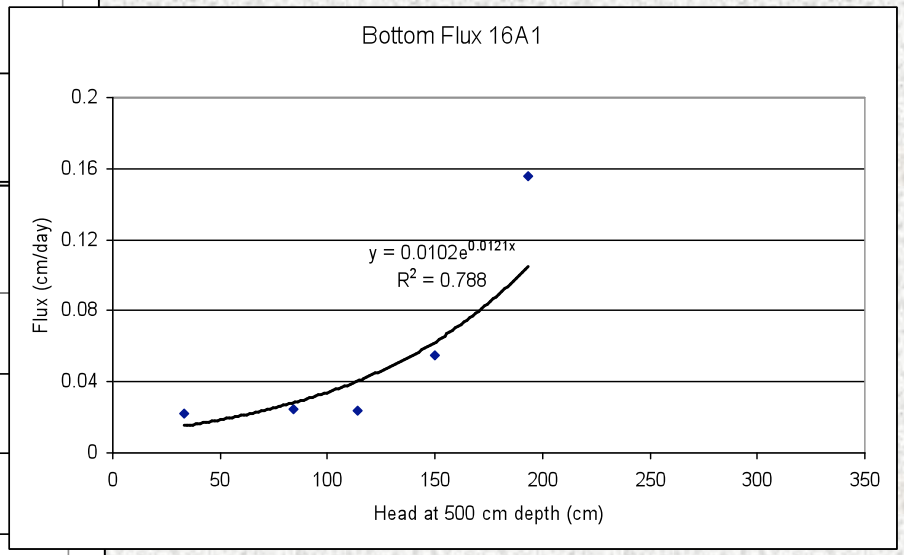
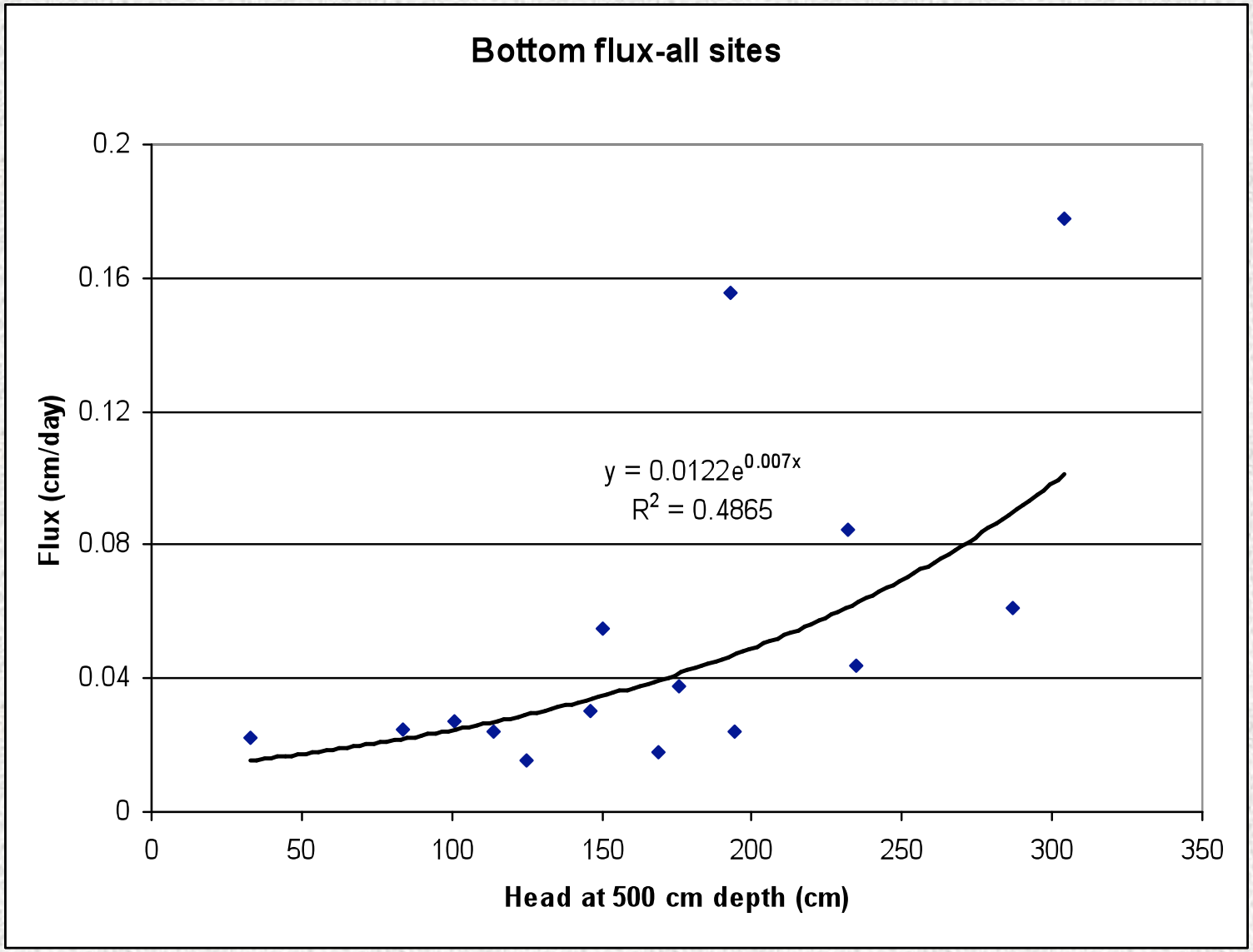
- **Sustainability and groundwater attenuation**

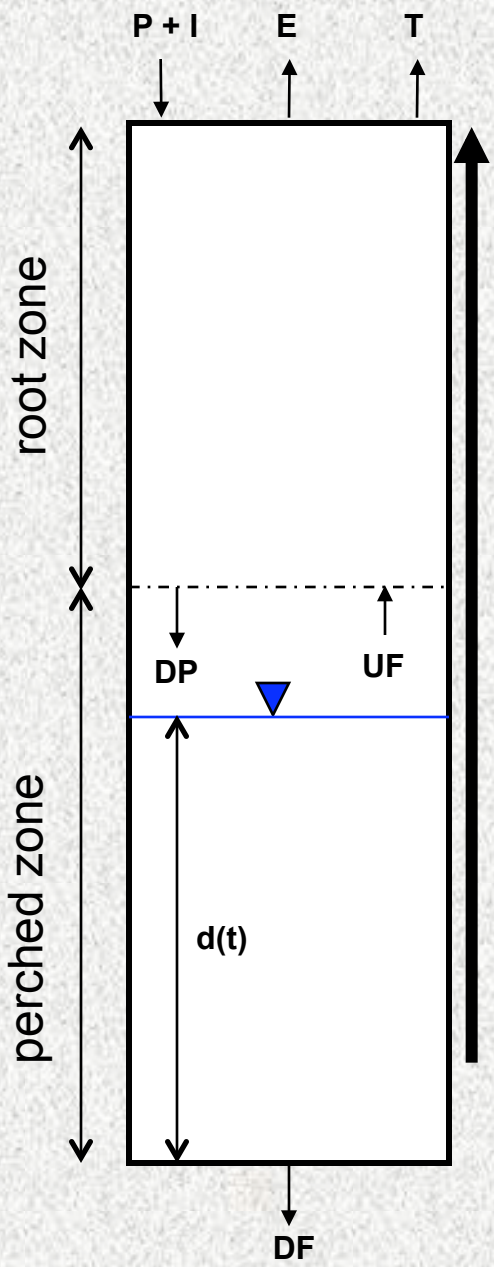

Bottom flux 15M1
Flux (cm/day)
0.2
0.16
0.12
0.08
0.04
0
0
50
100
150
200
250
300
Head at 500 cm depth (cm)
y = 0.008e^0.01x
R^2 = 0.9574


Bottom flux 15P1
Flux (cm/day)
0.2
0.16
0.12
0.08
0.04
0
0
50
100
150
200
250
300
350
Head at 500 cm depth (cm)
y = 0.0044e^0.0092x
R^2 = 0.9549


Bottom Flux 16A1
Flux (cm/day)
0.2
0.16
0.12
0.08
0.04
0
0
50
100
150
200
250
300
350
Head at 500 cm depth (cm)
y = 0.0102e^0.0121x
R^2 = 0.788


Bottom flux-all sites
Flux (cm/day)
0.2
0.16
0.12
0.08
0.04
0
y = 0.0122e^0.007x
R^2 = 0.4865
0
50
100
150
200
250
300
350
Head at 500 cm depth (cm)

Conclusion



Check salt balance in root zone for sustainability

Chose P+I-E-T=(DP-UF)

If d does not change (DP-UF)=DF

DF(d(t)) = downward flux below perched zone

A bottom up approach

Thank You!