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Vadose-zone Monitoring as a key to Groundwater Protection and Optimization of Remediation Strategies

Sponsored by: USEPA Technology Innovation & Field Services Division

Delivered: April 07, 2010, 1:00 PM - 3:00 PM, EDT (17:00-19:00 GMT)

Instructor:
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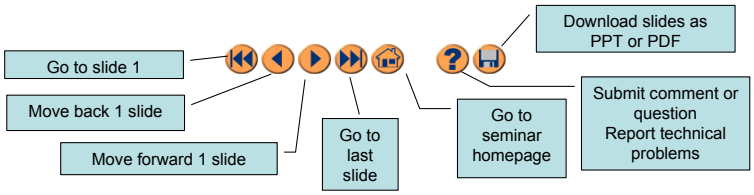

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Although I'm sure that some of you have these rules memorized from previous CLU-IN events, let's run through them quickly for our new participants.

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You should note that throughout the seminar, we will ask for your feedback. You do not need to wait for Q&A breaks to ask questions or provide comments. To submit comments/questions and report technical problems, please use the ? Icon at the top of your screen. You can move forward/backward in the slides by using the single arrow buttons (left moves back 1 slide, right moves advances 1 slide). The double arrowed buttons will take you to 1st and last slides respectively. You may also advance to any slide using the numbered links that appear on the left side of your screen. The button with a house icon will take you back to main seminar page which displays our agenda, speaker information, links to the slides and additional resources. Lastly, the button with a computer disc can be used to download and save today's presentation materials.

With that, please move to slide 3.

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Vadose-zone Monitoring System

key to groundwater protection and optimization of remediation strategies

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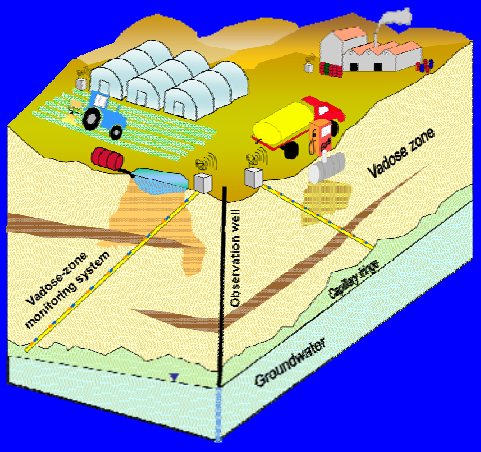

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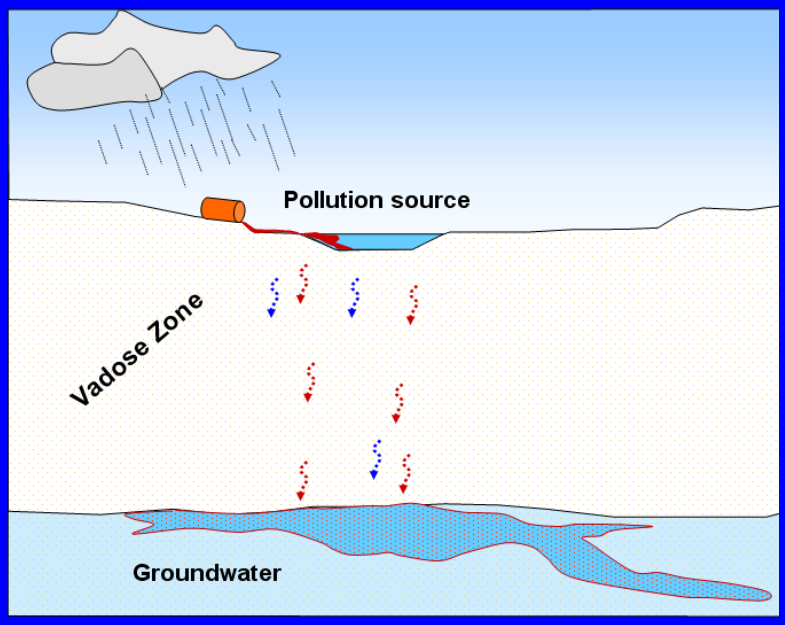
Subsurface pollution



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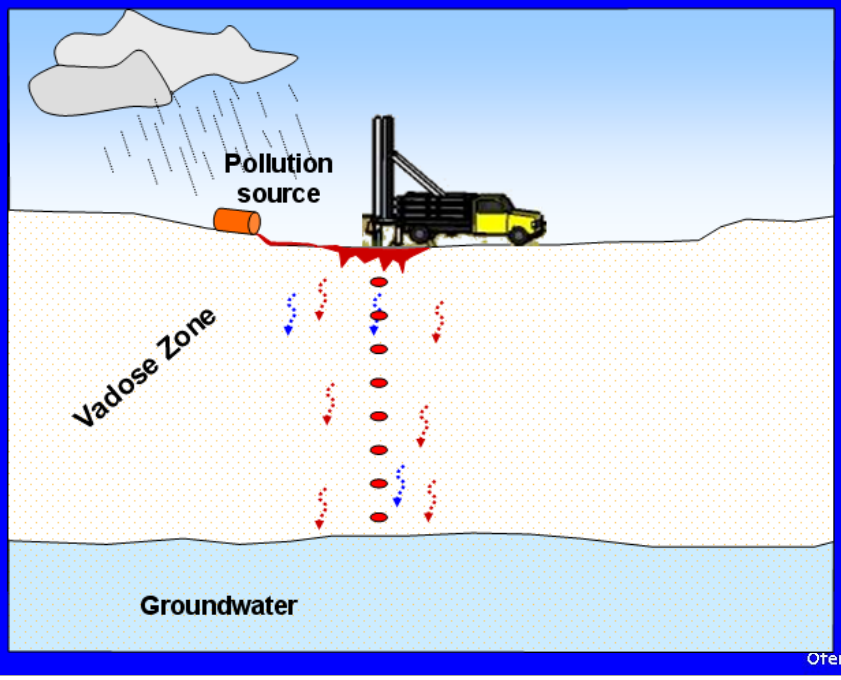
Site characterization



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Profiles- a snap shot in time of dynamic processes

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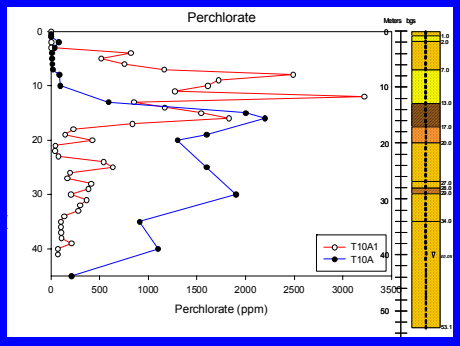

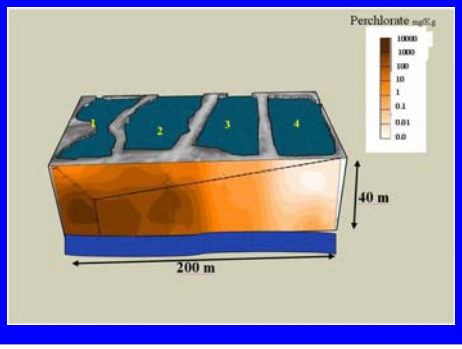

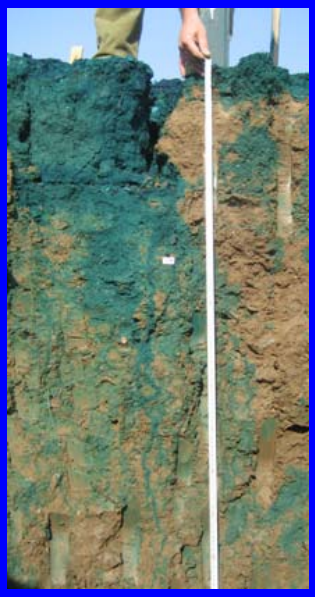

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Groundwater monitoring through observation wells

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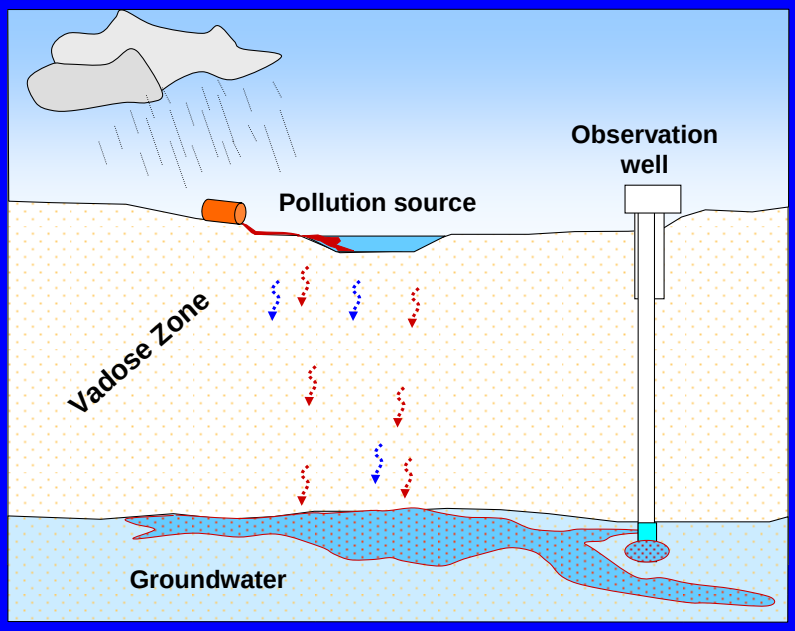

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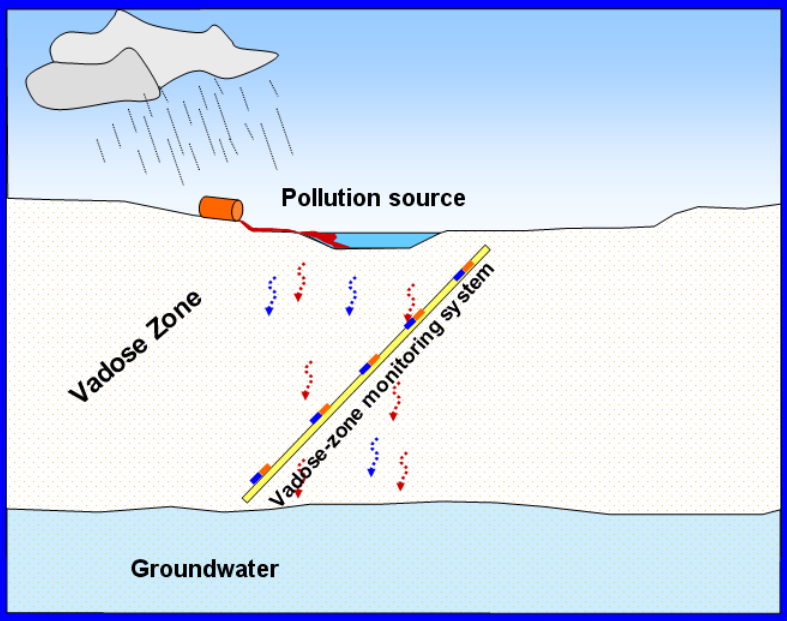
Direct monitoring of water flow and contaminant transport through the vadose zone



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3-D representation of a vadose zone monitoring system

Ashdod – Coastal plain, Israel

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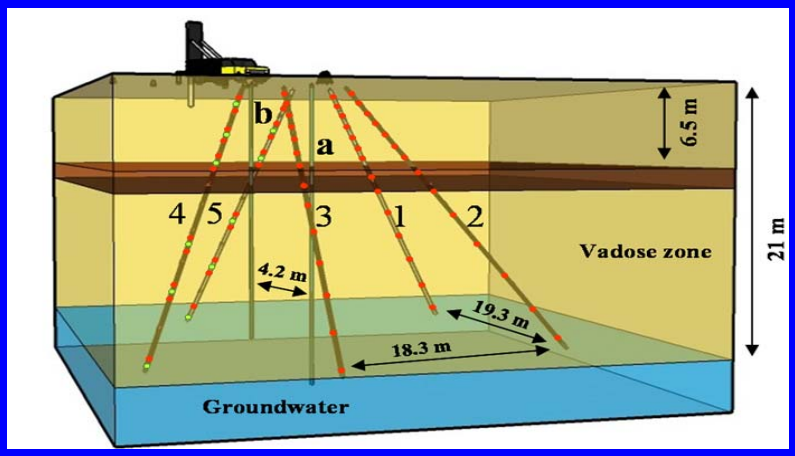

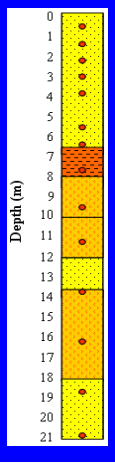

Sand (sand>90%, clay<5%)
Sandy clay (72%<sand<82%, 9%<clay<15%)
Clay (50% sand, 23% clay)

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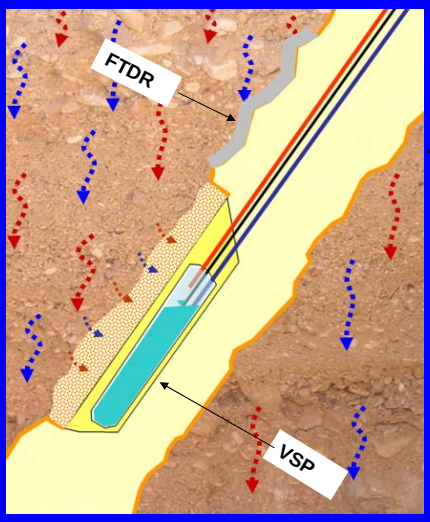
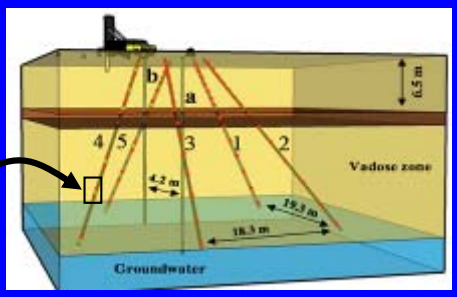
Vadose zone Monitoring System - VMS

Sampling unit





VMS installation

*Patents pending

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Preparation

Installation

Monitoring

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VADOSE ZONE MONITORING SYSTEM

Designed to provide:

Continuous real-time information on the hydraulic and chemical properties of the percolating water in deep vadose zone through in-situ measurements of natural undisturbed conditions

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VMS application in projects on water percolation and contaminant transport through the vadose zone

Natural rain water infiltration through sand dunes

Waste water infiltration from contaminated stream channels

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VMS application in projects on water percolation and contaminant transport through the vadose zone

Agricultural setups

Orchard

Open field crop

Green house

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VMS application in projects on water percolation and contaminant transport through the vadose zone

Flood water infiltration

Water infiltration from reservoirs

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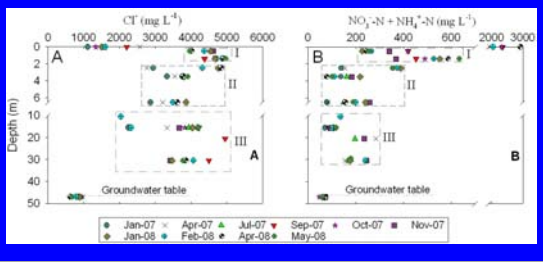
VMS application in projects on water percolation and contaminant transport through the vadose zone

Diary farm influence on groundwater



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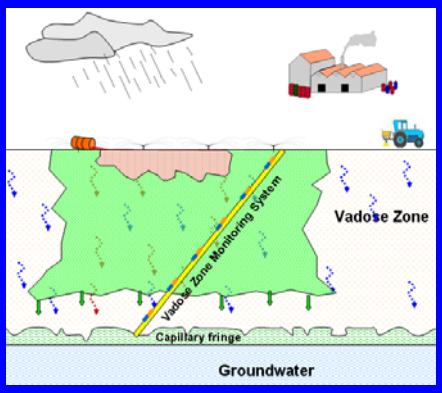
VMS application in projects on water percolation and contaminant transport through the vadose zone

Controlled remediation of contaminated vadose zone



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Floodwater Percolation and Groundwater Recharge in Arid Lands

Dahan et al., 2007. Journal of Hydrology
Dahan et al., 2008. Groundwater
Dahan et al., 2009. Vadose zone Journal

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Kuiseb River, Namibia

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Monitoring of floodwater percolation and groundwater recharge in arid lands – Kuiseb River, Namibia

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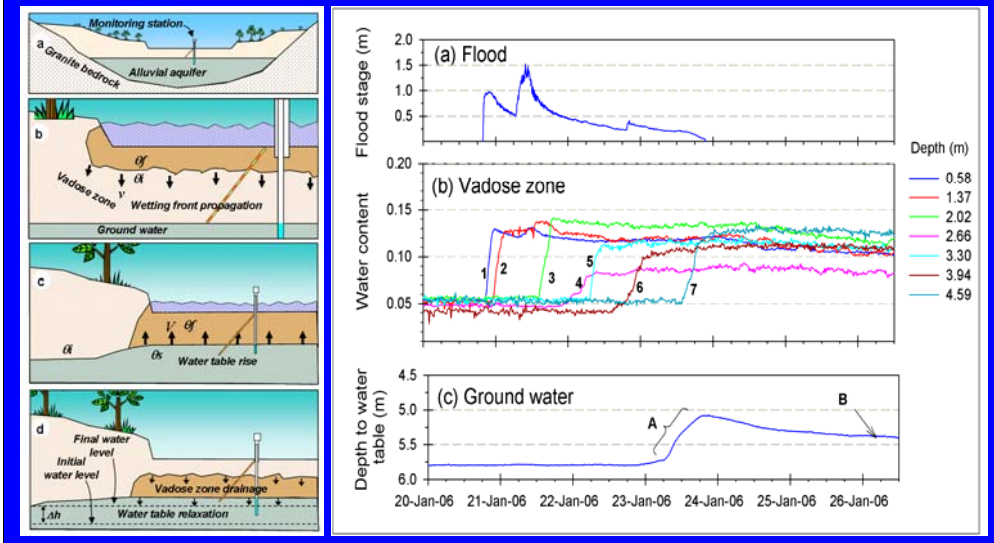

Dahan et al., 2008. Groundwater
Morin et al., 2009. J of Hydrology

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Flood water percolation during sequential floods-Kuiseb River - Namibia

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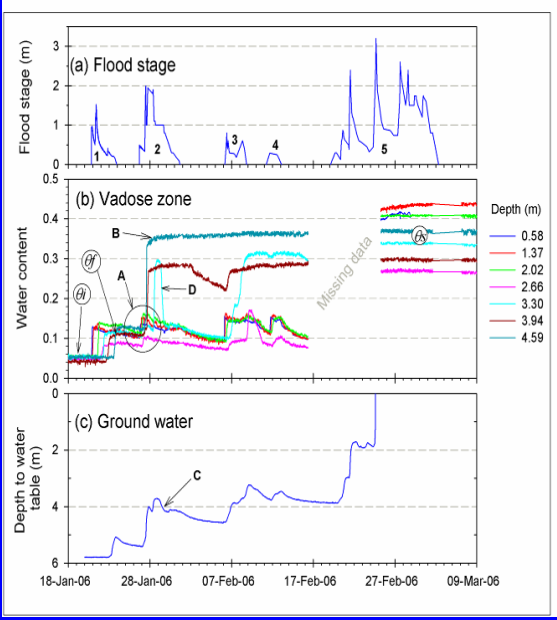

Calculated recharge fluxes for all floods by various methods

Calculation method	Calculated flux for sequential floods (cm h^{-1})				
	1st	2nd	3rd	4th	5th
Wetting-front propagation in the vadose zone	1	0.9	1.5	0.7	
Water-table rising rate	1.4	1.38	0.57	0.39	1.05
Increase in ground-water storage	0.71	0.91	0.83		

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Infiltration from reservoirs

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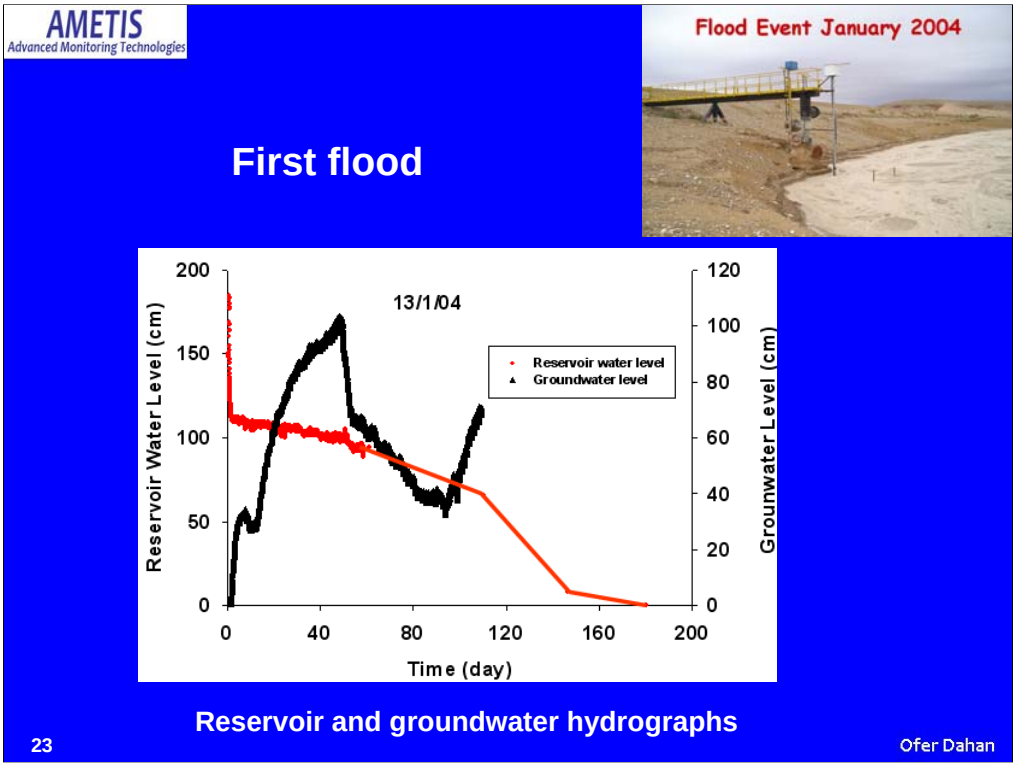


כעת אעבור לתוצאות משני ארועי שיטפון שנמדדו בתחנת TZ1 .

הראשון בינואר 2004.

על פי ההידרוגרף באדום אפשר לראות שתוך יומיים מכניסת מים למאגר מפלס המאגר ירד ב 75 ס"מ.

לאחר יומיים קצב ירידת מפלס המאגר תואם את קצב ההתאדות הפוטנציאלית אשר מתגבר לעבר חודשי הקיץ

כלומר אחרי יומיים אין כניסת מים מלמעלה

על כן קצב ירידת המפלס גדל בהתאם.

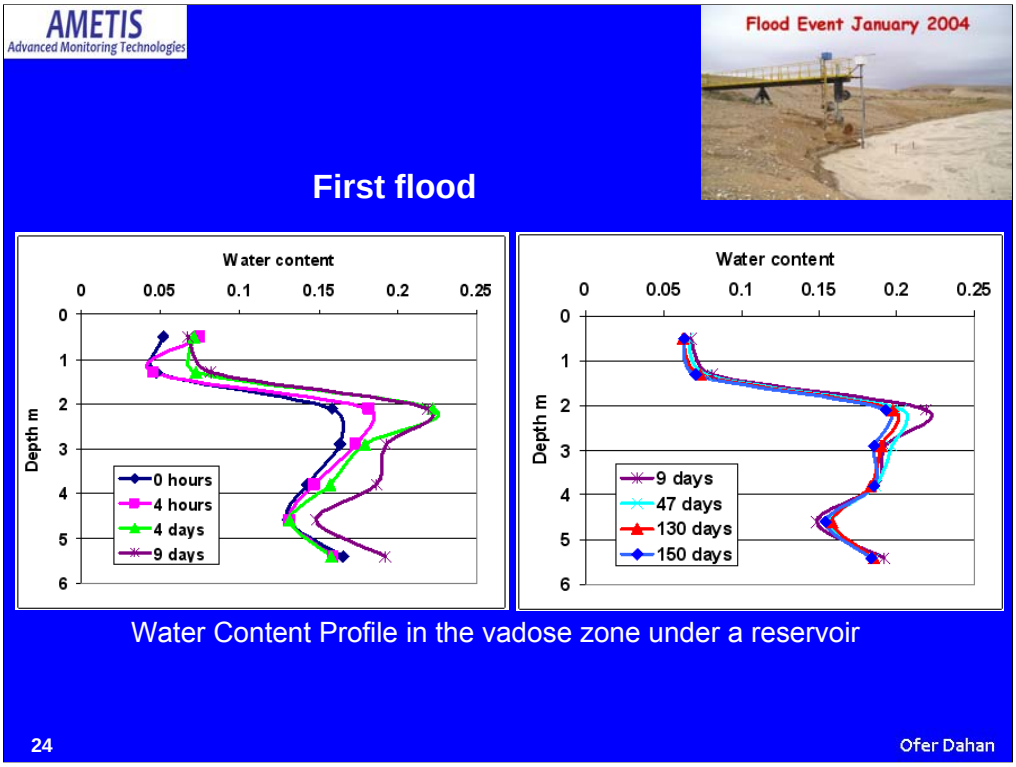
עלית מפלס מי התהום בשחור מצביעה על עלייה של מעל 50 ס"מ במפלס כתוצאה ישירה של חידור מי השיטפון

ולאחר מכן ישנה עלייה משמעותית נוספת.

אנו משערים שכמו שהוצג בשיטפון בעין יהב,

גם כאן ישנה עליה כתוצאה מהגעת מי שיטפון שחילחלו במעלה הנחל והגיעו בזרימה אופקית איטית יותר.

את הנפילה הגדולה אפשר להסביר כתגובת המפלס לשאיבות ממשאבות צופר 5 ו 15 אשר ממוקמות בקרבה.



החתך באזור המאגר מאופיין ע"י שכבות חוליות וחצציות וביניהן שכבות דקות של חומר דק גרגר בדומה לאזור עין יהב,

כשבעומק 2.5 מטרים ישנו מטר של חומר חרסיתי יותר.

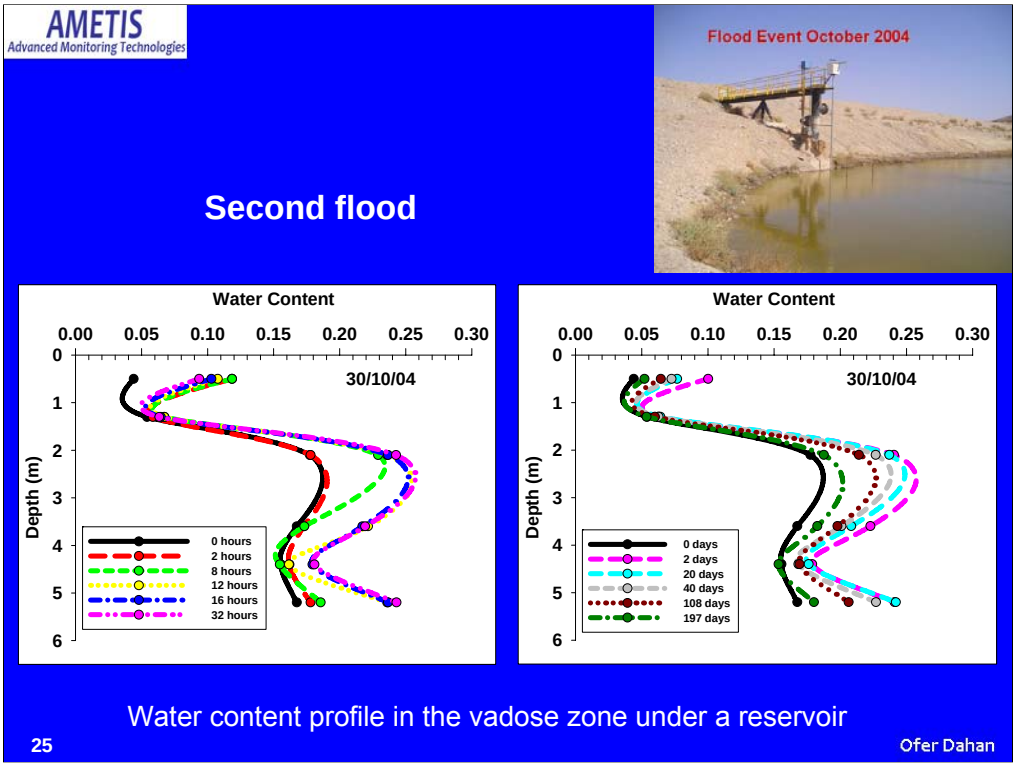
בחלק שמכיל יותר חרסית השינויים בתכולת הרטיבות גדולים יותר מאשר חלקים אחרים.

השינויים נעים מחצי אחוז ועד 7 אחוזים.

זמן ההרטבה הגיע ל 9 ימים ואילו זמן הניקוז נמשך מעל חצי שנה.

אולם הניקוז החל לאחר ימים ספורים הרבה לפני שהמאגר התרוקן ולכן הדבר מחזק את הטענה שנראתה מנתוני מפלס המאגר.

לאחר זמן קצר המאגר מפסיק לתפקד כ מאגר חידור והופך למאגר איבוד מים.



פרופיל הקרקע הורטב עם כניסת השיטפון למאגר תוך כ 30 שעות עד לעומק של 5.5 מטרים.
שוב השינוי ברטיבויות נע בין חצי אחוז ל 7 אחוזים. עוד עדות לזרימה מועדפת בעומק 4.4 מטרים.
התנקזות החתך החלה לאחר ימים בודדים ונמשכה יותר מחצי שנה.

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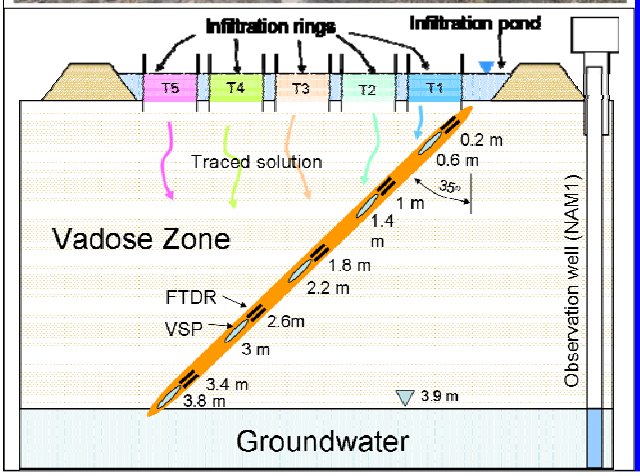
Silt & clay accumulation on the bottom an infiltration reservoir as a consequence of a single flood event



Water percolation and solute transport through layered heterogeneous sediments

Dahan et al., 2009. Vadose zone Journal.

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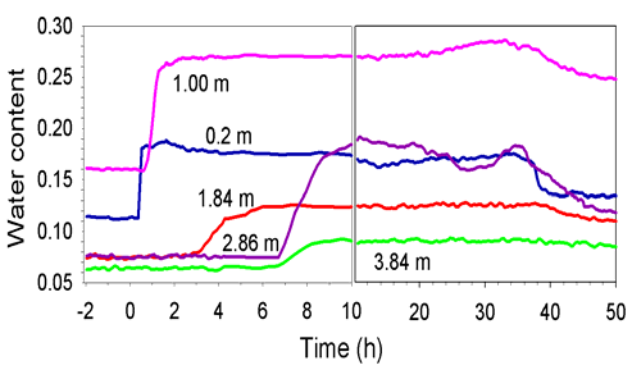
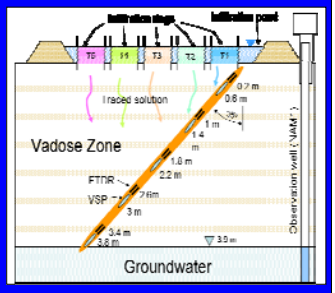
Water percolation and solute transport through layered heterogeneous sediments

Water content variation





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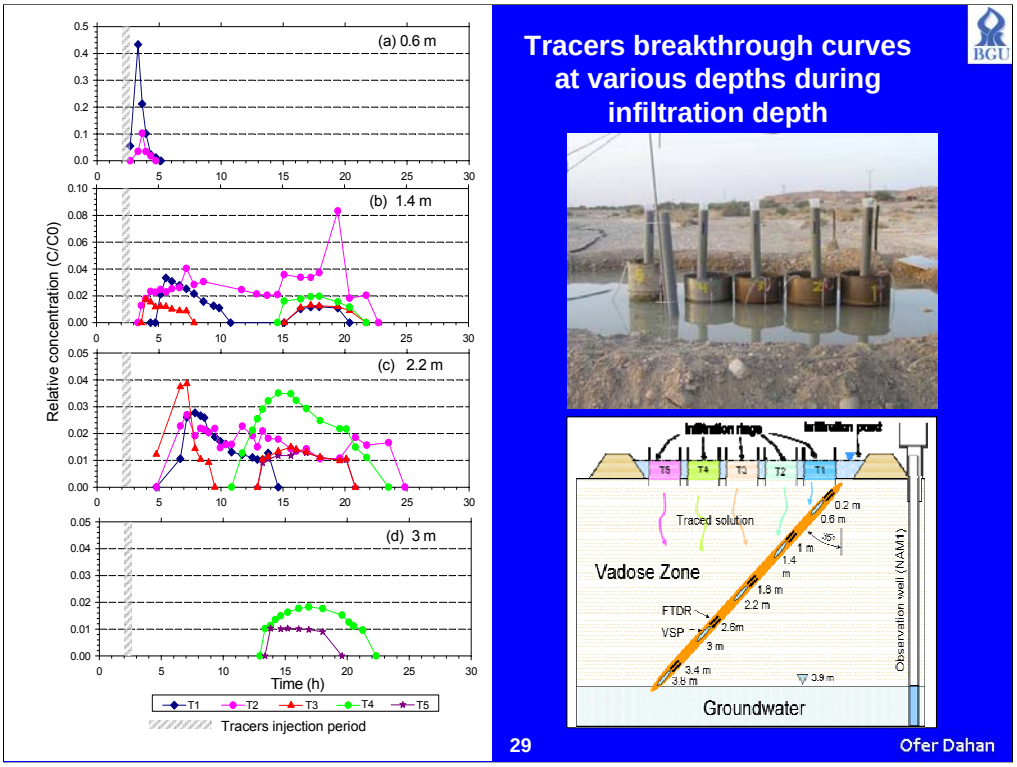
Tracers breakthrough curves at various depths during infiltration depth
(a) 0.6 m
(b) 1.4 m
(c) 2.2 m
(d) 3 m
Relative concentration (C/C0)
Time (h)
T1
T2
T3
T4
T5
Tracers injection period
Infiltration ridge
Infiltration pond
Traced solution
Vadose Zone
FTDR
VSP
Observation well (NAM1)
Groundwater
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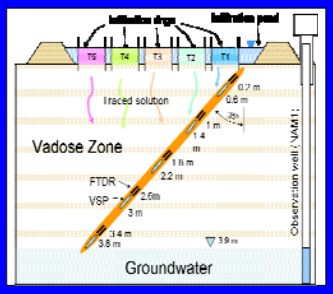
Flux rate measured through the wetting sequence of the FTDR probes in the vadose zone

Probe depth (m)	$\Delta\theta$ (%)	Velocity, v (m/h)	*Flux, q* (m/h)
0.2	0.07	0.24	0.017
1	0.11	3.56	0.384
1.8	0.05	0.30	0.014
2.6	0.03	0.23	0.006
3.4	0.11	2.34	0.258

Average vertical flow velocity of tracers across the vadose zone

Sampling depth (m)	Velocity, v (m/h)
0.60	0.41
1.40	0.83
2.23	0.72
3.00	0.26



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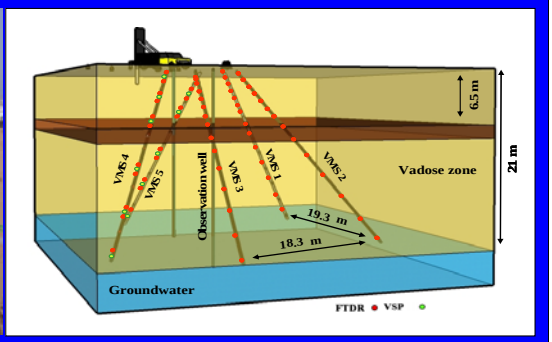
Water Percolation Through Deep Vadose Zone

Field installation

3-D representation of the monitoring setup



Rimon et al., 2007: Water percolation through the deep vadose zone and groundwater recharge: preliminary results based on a new vadose-zone monitoring system. Water Resources Research.

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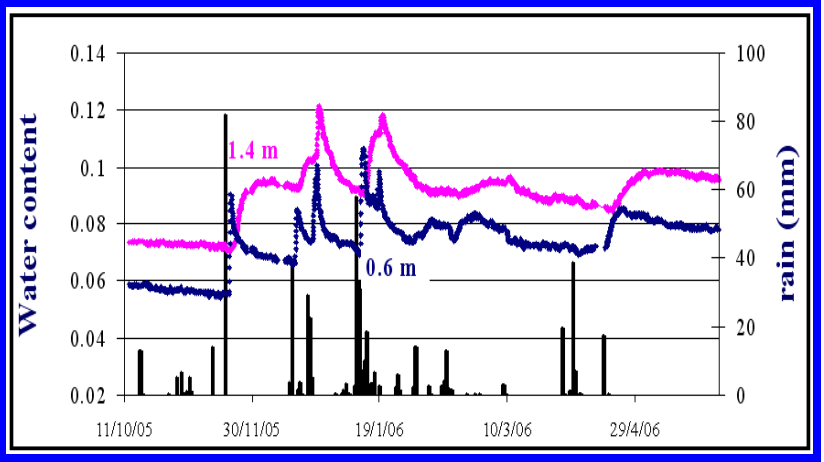
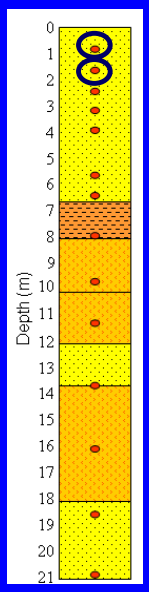
Water content variation due to rain induced infiltration events across a 21m thick vadose zone





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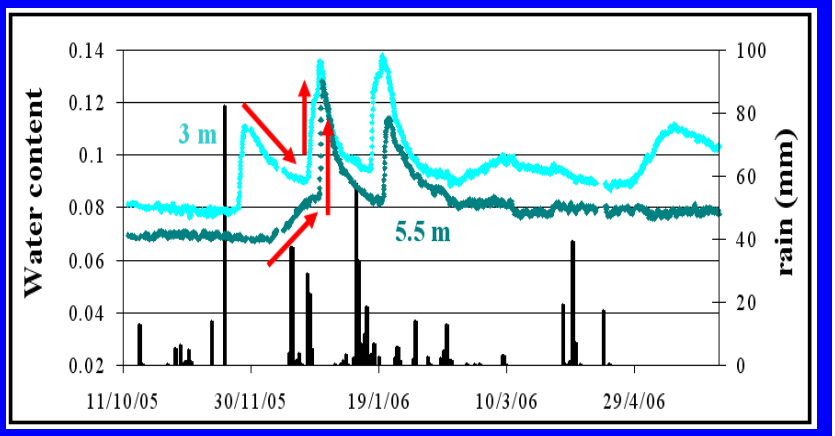
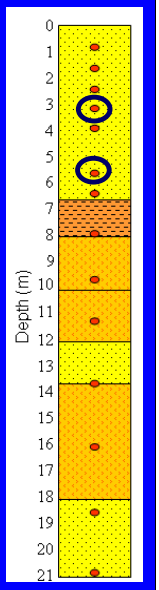
Water content variation due to infiltration events across a 21m thick vadose zone





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Water content variation due to infiltration events across a 21m thick vadose zone

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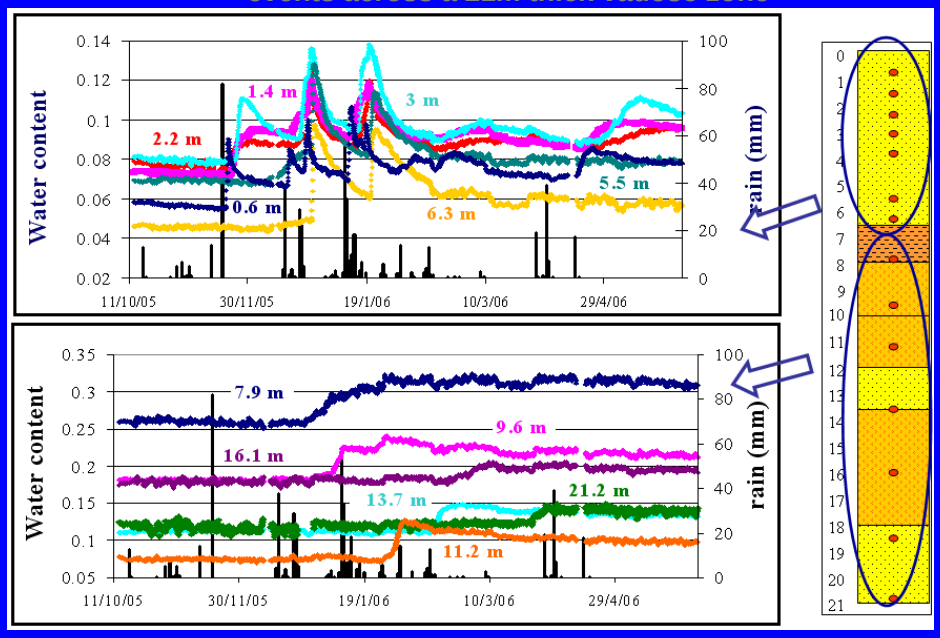

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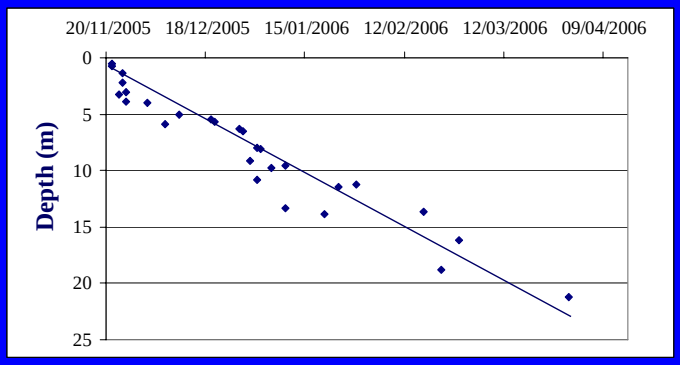
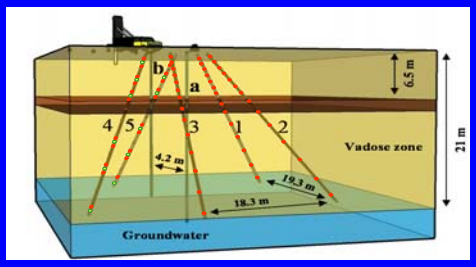
Wetting front propagation across the vadose zone





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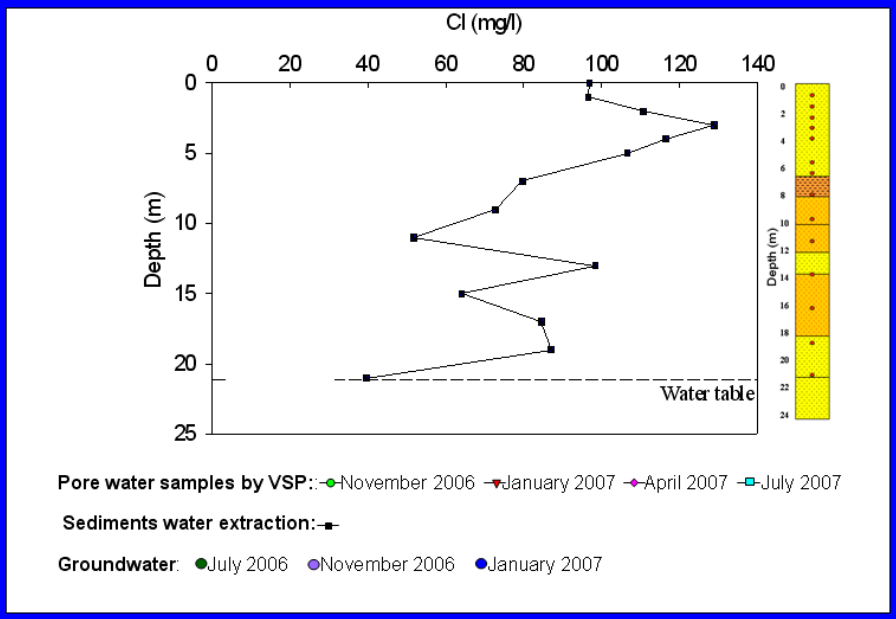
Chloride profiles



Pore water samples by VSP: November 2006 January 2007 April 2007 July 2007

Sediments water extraction:

Groundwater: July 2006 November 2006 January 2007

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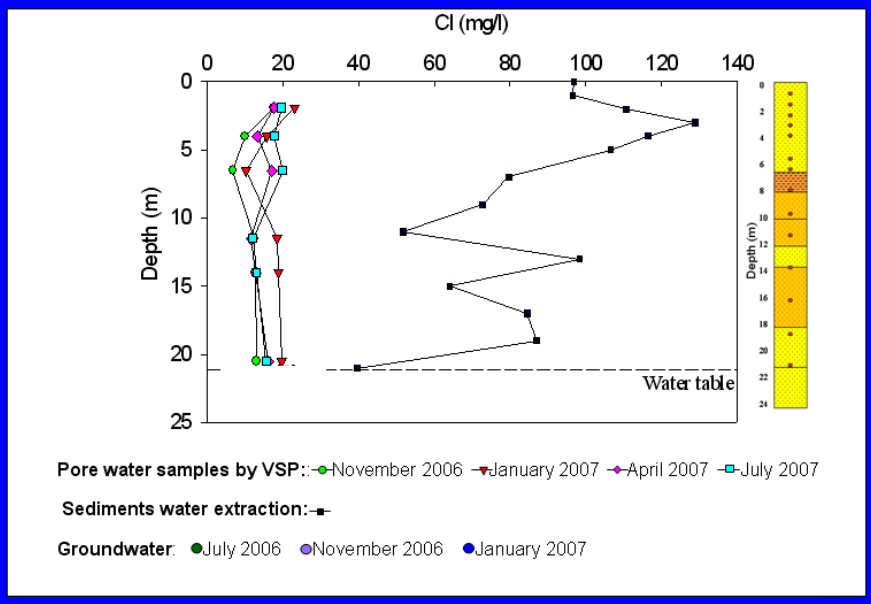
Chloride profiles



Pore water samples by VSP:-November 2006 -January 2007 -April 2007 -July 2007

Sediments water extraction:-

Groundwater: July 2006 November 2006 January 2007

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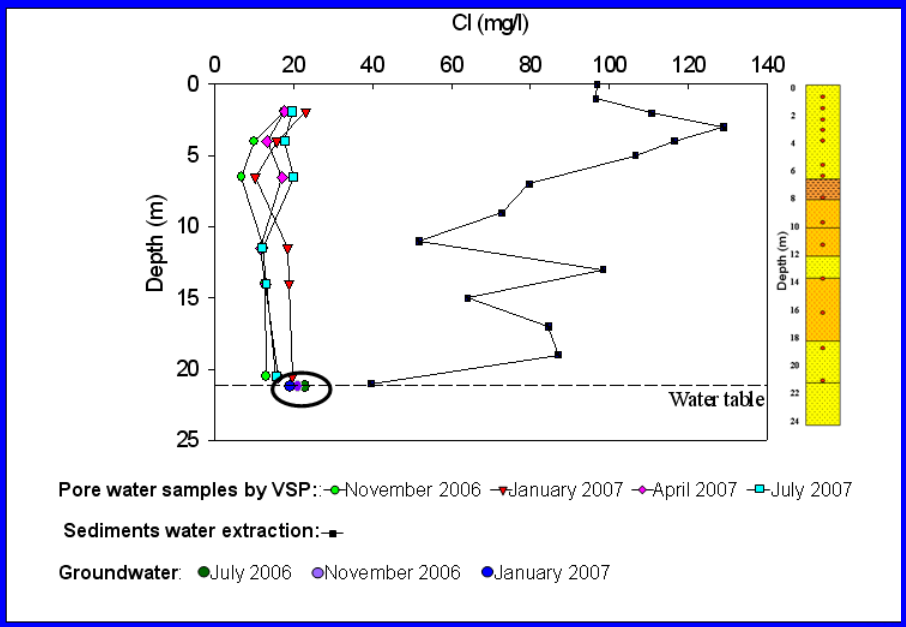
Chloride profiles



Pore water samples by VSP: November 2006 January 2007 April 2007 July 2007

Sediments water extraction:

Groundwater: July 2006 November 2006 January 2007

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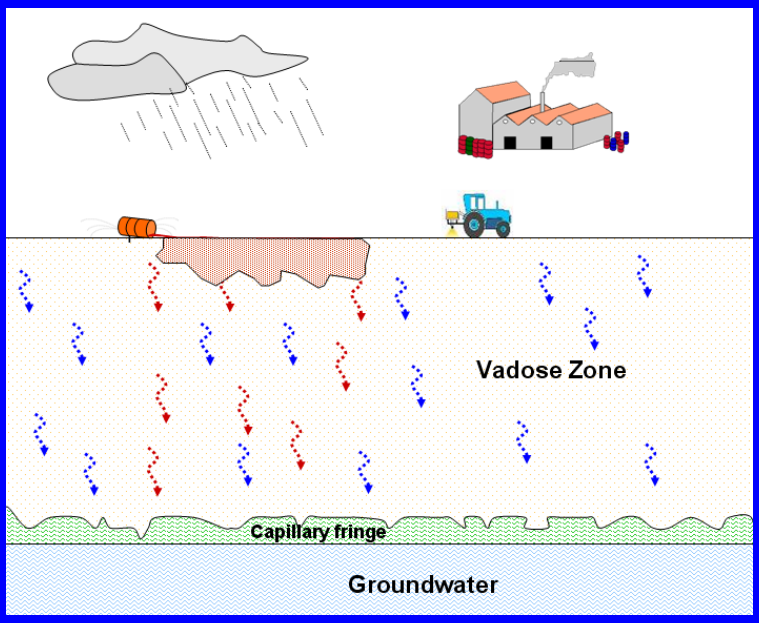
Bioremediation of polluted vadose zone



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Bioremediation of polluted vadose zone

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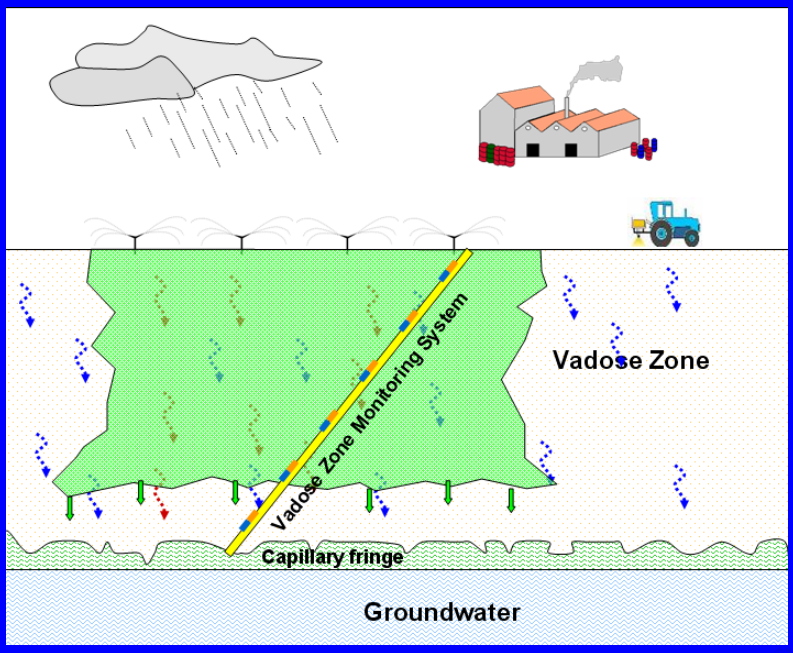

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Bioremediation of polluted vadose zone underlying a gas station

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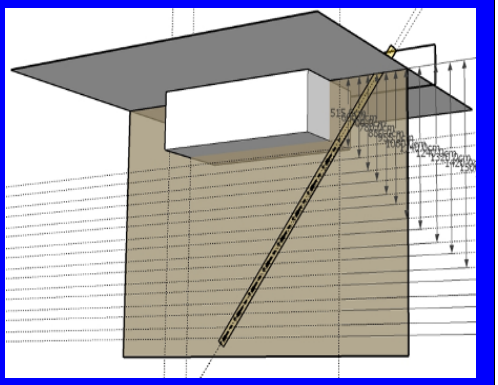
Excavation of contaminated top soil

3-D representation of the remediated site



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Control panel

VMS installation

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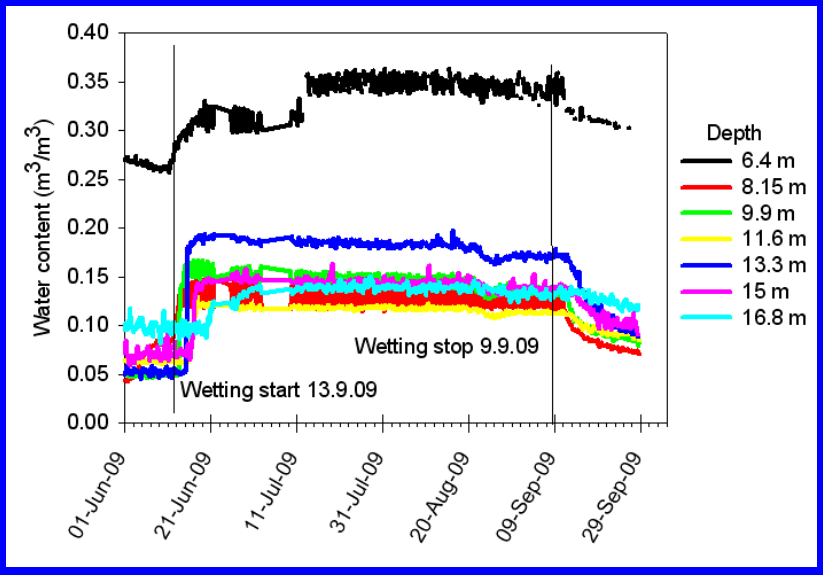
Water content variations with depth during wetting process



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VOC concentration in the vadose zone pore water during wetting process

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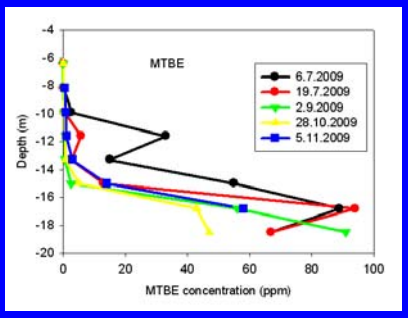

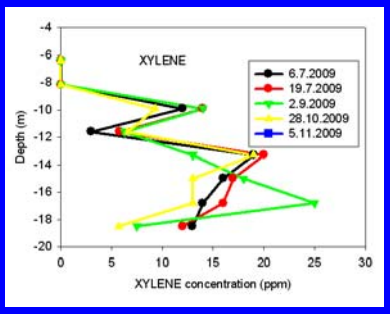

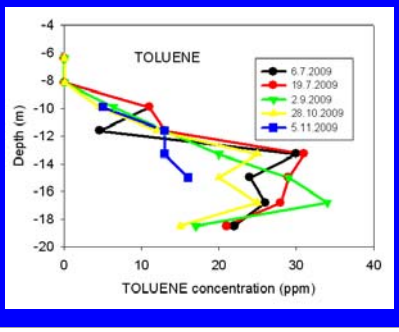

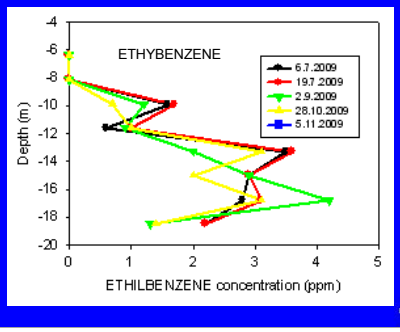

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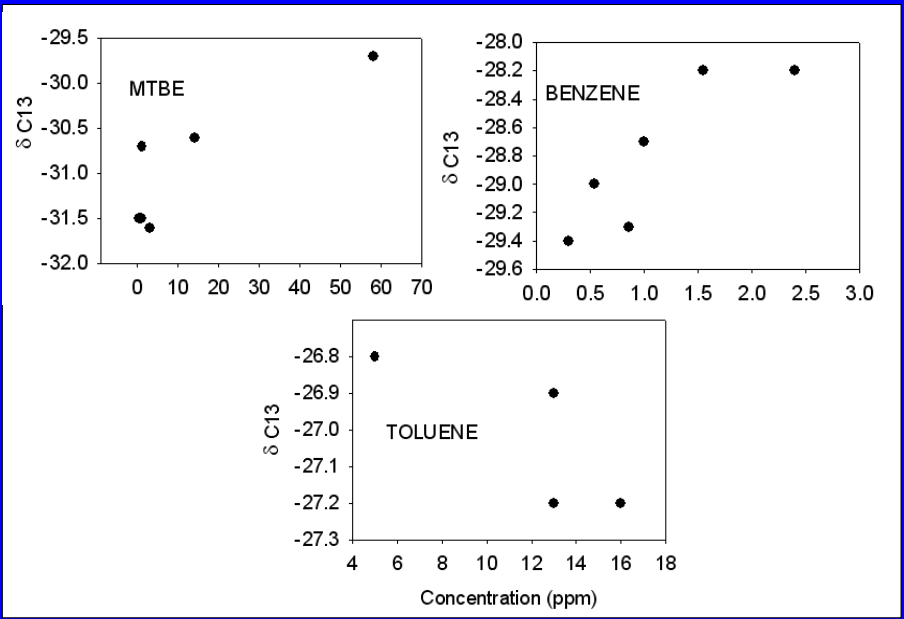
Isotopic composition of selected VOCs



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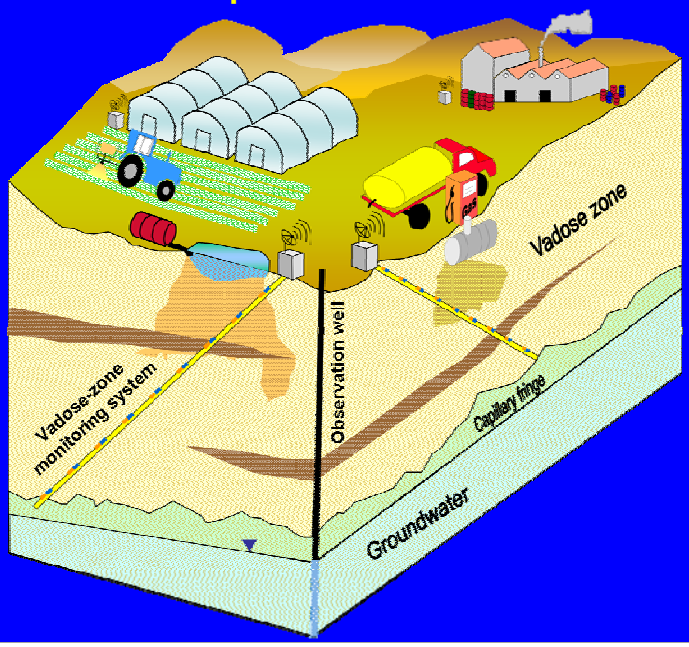
Continuous monitoring of flow and transport in the vadose zone



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Potential monitoring application

- Leaches under **LANDFILLS**
- Fuel leaks from **GAS STATIONS**
- Leaks **HAZARDOUS WASTE** from tanks, storage lagoons and sensitive factories of potential pollution
- On line monitoring and control of **REMRDIATION** efficiency

*** The monitoring system may be installed under existing active facilities with minimal disturbance**

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Thanks

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