Significance of ^{18}o and Hydrochemical Composition to Characterize Water Dynamics in Hyporheic Zone of Yamuna River Flood Plains in Delhi Area

PROF. P. S. DATTA

Indian Agricultural Research Institute

New Delhi – 110012, India

e-mail: dattapsdsd@rediffmail.com

and

Dr. S. Kumar

National Institute of Hydrology , Roorkee

Presented on 2nd May, 2011, at BAKU, Vienna, Austria

GENESIS OF THE STUDY

In Delhi, water demand and anthropogenic wastes increased due to rapid growth in population, urbanization, and industrial activities.

The Yamuna River meets about one-fifth of Delhi's water requirement .

Unused surplus monsoon discharge: ~ 4000 MCM (four times the annual water supply).

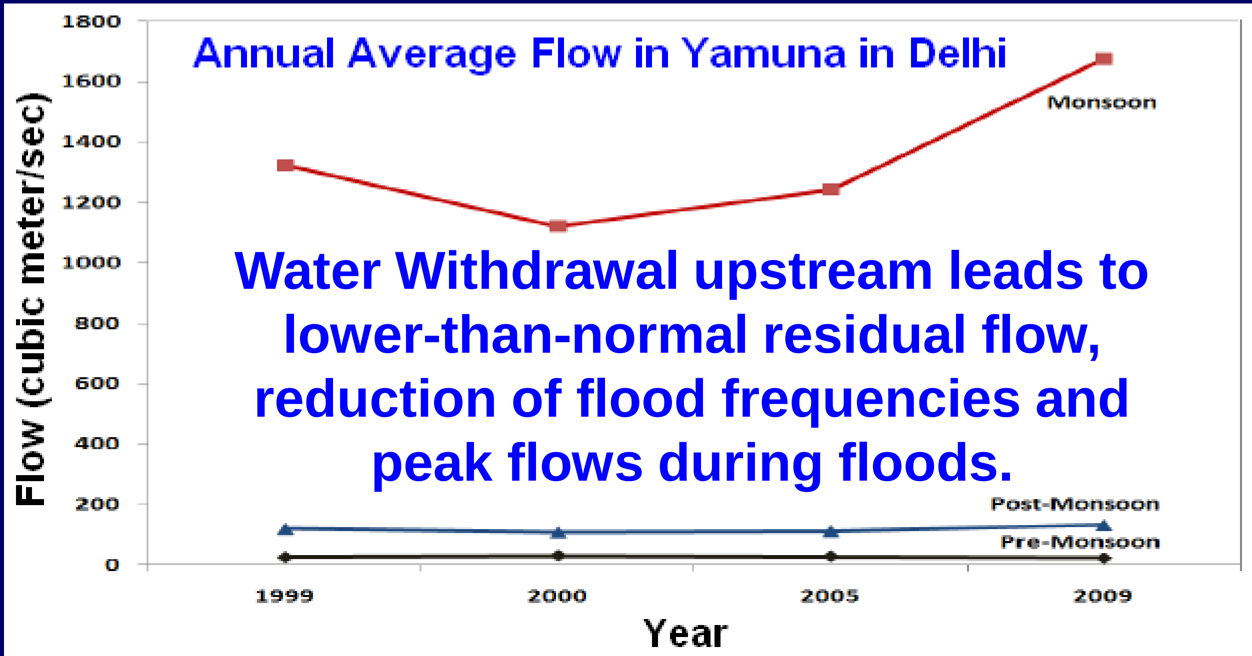
During floods, enhanced water exchange occurs between river and GW in the river flood plains.

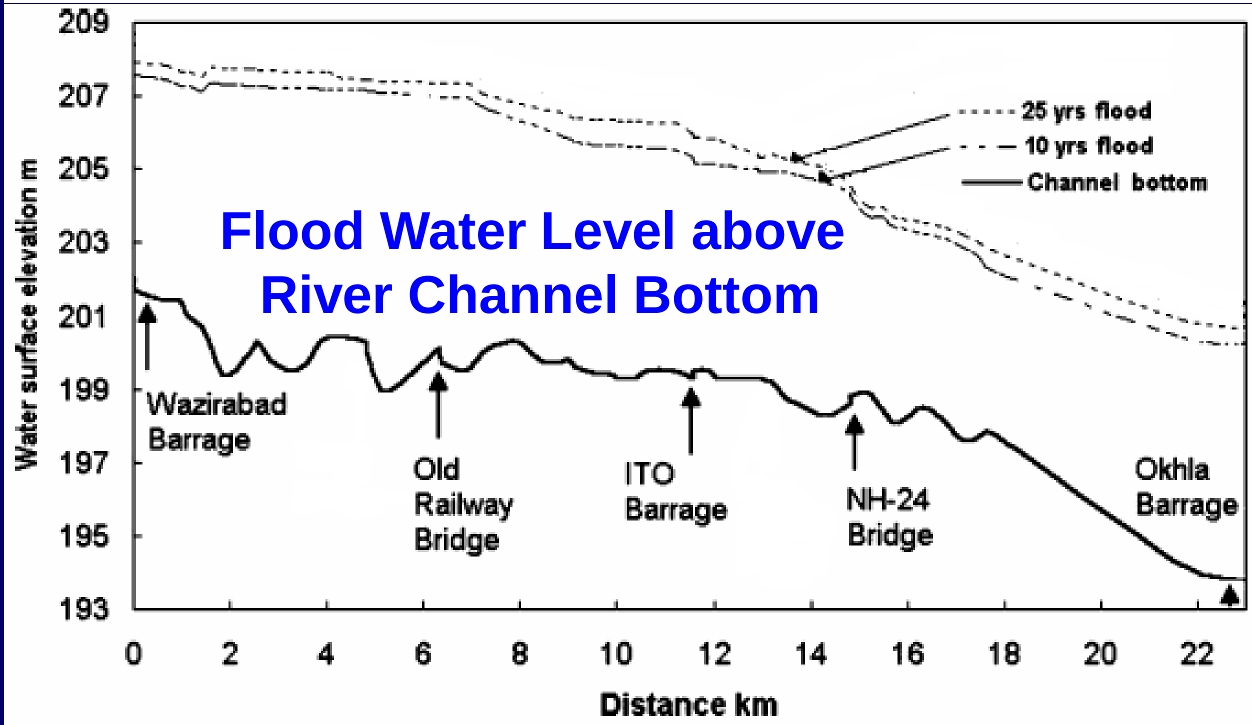
Hence, scope exists to restore the GW recharge under the floodplains via the hyporheic zone.

RECENT CONCERNS

Sewage generated: 3800 MLD.
Sewage discharged untreated in Yamuna: 1500 MLD.

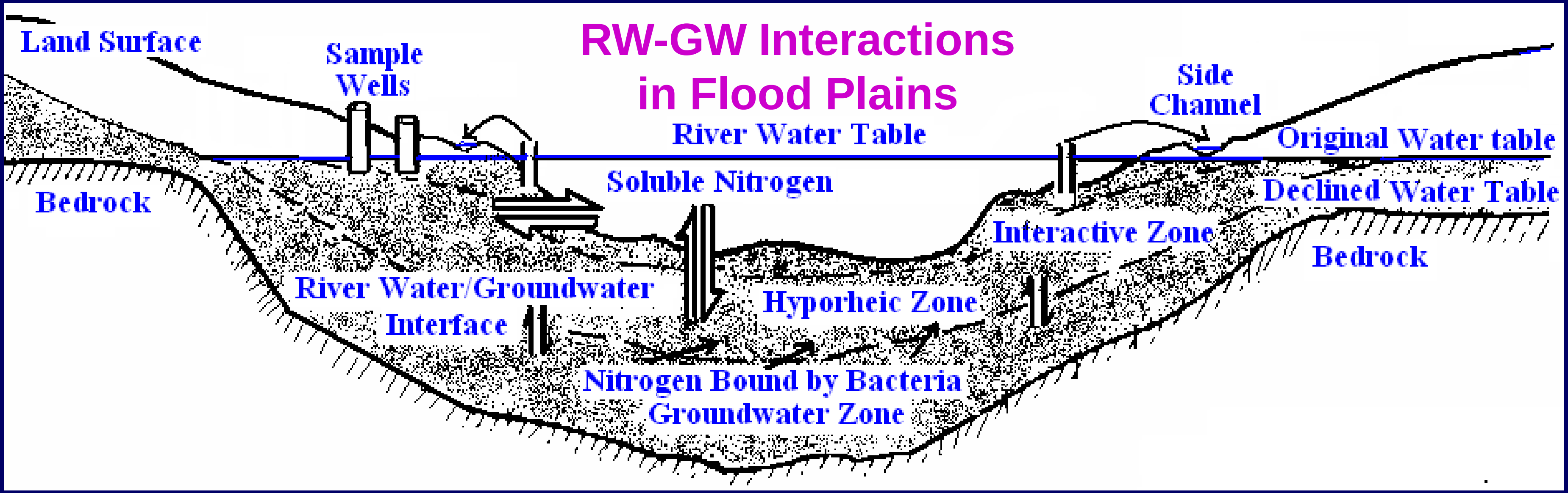
R. Yamuna & GW along the Delhi stretch are vulnerable to pollution.





SYMPTOMS OF THE PROBLEM

Uncontrolled Flood flow cause adverse effect on the YFP recharge & ecosystem.



Suggested Solution:

Assess the extent of hyporheic zone and GW Recharge.
Pump out GW below the flood plain before arrival of flood.
Allow the flood water to get soaked in the hyporheic zone.

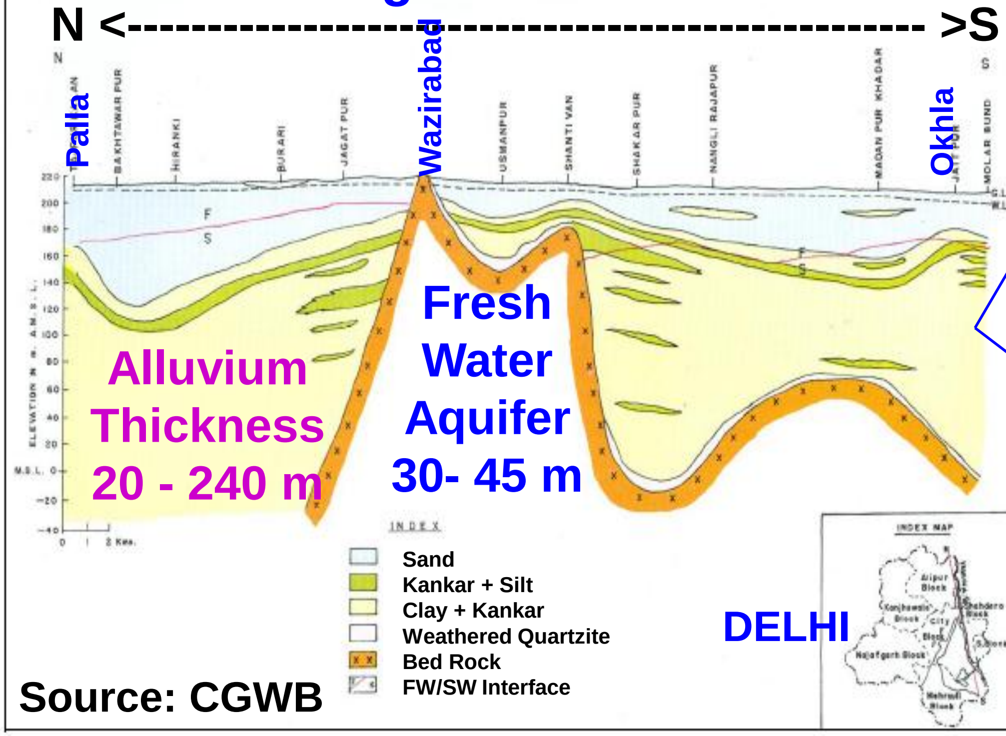
To Manage Flood Water & Protect Ecology.

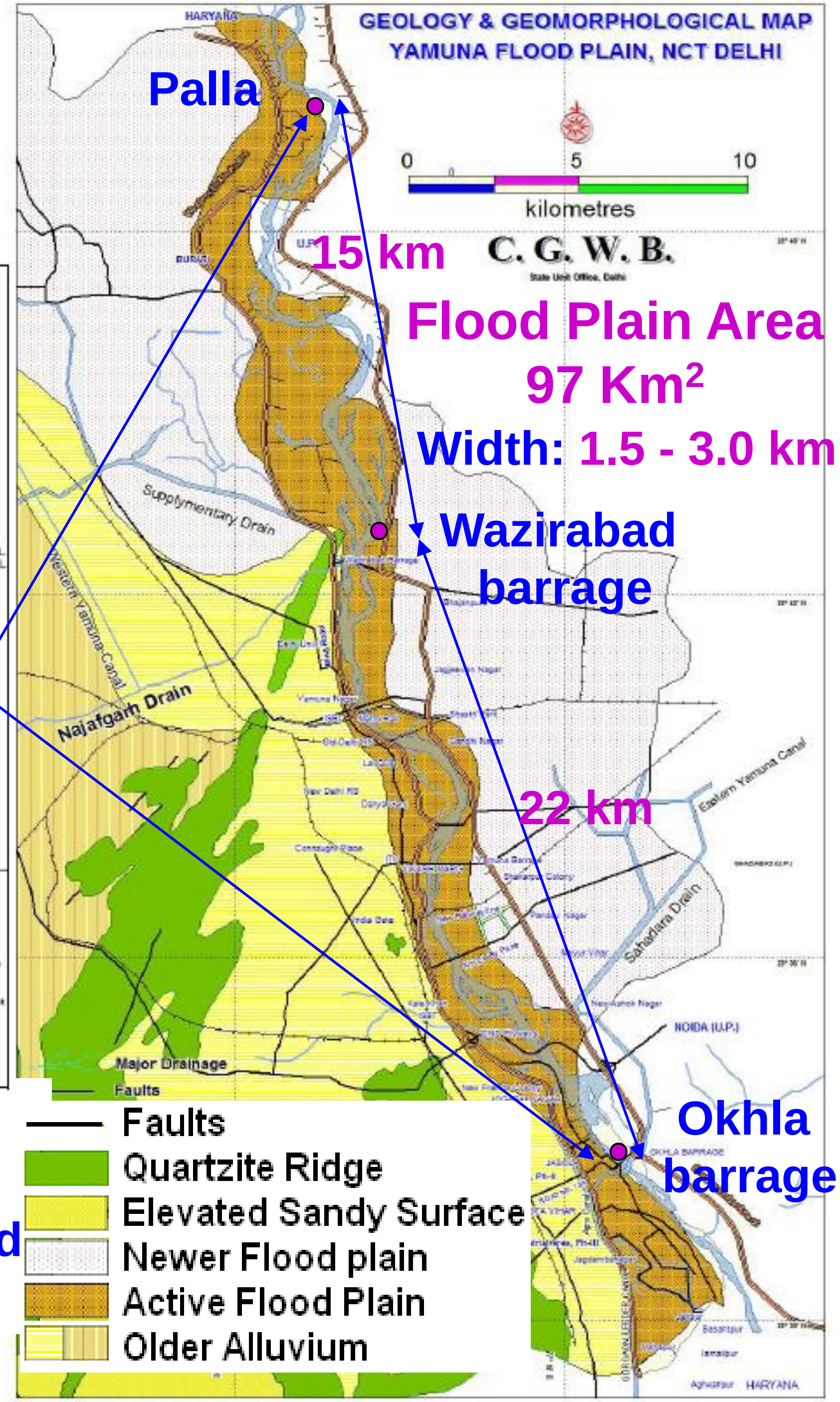
Yamuna Flood Plain Delhi

28° 24’ 15” and 28° 53’ 00”N

76° 50’24” and 77° 20’ 30” E

Sub-Surface Geological Cross Section Along River Stretch





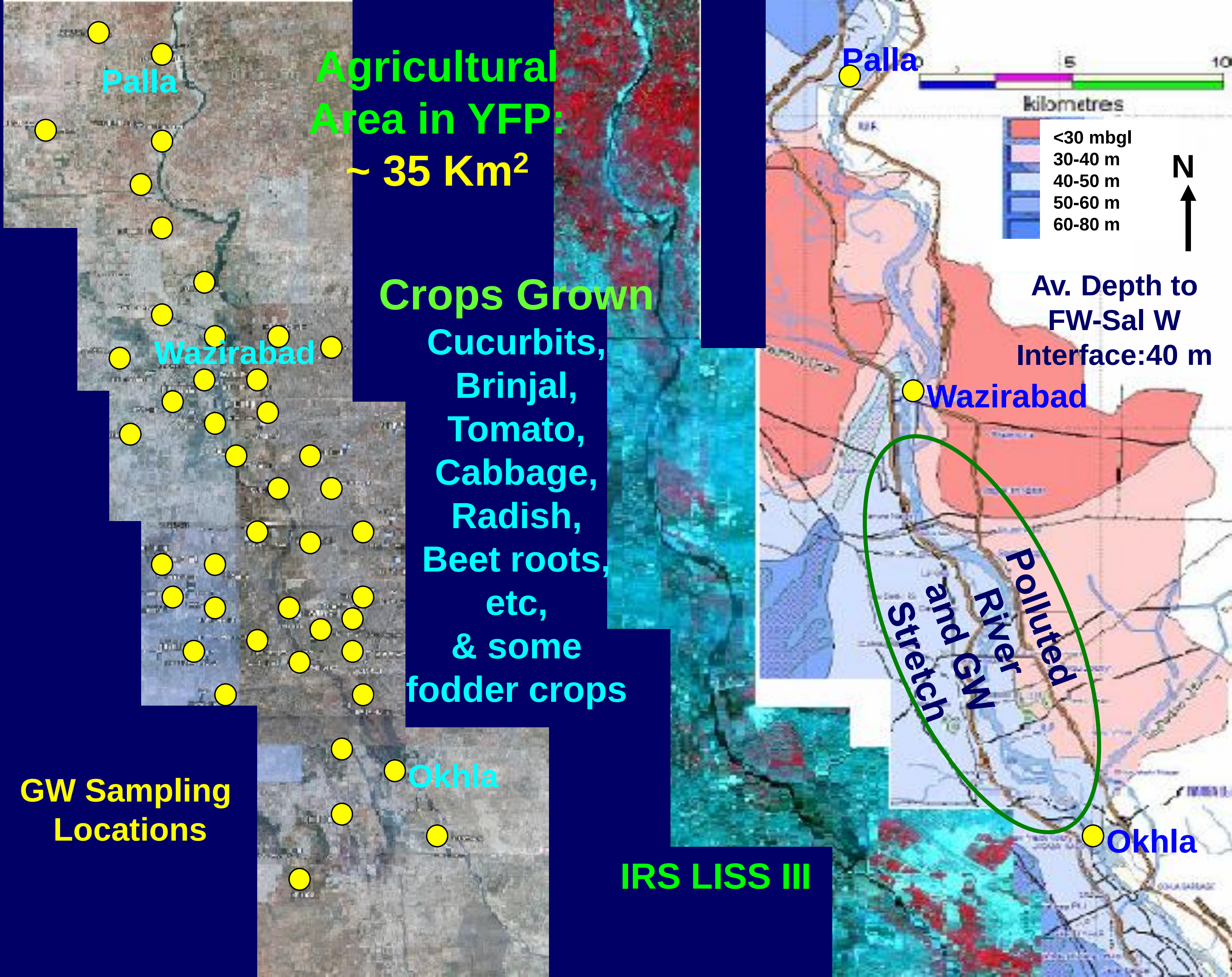
Flood prone area: ~ 25 Km²

Old Alluvium Transmitivity: 130 - 350 m²/d

New Alluvium Transmitivity: 730 - 2100 m²/d

New Alluvium Thickness: 40 - 55 m

Agricultural Area in YFP: ~ 35 Km^2



Crops Grown

Cucurbits, Brinjal, Tomato, Cabbage, Radish, Beet roots, etc, & some fodder crops

GW Sampling Locations

Av. Depth to FW-Sal W Interface:40 m

Why Isotopes?

Water memorises its origin and path

Isotopic fingerprints are imparted during:

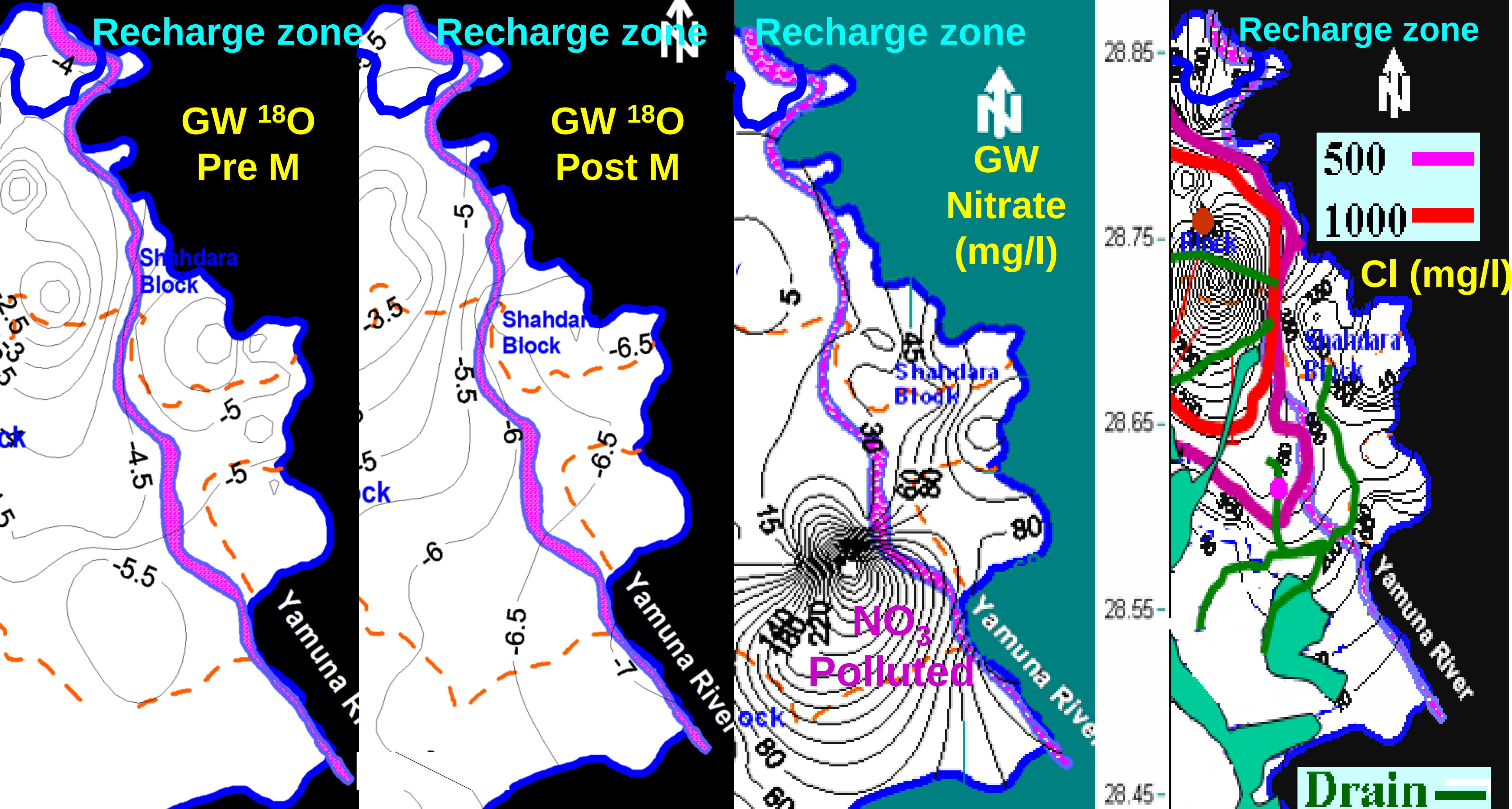
1. **Phase change:** fractionation during evaporation and condensation – temperature & humidity dependent.
2. **Mixing of different water** masses.
3. **Selection of rain events** during runoff and GW recharge.

Isotopes fingerprints in rain, streams and GW represent an integration of source inputs to the system that extend over large spatial and temporal scales.
Integrate **processes in space and time,**
Indicate **the magnitude of key processes,**
Record **responses to change condition,**
Trace **origin and movement of key elements.**

Stable Isotopes in Water ($^{1}H_2O$)

$^{1}H_2{}^{18}O$	$\delta^{18}O$(‰)
$^{1}H^{2}H^{16}O$	δD (‰)

δ (‰) = $(R_x/R_s - 1) \times 1000$
R=Ratio ($^{18}O/^{16}O$; $^{2}H/^{1}H$)



Post- M ^{18}O is depleted.

At some stretches NO_3 > MPL

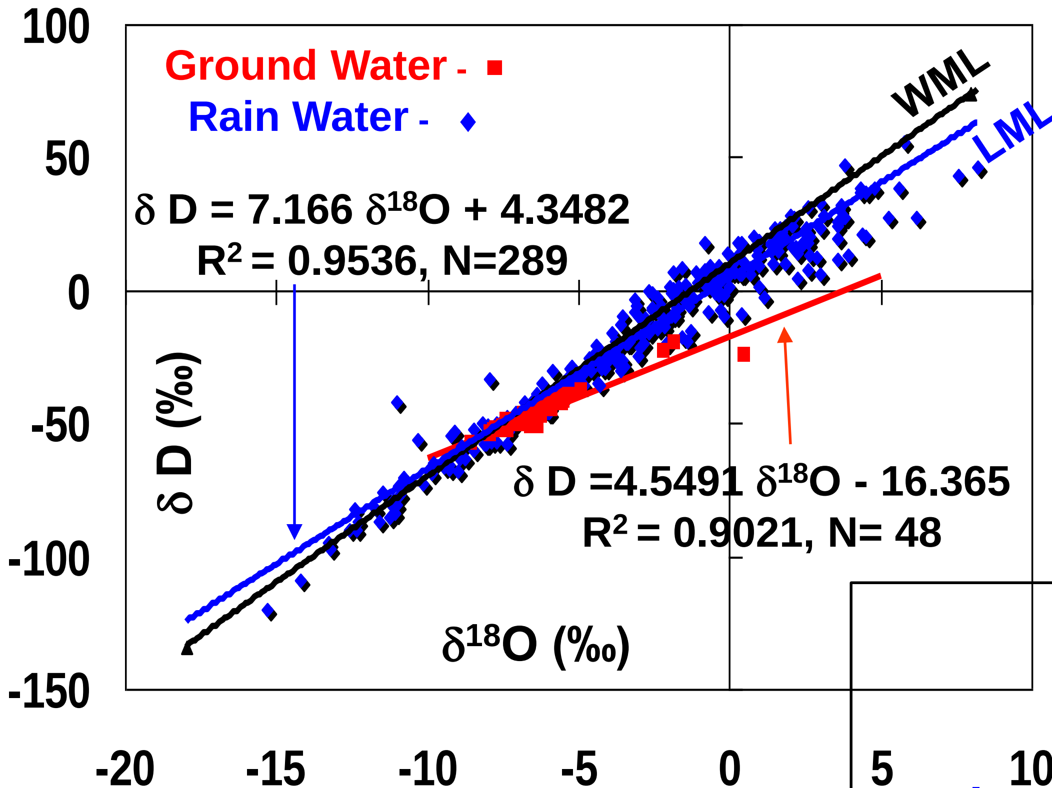
Plumes Dynamics

Recharge from rainfall to relatively older GW adjacent to the YFP: 1-10%.

GW contains very low NO_3 and NH_4 all along the river stretch.

^{18}O & Hydro-chemical Characterization of GW

δD - $\delta^{18}O$ Relationship in Rainwater & GW in New Delhi



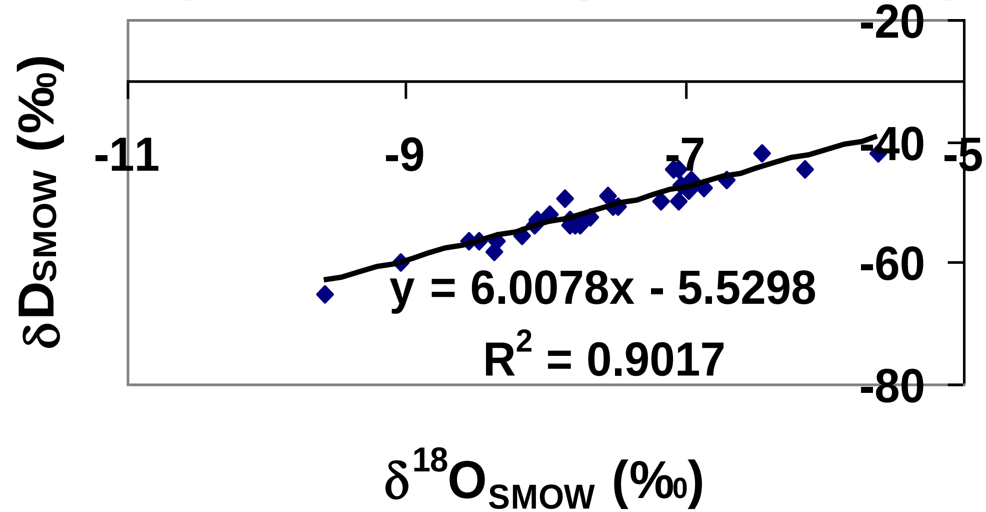
GW $\delta^{18}O$ (- 5.6 to - 9.6‰) is enriched compared to river water $\delta^{18}O$ (- 9.7‰).

Significant evaporative enrichment of rainwater & GW.

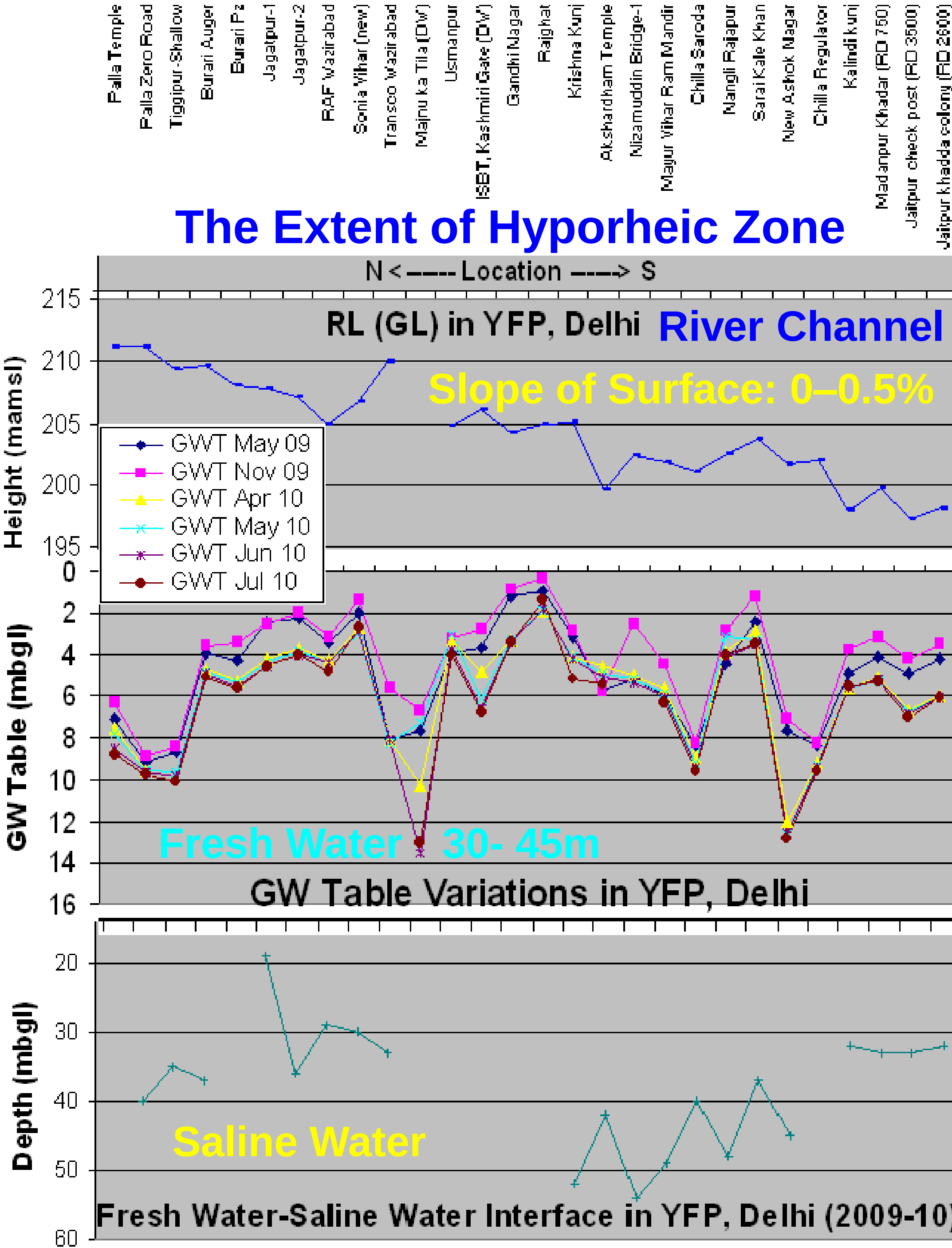
Freshly infiltrated hyporheic GW could be distinguished from other GW by its short residence time of a few days in the subsurface.

$\delta^{18}O$ - δD Relationship in YFP GW Delhi (Nov 2009)

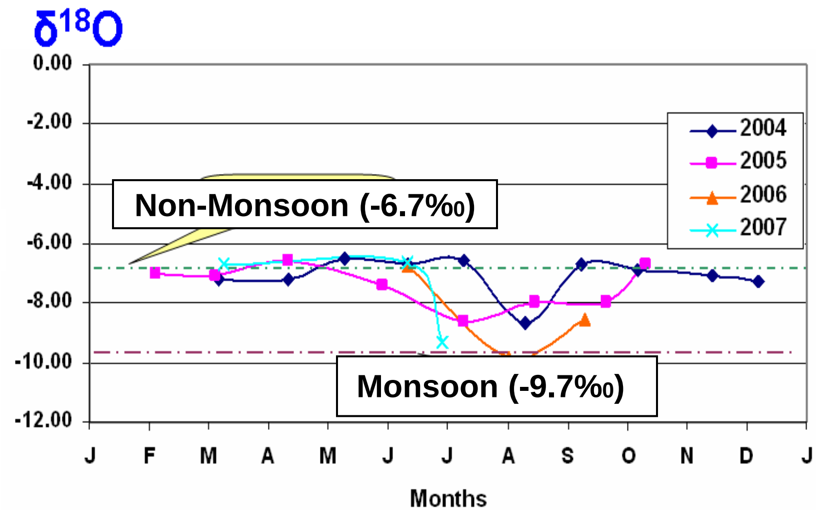
Jul-Sep 2009 Rain $\delta^{18}O$ (- 6.1 to - 11.5 ‰)

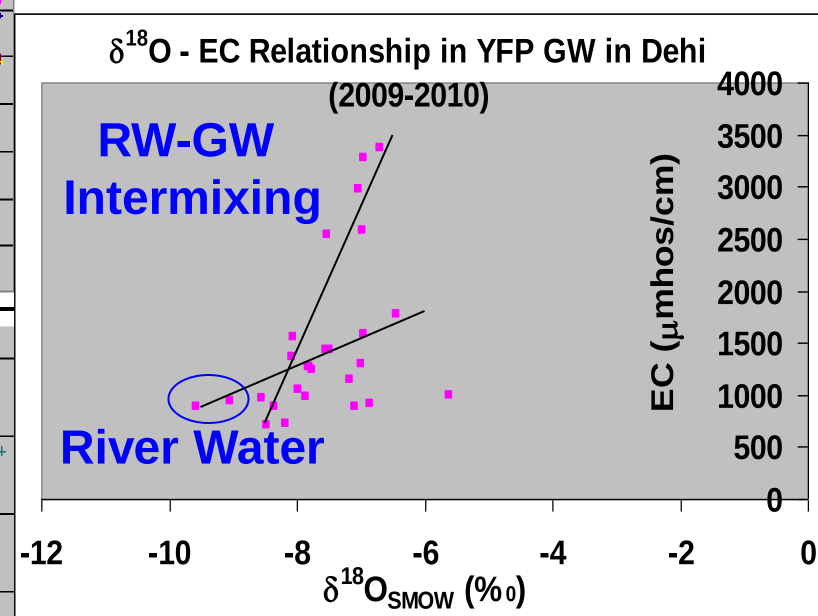


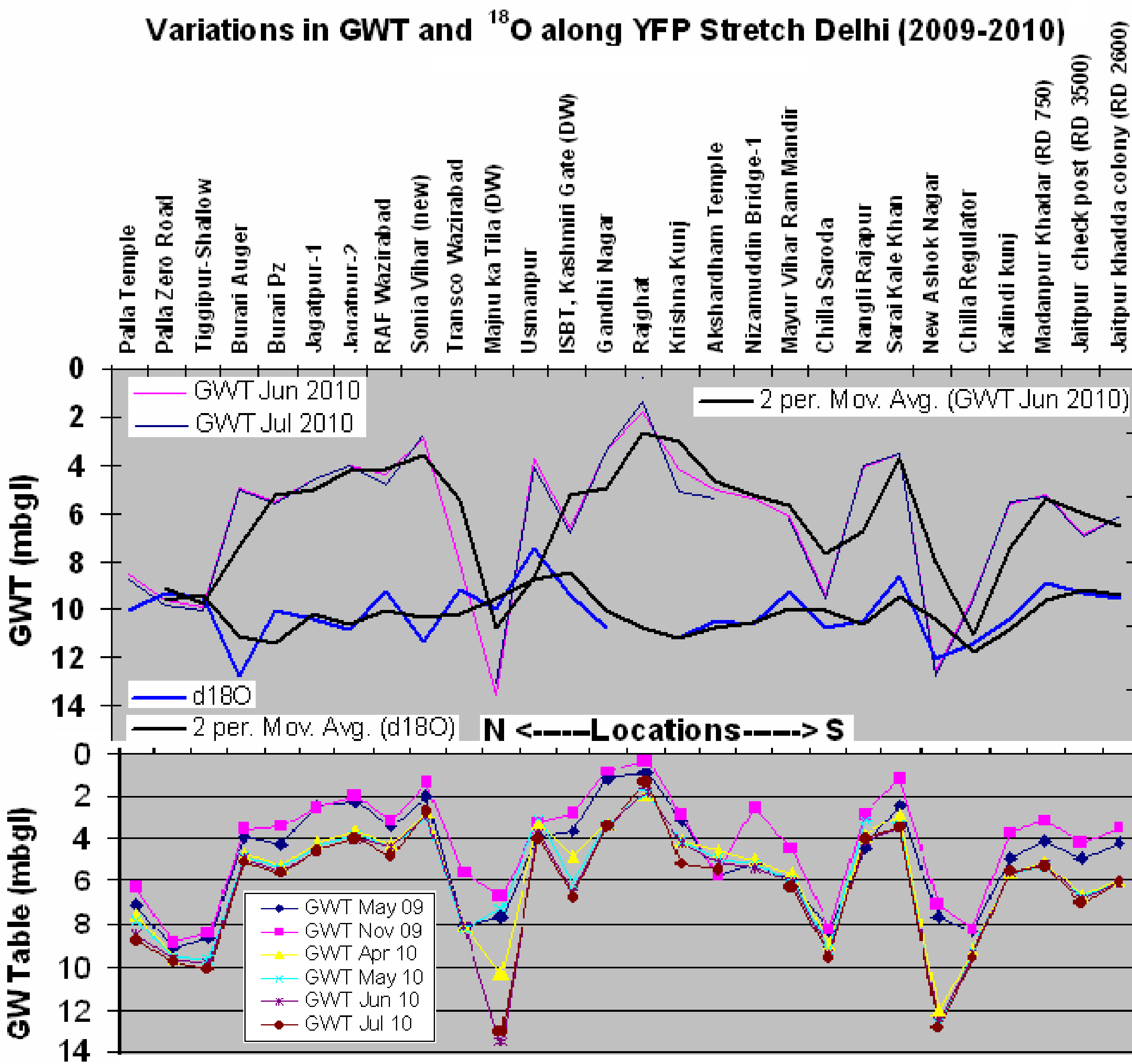
The Extent of Hyporheic Zone



Temporal Variation of GWT and $\delta^{18}O$ in Yamuna River





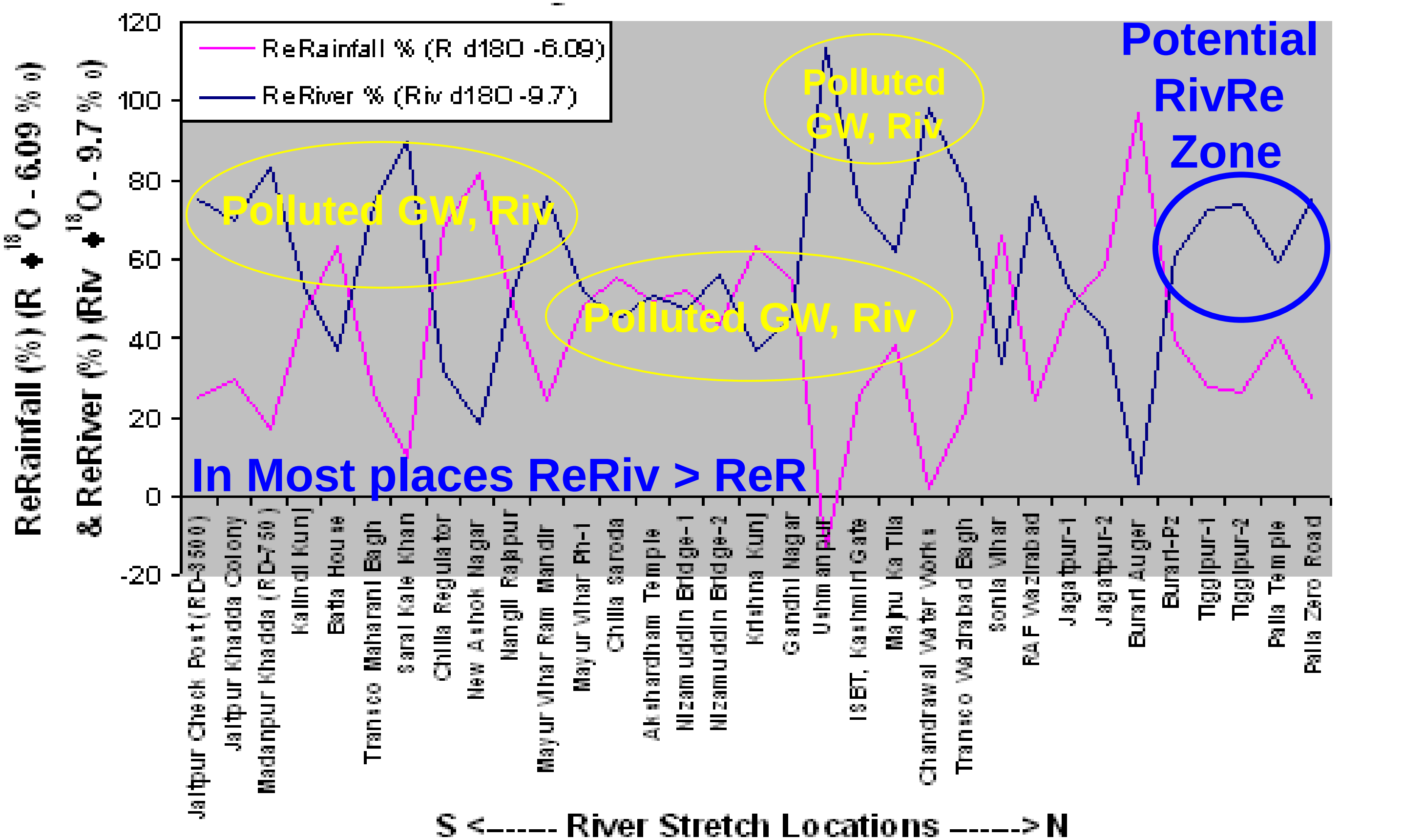


GWT Rise
^{18}O Depletion

GWT Decline
^{18}O Enrichment

Pre- to
Post-M
Av. Rise in
GWT: 2 - 4 m

GW Recharge Zone and Development Potential



Mixing Model for RivRe (%) = $(\delta_g - \delta_R)/(\delta_{Riv} - \delta_R)$ x 100 = 2 - 96 %

(a) Volume of Palla FP aquifer (Area x FW-Sal W depth) = (10.68x40) = 472 MCM

(b) Water holding capacity of the Palla FP aquifer [50% of (a)] = ~ 213 MCM

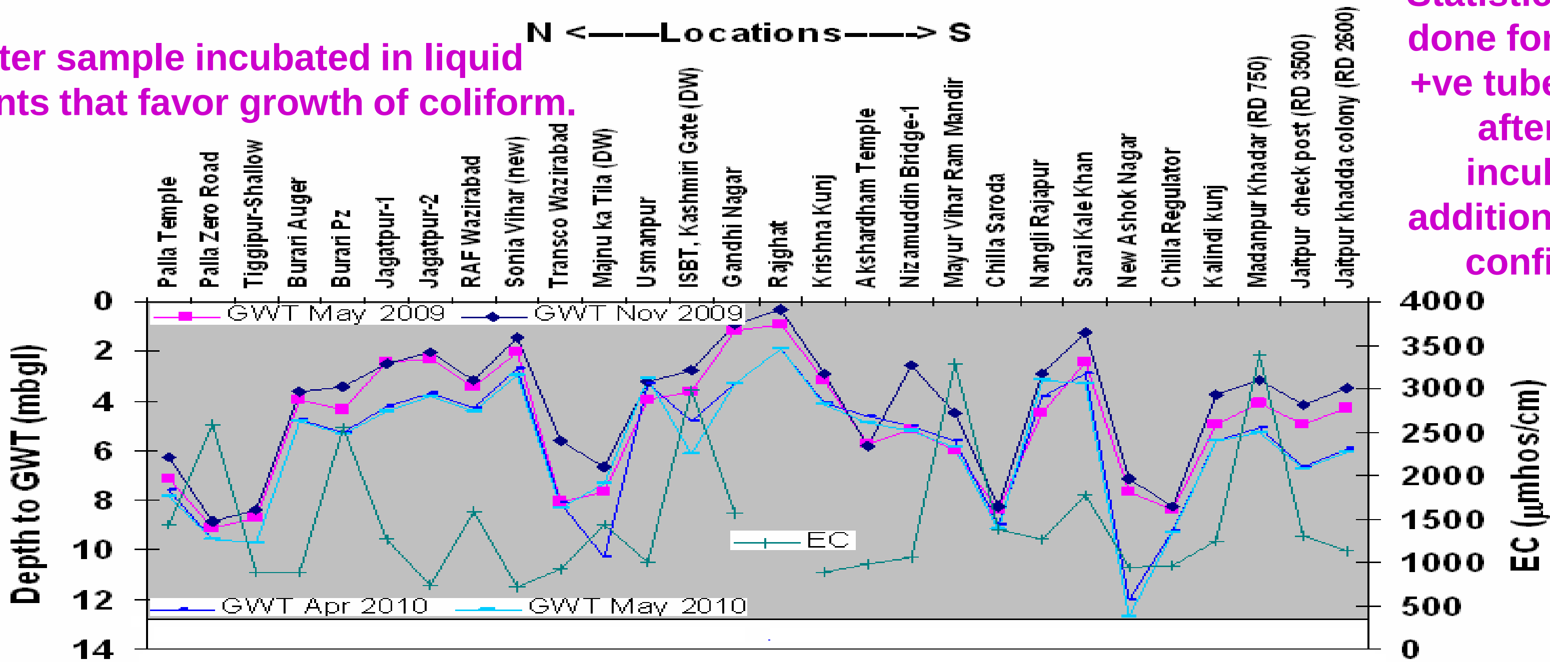
(c) Re Potential (Sp. Yield) of the Palla FP aquifer [Av. 26% of (a)] = ~ 111 MCM

(d) Recharge from River in Palla FP = [Av. 75% of (c)] = ~ 83 MCM/yr (~ 49 MGD)

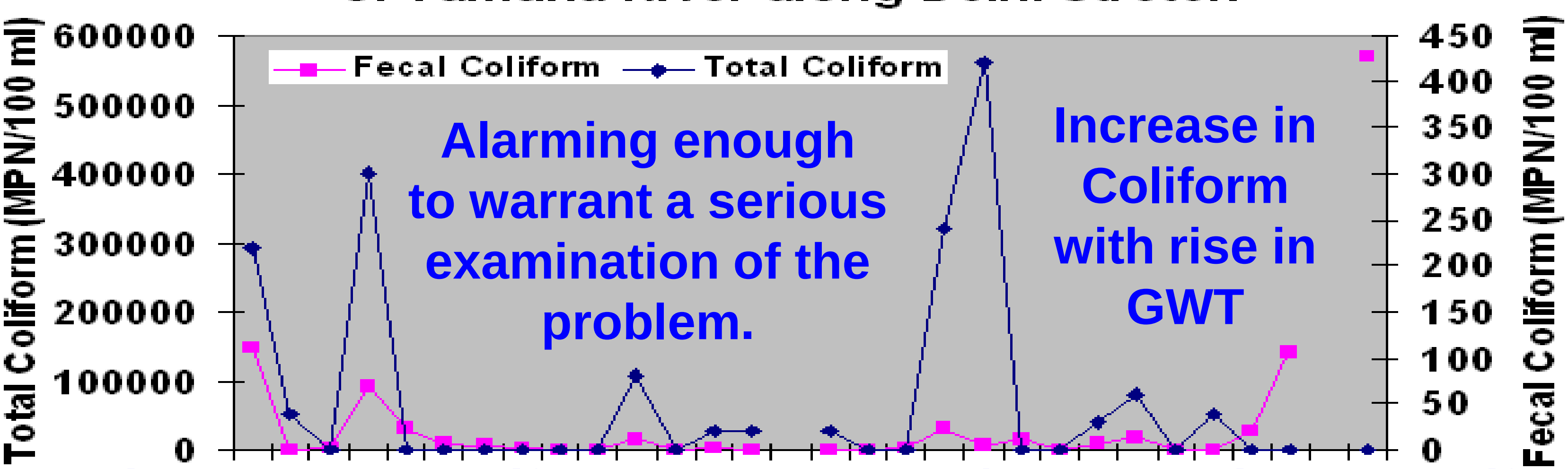
GWT Fluctuations and EC in YFP Delhi (2009-2010)

Water sample incubated in liquid nutrients that favor growth of coliform.

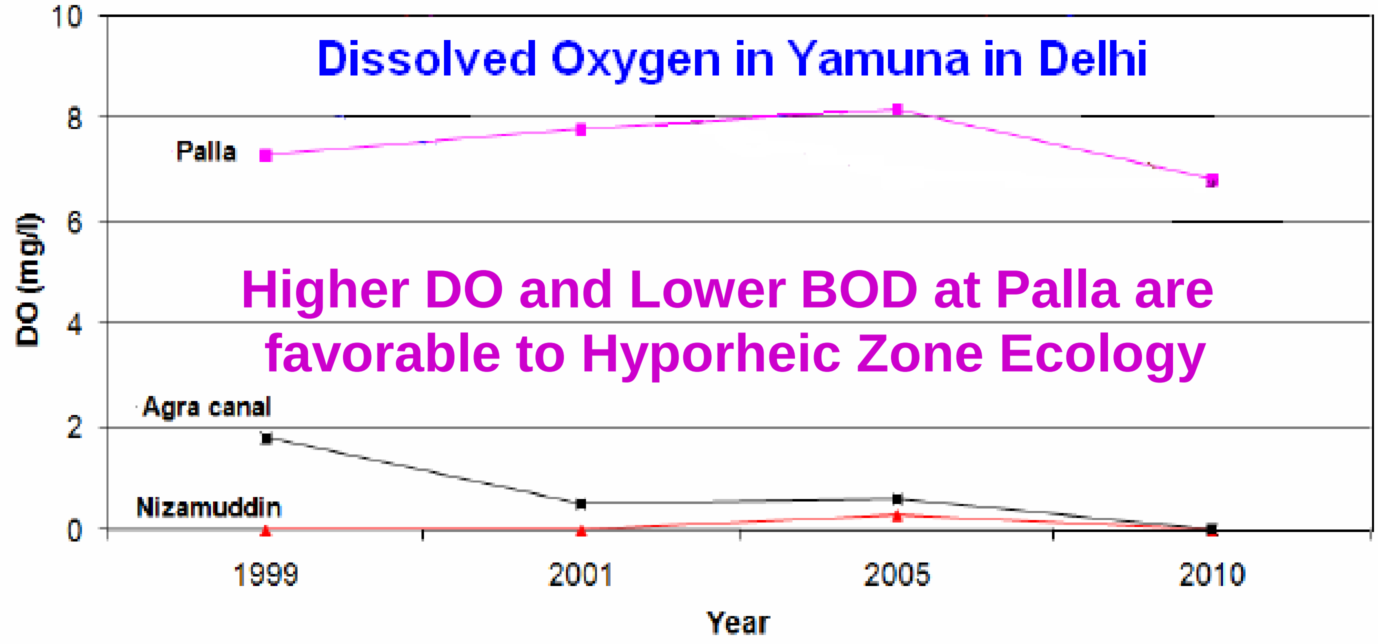
Statistical counting done for number of +ve tubes of media after 48 hrs incubation & additional 48 hrs of confirmation

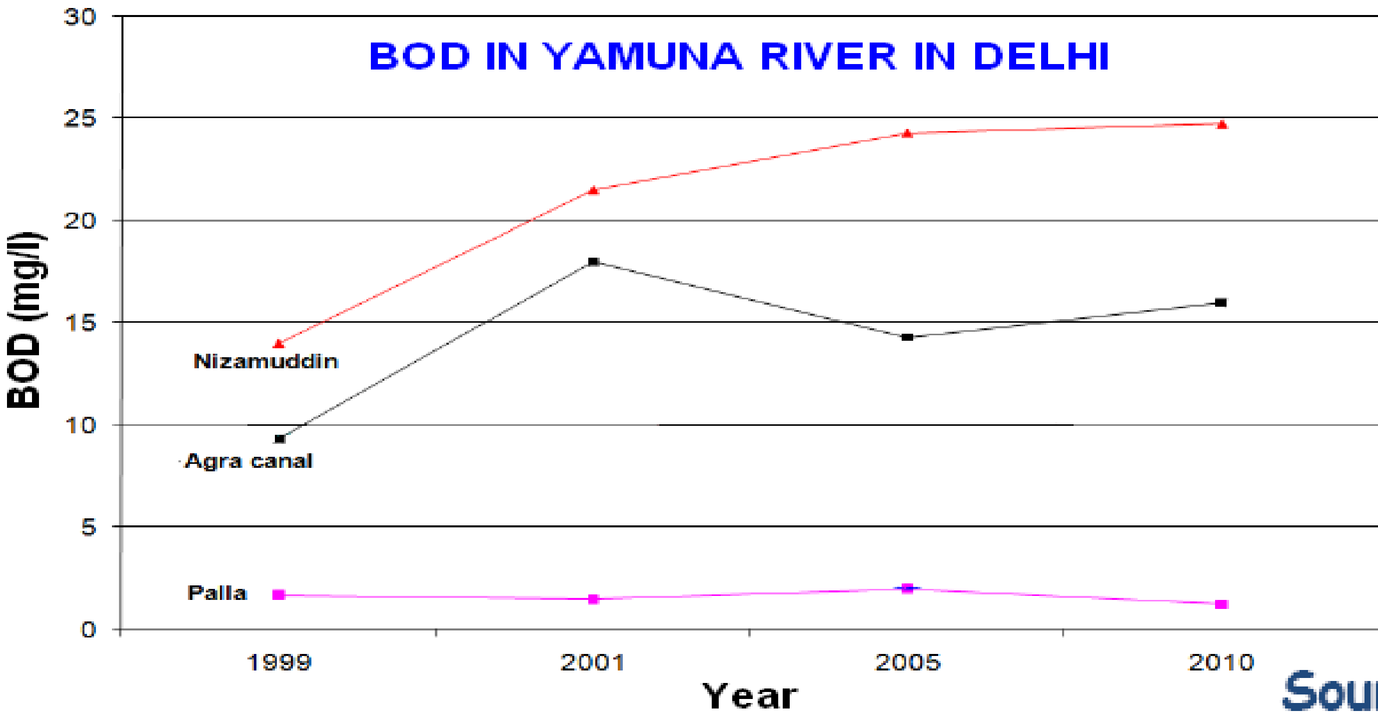


Total Coliform and Fecal Coliform in Hyporeic Zone of Yamuna River along Delhi Stretch



The GW Total Coliform 1-570000MPN/100ml and Fecal Coliform 1- 420MPN/100ml (exceeds standards at all locations).


Dissolved Oxygen in Yamuna in Delhi
Higher DO and Lower BOD at Palla are favorable to Hyporheic Zone Ecology
DO (mg/l)
Palla
Agra canal
Nizamuddin
10
8
6
4
2
0
1999
2001
2005
2010
Year


BOD IN YAMUNA RIVER IN DELHI
BOD (mg/l)
Nizamuddin
Agra canal
Palla
30
25
20
15
10
5
0
1999
2001
2005
2010
Year

Source: CPCB

CONCLUDING REMARKS

In YFP, GW wells used for drinking contains
a significant contribution (Av. 75%) of bank filtrate.

Scope exists to restore the annual recharge under the YFP via the hyporheic zone.

Although, the groundwater development potential is considerable, yet, there exists contamination risk below the flood plains.

Flood plains need to be preserved from sewage disposal, as these areas have potential to reduce GW nitrate levels.

It is necessary to bridge gaps on
the functional significance of the hyporheic zone
to manage and restore river floodplain through
Network Programme with Community Participation.

Supported these endeavours:

The Organizers, HydroEco 2011

Central Ground Water Board, New Delhi
Central Pollution Control Board, Delhi

Indian Agricultural Research Institute, New Delhi
Indian Council of Agricultural Research, New Delhi
National Institute of Hydrology, Roorkee