TRANSPORT AND LOSS OF NITROGEN WITHIN THE UPPER FLORIDAN AQUIFER IN THE SILVER SPRINGS SPRINGSHED

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Research questions
and objectives

- Which parts of the aquifer have the highest nitrate fluxes?
- How much nitrate transformation occurs in different parts of the aquifer?
- How do long/short aquifer flow paths correlate to nitrate loads and transformations?

Research questions

and objectives

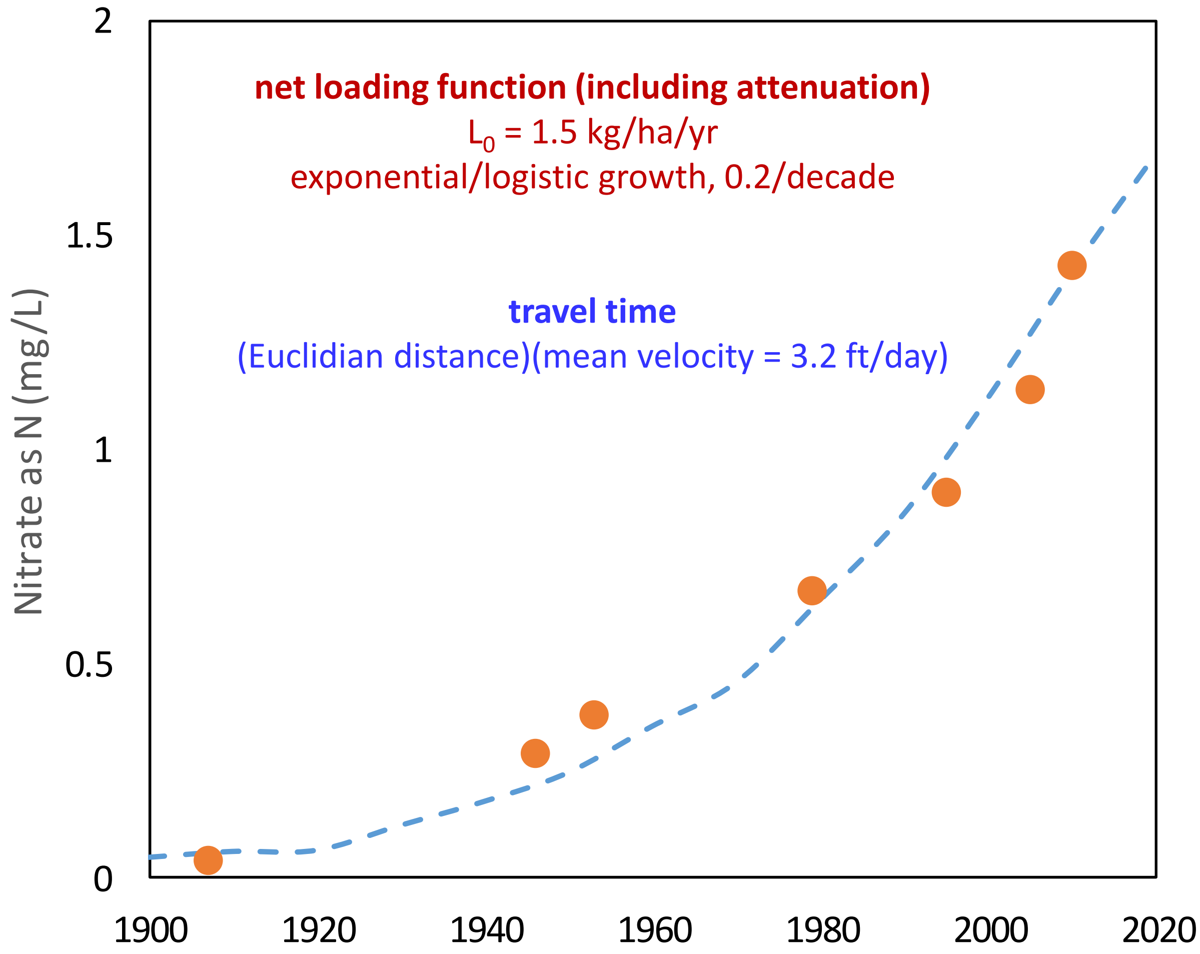
- Which parts of the aquifer have the highest nitrate fluxes?
  - *Measure groundwater and nitrate flux distribution*

    [Passive flux meters]
- How much nitrate transformation occurs in different parts of the aquifer?
  - *Measure fluxes of N species, along with reactants*

    [PFMs]
  - *Measure in situ local nitrate transformation rates*

    [Push-pull tracer tests]
- How do long/short aquifer flow paths correlate to nitrate loads and transformations?
  - *Measure groundwater ages and nitrate transformations*

    [Age dating]


net loading function (including attenuation)
L0 = 1.5 kg/ha/yr
exponential/logistic growth, 0.2/decade
travel time
(Euclidian distance)(mean velocity = 3.2 ft/day)
Nitrate as N (mg/L)
2
1.5
1
0.5
0
1900
1920
1940
1960
1980
2000
2020

Heterogeneous DISTRIBUTION OF

~~homogeneous~~ ~~mean~~ velocit~~y~~*ies*

Mean Groundwater Velocities in the Study Area Based upon the Mid-Point of First Arrival Times of Tracer Dyes

Introduction Location	Detection Station (Table 3 lists name and number)	Distance (ft)	Travel Time (days)	Mean Velocity (ft/day)
Heagy-Burry Sink	54 Reddick Elementary School Well 5	22,180	9.5	2,335
Heagy-Burry Sink	57 Marion Correctional Institution Well 1	44,880	187.5	245
Heagy-Burry Sink	58 IFAS Well A	11,620	23.5	495
Heagy-Burry Sink	59 IFAS Well D	11,090	9.5	1,165
Civic Theatre	SSG Stations 1, 4, 7, 9, 32, & 33	7,920	7.5	1,055
Civic Theatre	SSG Stations 2 & 5	7,920	13	610
Civic Theatre	SSG Stations 6, 10, 12, & 13	7,920	18.5	430
Civic Theatre	SSG Station 11	7,920	35.5	225
Civic Theatre	SSG Station 19	7,920	42	190
Civic Theatre	SSG Stations 18, 20, 23	7,920	82	95
Civic Theatre	SSG Stations 21 & 28	7,920	118	65
Civic Theatre	SSG Station 14	7,920	286	30
Tuscawilla	32 South Boathouse Vent	26,930	303.5	90
Pontiac Pit Sink	62 Blue Skies Well 1	18,480	103	180
Pontiac Pit Sink	63 Cedar Hills Well	12,670	53.5	235

Euclidean model, homogeneous
mean velocity = 3.2 ft/day

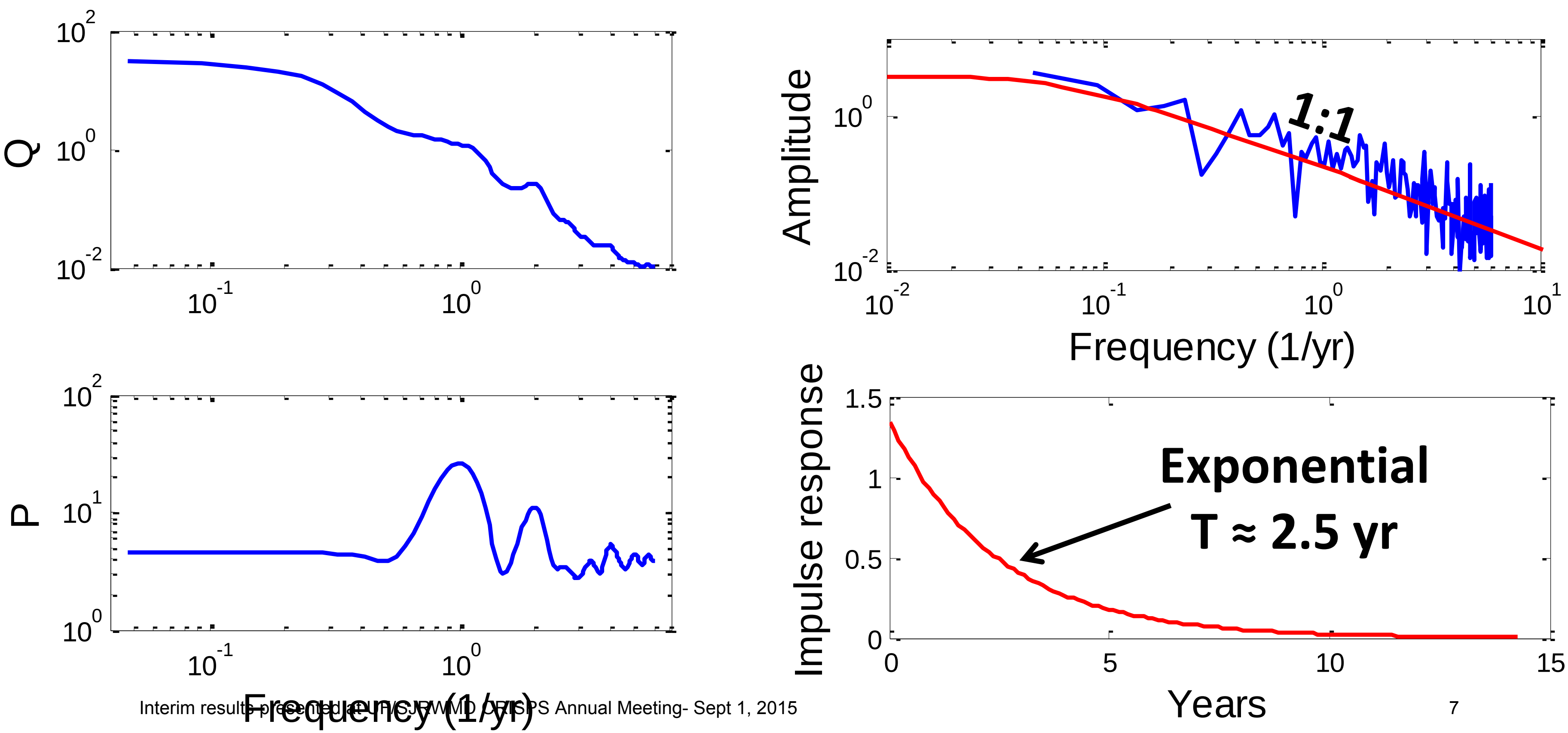
SJRWMD, 2012. *Silver Springs Nutrient Pathway Characterization Project Final Report*, Special Publication SJ2012-SP3, p. 8-3

Fourier spectral analysis

Variance vs frequency: Landscape as low-pass filter

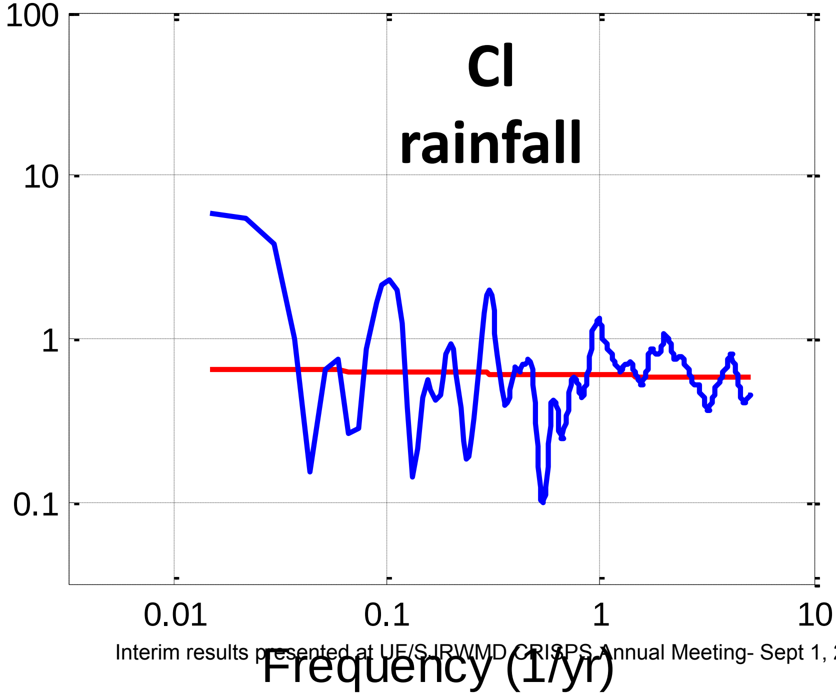
Spectral estimates
of rainfall and discharge

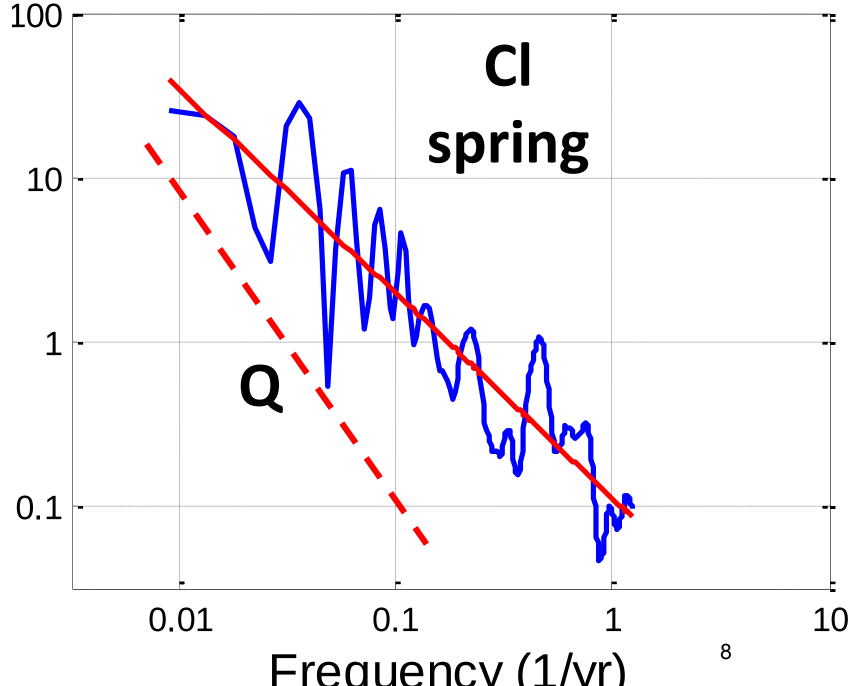
Transfer function
between rainfall and discharge



Chloride concentration in rainfall vs. spring discharge

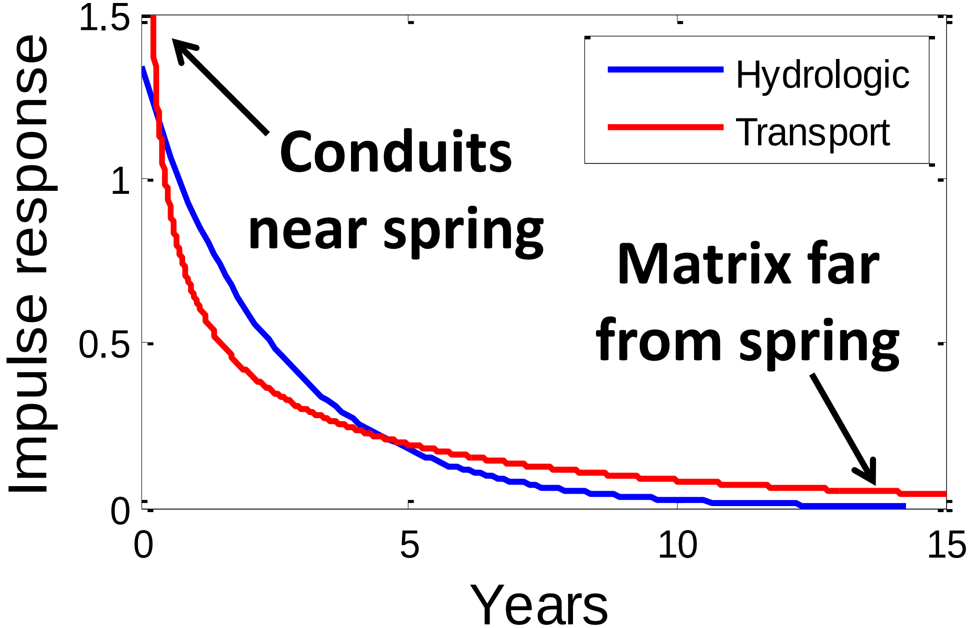
- Similar to rainfall, Cl in rainfall is also white noise
- However, slope of Cl in spring spectrum is half that of Q





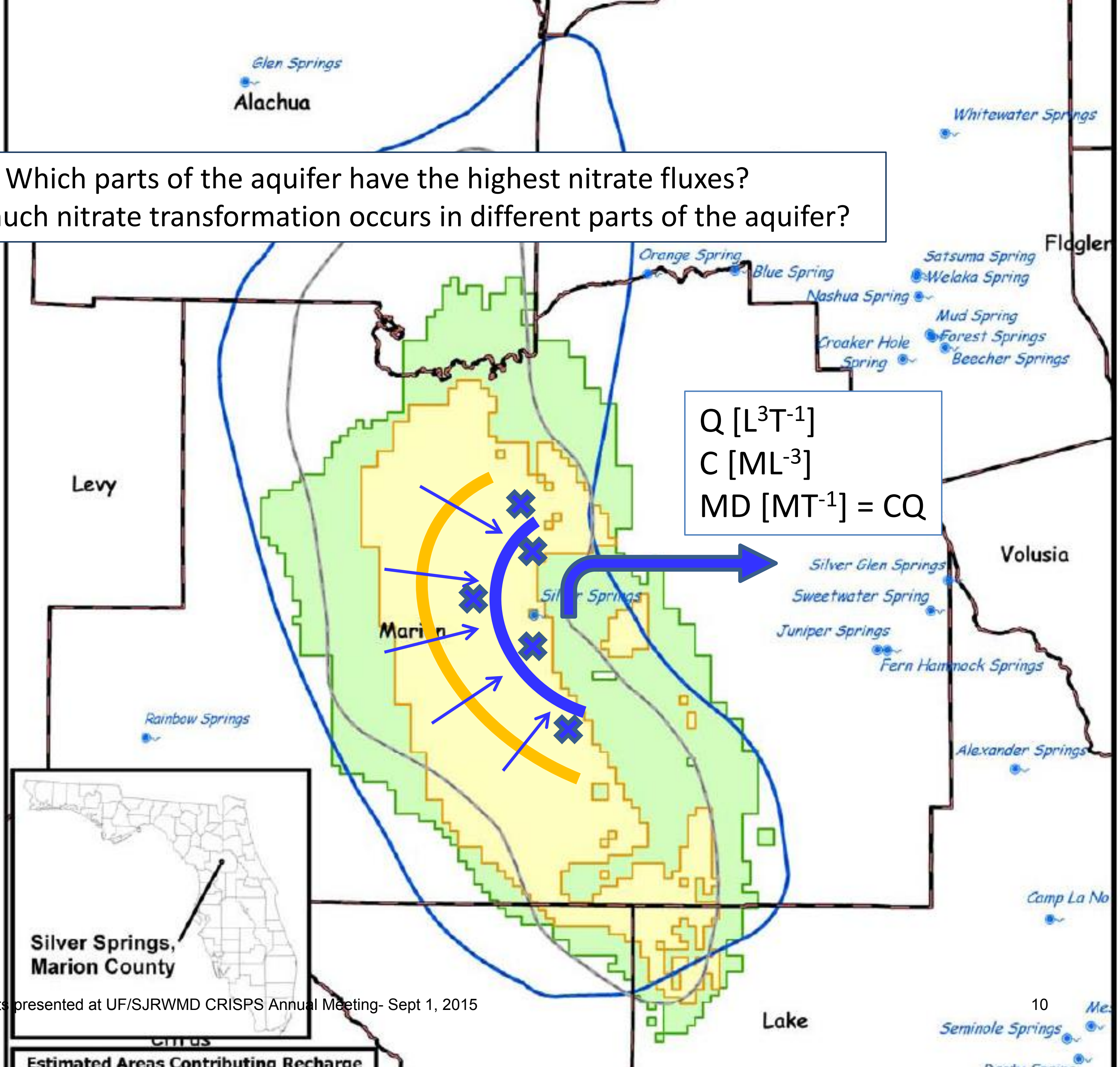
Travel time distribution

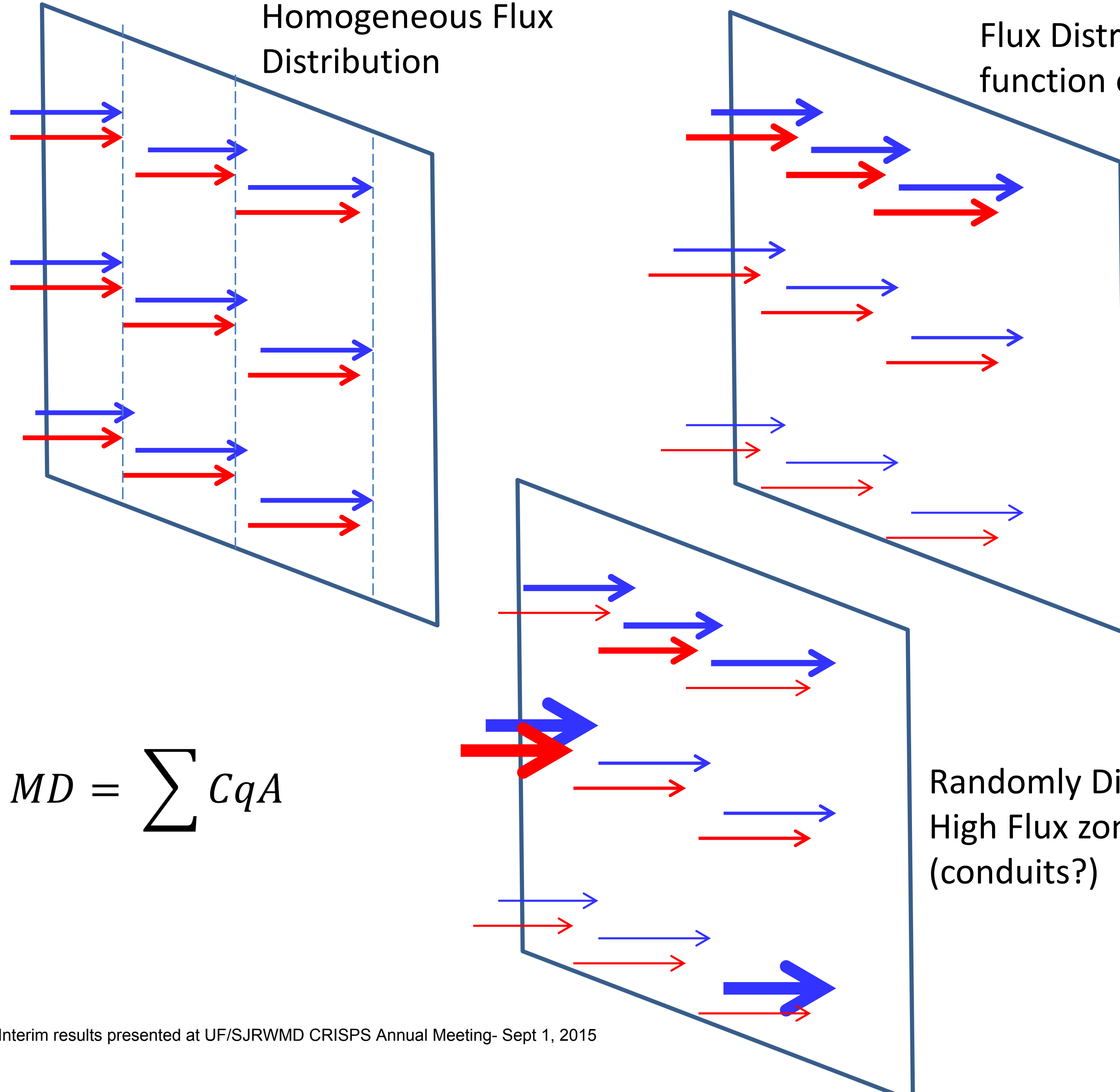
- This indicates a travel time distribution of the gamma type (we also see in other springs)
- Large initial peak (karst conduits) and long tail (matrix)



Which parts of the aquifer have the highest nitrate fluxes?
How much nitrate transformation occurs in different parts of the aquifer?

$Q\ [L^3T^{-1}]$
$C\ [ML^{-3}]$
$MD\ [MT^{-1}] = CQ$

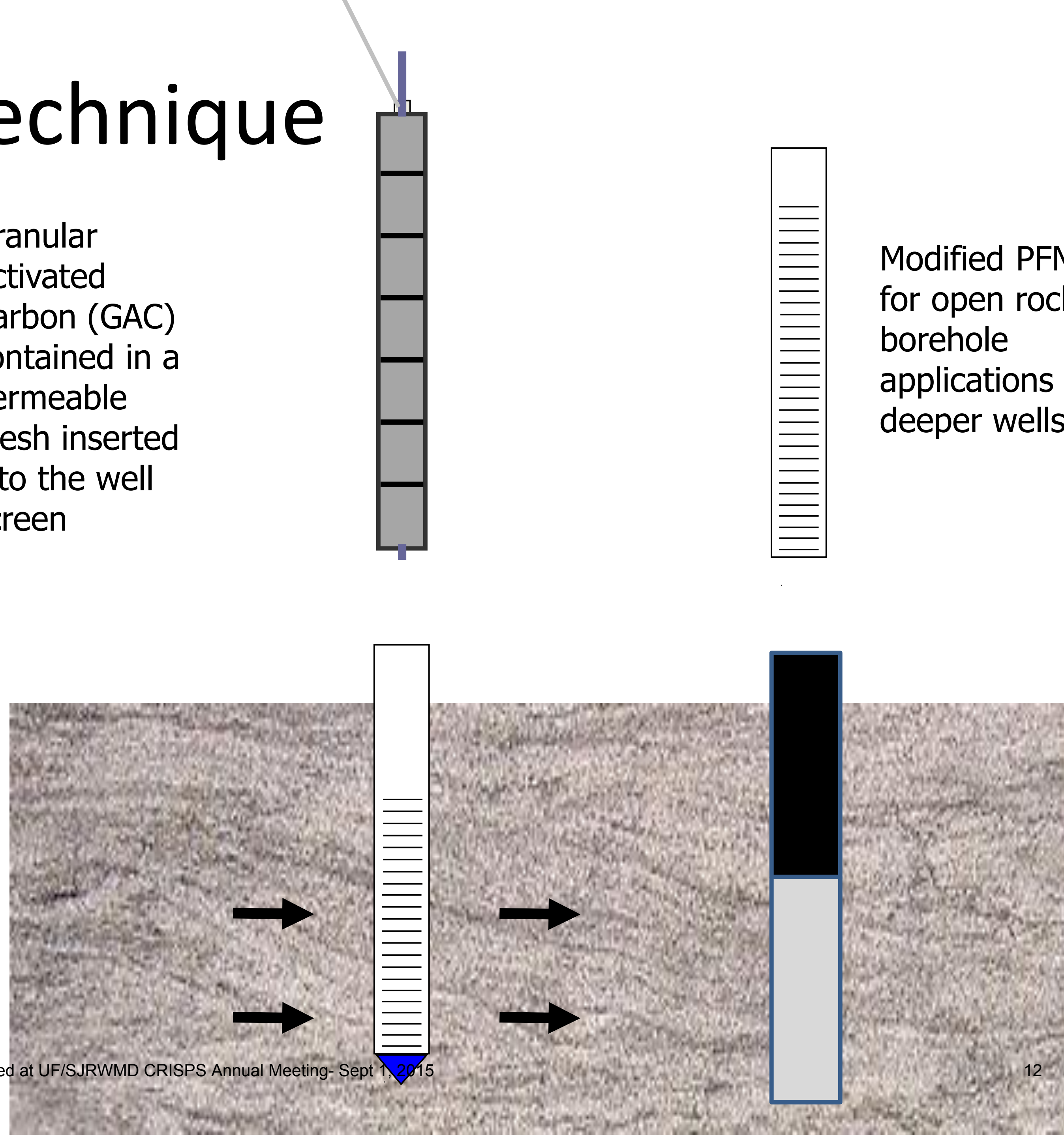



Homogeneous Flux Distribution
Flux Distribution a function of depth
Randomly Distributed High Flux zones (conduits?)

$$MD = \sum CqA$$

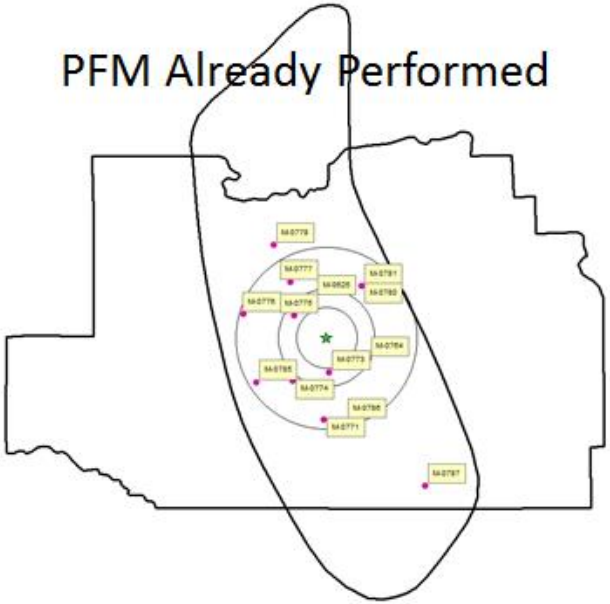
PFM Technique

Granular Activated Carbon (GAC) contained in a permeable mesh inserted into the well screen

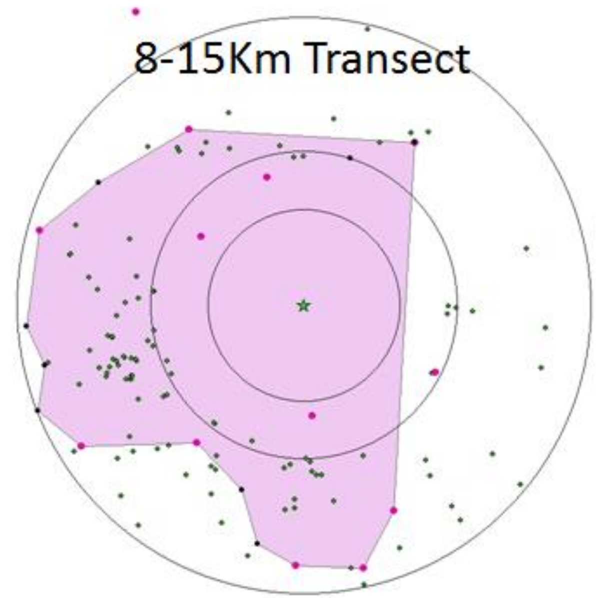


Modified PFM for open rock borehole applications in deeper wells

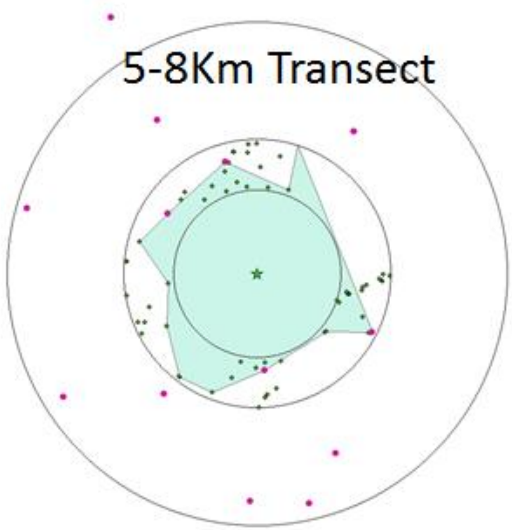
PFM Already Performed



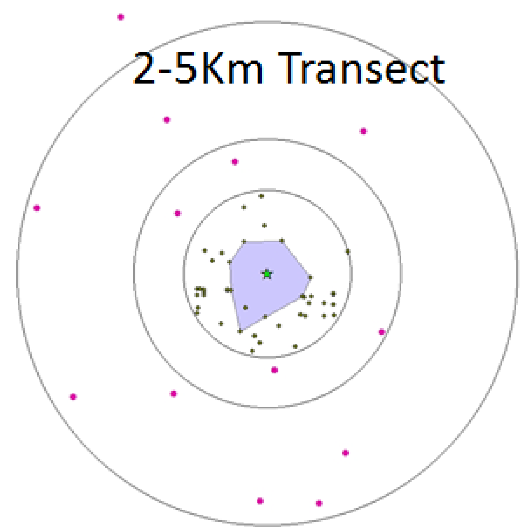
8-15Km Transect



5-8Km Transect



2-5Km Transect



aquifer (PFM) vs spring *discharge*

Σ (qA)

SS flow

	Transect 1	Transect 2
Water flux	5 cm/d	6 cm/d
Depth	40 m	60 m
Length	51 km	75 km
Σ (qA)	**1.25 m^3/s**	**3.2 m^3/s**

~ 22 m^3/s

aquifer (PFM) vs spring

nitrate solute mass

Σ (qAC) SS mass discharge

	Transect 1
Water flux	5 cm/d
Depth	40 m
Length	51 km
Nitrate	**1.1 mg/L**
Σ (qAC)	**115 kg/d**

1,900 kg/d

aquifer (PFM) vs spring

sulfate solute mass

Σ (qAC)

SS mass discharge

	Transect 1
Water flux	5 cm/d
Depth	40 m
Length	51 km
Sulfate	**13 mg/L**
Σ (qAC)	**1,400 kg/d**

94,000 kg/d

high-velocity zones

finding fractures/conduits

Σ (qA)

SS flow

	Wells (n = 16)
Water flux	**6.0 ± 1.9 cm/d**
Σ (qA)	1 -3 m^3/s

100 cm/d

22 m^3/s

high-velocity zones

finding fractures/conduits

Σ (qA) | Tracers | SS flow

	Wells (n = 16)
Water flux	**6.0 ± 1.9 cm/d**
Σ (qA)	1 -3 m^3/s

Tracers: **1500 cm/d**

SS flow: **100 cm/d**

22 m^3/s

high-velocity zones

finding fractures/conduits

Σ (qA)

Tracers

SS flow

	Wells (n = 16)
Water flux	**6.0 ± 1.9 cm/d**
Σ (qA)	1 -3 m^3/s

1500 cm/d

100 cm/d

22 m^3/s

$$q_T A_T = q_c A_c + q_m A_m$$

$$A_c / A_T \approx 0.06$$

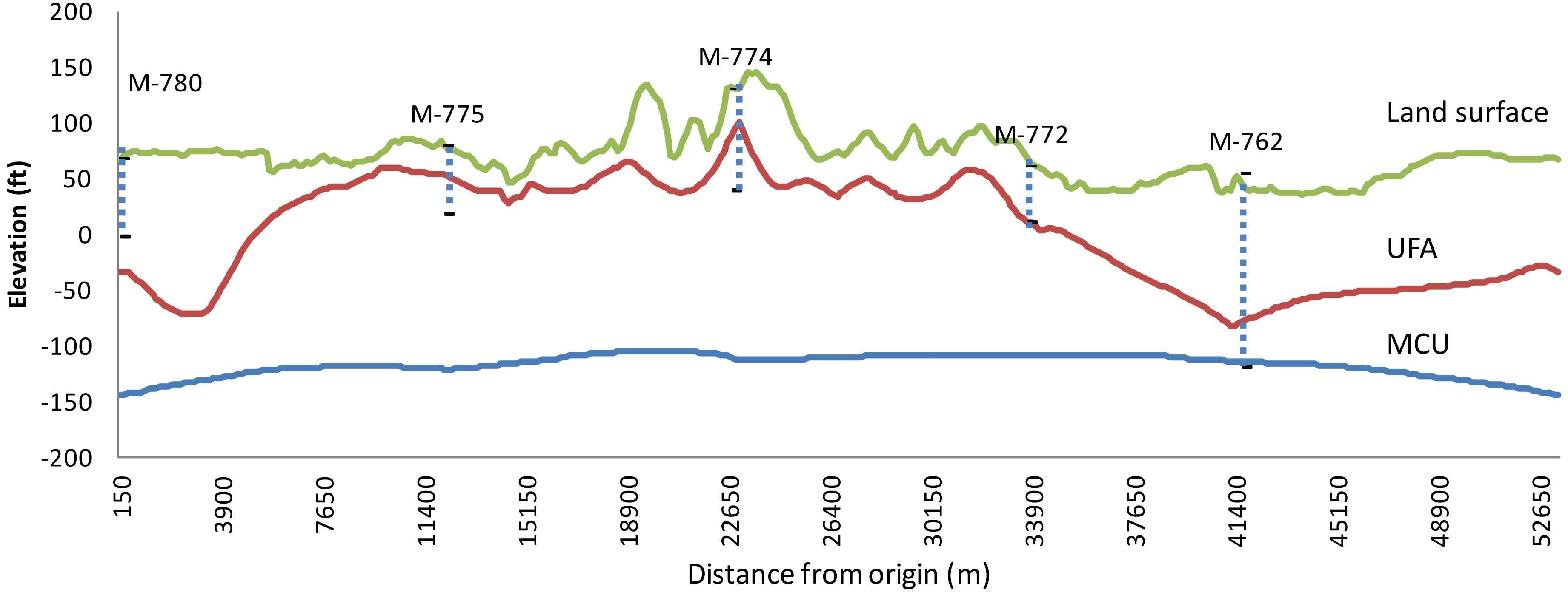
video

well M-0625

Indian Lake State Forest

Total depth: 193.2 ft

</end>


200
150
100
50
0
-50
-100
-150
-200
Elevation (ft)
M-780
M-775
M-774
M-772
M-762
Land surface
UFA
MCU
150
3900
7650
11400
15150
18900
22650
26400
30150
33900
37650
41400
45150
48900
52650
Distance from origin (m)