Tracer-Dilution Bromide Test and Slug Test at Durbin Wetland in McLean County, IL

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Objective

The objective of the project was to determine is the wetland at the Durbin farms was leaky for The Nature Conservancy. Using a bromide tracer test, the integrity of the wetland was tested and the rate of seepage (movement) from the wetland were calculated. The tracer test was completed from May 13, 2013 to May 29, 2013 and a slug test to determine hydraulic conductivity and matrix material was completed May 16, 2014.

Study Site

Field investigation focuses on the Durbin wetland located 40.2 km (25 miles) east of Normal/ Bloomington, Illinois in McLean County; $40^0$30'22.61 N and $88^0$36'21.63 W. The wetland (Figure 1) was built to treat the excess nutrients, nitrogen and phosphorous, transported by tile drains from surrounding farm fields. Construction of the wetland includes an overflow wetland for additional water storage. The dimensions of the wetland are 76.2 meters by 45.7 meters and 2.02 meters deep. Since the initial construction of the wetland, the wetland goes dry during the summer. The fate of the water from the wetland is in question.

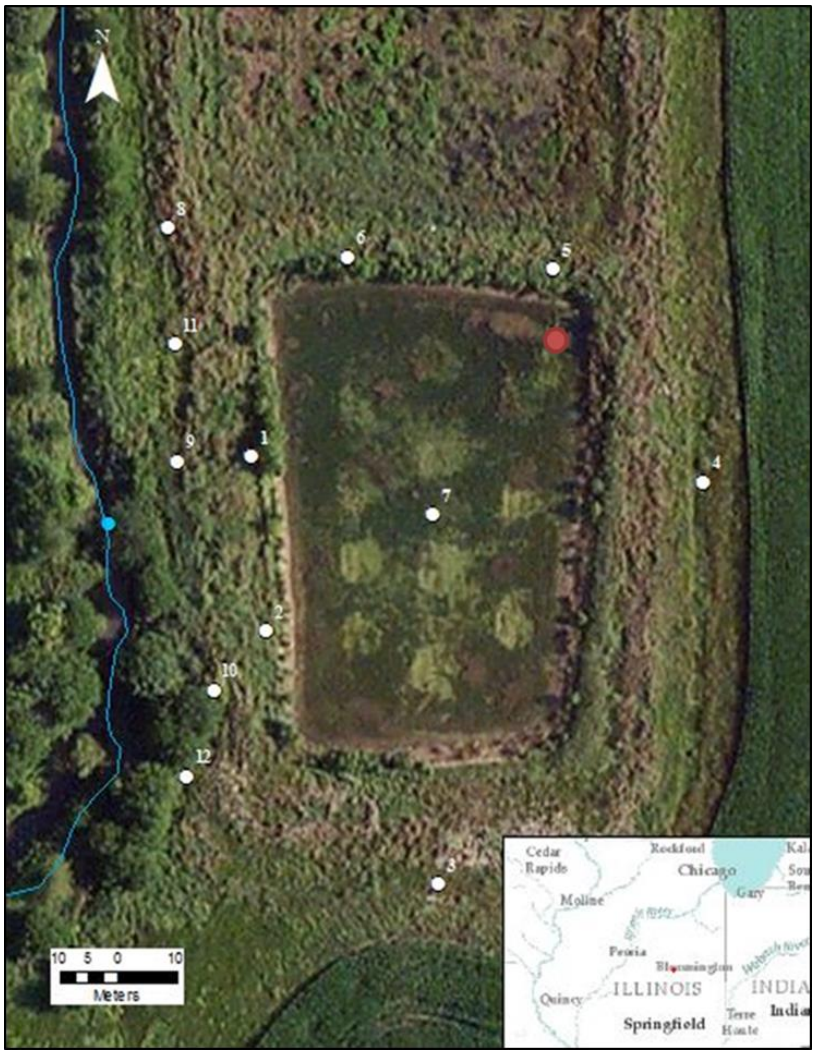

Figure 1: Areal view of Durbin wetland. The blue line is the stream located west of wetland. The red circle is the inlet pipe and the yellow is the outlet pipe. The white circles are the observation wells.

RESULTS

Tracer-Dilution Test

The test performed at the Durbin site wetland was a bromide tracer test to determine the wetlands capacity to retain water. Around the wetland, 10 observation wells were initially installed to monitor the shallow groundwater in the vicinity of the wetland (Figure 1). Subsequent to the tracer test, two additional wells have been installed. The wells were constructed from ten foot PVC with the bottom screened at locations around the wetland; locations were recorded with a Trimble GPS (Table 1).

Table 1: Universal Transverse Mercator (UTM) easting and northing for each well and stream at the Durbin wetland.

WELL	UTM Easting	UTM Northing
	Meters (m)	Meters (m)
1	363893.084	4484991.111
2	363895.428	4484961.562
3	363924.849	4484918.804
4	363970.394	4484986.82
5	363944.626	4485022.663
6	363909.363	4485024.841
7 (wetland/ reservoir)	363924.057	4484981.173
8	363878.577	4485029.749
9	363880.435	4484990.232
10	363886.4866	4484951.643
Stream	363868.551	4484979.84

On May 14, 2013, 400 gallons of water with 48 kg of sodium bromide (NaBr) were mixed into the wetland. Water samples were collected from May 14, 2013 to May 29, 2013 from the wetland, nine wells (wells 3 did not yield water), and from the adjacent stream. The water samples were analyzed on the ion chromatograph (I.C.) in Geology Department for anions (F^-, Br^-, Cl^-, $N\text{-}NO_3^-$, PO_4^{3-}, and SO_4^{2-}).

The average concentrations of bromide within the wetland was 12.95 mg/L +/- 2.13 mg/L and remained constant from the second day to the sixteenth day when field testing was complete. Over the course of the sampling, bromide we observed in all of the wells (with the exception of well 3, which was not sampled). Traces of bromide were detected within the first six hours from the initiation of the test in wells 4, 5, 8, and 9. However after the initial detection in wells 4, 5, 8, and 9, bromide was not observed again until the third day for well 5 and well 8 and the sixth day for well 4 and well 9. An estimated velocity was determined by dividing the distance of the well from the center of wetland by the initial time of observation or “hit” (Table 2). Calculation is based on UTM coordinates (Table 1) to derive distance from center of wetland (well 7), a

common datum. However, the estimated velocity will be slower because the distance from each well to the edge of wetland is smaller than the distance to the center of the wetland, thus the ion would travel a smaller distance.

Table 2. The bromide tracer-dilution results. The velocity was determined by using the distance of each well from well 7(wetland) divided by the arrival time.

Well ID	Distance	Initial Arrival Time	Velocity
	m	sec	m/s
Well 1	32.53	109500	2.97×10^{-4}
Well 2	34.70	108180	3.21×10^{-4}
Well 4	46.68	24900	1.87×10^{-3}
Well 5	46.31	24360	1.90×10^{-3}
Well 6	46.07	192600	2.39×10^{-4}
Well 7	0.00	12480	0.00
Well 8	66.54	23700	2.81×10^{-3}
Well 9	44.55	23700	1.88×10^{-3}
Well 10	7.79	22500	2.12×10^{-3}

Slug Test

Another test on May 16, 2014 was conducted using the slug method. The slug test uses falling and rising techniques to understand the groundwater's rate to equalize. The groundwater's ability to reach equilibrium is based on the matrix material. The test was done on wells 3, 4, and the newly put in wells 11 and 12. The wells were all within geometric mean of $6.13X10^{-5}$ ft/s or $1.87X10^{-5}$ m/s as the hydraulic conductivity. This indicates that the matrix ranges from sandy clay to silty sand which is an appropriate interpretation for the geologic setting of glacial deposits in the area.

CONCLUSION

- Bromide was observed in all wells within three days.
- Concentrations within wells approached the mean concentration within the wetland, suggesting that the wetland is leaking and that there is limited dilution by groundwater.
- Based upon the initial arrival of bromide at the wells, a conservative mean velocity for groundwater movement is 1.27×10^{-3} m/s.
- Slug test indicates matrix material as sandy clay to silty sand with a geometric hydraulic conductivity mean of $6.13X10^{-5}$ ft/s or $1.87X10^{-5}$ m/s.