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Summary of Findings: Upper Onion Creek Dye Trace, Hays County, Texas, Winter 2017

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Introduction

A consortium of central Texas agencies and groundwater scientists conducted a series of studies of the Trinity Aquifers that culminated in publication of the Hydrogeologic Atlas of the Hill Country Trinity Aquifer (Wierman et al., 2010). A continuation of those studies has revealed a hydrologic connection between the Middle Trinity Aquifer and the Blanco River and portions of Upper Onion Creek (Hunt et al., 2016; 2017).

An initial phase of dye tracing in the vicinity of Dripping Springs began in December, 2017 as a continuation of the previous work on surface water and groundwater interactions in Onion Creek. The study was designed to help delineate recharge areas, groundwater flow paths and travel times, and to identify potential sources to springs discharging within the basin. The study lasted for approximately five months, with the final samples collected in April 2018. An interagency memo was published in January 2018 that provided initial results of this study (IM, 2018). This memo provides a complete summary of the data and findings as the study has concluded.

Study area and Setting

The study area is shown in Figure 1 and is entirely within the watersheds of Onion and South Onion Creeks. The area is underlain by the Upper Glen Rose formation. The Upper Glen Rose contains layers with contrasting hydrologic properties with some areas behaving as aquitards (spring intervals), and other areas very permeable (recharge). The influence of the stratigraphy on the hydrogeology is further described in Watson et al., (2018). Additional factors relating to the surface and groundwater interaction relate to the fact that the Upper Glen Rose within portions of the creek are thin and fractured, and have well-developed karst features. Two karst recharge features were identified within the channel of Onion Creek for this study for direct injection: Howard Ranch Swallet and Bigote Swallet.

Beneath the Upper Glen Rose formation are the units that comprise the Middle Trinity Aquifer, including the Lower Glen Rose, Hensel, and Cow Creek. This is the primary aquifer unit. The reader is referred to a detailed review of the hydrogeology in Hunt et al., 2016 and 2017.

Hydrologic conditions

Most reaches of Onion Creek and South Onion Creek were not flowing at the beginning of the dye trace study (Figures 1 and 2). However, spring-fed pools were intermittently present along dry portions of the Onion Creek streambed (Figure 1). In some cases these pools were drained by small channels which stopped flowing just downstream. During both dye injections into karst features there were small amounts of water flowing into the features (0.1 cfs estimated). At Howard Ranch Swallet (Fluorescein) some creek flow entered the feature, and some continued past the swallet approximately 1500 ft before ceasing flow. At Bigote Swallet (RWT) all the water within the creek entered the feature and no water flowed past.

During the injection, South Onion Creek was flowing at the Gatlin Creek Road (Eosine injection site) crossing about 0.1 cfs (estimated). However, South Onion Creek was dry about 4 miles downstream at RR 12. Thus, flow along the stream recharged somewhere between the Gatlin Creek and the RR 12 crossings. Limited access along South Onion Creek prevented accurate determination of which reaches were flowing or not flowing.

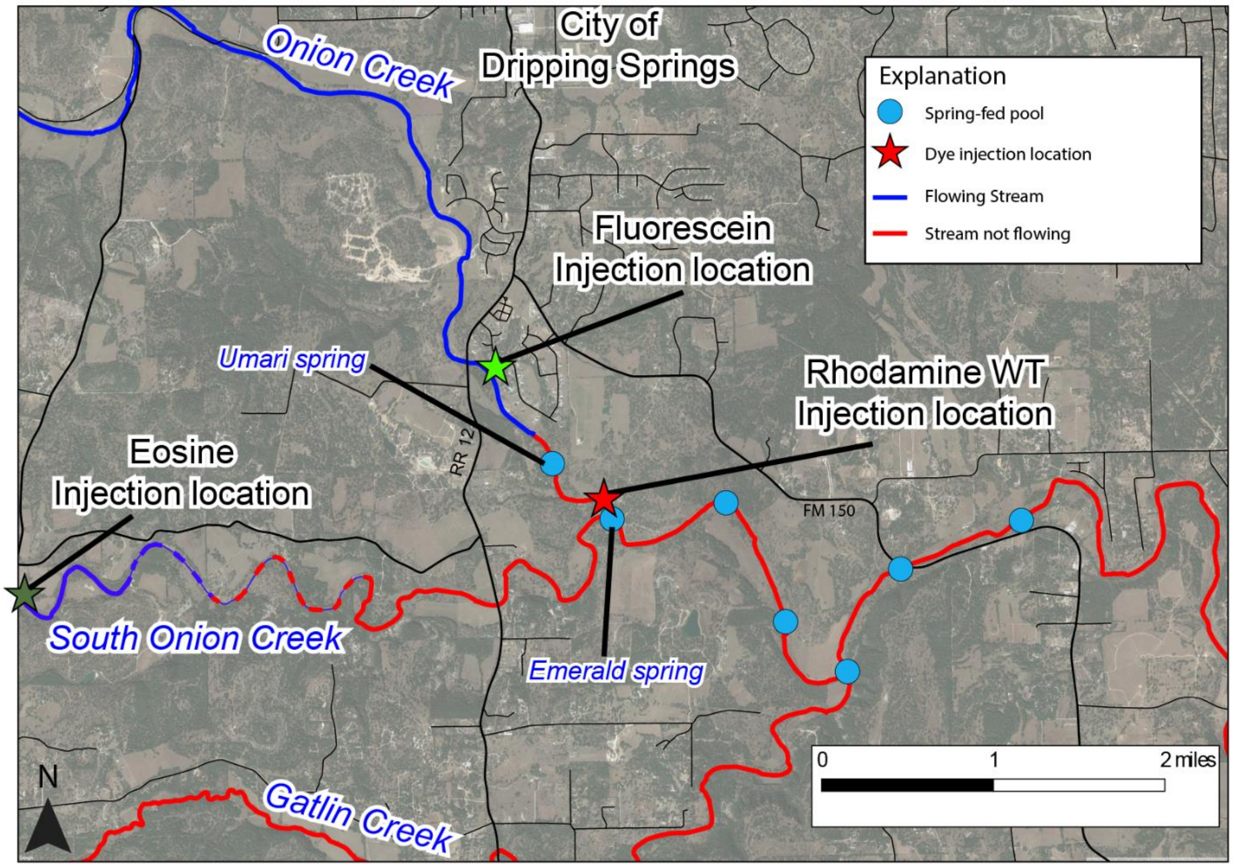

Figure 1-Study area map, and surface water flow conditions at the start of the dye trace study. Flowing/non-flowing stream reaches along South Onion Creek are inferred as access to creek frontage was limited.

After dye injection, flow conditions remained relatively stable through the first four months of the study (12/4/17 to 3/28/18). Streamflow reported at the Onion Creek USGS Driftwood gage (ID: 08158700), approximately 12 miles downstream of the study reach, slowly declined during this period (Figure 2). A relatively large rainfall event of over 3 inches occurred on 3/28/18 to 3/29/18 in the study area. This event significantly increased flows in Onion Creek (and likely South Onion), resulting in continuous flow across the study area. Most dye trace sampling had been concluded before the March 2018 rainfall event.

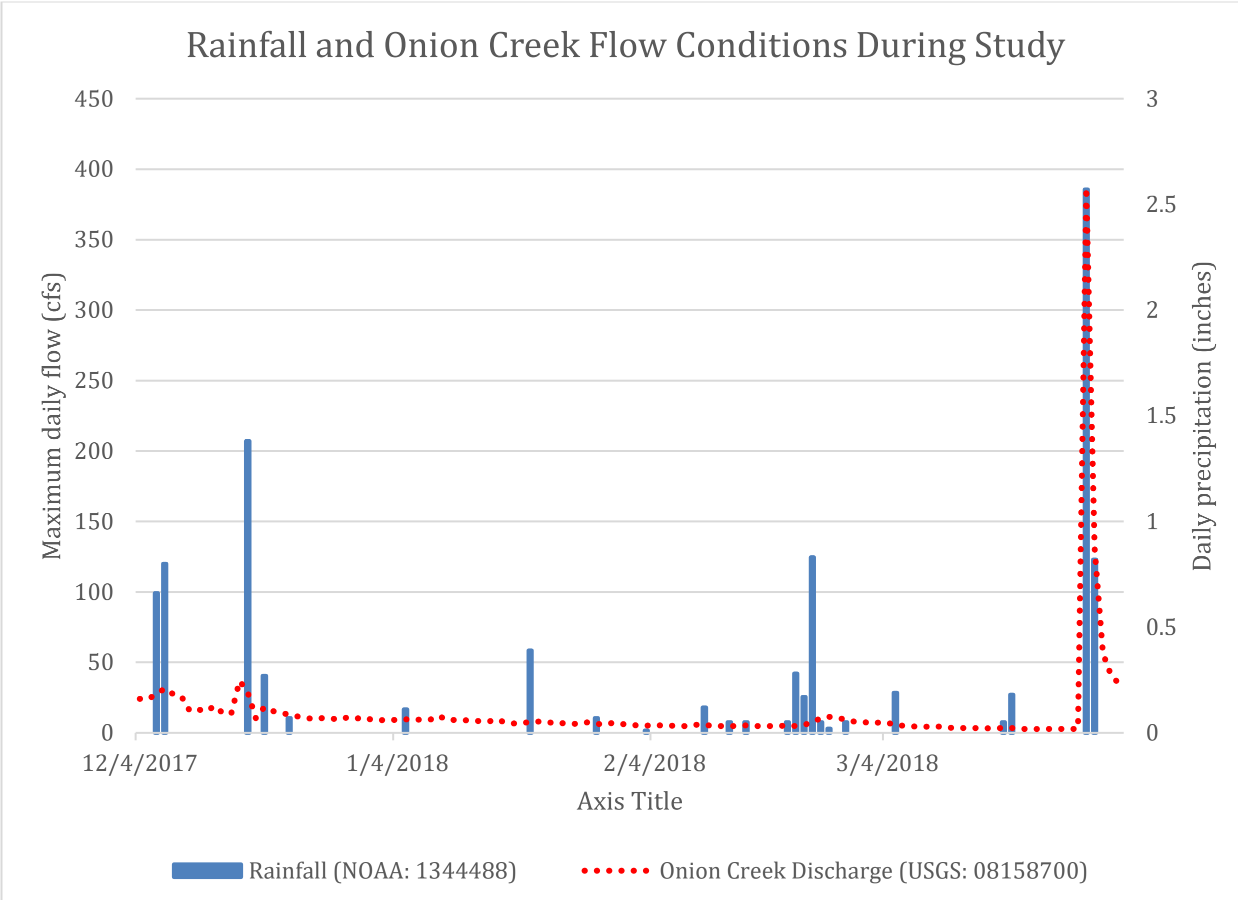

Figure 2-Daily Onion Creek flow and rainfall during the dye trace study. Onion Creek streamflow is reported from the USGS Driftwood gage, approximately 12 miles downstream of the study reach.

Methods

Dye tracing is a long-established, safe, and scientifically sound approach to characterize surface and groundwater interactions. Non-toxic fluorescent dyes are introduced into recharge features, such as caves, sinkholes, swallets, and fractures, or into streams that flow across the recharge zones of an aquifer. Water samples and absorbent charcoal packets are collected routinely at downgradient wells and springs and analyzed for the presence of the injected dyes (Aley, 2002).

Dye was introduced into two locations along Onion Creek and one location along South Onion Creek. Specific details on these locations and the type of dye used for the study are summarized in Table 1. Monitoring included discrete water samples and activated charcoal packets, which adsorb the organic dyes continuously from the water over the time they are in place. Lab results from water samples provide more accurate data on the concentration of dye in the water whereas lab results from analysis of charcoal packets determine the presence or absence. Charcoal packets have the advantage of allowing very low concentration of dye to accumulate over time to levels that can be detected in the laboratory.

Table 1: Summary of dye injections.

Site	Latitude (DD)	Longitude (DD)	Injection date	Dye
Howard ranch swallet (Onion Creek)	30.1597	-98.0890	12/4/2017 15:00	Fluorescein (7lbs)
Bigote swallet (Onion Creek)	30.1487	-98.0778	12/4/2017 16:30	Rhodamine WT (25 lbs)
South Onion Creek at Gatlin Creek Rd.	30.1422	-98.1362	12/6/2017 15:15	Eosine (10lbs)

For the Howard Ranch and Bigote Swallet injections, dye was introduced directly into recharging karst features (swallets) in the bed of Onion Creek (Figure 3). Dye from the Howard Ranch Swallet injection was carried into the subsurface by flow from Onion Creek. Dye from the Bigote Swallet injection was carried into the subsurface by flow from a nearby spring. The South Onion Creek injection was carried out by introducing dye into a pool of surface water. The dye was then carried downstream by creek flow across a known losing (recharging) reach although specific swallets are not currently known.

Figure 3-Dye injection photos: (left) Howard Ranch Swallet; (middle) Bigote Swallet; (right) South Onion Creek at Gatlin Creek Rd. crossing.

Water and charcoal packets were collected from a monitoring network of 36 wells and surface-water sites at various time intervals. After injection samples were collected at various time intervals from daily to monthly. Samples were shipped to Ozark Underground Laboratory (OUL), a lab in Missouri that specializes in analyses for dye-trace studies. OUL is equipped to analyze the samples for each of the three types of dye used in the study.

A continuously recording fluorimeter was installed at Emerald Spring by Barton Springs Edwards Aquifer Conservation District (BSEACD) staff. In addition, some duplicate samples were qualitatively analyzed for screening purposes at the BSEACD office using a desktop fluorimeter.

As a quality control measure, monitor sites were sampled in the week prior to dye injection to ensure that background dye was not already present in the groundwater or surface water system. In addition, two sites upstream of injection locations in Onion Creek and South Onion Creek were sampled throughout the duration of the study to monitor for outside sources of dye. During subsequent sampling a control sample was carried with the sampler to monitor any potential cross-site contamination.

Results

Table 2 contains a summary of all the dye detections. Complete dye analysis results from OUL labs are provided in the Appendix of this report. Results from each injection are summarized by the respective injection location and dye below.

Table 2- Summary of dye detections.

Site ID	Distance (mi)	First detection (days)
Fluorescein dye detections		
#2 (well)	0.1	1
#6 (well)	0.78	14-30
#16 (surface water)	1.0	1-7
#24 (well)	3.28	8-15
Rhodamine dye detections		
#18 (surface water)	0.69	14-30
#19 (well)	0.67	7-14
#21 (surface water)	1.28	30-49
#24 (well)	2.47	8-15
#28 (well)	1.34	1*
#33 (well)	1.76	14*
#35 (well)	1.79	14*
Eosine dye detections		
#22 FM 150 (surface water)	5.19	49-106
#29 Mt. Gainor (surface water)**	NA	NA
#1 RR 12 (surface water)	2.98	57-106
#5 Umari spring (surface water)	3.2	49-106

*Visible dye arrival time reported by owner. Presence of dye later confirmed by sample analysis.

**Detected upstream of injection location, indicates possible outside source of dye.

Fluorescein Results

Fluorescein was detected at three wells (groundwater) and one surface water site following dye injection into Howard Ranch Swallet (Figure 4).

The detection of dye at surface water site (#16) indicates a shallow groundwater flow path. However, the detection of dye within the three residential water supply wells indicates a deeper groundwater flow path within the Middle Trinity Aquifer. Well #2 was drilled to 340 ft deep, and has 100 feet of casing and grout isolating it from the surface and shallow groundwater (TWDB 2018).

The longest flow path present was site ID #24, which was 3.3 miles away from the Fluorescein injection location (Table 2). This detection was recorded in a charcoal sampler 7-15 days after dye introduction into Howard Ranch swallet, indicating a flow velocity of 0.22 -0.47 miles-per-day (1160 – 2480 ft/d).

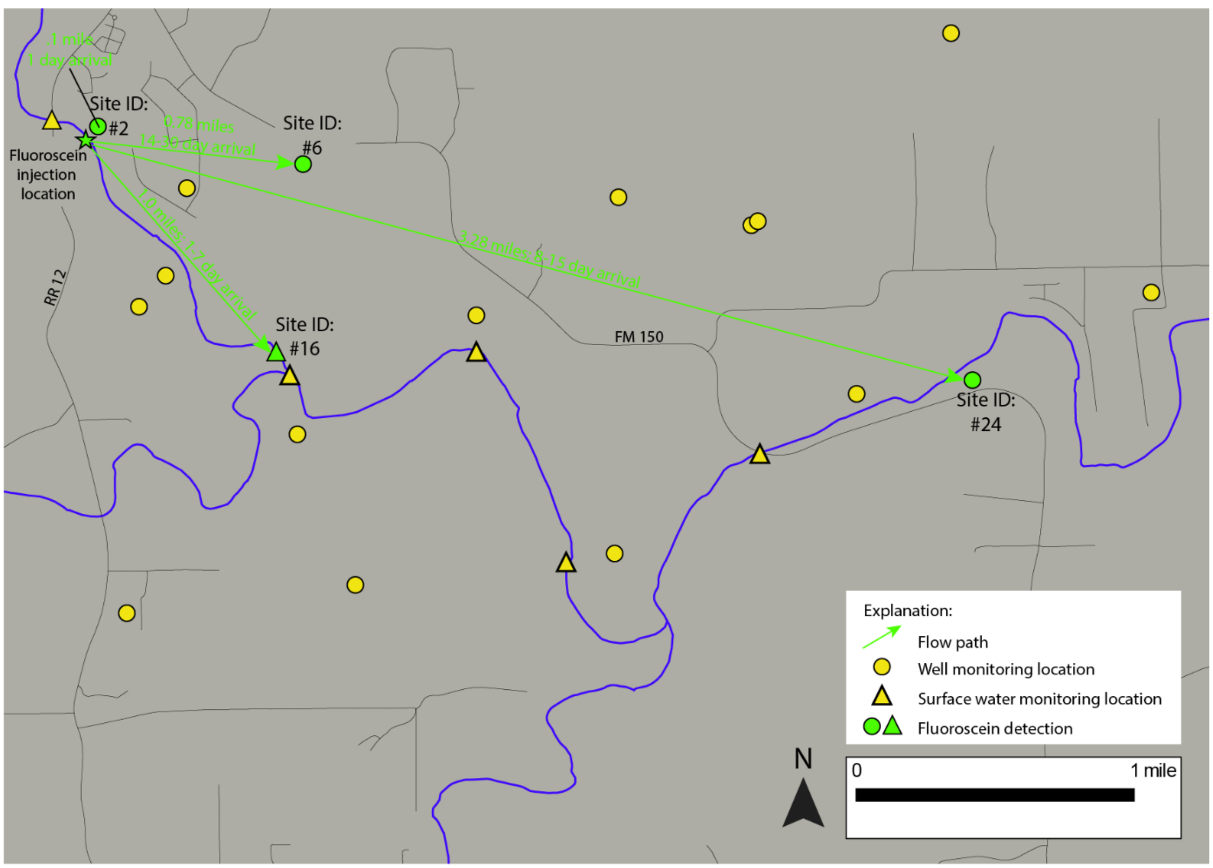

Figure 4-Map of fluorescein dye detections.

Rhodamine WT Results

Rhodamine WT (RWT) was detected in five wells (groundwater) and two surface water sites following dye injection into Bigote swallet (Figure 5). Groundwater detections at wells indicate relatively fast flow paths. At well site #28 visible dye was reported by the owner 1 day after dye injection (Figure 6). Subsequent laboratory testing confirmed that pink water observed in the well was RWT. This indicates a flow velocity of approximately 1.3 miles-per-day (6900 ft/d). In well #28 peak concentration of RWT measured in water samples was 1,140 parts-per-billion (Figure 7). This sample was taken one day after injection of RWT into Bigote Swallet. In subsequent weeks RWT concentrations in well #28 dropped below 10 ppb, though the dye persisted and was still detectible throughout the duration of the study.

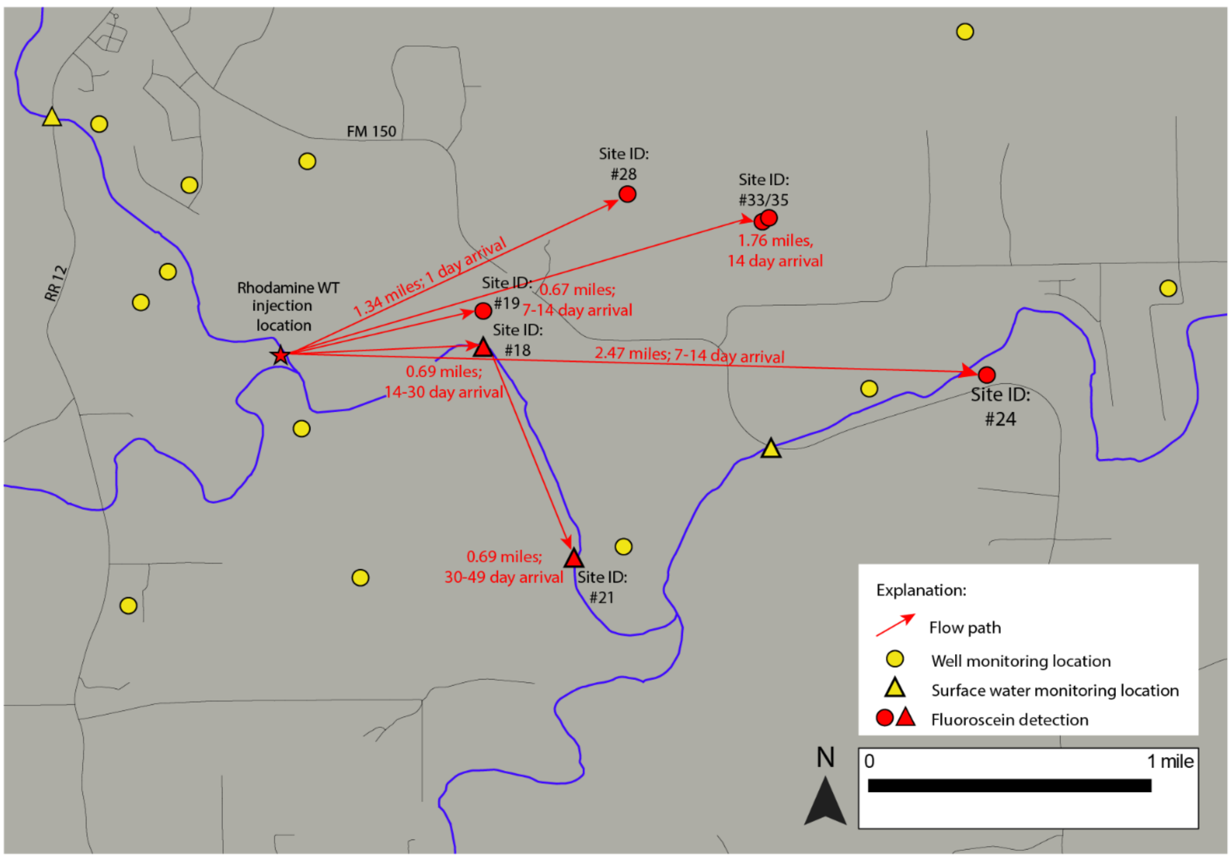

Figure 5-Map of Rhodamine WT dye detections.

Rhodamine detections at sites #18 and #21 indicate that the dye made its way downstream of the injection site along Onion Creek. These surface water monitoring sites were spring-fed pools that were not connected by surface water flow, suggesting that dye was travelling along a shallow groundwater flow path connecting the pools. This shallower groundwater flow appeared to be moving at a significantly slower rate (0.025-0.05 mi/d) than deeper well flow paths.

Figure 6-Sample of well water with visible RWT.

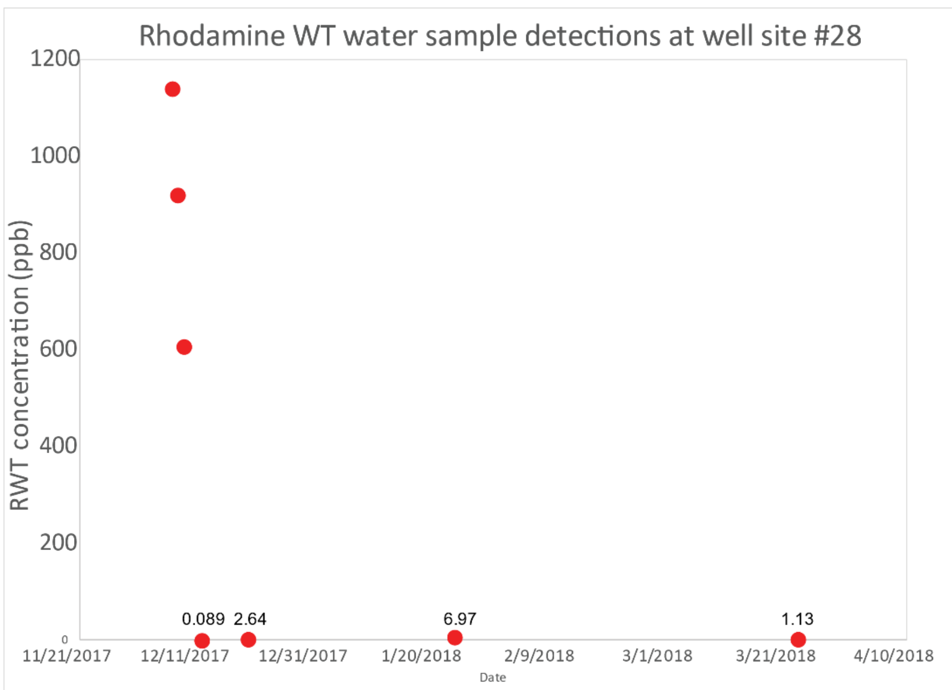

Figure 7-Water sample RWT concentrations from well ID #28.

Eosine Results

Eosine detections were reported at four surface water sites toward the latter end of the dye trace study (table 2). One of the detections came from the Mt. Gainor upstream control site (ID#, which may suggest that an outside source of eosine was present in South Onion Creek. The detection in Onion Creek at the RR 12 crossing is downgradient of the eosine injection location and could represent a subsurface flowpath from South Onion Creek (Figure 8). But it may also represent an outside source of eosine.

The Umari spring (ID #5) surface water detection met all the criteria for the eosine fluorescence peak (Appendix). This suggests that the eosine may have come from the injection location at the E. Gatlin Creek crossing, and that South Onion Creek may be a source of water to the spring.

An alternate possibility for the Umari spring eosine detection is influence from the nearby Dripping Springs Wastewater Treatment Plant (WWTP). In some cases treated effluent from WWTPs can contain chemicals that fluoresce and could potentially provide a false positive. However, water grab samples taken from shallow groundwater ports adjacent to the WWTP spray field did not show any dye detections (Appendix).

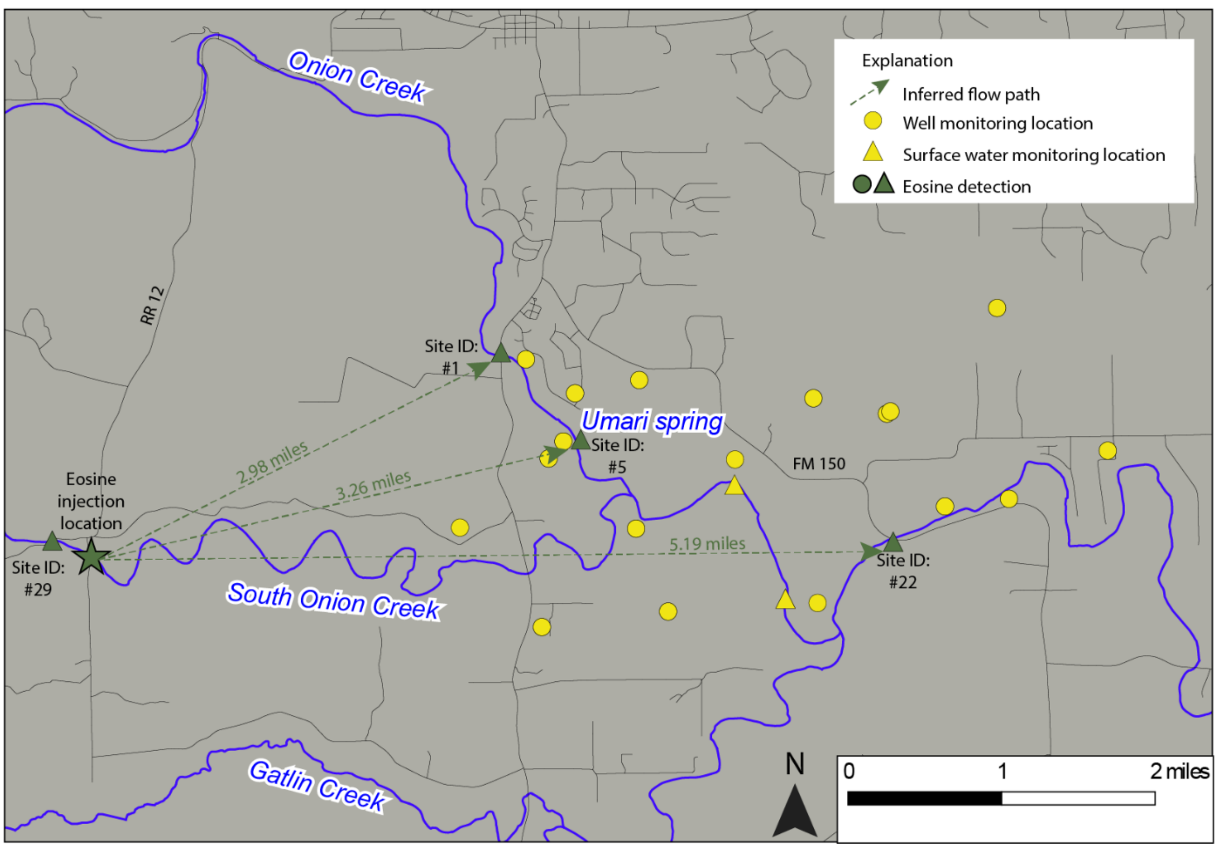

Figure 8- Map of eosine detections. Dotted arrows represent inferred flow paths as eosine detections were not as definitive as the fluorescein and RWT detections.

Control Results

Eosine was detected in charcoal packs at both of upstream monitoring sites 2-3 months after the eosine injection date (Table 3). This suggests that there may have been an upstream source of eosine present in surface water during the latter part of the dye trace study. Rhodamine WT and fluorescein were not detected in the upstream control sites, or within any sampler control samples.

To test for possible cross-contamination between field sites, the sampler carried a “field blank” charcoal pack during one of the sample days. No dye was detected when the sample was sent to the lab for analysis.

Table 3- Summary of upstream sample locations

RR 12 Control samples				South Onion at Mt Gainor Crossing			
Date range	**Eosine**	**RWT**	**Fluorescein**	**Date range**	**Eosine**	**RWT**	**Fluorescein**
12/4/17-12/12/17	ND	ND	ND	12/5/17-1/3/18	ND	ND	ND
12/12/2017 -1/2/18	ND	ND	ND	1/3/18-1/24/18	ND	ND	ND
1/30-18-3/22/18	0.594	ND	ND	1/24/18/3/22/18	2.26	ND	ND

Conclusions

Results from the Upper Onion Creek dye trace study demonstrate a clear surface water and groundwater connection between Onion Creek and the underlying Trinity Aquifer. The dye trace supports the conclusions of previous studies describing recharge along upper Onion Creek to the Middle Trinity Aquifer (Hunt et al., 2016; 2017). New insights this study are the rapid groundwater flow rates of up to 1.3 miles/day (6864 ft/d), and detections as far as 3.3 miles from the point of injection. The dye results also document recharge to a shallow groundwater system with a slower velocity of (0.025-0.05 miles/day).

Although the eosine results are less definitive, they demonstrate that water from South Onion Creek likely recharges the shallow groundwater system and moves eastward, providing flow to springs discharging along Onion Creek. In summary, these results demonstrate that streams within the Upper Onion Creek basin have an important influence on the Trinity Aquifer.

Future Work

The Upper Onion Creek dye trace study was the first of its kind in the area and yielded valuable insights. These results can be integrated with existing lithologic, geochemical, gain/loss, and hydrograph data to create a more complete picture of groundwater and surface water interactions in the area. This study should be viewed as a first phase of tracing in the study area. Going forward, additional dye studies should be done under varying hydrologic conditions and different injection locations. Future results will help refine our understanding of recharge from surface water streams in the upper Onion Creek Basin.

Acknowledgements

This study would not have been possible without the cooperation of land owners in providing property access and valuable information on the locations of wells and karst features in the area. Special thanks to Holton and Reed Burns for providing access to Charro Ranch for dye sampling and valuable scouting information on the location of Bigote Swallet. We would like to thank Dripping Springs Water Supply Company (DSWSC) for providing access to their public water supply wells for dye monitoring purposes.

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Appendix: Dye analysis results from Ozark Underground Laboratory:

OUL Number	Station Number	Station Name	Date/Time Placed	Date/Time Collected	Fluorescein		Eosine		RWT	
					Peak (nm)	Conc. (ppb)	Peak (nm)	Conc. (ppb)	Peak (nm)	Conc. (ppb)
C7553	**17**	**Browning #1**	**12/4/17 0930**	**12/11/17 0955**	**ND**		**ND**		**ND**	
C7843	**17**	**Browning 1**	**12/11/17 0955**	**12/18/17 0940**	**ND**		**ND**		**ND**	
C7865	17	Browning 1	12/18/17 0940	1/3/18 1009	ND		ND		ND	
C8417	17	Browning 1	1/3/18 1009	1/22/18 1115	ND		ND		ND	
C9282	17	Browning 1	1/22/18 1115	3/22/18 0938	ND		ND		ND	
C7562	18	Browning 2	12/4/17 0937	12/11/17 1015	ND		ND		ND	
C7864	**18**	**Browning 2**	**12/18/17 1110**	**1/3/18 1022**	**ND**		**ND**		**567.8**	**3.35**
C7936	**18**	**Browning 2**	**Water**	**1/3/18 1022**	**ND**		**ND**		**575.2**	**0.144**
C8418	18	Browning 2	1/3/18 1022	1/22/18 1149	ND		ND		568.4	6.63
C8492	18	Browning 2	**Water**	1/22/18 1149	ND		ND		576.2	0.077
C9284	18	Browning 2	1/22/18 1149	3/22/18 0930	ND		ND		566.4	3.91
C9390	18	Browning 2	11/29/17 1130	12/4/17 0937	ND		ND		ND	
C9398	18	Browning 2	12/11/17 1015	12/18/17 1110	ND		ND		ND	
C7561	19	Browning 3	12/4/17 0955	12/11/17 1020	ND		ND		ND	
C7830	**19**	**Browning 3**	**12/11/17 1020**	**12/18/17 1056**	**ND**		**ND**		**568.0**	**74.1**
C7862	19	Browning 3	12/18/17 1056	1/3/18 1031	ND		ND		568.0	252
C7932	**19**	**Browning 3**	**Water**	**12/18/17 1056**	**ND**		**ND**		**574.1**	**1.07**
C7935	19	Browning 3	**Water**	1/3/18 1031	ND		ND		574.5	0.218
C8419	19	Browning 3	1/3/18 1031	1/22/18 1155	ND		ND		568.2	12.6
C8493	19	Browning 3	**Water**	1/22/18 1155	ND		ND		572.8	0.120
C9285	19	Browning 3	1/22/18 1155	3/22/18 0930	ND		ND		567.4	8.92
C9391	19	Browning 3	11/29/17 1145	12/4/17 0955	ND		ND		ND	
C7565	20	Browning 4	12/4/17 1000	12/11/17 1055	ND		ND		ND	
C7831	**20**	**Browning 4**	**12/11/17 1055**	**12/18/17 1018**	**ND**		**ND**		**ND**	
C7866	20	Browning 4	12/18/17 1008	1/3/18 1051	ND		ND		ND	
C8421	20	Browning 4	1/3/18 1051	1/22/18 1210	ND		ND		ND	
C9286	20	Browning 4	1/22/18 1210	3/22/18 0930	ND		ND		ND	
C7863	**21**	**Browning 5**	**12/18/17 1008**	**1/3/18 1059**	**ND**		**ND**		**ND**	
C8422	21	Browning 5	1/3/18 1059	1/22/18 1221	ND		ND		568.0	1.75

C8494	21	Browning 5	**Water**	1/22/18 1221	ND		ND		575.6 (1)	0.026
C9283	21	Browning 5	1/22/18 1221	3/22/18 1001	ND		ND		ND	
C7556	**6**	**Burns 1**	**12/4/17 1255**	**12/11/17 1526**	**ND**		**ND**		**ND**	
C7828	**6**	**Burns 1**	**12/11/17 1526**	**12/18/17 1800**	**ND**		**ND**		**ND**	
C7855	6	Burns 1	12/18/17 1800	1/3/18 1630	515.2	0.778	ND		ND	
C7934	**6**	**Burns 1**	**Water**	**1/3/18 1630**	**ND**		**ND**		**ND**	
C8411	6	Burns 1	1/3/18 1630	1/22/18 1653	513.6 **	0.298	ND		ND	
C8491	6	Burns 1	**Water**	1/22/18 1653	ND		ND		ND	
C9253		Burns 1	1/3/18 1630	2/9/18 1332	ND		ND		ND	
C9255	6	Burns 1	2/9/18 1332	3/1/18 1552	ND		ND		ND	
C9395	6	Burns 1	11/14/17 1015	12/4/17 1255	ND		ND		ND	
C7530	15	Burns 10	12/1/17 1152	12/4/17 1430	ND		ND		ND	
C7555	15	Burns 10	12/4/17 1430	12/11/17 1557	ND		ND		ND	
C7838	**15**	**Burns 10**	**12/11/17 1557**	**12/14/17 1610**	**ND**		**ND**		**ND**	
C7834	15	Burns 10	12/14/17 1610	12/18/17 1730	ND		ND		ND	
C7850	15	Burns 10	12/18/17 1730	1/3/18 1153	ND		ND		ND	
C8403	15	Burns 10	1/3/18 1153	1/10/18 1147	ND		ND		ND	
C8404	15	Burns 10	1/10/18 1147	1/22/18 1417	ND		ND		ND	
C9252	15	Burns 10	1/22/18 1417	3/1/18 1342	ND		ND		ND	
C9319	15	Burns 10	**Water**	2/6/18 1106	ND		ND		ND	
C9638	15	Burns 10	4/5/18 1106	4/20/18 1330	ND		ND		ND	
C7559	16	Burns 11	12/4/17 1315	12/11/17 1505	514.8	1.17	ND		ND	
C7618	**16**	**Burns 11**	**Water**	**12/11/17 1505**	**ND**		**ND**		**ND**	
C7913	16	Burns 11	11/14/17 1130	12/4/17 1315	ND		ND		ND	
C7836	**16**	**Burns 11**	**12/11/17 1505**	**12/18/17 1720**	**ND**		**ND**		**ND**	
C7848	16	Burns 11	12/18/17 1720	1/3/18 1602	ND		ND		ND	
C8407	16	Burns 11	1/3/18 1602	1/10/18 1214	ND		ND		ND	
C8408	16	Burns 11	1/10/18 1214	1/22/18 1449	ND		ND		ND	
C9262	16	Burns 11	1/22/18 1622	3/1/18 1503	ND		ND		ND	
C7615	31	Burns 12	**Water**	12/12/17 1045	ND		ND		ND	
C7841	**32**	**Burns 13**	**12/14/17 1601**	**12/18/17 1700**	**ND**		**ND**		**ND**	
C7857	32	Burns 13	12/18/17 1700	1/3/18 1619	ND		ND		ND	
C7946	**32**	**Burns 13**	**Water**	**12/14/17 1601**	**ND**		**ND**		**ND**	
C8413	32	Burns 13	1/3/18 1619	1/22/18 1507	ND		ND		ND	

C9250	32	Burns 13	1/22/18 1507	3/1/18 1500	ND		541.4 **	0.227	ND	
C9403	32	Burns 13	**Water**	3/1/18 1500	ND		ND		ND	
C7552	7	Burns 2	12/4/17 1300	12/11/17 1426	ND		ND		ND	
C7847	**7**	**Burns 2**	**12/11/17 1426**	**12/18/17 1655**	**ND**		**ND**		**ND**	
C7861	7	Burns 2	12/18/17 1655	1/3/18 1431	ND		ND		ND	
C8414	7	Burns 2	1/3/18 1431	1/22/18 1336	ND		ND		ND	
C9258	7	Burns 2	1/22/18 1336	3/1/18 1538	ND		ND		ND	
C8402	8	Burns 3	12/4/17 1230	1/22/18 1400	ND		ND		ND	
C9259	8	Burns 3	1/22/18 1400	3/1/18 1517	ND		ND		ND	
C7564	9	Burns 4	12/4/17 1345	12/11/17 1700	ND		ND		ND	
C7822	**9**	**Burns 4**	**12/11/17 1700**	**12/19/17 1705**	**ND**		**ND**		**ND**	
C7858	9	Burns 4	12/19/17 1705	1/3/18 1549	ND		ND		ND	
C8412	9	Burns 4	1/3/18 1549	1/22/18 1644	ND		ND		ND	
C9261	9	Burns 4	1/22/18 1644	3/1/18 1425	ND		ND		ND	
C7548	10	Burns 5	12/4/17 1400	12/11/17 1627	ND		ND		ND	
C7824	**10**	**Burns 5**	**12/11/17 1627**	**12/19/17 1725**	**ND**		**ND**		**ND**	
C7851	10	Burns 5	12/19/17 1725	1/3/18 1535	ND		ND		ND	
C8409	10	Burns 5	1/3/18 1535	1/22/18 1622	ND		ND		ND	
C9256	10	Burns 5	1/22/18 1622	3/1/18 1455	ND		ND		ND	
C7558	11	Burns 6	12/4/17 0000	12/11/17 1605	ND		ND		ND	
C7823	**11**	**Burns 6**	**12/11/17 1605**	**12/19/17 1719**	**ND**		**ND**		**ND**	
C7859	11	Burns 6	12/19/17 1719	1/3/18 1531	ND		ND		ND	
C8410	11	Burns 6	1/3/18 1531	1/22/18 1613	ND		ND		ND	
C9257	11	Burns 6	1/22/18 1613	3/1/18 1443	ND		ND		ND	
C7551	12	Burns 7	12/4/17 1350	12/11/17 1710	ND		ND		ND	
C7825	**12**	**Burns 7**	**12/11/17 1710**	**12/19/17 1650**	**ND**		**ND**		**ND**	
C7856	12	Burns 7	12/18/17 1650	1/3/18 1518	ND		ND		ND	
C8433	12	Burns 7	1/3/18 1518	1/22/18 1533	ND		ND		ND	
C9254	12	Burns 7	1/22/18 1533	3/1/18 1414	ND		ND		ND	
C7557	13	Burns 8	12/4/17 1315	12/11/17 1505	ND		ND		569.2	8.67
C7617	13	Burns 8	**Water**	12/11/17 1505	ND		ND		ND	
C7912	13	Burns 8	12/1/17 1030	12/4/17 1313	ND		ND		ND	
C8490	13	Burns 8	**Water**	1/22/18 1455	ND		ND		ND	
C7916	14	Burns 9	12/4/17 1430	12/11/17 1557	ND		ND		ND	

C7854	**14**	**Burns 9**	**12/18/17 1730**	**1/3/18 1153**	**ND**		**ND**		**ND**	
C8405	14	Burns 9	1/3/18 1153	1/10/18 1147	ND		ND		ND	
C8406	14	Burns 9	1/10/18 1147	1/22/18 1420	ND		ND		ND	
C9251	14	Burns 9	1/22/18 1420	3/1/18 1342	ND		540.2 *	0.149	ND	
C9396	14	Burns 9	12/1/17 1145	12/4/17 1430	ND		ND		ND	
C9404	14	Burns 9	**Water**	3/1/18 1342	ND		ND		ND	
C7943	**39**	**Burns Sp 2**	**Water**	**12/18/17 1630**	**ND**		**ND**		**ND**	
C7534	**28**	**Cox**	**12/6/17 1557**	**12/7/17 1200**	**ND**		**ND**		**567.5**	**4,990**
C7543	28	Cox	12/7/17 1200	12/8/17 1255	ND		ND		567.0	51,400
C7567	28	Cox	12/8/17 1255	12/11/17 1248	ND		ND		567.4	3,750
C7610	**28**	**Cox**	**Water**	**12/6/17 1557**	**ND**		**ND**		**574.5**	**1,140**
C7612	28	Cox	**Water**	12/7/17 1200	ND		ND		574.3	920
C7614	28	Cox	**Water**	12/8/17 1255	ND		ND		574.5	606
C7619	28	Cox	**Water**	12/11/17 1248	ND		ND		577.2	0.089
C7835	**28**	**Cox**	**12/11/17 1248**	**12/19/17 1135**	**ND**		**ND**		**567.0**	**8,450**
C7933	**28**	**Cox**	**Water**	**12/19/17 1135**	**ND**		**ND**		**574.2**	**2.64**
C8423	28	Cox	12/19/17 1135	1/23/18 1118	ND		ND		568.1	380
C8495	28	Cox	**Water**	1/23/18 1118	ND		ND		573.6	6.97
C9274	28	Cox	1/23/18 1118	3/22/18 1108	ND		ND		567.7	42.9
C9326	28	Cox	**Water**	3/22/18 1108	ND		535.8 *	0.507	573.2	1.13
C9637	28	Cox	4/5/18 1038	4/20/18 1343	ND		ND		567.2	1.30
C9683	28	Cox	**Water**	4/20/18 1343	ND		ND		ND	
C7533	**2**	**Daniels**	**12/4/17 1230**	**12/5/17 1627**	**515.4**	**0.508**	**ND**		**ND**	
C7538	2	Daniels	12/5/17 1627	12/7/17 1125	515.5	190	ND		ND	
C7554	2	Daniels	12/7/17 1310	12/11/17 1330	516.4	1,970	ND		ND	
C7611	**2**	**Daniels**	**Water**	**12/5/17 1627**	**507.5**	**7.96**	**ND**		**ND**	
C7613	2	Daniels	**Water**	12/7/17 1125	507.5	33.1	ND		ND	
C7616	2	Daniels	**Water**	12/11/17 1330	507.3	3.18	ND		ND	
C7827	**2**	**Daniels**	**12/11/17 1330**	**12/19/17 1108**	**516.2**	**442**	**ND**		**ND**	
C7873	2	Daniels	12/19/17 1108	1/4/18 1102	515.2	64.1	ND		ND	
C7931	**2**	**Daniels**	**Water**	**12/19/17 1108**	**507.0**	**0.637**	**ND**		**ND**	
C7938	2	Daniels	**Water**	1/4/18 1102	506.7	0.084	ND		ND	
C8428	2	Daniels	1/4/18 1102	1/23/18 0958	515.0	0.645	ND		ND	
C8496	2	Daniels	**Water**	1/23/18 0958	508.8	0.073	ND		ND	

C9264	2	Daniels	1/23/18 0958	2/15/18 1440	515.9	13.2	ND		ND	
C9265	2	Daniels	2/15/18 1440	3/22/18 1053	515.2	2.72	ND		ND	
C9322	2	Daniels	**Water**	2/15/18 1440	506.4 (1)	0.010	ND		ND	
C9323	2	Daniels	**Water**	3/22/18 1053	506.0 (1)	0.029	ND		ND	
C7537	**26**	**DS3**	**12/4/17 1125**	**12/7/17 1320**	**ND**		**ND**		**ND**	
C7547	26	DS3	12/7/17 1320	12/11/17 1156	ND		ND		ND	
C7829	**26**	**DS3**	**12/11/17 1156**	**12/18/17 1558**	**ND**		**ND**		**ND**	
C7853	26	DS3	12/18/17 1558	1/3/18 1402	ND		ND		ND	
C8415	26	DS3	1/3/18 1402	1/24/18 1202	ND		ND		ND	
C9268	26	DS3	1/24/18 1402	3/22/18 1350	ND		ND		ND	
C7531	27	DS4	12/4/17 1120	12/7/17 1320	ND		ND		ND	
C7550	27	DS4	12/7/17 1320	12/11/17 1146	ND		ND		ND	
C7839	**27**	**DS4**	**12/11/17 1146**	**12/18/17 1515**	**ND**		**ND**		**ND**	
C7868	27	DS4	12/18/17 1515	1/3/18 1358	ND		ND		ND	
C8416	27	DS4	1/3/18 1358	1/24/18 1158	ND		ND		ND	
C9269	27	DS4	1/24/18 1358	3/22/18 1350	ND		ND		ND	
C8437	41	DS5	1/30/18 1400	1/31/18 0955	ND		ND		ND	
C8499	41	DS5	**Water**	1/30/18 1400	ND		ND		ND	
C9271	41	DS5	1/31/18 0955	2/1/18 1200	ND		ND		ND	
C9272	41	DS5	2/1/18 1200	2/9/18 1505	ND		ND		ND	
C8501	42	DSISD	**Water**	1/31/18 1120	ND		ND		ND	
C9263	42	DSISD	2/14/18 1100	2/15/18 0850	ND		ND		ND	
C9639	42	DSISD	2/15/18 0850	2/16/18 1300	ND		ND		ND	
C9321	43	DSISD 2	**Water**	3/13/18 1051	ND		ND		ND	
C7870	**34**	**Felton**	**12/18/17 1300**	**1/4/18 1150**	**ND**		**ND**		**ND**	
C7942	**34**	**Felton**	**Water**	**12/18/17 1300**	**ND**		**ND**		**ND**	
C8435	34	Felton	1/4/18 1150	1/30/18 1310	ND		ND		ND	
C9266		Field Blank	3/22/18 1415	3/22/18 1415	ND		ND		ND	
C7846	**22**	**FM 150**	**12/4/17 0820**	**1/2/18 1004**	**ND**		**ND**		**ND**	
C9249	22	FM 150	1/24/18 1516	3/22/18 1309	ND		541.4	0.459	ND	
C9318	22	FM 150	**Water**	3/22/18 1309	ND		ND		ND	
C9393	22	FM 150	11/28/17 1200	12/4/17 0820	ND		ND		ND	
C8426	22	FM 15O	1/2/18 1004	1/24/18 1516	ND		ND		ND	
C7544	**25**	**Irick**	**12/4/17 0855**	**12/12/17 1008**	**ND**		**ND**		**ND**	

C7845	**25**	**Irick**	**12/12/17 1008**	**12/18/17 1322**	**ND**		**ND**		**ND**	
C7869	25	Irick	12/18/17 1322	1/4/18 1132	ND		ND		ND	
C8431	25	Irick	1/4/18 1132	1/22/18 1057	ND		ND		ND	
C9270	25	Irick	1/22/18 1057	3/22/18 1146	ND		ND		ND	
C7944	**35**	**Latta**	**Water**	**12/18/17 1830**	**ND**		**ND**		**574.2**	**88.3**
C9273	29	Mt Gainor	1/24/18 1454	3/22/18 1029	ND		542.0	2.26	ND	
C9325	29	Mt Gainor	**Water**	3/22/18 1029	ND		ND		ND	
C9399	29	Mt Gainor	12/5/17 1700	1/3/18 0940	ND		ND		ND	
C9401	29	Mt Gainor	1/3/18 0940	1/24/18 1454	ND		ND		ND	
C9450	29	Mt Gainor	**Water**	12/5/17 1700	ND		ND		ND	
C7536	**3**	**Pennington**	**12/4/17 1030**	**12/5/17 1440**	**ND**		**ND**		**ND**	
C7542	3	Pennington	12/5/17 1440	12/7/17 1140	ND		ND		ND	
C7549	3	Pennington	12/7/17 1140	12/11/17 1315	ND		ND		ND	
C7832	**3**	**Pennington**	**12/11/17 1315**	**12/19/17 1120**	**ND**		**ND**		**ND**	
C7875	3	Pennington	12/19/17 1120	1/4/18 1112	ND		ND		ND	
C8430	3	Pennington	1/4/18 1112	1/23/18 1007	ND		ND		ND	
C9281	3	Pennington	1/23/18 1007	3/22/18 1049	ND		ND		ND	
C7545	**23**	**Pitts**	**12/4/17 0843**	**12/12/17 1031**	**ND**		**ND**		**ND**	
C7826	**23**	**Pitts**	**12/12/17 1031**	**12/18/17 1340**	**ND**		**ND**		**ND**	
C7872	23	Pitts	12/18/17 1340	1/4/18 1210	ND		ND		ND	
C8429	23	Pitts	1/4/18 1210	1/23/18 1048	ND		ND		ND	
C9277	23	Pitts	1/23/18 1048	3/22/18 1138	ND		ND		ND	
C7541	**30**	**Ramirez**	**12/7/17 1355**	**12/11/17 1350**	**ND**		**ND**		**ND**	
C7844	**30**	**Ramirez**	**12/11/17 1350**	**12/18/17 0910**	**ND**		**ND**		**ND**	
C7852	30	Ramirez	12/18/17 0910	1/3/18 1413	ND		ND		ND	
C8427	30	Ramirez	1/3/18 1413	1/22/18 1241	ND		ND		ND	
C9278	30	Ramirez	1/22/18 1241	3/22/18 1015	ND		ND		ND	
C8436	1	RR12	1/2/18 1023	1/30/18 1341	ND		ND		ND	
C9248	1	RR12	1/30/18 1341	3/22/18 1058	ND		542.0	0.594	ND	
C9317	1	RR12	**Water**	3/22/18 1058	ND		ND		ND	
C9392	1	RR12	11/28/17 1315	12/4/17 1215	ND		ND		ND	
C9397	1	RR12	12/4/17 1215	12/12/17 0930	ND		ND		ND	
C9402	1	RR12	**Water**	1/2/18 1023	ND		ND		ND	
C7874	**33**	**Stover**	**12/18/17 1205**	**1/4/18 1235**	**ND**		**ND**		**566.6**	**40,700**

C7945	**33**	**Stover**	**Water**	**12/18/17 1205**	**ND**		**ND**		**573.8**	**106**
C7939	33	Stover	**Water**	1/4/18 1235	ND		ND		573.9	36.6
C8434	33	Stover	1/4/18 1235	1/23/18 1105	ND		ND		566.9	17,800
C8498	33	Stover	**Water**	1/23/18 1105	ND		ND		573.2	14.7
C9267	33	Stover	1/23/18 1105	3/22/18 1122	ND		ND		567.8	97.0
C9324	33	Stover	**Water**	3/22/18 1122	511.4 **	0.292	ND		572.6	8.57
C7539	**5**	**Tingari Sp 2**	**12/5/17 1610**	**12/7/17 1310**	**ND**		**ND**		**ND**	
C7566	5	Tingari Sp 2	12/8/17 1315	12/11/17 1124	ND		ND		ND	
C7914	5	Tingari Sp 2	12/4/17 1105	12/5/17 1610	ND		ND		ND	
C7915	5	Tingari Sp 2	12/7/17 1310	12/8/17 1315	ND		ND		ND	
C7833	**5**	**Tingari Sp 2**	**12/11/17 1124**	**12/18/17 1455**	**ND**		**ND**		**ND**	
C7849	5	Tingari Sp 2	12/18/17 1455	1/3/18 1340	ND		ND		ND	
C8425	5	Tingari Sp 2	1/3/18 1340	1/24/18 1145	ND		ND		ND	
C9276	5	Tingari Sp 2	1/24/18 1145	3/22/18 1333	ND		540.8	1.02	ND	
C7532	**4**	**Tingari Well**	**12/4/17 1100**	**12/5/17 1555**	**ND**		**ND**		**ND**	
C7535	4	Tingari Well	12/5/17 1555	12/7/17 1303	ND		ND		ND	
C7563	4	Tingari Well	12/8/17 1315	12/11/17 1115	ND		ND		ND	
C7842	**4**	**Tingari Well**	**12/11/17 1115**	**12/18/17 1445**	**ND**		**ND**		**ND**	
C7867	4	Tingari Well	12/18/17 1445	1/3/18 1333	ND		ND		ND	
C8424	4	Tingari Well	1/3/18 1333	1/24/18 1136	ND		ND		ND	
C9275	4	Tingari Well	1/24/18 1136	3/22/18 1328	ND		ND		ND	
C7546	**24**	**Williamson**	**12/4/17 0825**	**12/12/17 1108**	**ND**		**ND**		**ND**	
C7821	**24**	**Williamson**	**12/12/17 1108**	**12/19/17 1748**	**515.5**	**81.4**	**ND**		**567.9**	**572**
C7871	24	Williamson	12/19/17 1748	1/4/18 1248	515.2	17.0	ND		567.4	273
C7930	**24**	**Williamson**	**Water**	**12/19/17 1748**	**508.2**	**0.803**	**ND**		**573.8**	**5.45**
C7937	24	Williamson	**Water**	1/4/18 1248	ND		ND		ND	
C8432	24	Williamson	1/4/18 1248	1/23/18 1033	515.1	2.15	ND		567.2	218
C8497	24	Williamson	**Water**	1/23/18 1033	ND		ND		573.2	1.74
C9279	24	Williamson	1/23/18 1033	3/22/18 1250	ND		ND		567.5	88.5
C9327	24	Williamson	**Water**	3/22/18 1250	ND		ND		572.2	0.623
C9394	24	Williamson	11/28/17 1100	12/4/17 0825	ND		ND		ND	