



**APPENDIX Y
FINAL KARST REPORT (REDACTED)**

TECHNICAL REPORT APPENDICES

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Trace 05-19:

On February 28, 2005, one-half pound of eosine dye mixture containing approximately 75% dye and 25% diluent was placed in a sinkhole (GIS insurgence feature No.400) as a dry set. The dry set was designed to allow the dye to be transported into the groundwater system during a runoff-producing storm. The dye introduction location is approximately at [redacted] at an elevation of approximately 756 feet msl. The purpose of the trace was to characterize groundwater flow patterns in this portion of the corridor.

On April 5, 2005, 2,000 gallons of potable water was pumped into the sinkhole to ensure that the dye entered the groundwater system. The water was introduced from 1036 to 1057 hours.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-19. Dye from this trace was also detected at the downstream sampling station, (Station 131). The figure does not show Station 131 because it is too far west to appear at the figure's scale.

The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 05-19 at

Trace 05-19 Trace Dye Detections at Station 102.

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
1/19 to 2/9/05	ND	ND
2/9 to 3/29/05	541.3	3,230
3/29 to 4/4/05	540.2	1,270
4/4/ to 4/13/05	541.1	3,320
4/13 to 4/20/05	540.8	254

Some, but not all, of the dye entered the groundwater system during a storm on March 22, 2005. The remainder was mobilized by water introduced on April 5, 2005. The velocity of the dye front was calculated based on this interpretation.

Based on the detection at the downstream Station 131, the first dye arrival and the peak dye concentration at [redacted] (Station 102) were about one day after the March 22, 2005 storm event. The straight-line flow path distance was approximately 809 feet. The elevation loss is approximately 56 feet. The mean gradient along this flow path is approximately 365 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 980 feet per day, based on the detection at Station 131. After introduction, dye from this trace was detectable for about >51 days at [redacted] when sampling was halted.

Trace 05-19 hydrologically linked a large sinkhole in the corridor to a previously undocumented spring also located in the Section 5 corridor. [redacted] has not been demonstrated to have special significance for this project.

Trace 05-20:

On March 23, 2005 at 1313 hours, one-half pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into a ditch failure in the median of SR 37). There were approximately five gpm of stormwater runoff entering the groundwater system at the time of dye introduction. The dye introduction location is approximately at _____ at an elevation of approximately 758 feet msl. The purpose of the trace was to characterize groundwater flow patterns in this portion of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-20.

The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 05-20.

Trace 05-20 Trace Dye Detections at Station 148.

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
2/25 to 3/22/05	ND	ND
3/22 to 3/29/05	568.9*	455*
3/29 to 4/5/05	567.8	6,140
4/5 to 4/13/05	568.5	2,350
4/13 to 4/20/05	569.2	1,120

* Values are the mean of two samples.

The first dye arrival at _____ (Station 148) was about six days after the dye introduction. The straight-line flow path distance was approximately 804 feet. The elevation loss is approximately 28 feet. The mean gradient along this flow path is approximately 154 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 132 feet per day. After introduction, dye from this trace was detectable for about 28 days at _____. Dye was still detectable when sampling was halted.

Trace 05-20 hydrologically linked a sinkhole in the median of SR37 with a previously undocumented spring that is also located in the Section 5 corridor. _____ has not been demonstrated to have any special significance for the project.

Trace 05-21:

On April 2, 2005 at 1127 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.316) that was reopening in the road ditch along SR 37. At 1128 hours, 0.25 pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1147 hours. Approximately 1,800 gallons of water was introduced to start Trace 05-21. The dye introduction point is located approximately at

at an elevation of approximately 707 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-21.

The following table shows the groundwater flow route detections in activated carbon samplers of dye from Trace 05-21 at

Trace 05-21 Trace Dye Detections at Station 163.

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
3/23 to 3/30/05	ND	ND
3/30 to 4/7/05	541.3	1,160
4/7 to 4/14/05	541.0*	296*
4/14 to 4/20/05	541.1	76.9

* Values are the mean of two samples.

Eosine dye from Trace 05-21 was observed discharging from (Station 163) at 1153 hours on April 2, 2005. The minimum velocity of the dye front is based on this observation.

Eosine dye was also detected at

Trace 05-21 Trace Dye Detections at Station 166.

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
4/7 to 4/14/05	ND	ND
4/14 to 4/20/05	541.0	2.83

The flow path to seems to be minor leakage from the main flow path that discharges at

The first dye arrival at (Station 163) was in less than 20 minutes after the dye introduction. The straight-line flow path distance was approximately 243 feet. The elevation loss is approximately 24 feet. The mean gradient along this flow path is approximately 521 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 13,997 feet per day. After introduction, dye from this trace was detectable for about 18 days at at which time sampling was halted.

The first dye arrival at (Station 166) was between 12 and 18 days after the dye introduction. The straight-line flow path distance was approximately 365 feet. The elevation loss is approximately 27 feet. The mean gradient along this flow path is approximately 391 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 20 feet per day. Dye from this trace was not detected at Station 166 until the last sampling event. After introduction, dye from this trace was detectable at for >18 days at which time sampling was halted.

The dye introduction point receives runoff from SR37. The springs to which the dye introduction point has been connected are also in the Section 5 corridor. Neither of these springs was documented prior to this investigation. The groundwater system identified by Trace 05-21 has not been demonstrated to have special significance for this project.

Trace 05-22:

On April 2, 2005 at 1233 hours, potable water was introduced into a sinkhole that was reopening in the road ditch along SR 37. At 1238 hours, 0.25 pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1248 hours. Approximately 1,000 gallons of water was introduced to start Trace 05-22. There was some ponding of water during water introduction. The dye introduction point is located approximately at _____ at an elevation of approximately 781 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-22. The figure does not show Station 128 because it is covered by the title block.

The following table shows groundwater flow route detections of dye in activated carbon samplers from Trace 05-22 at

Trace 05-22 Trace Dye Detections at Station 135.

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
2/10 to 3/24/05	ND	ND
3/24 to 4/5/05	541.3	3,740
4/5 to 4/12/05	541.2	685
4/12 to 4/19/05	540.7	167

Dye from this trace was detected at the following sampling stations downstream of

Based on the detection at _____ (Station 128), the first dye arrival at (Station 135) was about six hours after the dye introduction. The straight-line flow path distance was approximately 689 feet. The elevation loss is approximately 27 feet. The mean gradient along this flow path is approximately 207 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 2,869 feet per day, based on the detection at _____ (Station 128). After introduction, dye from this trace was detectable for about 17 days at _____ at which time sampling was halted.

Trace 05-22 linked a reopening sinkhole that receives runoff from SR37 with a previously undocumented spring located in the Section 5 corridor. This groundwater system has not been demonstrated to have special significance for this project. Trace 05-22 demonstrated the presence of a karst flowpath that crosses under SR37.

Trace 05-23:

On April 2, 2005 at 1256 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.405) that was reopening in the road ditch along SR 37. At 1258 hours, 0.5 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the groundwater system. Water introduction ended at 1300 hours. Approximately 800 gallons of water was introduced to start Trace 05-23. The dye introduction point is located approximately at an elevation of approximately 756 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-23.

The following table shows groundwater flow route detections of dye in activated carbon samplers from Trace 05-23.

Trace 05-23 Trace Dye Detections at Station 102.

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
2/9 to 3/29/05	ND	ND
3/29 to 4/4/05	567.8	14,700
4/4 to 4/13/05	571.4	378*
4/13 to 4/20/05	571.6	56.5*

* Due to a large concentration of eosine in the sample, the rhodamine WT concentration cannot be accurately calculated.

Dye from this trace was also detected at the downstream sampling station, (Station 131). The figure does not show Station 131 because it is too far west to appear at the figure's scale.

Based on the detection at the downstream Station 131, the first dye arrival and the peak dye concentration at (Station 102) were less than six hours after dye introduction. The straight-line flow path distance was approximately 758 feet. The elevation loss is approximately 56 feet. The mean gradient along this flow path is approximately 390 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 3,087 feet per day, based on the detection at Station 131. Dye from this trace was detectable for about 18 days at at which time sampling was halted.

Trace 05-23 hydrologically linked one sinkhole in a cluster of sinkholes that are located in the corridor to a spring also located in the Section 5 corridor. This was the second trace to has not been demonstrated to have special significance for this project. The trace demonstrated the presence of a karst flowpath crossing SR37.

Trace 05-24:

On April 2, 2005 at 1405 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.226) north of [redacted]. At 1410 hours, one pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1430 hours. Approximately 1,800 gallons of water was introduced to start Trace 05-24. The dye introduction point is located approximately at [redacted] at an elevation of approximately 790 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-24. The figure does not show Station 185, since it is too far north to appear at the figure's scale.

The following tables show the groundwater flow route detection of dye in activated carbon samplers from Trace 05-24 at

Trace 05-24 Trace Dye Detections at Station 89.

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
11/17 to 12/3/04	ND	
12/3/04 to 4/7/05	540.7	11.0
4/7 to 4/15/05	540.5	8.50
4/15 to 4/20/05	541.1*	14.20*

* Based on the mean of two samplers each analyzed twice.

Trace 05-24 Trace Dye Detections at Station 87.

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
3/16 to 3/29/05	ND	ND
3/29 to 4/7/05	540.9	96.9
4/7 to 4/14/05	540.7	12.6
4/14 to 4/20/05	540.5	4.82

The dye was detected at [redacted] (Station 89) and in higher concentrations at [redacted] (Station 87), indicating that most of the dye was discharged downstream of [redacted]. It was also detected at the following downstream sampling stations:

Based on the detection at Station 185, the first dye arrival at [redacted] (Station 87) was about 1.5 days after dye introduction. The straight-line groundwater flow path distance was approximately 5,052 feet. The elevation loss is approximately 140 feet. The mean gradient along this flow path is approximately 146 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 3,770 feet per day, based on the detection at Station 185. After introduction, dye was detectable for about 18 days at [redacted] at which time sampling was halted. After introduction dye was detectable for >18 days at Station 89

Trace 05-24 was the second trace to flow to [redacted] previously undocumented springs. The springs in [redacted] have not been demonstrated to have special significance for the project.

Trace 05-25:

On April 4, 2005 beginning at 1634 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.318) that is north of [redacted]. At 1635 hours, one ounce of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1639 hours. Approximately 1,000 gallons of water was introduced to start Trace 05-25. The dye introduction point is located approximately at [redacted] at an elevation of approximately 699 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-25.

The following table shows groundwater flow route detections of dye in activated carbon samplers from Trace 05-25.

Trace 05-25 Trace Dye Detections at Station 169.

Sampling Period	Peak Emission Wavelength (nm)	Fluorescein Dye Concentration (ppb)
3/23 to 3/30/05	ND	ND
3/30 to 4/7/05	517.0	18,700
4/7 to 4/14/05	516.9	833
4/14 to 4/20/05	516.9	579

Dye was also detected at Station 190, which is located in the SR37 ditch. There is only wet-weather flow at Station 190. Given the hydrogeologic setting it is likely that the fluorescein detected at Station 190 flowed through the epikarstic zone from the dye introduction point. The dye concentration from the positive activated carbon sampler was 64.8 ppb. This is much larger than fluorescein detections commonly derived from parking lots and highways, so highway runoff is an unlikely source for the dye detected at Station 190. Under the conditions tested water movement to Station 190 represents a minor flow path. Figure 37 shows flow paths to both Stations 169 and 190.

The first dye arrival and peak dye concentration at [redacted] (Station 169) were less than three days after dye introduction. The straight-line groundwater flow path distance was approximately 314 feet. The elevation loss is approximately 31 feet. The mean gradient along this flow path is approximately 521 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 107 feet per day. After introduction dye was detectable for >16 days at [redacted] before sampling was halted.

Trace 05-25 hydrologically linked a sinkhole in the Section 5 corridor to a previously undocumented spring that is also in the corridor. [redacted] has not been demonstrated to have special significance for the project.

Trace 05-26:

On April 4, 2005 at 1647 hours, potable water was pumped into a sinkhole (GIS insurgence feature No.315) that was reopening in a slope above the southwest corner of [redacted] At 1650 hours, one-quarter of a pound of sulforhodamine B dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1657 hours. Approximately 1,000 gallons of water was introduced to start Trace 05-26. The dye introduction point is located approximately at [redacted] at an elevation of approximately 719 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-26.

The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 05-26.

Trace 05-26 Trace Dye Detections at Station 166.

Sampling Period	Peak Emission Wavelength (nm)	Sulforhodamine B Dye Concentration (ppb)
3/30 to 4/7/05	ND	ND
4/7 to 4/14/05	577.4	4.11
4/14 to 4/20/05	577.0	4.86

The first dye arrival at [redacted] (Station 166) was less than ten days after dye introduction. The straight-line groundwater flow path distance was approximately 687 feet. The elevation loss is approximately 39 feet. The mean gradient along this flow path is approximately 300 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 71 feet per day. After introduction, dye was detectable for about 16 days at [redacted] before sampling was halted.

Trace 05-26 demonstrates a karst flowpath that [redacted] The trace links a reopening sinkhole that abuts SR37 with a previously undocumented spring that is in the Section 5 corridor. [redacted] has not been demonstrated to have special significance for the project.

Trace 05-27:

On April 4, 2005 at 1734 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.442) that was reopening in the road ditch along SR 37. At 1735 hours, 0.5 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the groundwater system. The water introduction ended at 1738 hours. Approximately 1,000 gallons of water was introduced to start Trace 05-27. The dye introduction point is located approximately at an elevation of approximately 789 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-27.

The following table shows groundwater flow route detections of dye in activated carbon samplers from Trace 05-27.

Trace 05-27 Trace Dye Detections at Station 198.

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
4/3/05 (water)	ND	ND
4/3 to 4/6/05	568.6	5.37
4/6 to 4/13/05	569.4	333
4/13 to 4/19/05	568.4	278

The first dye arrival at (Station 198) was less than two days after dye introduction. The peak concentration of dye arrived between two and nine days after dye introduction. The straight-line groundwater flow path distance was approximately 478 feet. The elevation loss is approximately 20 feet. The mean gradient along this flow path is approximately 221 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 293 feet per day. After introduction, dye was detectable for about 15 days at before sampling was halted.

The trace links a reopening sinkhole that abuts SR37 with , a previously undocumented spring in the Section 5 corridor. has not been demonstrated to have special significance for the project.

Trace 05-28:

On April 4, 2005 at 1834 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.322) that was reopening in the road ditch along SR 37. At 1836 hours, 0.25 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the groundwater system. The water introduction ended at 1742 hours. Approximately 1,500 gallons of water was introduced to start Trace 05-28. The dye introduction point is located approximately at an elevation of approximately 700 feet msl. The purpose of the trace was to help characterize groundwater flow patterns along an alignment of a possible new terrain interchange associated with Kinser Pike.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-28.

The following table shows dye detections in activated carbon samplers from Trace 05-28 at

Trace 05-28 Trace Dye Detections at Station 173.

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
3/23 to 3/30/05	ND	ND
3/30 to 4/7/05	568.1	4,110
4/7 to 4/14/05	569.9	696
4/14 to 4/20/05	568.8	218

Rhodamine WT dye was observed discharging from (Station 173) at 1844 hours on April 4, 2005. The minimum velocity of the dye front was calculated from this observation. The first dye arrival at (Station 173) was approximately eight minutes after dye introduction. The straight-line groundwater flow path distance was approximately 268 feet. The elevation loss is approximately 30 feet. The mean gradient along this flow path is approximately 591 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 48,240 feet per day. After introduction, dye was detectable for about 16 days at before sampling was halted.

Dye from Trace 05-28 was also detected at (Station 172). The following table shows dye detections in activated carbon samplers from Trace 05-28 at

Trace 05-28 Trace Dye Detections at Station 172.

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
3/23 to 3/30/05	ND	ND
3/30 to 4/14/05	569.1	14.0

The first dye arrival at (Station 172) was less than ten days after dye introduction. The straight-line groundwater flow path distance was approximately 1,195 feet. The elevation loss is approximately 55 feet. The mean gradient along this flow path is approximately 243 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 125 feet per day. This flow path is relatively minor under these flow conditions compared with the flow pathway to After introduction, dye was detected at for about 10 days before sampling was halted.

Neither of the springs that received water from Trace 05-28 were documented prior to this investigation. This groundwater system and these two springs have not been demonstrated to have special significance for this project.

Trace 08-01:

At 1628 hours on November 19, 2008, the introduction of potable water into a sinkhole began (GIS insurgence feature No.66). The dye introduction point is located at approximately at an elevation of approximately 778 feet msl. The water was hauled to the location by truck. At 1630 hours, 0.25 pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into the flowing water. Water was continuously discharged into the sinkhole until 1637 hours. A total of 2,200 gallons was used to start this trace. The purpose of this trace was to help delineate the recharge area of

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detection of dye in activated carbon samplers from Trace 08-01.

Trace 08-01: Trace Dye Detections at

Sampling Period	Station 83 Fluorescein Dye Concentration (ppb)	Station 84 Fluorescein Dye Concentration (ppb)
10/16 to 11/19/08	ND	1.85*
11/19 to 11/25/08	279	17,500
11/25 to 12/3/08	135	968
12/3 to 12/10/08	48.1	281
12/10 to 12/20/08	13.4	83.4
12/20/08 to 1/8/09	10.3	44.2
1/8 to 1/23/09	3.09	27.9
1/23 to 4/21/09	3.40	17.2
4/21 to 4/27/09	1.22	3.83
4/27 to 5/4/09	1.55	2.53

* background value

Dye from this trace was detected at the following sampling stations downstream of

The dye first arrived at in less than 1.5 days. The straight-line distance of this flowpath is approximately 1,306 feet. The elevation loss is approximately 97 feet. The mean gradient along this flow path is approximately 392 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,037 feet per day based on the Station 12 dye detection. After introduction, dye was detectable for about 166 days at before sampling was halted.

It is not clear if groundwater flow to had a faster or slower velocity than flow to
However, it is likely that the travel rate to was slower than to
since had lower concentrations of dye both in this trace and in Trace 04-07
These concentrations support the concept that contributes water to
The straight-line groundwater flow path distance is approximately 1,605 feet. The elevation

loss is approximately 108 feet. The mean gradient along this flow path is approximately 355 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 297 feet per day. After introduction, dye was detectable for about 166 days at before sampling was halted.

This trace demonstrates that the sinkhole traced does not contribute water to and lies outside its recharge area. This groundwater system has limited biological significance; see the discussion for Trace 09-07.

Trace 08-02:

At 1648 hours on November 19, 2008, the introduction of potable water into a sinkhole began (GIS insurgence feature No.49). The dye introduction point is at approximately at an elevation of approximately 768 feet msl. Water was conveyed into the sinkhole via a garden hose. The hose was discharging approximately 4.8 gpm. At 1702 hours, 0.75 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced. At 0850 hours on November 20, 2008, water introduction was halted. Approximately 4,600 gallons of water was used to start this trace. The purpose of this trace was to help delineate the recharge area of

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 08-02.

Trace 08-02 Trace Dye Detections at Station 55:

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
11/25 to 12/3/08	ND	ND
12/3 to 12/10/08	(1)	
12/10 to 12/20/08	(1)	
12/20/08 to 1/9/09	568.0	24.0
1/9 to 1/23/09	ND	

(1) = A small amount of rhodamine WT may be present in this sample, but it cannot be accurately calculated due to the presence of another dye.

Dye was only detected at between 31 and 51 days after dye introduction. The straight-line groundwater flow path distance was approximately 2,561 feet. The elevation loss is approximately 103 feet. The mean gradient along this flow path is approximately 212 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 50 feet per day, although the first arrival of rhodamine WT may have been obscured by another dye. After introduction, dye was detectable for about 51 days at

The trace demonstrates that the sinkhole into which dye was introduced does not contribute water to and lies outside of the recharge area. Trace 08-02 was the second trace detected at Trace 08-03, while introduced a few minutes later than Trace 08-02, was detected earlier. is a large spring in the study area, but has no other known project significance.

Trace 08-03:

At 1722 hours on November 19, 2008, one pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the discharge from a small spring in a losing stream reach within a large sinkhole (GIS insurgence feature No.103). Flow was estimated to be approximately 0.25 gpm and all re-entered the groundwater system within about 30 feet of the dye introduction point. On November 20, 2008 at 0925 hours, almost all dye had moved into the groundwater system. Nevertheless, a fire hydrant about 800 feet upstream of the dye introduction point was opened and discharged through a water meter. Approximately 17,500 gallons of water was discharged between 0931 and 1030 hours. This water increased the velocity of dyed water flowing through the groundwater system. If this much water had been used at the time of dye introduction it would have moved some of the dye down the valley instead of allowing almost all of it to enter the groundwater system.

The dye introduction point is located at approximately _____ at an elevation of approximately 750 feet msl. The purpose of this trace was to help delineate the recharge area of _____

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29. The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 08-03 at _____

Trace 08-03 Trace Dye Detections at Station 55:

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
10/16 to 11/19/08	ND	ND
11/19 to 11/25/08	541.3	600
11/25 to 12/3/08	541.6	1,110
12/3 to 12/10/08	541.2	340
12/10 to 12/20/08	541.2	215
12/20/08 to 1/9/09	541.1	59.7
1/9 to 1/23/09	541.0	50.0

Note: There are additional eosine detections from Trace 08-03 at this sampling station; the data are found in Appendix B.

Dye from this trace was detected at the following sampling stations: _____

Based on the Station 80 dye detection, dye first arrived at _____ about three days after dye introduction. The straight-line groundwater flow path distance is approximately 5,041 feet. The elevation loss is approximately 85 feet. The mean gradient along this flow path is approximately 89 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,688 feet per day. After introduction, dye was detectable for about 336 days at _____ before sampling was halted.

This is one of two traces detected at _____ The groundwater trace crossed the subwatershed boundary and thus demonstrates interbasin transfer of water from the _____ basin to the _____ basin. The trace also demonstrates that the dye introduction feature does not contribute water to _____ and therefore lies outside its recharge area. While _____ is a relatively large spring for this study area, it has no other known project significance.

Trace 09-04:

At 1630 hours on February 1, 2009, one pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into snow melt running down the tributary stream (GIS insurgence feature No. ss1) in which _____ is located. Flow was estimated to be approximately 1.5 gpm. The dye introduction point is located at approximately _____ at an elevation of approximately 736 feet msl.

A dye introduction (Trace 04-11) at the headwaters of this stream demonstrated that a portion of this tributary loses water to _____. The purpose of Trace 09-04 was to help define what portion of the tributary loses water to _____.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-04 that discharged from springs.

Trace 09-04: Trace Dye Detections

Sampling Period	Station 74 Eosine Dye Concentration (ppb)	Station 73 Eosine Dye Concentration (ppb)	
1/23 to 2/3/09	ND	ND	
2/3 to 2/10/09	ND	7.44	
2/10 to 2/17/09	0.842*	6.21	
2/17 to 2/26/09	0.487*	7.06	
2/26 to 3/6/09	1.20	12.9	

* mean of two samples ** Background not from Trace 09-04.

Note: There are additional eosine detections from Trace 09-04 at Stations 73 and 74; the data are found in Appendix B.

Dye from this trace was also detected at the following sampling stations but derived their dye from surface flowpaths or dye discharged from the springs above.

Even though _____ is farther downstream in the system than _____ it had an order of magnitude higher dye concentration than _____ and had an earlier dye detection. That indicates that _____ receives more of its recharge from the dyed tributary than does _____ is merely sampling passing surface water in this trace.

This trace demonstrates that the dye introduction point is downstream of the reach that loses water into the _____ groundwater system and is thus not part of the _____ recharge area.

Dye first arrived at _____ between 9 and 16 days after dye introduction. The straight-line groundwater flowpath distance was approximately 4,137 feet. The elevation loss is approximately 69 feet. The mean gradient along this flow path is approximately 88 feet per mile. The minimum mean

groundwater flow velocity along this flow path under these flow conditions was approximately 262 feet per day. After introduction, dye was detectable for >170 days at before sampling was halted.

Dye first arrived at about five days after dye introduction. The straight-line groundwater flowpath distance was approximately 5,014 feet. The elevation loss is approximately 82 feet. The mean gradient along this flow path is approximately 86 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,002 feet per day based on the Station 68 dye detection. Dye from this trace was overridden by dye from Trace 09-10, so the persistence of the dye from Trace 09-04 is unknown. However, it was >85 days. The same duration applies to

Trace 09-05:

At 1142 hours on February 2, 2009, potable water was introduced into a sinkhole (GIS insurgence feature No.55) in preparation for dye introduction. The water was hauled to the dye introduction point by truck. At 1144 hours, 0.25 pound of fluorescein dye mixture containing approximately 75% dye equivalent and 25% diluent was introduced into the water flow. At 1151 hours, the first load of water, amounting to 2,100 gallons, had been discharged to the ground. A second load of water was discharged at the same location from 1232 to 1241 hours. A total of 4, 200 gallons of water were used to start this trace. The purpose of this trace was to help delineate the recharge area of

The location of the dye introduction point is approximately _____ at an elevation of approximately 745 feet msl.

The dye introduction point and diagrammatic flow paths of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-05.

Trace 09-05:

Sampling Period	Station 150 Fluorescein Dye Concentration (ppb)	Station 201 Fluorescein Dye Concentration (ppb)	Station 203 Fluorescein Dye Concentration (ppb)
1/9 to 1/23/09	ND	0.724**	NS
1/23 to 2/3/09	314		
1/23 to 2/10/09		288	58.5
2/3 to 2/10/09	668		
2/10 to 2/17/09	87.7	9.79	0.935
2/17 to 2/26/09	12.1	6.64	ND
2/26 to 3/6/09	11.6	6.20	ND
3/6 to 3/17/09	4.69*	4.89	ND
3/17 to 3/23/09	4.20	2.16	ND
3/23 to 3/31/09	4.72	2.92	ND
3/31 to 4/15/09	7.81	1.50	ND

* mean of three samples ** background value NS = No sample

Dye from Trace 09-05 was detected at the following additional sampling station:

- Station 202: (this station only had flow for one sampling period during this trace)
The table above is truncated; the complete results are provided in Appendix B.

Dye first arrived at Station 150 _____ in less than 1.5 day after dye introduction. The straight-line groundwater flowpath distance was approximately 1,210 feet. The elevation loss is approximately 49 feet. The mean gradient along this flow path is approximately 214 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,076 feet per day. After introduction, dye was detectable for 96 days at Station 150

Dye first arrived at Station 201 within eight days after dye introduction. The straight-line groundwater flowpath distance was approximately 7,098 feet. The elevation loss is approximately 99 feet. The mean gradient along this flow path is approximately 74 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 883 feet per day. After introduction, dye was detectable for 78 days at

Dye first arrived at Station 202 and its associated downstream sampling station within eight days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,574 feet. The elevation loss is approximately 101 feet. The mean gradient along this flow path is approximately 81 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 817 feet per day. After introduction, dye was detectable for 8 days at Station 202 and for 15 days at Station 203. The dye concentration was substantially greater at Station 203 than at Station 202.

Trace 09-05 demonstrates complexity in the groundwater distribution pattern in the southern part of the Section 5 corridor. The most extremely separated springs, had similar dye concentrations and duration of dye discharge, while the spring between them had much lower concentrations and a much briefer period of dye discharge.

This groundwater system has limited biological significance; see the discussion for Trace 09-07. The sinkhole used for this dye introduction did not contribute water to and therefore lies outside of the recharge area.

Trace 09-06:

At 1516 hours on February 3, 2009, 0.75 pound of sulforhodamine B dye mixture containing approximately 75% dye and 25% diluent was placed as a dry set in a snow-covered sinkhole (GIS insurgence feature No.154). The location of the dye introduction point is approximately at an elevation of approximately 738 feet msl. The purpose of the trace was to help delineate the recharge area.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29. Dye was not detected at any spring; however sulforhodamine dye was detected at several locations in the unnamed tributary containing including a sampling station established after the dye introduction. This station was called (Station 204). was the most upstream of the stations sampled with a positive dye detection from this trace.

Dye from Trace 09-06 was detected at the following sampling stations located downstream from Station 204:

Since Station 204 is not a spring, there is either a spring we failed to locate, or more likely, simply a gaining stream reach between (Station 75) and Station 204 that received water from the

The temperature stayed below freezing until February 5, when the daytime highs reached the mid-50s. There was probably not enough snow to create runoff to mobilize the dye, but it did create good antecedent conditions. The rainfall event on February 10, 2009 on wet soil probably moved the dye into the groundwater system and the calculations of first arrival and velocity are based on that assumption.

Based on the dye detection at Station 67 and the estimate that the dye did not move into the groundwater system until February 10, dye first arrived at Station 204 about half a day after dye introduction. The straight-line groundwater flowpath distance was approximately 1,280 feet. The elevation loss is approximately 50 feet. The mean gradient along this flow path is approximately 206 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 9,711 feet per day. After introduction, dye was detectable for 77 days at Station 204.

The sinkhole used for this dye introduction does not contribute water to and lies outside their recharge areas.

Trace 09-07: SR 37

At 1830 hours on April 27, 2009, potable water began to be discharged to a roadside ditch. At 1832 hours, three pounds of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the potable water discharge. At 1840 hours, the first load of approximately 2,100 gallons of water had been discharged to the ditch. A second load of potable water was discharged at the same point from 1902 to 1911 hours. A total of approximately 4,200 gallons of water was used to start Trace 09-07. The location of the dye introduction point is approximately _____ at an elevation of approximately 769 feet msl. The purpose of the trace was to help delineate the recharge area and to test for recharge from areas that have no visible sinkhole development.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-07.

Trace 09-07: Trace Dye Detections

Sampling Period	Station 75 Eosine Dye Concentration (ppb)	Station 145 Eosine Dye Concentration (ppb)	Station 201 Eosine Dye Concentration (ppb)	Station 203 Eosine Dye Concentration (ppb)
4/21 to 4/27/09	14.8**	ND	ND	ND
4/27 to 5/4/09	37.0	ND	780	8.65
5/4 to 5/12/09	42.8	ND	159*	8.52
5/12 to 5/19/09	27.1	ND	0.521****	14.6
5/19 to 5/26/09	12.6			
5/26 to 6/2/09	18.5			
5/19 to 5/27/09		ND	27.8*	0.461****
5/27 to 6/2/09		ND	25.3	2.43
6/2 to 6/10/09	14.0	1.95	52.1	4.33*
6/10 to 6/16/09	33.0	4.34	84.4	11.9
6/16 to 6/24/09	32.4	3.42	31.2	5.74
6/24 to 7/6/09	12.2	1.23	14.7	0.705*

* mean of two samples ** residual dye from Trace 09-04 This sample did not meet all criteria for a positive detection but has been calculated as though it were the tracer dye.

Note: There are additional eosine detections from Trace 09-07 at all four sampling stations; the data are found in Appendix B.

Dye from this trace was detected at the following sampling station downstream of

detections are not at least an order of magnitude greater than the background sample. However, grab samples of water were also collected when the carbon samplers were replaced and the water samples went to non-detect between the traces.

Dye first arrived at (Station 75) less than seven days after dye introduction. The straight-line groundwater flowpath distance was approximately 1,196 feet. The elevation loss is approximately 65 feet. The mean gradient along this flow path is approximately 287 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 178 feet per day. After introduction, dye was detectable for at least 70 days at before it was overridden by dye from a subsequent trace.

Dye first arrived at (Station 145) between 77 and 85 days after dye introduction. The straight-line groundwater flowpath distance was approximately 869 feet. The elevation loss is approximately 49 feet. The mean gradient along this flow path is approximately 298 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 10 feet per day. After introduction, dye was detectable for about 177 days until sampling was halted.

Dye first arrived at less than seven days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,653 feet. The elevation loss is approximately 123 feet. The mean gradient along this flow path is approximately 98 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 996 feet per day. After introduction, dye was detectable for about 97 days at before sampling was halted.

Dye first arrived at less than seven days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,376 feet. The elevation loss is approximately 132 feet. The mean gradient along this flow path is approximately 109 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 954 feet per day. After introduction, dye was detectable for less than 85 days at Station 203

The dye introduction point is essentially on the HUC14 subwatershed boundary with no evidence of a karst feature or a buried karst feature. Not only was there recharge, but there was both fast and complex recharge with water going to both the basins and specifically to four different discharge points. This dye introduction point was less than 10 feet from the current SR37 shoulder. This has important implications for water and spills running off pavement even in areas without mapped karst features.

This trace links and from linkage through Traces 09-05 and 09-09, These spring systems may share a faunal assemblage with based on the hydrologic linkage. is biologically noteworthy (see Section 5.5 of the report), but with lesser significance than

This trace demonstrates that the area traced does not contribute water to and therefore lies outside its recharge area.

Trace 09-08:

At 1935 hours on April 27, 2009, one-half pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was placed in the (GIS insurgence feature No.109) as a dry set to be introduced into the groundwater system by a series of storms predicted over the following 24 hours. However, little of the dye had been mobilized overnight and potable water was hauled to the location to expedite the dye introduction. From 1214 hours to 1231 hours on April 28, approximately 2,100 gallons of potable water was introduced into the A second load was introduced from 1704 hours to 1719 hours. A total of approximately 4,200 gallons were used to start Trace 09-08. The location of the dye introduction point is approximately at an elevation of approximately 764 feet msl. The purpose of the trace was to help delineate the recharge area.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-08.

Trace 09-08 Trace Dye Detections at Station 48:

Sampling Period	Peak Emission Wavelength (nm)	Fluorescein Dye Concentration (ppb)
4/21 to 4/27/09		ND
4/27 to 5/4/09	516.3	5,810
5/4 to 5/12/09	515.5	62.8
5/12 to 5/19/09	515.7	15.3
5/19 to 5/26/09	515.8	11.6
5/26 to 6/2/09	515.5	10.9
6/2 to 6/10/09	515.9	4.97
6/10 to 6/16/09	515.6	4.74
6/16 to 6/24/09	515.5	4.46
6/24 to 7/6/09	515.9	4.71

Dye from Trace 09-08 was detected at the following sampling stations downstream of

Dye first arrived at less than seven days after dye introduction based on the Station 12 dye detection. The straight-line groundwater flowpath distance was approximately 3,903feet. The elevation loss is approximately 90 feet. The mean gradient along this flow path is approximately 122 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,186 feet per day. After introduction, dye was detectable for 70 days at before the dye was overridden by a subsequent trace.

The trace demonstrated that the _____ contributes water to _____ and therefore lies within the _____ recharge area. The trace also crossed the entire highway corridor as well as the subwatershed boundary and transferred water from the _____

Trace 09-09:

At 1037 hours on April 28, 2009, potable water began to be pumped to the (GIS insurgence feature No.40). The location of the dye introduction point is approximately at an elevation of approximately 765 feet msl. At 1041 hours, one pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the discharge. The first load of water was completely discharged at 1102 hours. A second load was introduced from 1117 to 1142 hours on April 28, 2009. A total of approximately 4,200 gallons of water were used to start Trace 09-09. The purpose of the trace was to help delineate the recharge area.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the detections of dye in activated carbon samplers from Trace 09-09.

Trace 09-09: Trace Dye Detections

Sampling Period	Station 150 Rhodamine WT Dye Concentration (ppb)	Station 201 Rhodamine WT Dye Concentration (ppb)	Station 203 Rhodamine WT Dye Concentration (ppb)
4/21 to 4/27/09		ND	ND
4/21 to 4/28/09	ND		
4/27 to 5/4/09		3,120	38.3
4/28 to 5/4/09	12.8		
5/4 to 5/12/09	ND	126.5*	9.61
5/12 to 5/19/09	ND	0.521**	30.3
5/19 to 5/27/09	ND	57.8*	ND
5/27 to 6/2/09	ND	22.4	ND
6/2 to 6/10/09	ND	25.6	ND
6/10 to 6/16/09	ND	ND	ND
6/16 to 6/24/09	ND	15.3**	ND
6/24 to 7/6/09	ND	18.2**	ND

* mean of two samples ** A fluorescence peak is present that does not meet all the criteria for a positive dye result. However, it has been calculated as though it were the tracer dye

Dye first arrived at Station 150 within six days after dye introduction. The straight-line groundwater flowpath distance was approximately 1,093 feet. The elevation loss is approximately 69 feet. The mean gradient along this flow path is approximately 333 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 181 feet per day. Dye was detectable for six days or less at so the groundwater velocity was higher than the minimum stated above.

Dye first arrived at Station 201 within six days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,504 feet. The elevation loss is approximately 119 feet. The mean gradient along this flow path is approximately 97 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,082 feet per day. After introduction, dye was detectable for 84 days at

Dye first arrived at Station 203 within six days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,195 feet. The elevation loss is approximately 128 feet. The mean gradient along this flow path is approximately 109 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,030 feet per day. After introduction, dye was detectable for 21 days at

This is the third trace to demonstrate that this suite of springs share recharge areas; the other traces were Trace 09-05 and 09-07. These spring systems may share a faunal assemblage with based on the hydrologic linkage demonstrated by Trace 09-07. is biologically noteworthy (see Section 5.5 of the report), but with lesser significance than

This trace demonstrates that the area traced does not contribute water to and lies outside its recharge area.

Trace 09-10:

At 0616 hours on July 7, 2009, potable water was introduced at the downstream end of a culvert under SR 37(GIS insurgence feature No.ss1). The location of the dye introduction point is approximately at an elevation of approximately 750 feet msl. Two and one-half pounds of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the discharged water at 0623 hours, at which time the first load of water had been fully discharged. A second load of water was discharged from 0641 hours to 0649 hours on July 7, 2009. Each load was approximately 2,100 gallons, resulting in a total of 4,200 gallons of water being introduced into this ephemeral stream.

Trace 04-11 demonstrated that some portion of the stream channel recharges while Trace 09-04 (initiated about 1,000 feet south of the point at which Trace 04-11 was started) showed that its dye introduction point was downstream of the stream reach that recharges. The purpose of Trace 09-10 was to better define the stream reach that recharges.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detections of dye in activated carbon samplers at from Trace 09-10.

Trace 09-10 Trace Dye Detections at Station 48

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
6/24 to 7/6/09	ND	ND
7/6 to 7/21/09	540.4	2,800
7/21 to 8/2/09	540.4	36.9
8/2 to 10/21/09	541.6	23.0

Trace 09-10 Trace Dye Detections at Station 73

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
6/24 to 7/6/09	541.4	3.34*
7/6 to 7/21/09	541.1	182

* This is residual dye from Trace 09-07

Earlier traces demonstrated that the more downstream reaches of this stream lose water that recharge and this trace did not reveal anything new about those flowpaths.

Dye from this trace was detected at the following additional sampling stations:

Based on the Station 12 dye detection, dye first arrived at _____ within 13 days after dye introduction. The straight-line groundwater flowpath distance was approximately 5,300 feet. The elevation loss is approximately 96 feet. The mean gradient along this flow path is approximately 96 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 409 feet per day. After introduction, dye was detectable for >106 days at _____ before sampling was halted. Dye was detected at Station 73 _____ and at Station 75 _____ for > 14 days before sampling was halted.

The trace demonstrated that the dye introduction point is within the stream reach that loses water into the _____ groundwater system and is therefore within the _____ recharge area.

Trace 09-11

From 0835 to 0845 hours on July 7, 2009, 0.25 pound of sulforhodamine B dye mixture containing approximately 75% dye and 25% diluent was introduced into a well. The location of the dye introduction point is approximately [redacted]. The dye had been previously dissolved in approximately 0.5 gallon of potable water in a disposable container and was poured into a disposable funnel that was connected to a disposable hose that reached standing water. The dye mixture was then flushed from the hose using five gallons of potable water. The elevation of the pooled water where the dye was introduced was approximately 720 feet msl. The purpose of the trace was to determine which spring(s) receive water passing through the dye introduction point and to help understand the hydrologic and biologic relationship among spring systems near [redacted].

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-11 at Station 75

Trace 09-11 Trace Dye Detections at Station 75

Sampling Period	Peak Emission Wavelength (nm)	Sulforhodamine B Dye Concentration (ppb)
6/24 to 7/6/09	ND	ND
7/6 to 7/21/09	577.2	6,850

Dye from Trace 09-11 was detected at the following additional sampling stations:

The additional detection points are located downstream of [redacted] Station 73 is fed by a karst groundwater flowpath from stream losses downstream of [redacted] Station 145 detected residual dye suggesting continuing low flow through the dye introduction point. There was detectable dye present in the water samples at Station 145 for a month after the dye introduction.

Based on the Station 67 dye detection, dye first arrived at [redacted] about 1.5 days after dye introduction. The straight-line groundwater flowpath distance was approximately 341 feet. The elevation loss is approximately 16 feet. The mean gradient along this flow path is approximately 248 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 301 feet per day. There was no sampling after the sampling period in which the initial detection was made so there are no data on the persistence of the dye.

The mean velocity calculated above consists mostly of a surface channel where flow may be faster than through the groundwater path.

Trace 09-12

At 1059 hours on July 7, 2009, potable water was introduced into a sinkhole (GIS insurgence feature No. 50). The location of the dye introduction point is approximately

at an elevation of approximately 776 feet msl. At 1103 hours, one pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into the discharge. The first load of water was completely discharged at 1106 hours. A second load of water was discharged at the same location from 1128 to 1135 hours on July 7, 2009. Each load was approximately 2,100 gallons, resulting in a total of 4,200 gallons of water being introduced for this trace. The purpose of this trace was to help delineate the recharge area.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-13.

Trace 09-12 Trace Dye Detections at Station 48

Sampling Period	Peak Emission Wavelength (nm)	Fluorescein Dye Concentration (ppb)
6/24 to 7/6/09	515.9	4.71*
7/6 to 7/21/09	516.4	16,200
7/21 to 8/2/09	516.5	154
8/2 to 10/21/09	516.3	92.8

* residual dye from Trace 09-08

Dye from this trace was detected at the following sampling stations downstream of

Based on Station 12 dye detections, dye first arrived at within seven days after dye introduction. The straight-line groundwater flowpath distance was approximately 3,764 feet. The elevation loss is approximately 102 feet. The mean gradient along this flow path is approximately 143 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 551 feet per day. After introduction, dye was detectable for >106 days at before sampling was halted.

Trace 09-12 hydrologically links a sinkhole in the corridor to and demonstrates a karst groundwater flowpath across SR37. It also demonstrates interbasin transfer across a subwatershed boundary between the The trace also demonstrates that the sinkhole contributes water to the groundwater system and therefore lies within the recharge area.

Trace 09-13

At 1203 hours on July 7, 2009, potable water was introduced into a sinkhole (GIS insurgence feature No. 72). The location of the dye introduction point is approximately

at an elevation of approximately 736 feet msl. At 1205 hours, 0.5 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the discharge. The first load of water was completely discharged at 1215 hours. A second load was introduced between 1238 and 1248 hours on July 7, 2009. Each load was approximately 2,100 gallons, resulting in a total of 4,200 gallons of water being introduced for this trace. The purpose of this trace was to help delineate the recharge area. The dye introduction point is outside the study corridor. but was necessary to complete the recharge area delineation

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detection of dye in activated carbon samplers from Trace 09-13 at Station 12

Trace 09-13 Trace Dye Detections at Station 12

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
6/24 to 7/6/09	ND	ND
7/6 to 7/21/09	567.1	74.9

Dye first arrived at Station 12 within 14 days after introduction. The straight-line groundwater flowpath distance was approximately 2,771 feet. The elevation loss is approximately 98 feet. The mean gradient along this flow path is approximately 187 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 200 feet per day. There was no repeat sampling after the initial dye detection at this sampling location, so the persistence of dye is unknown.

This trace demonstrates that the sinkhole traced does not contribute water to and lies outside their recharge areas. The groundwater system associated with this trace does not have any identified special significance for this project.

