Idaho Department of Water Resources

Open File Report



FLUORESCENT DYE TRACER TEST AT THE W-CANAL AQUIFER RECHARGE SITE

By

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ABSTRACT

A tracer test was successfully conducted at the W-Canal Recharge site on the Eastern Snake Plain Aquifer during the fall of 2008. The W-Canal Recharge site is pilot scale recharge site that was designed to investigate the potential of artificially recharging the declining water levels of the ESPA. The source of the recharge water for the project was canal water, derived from the existing W-Canal that flows adjacent to the site. Approximately 4.6 acre-feet (AF) were diverted from the canal into the constructed seepage basins on the site on October 8, 2008. The poor water quality of the canal water raised public health and safety concerns due to the potential of contaminating the aquifer through this recharge effort. To provide a measure of safety and a mechanism to track the movement of the recharged water, a Fluorescein dye was added to the seepage basins as they were being filled. Following the infiltration of the diverted water, nearby domestic and monitoring wells were routinely sampled for the dye, with detections only present in the closest monitoring well. The detected concentrations in the monitoring well have provided valuable information regarding the seepage rates, movement, and potential for additional recharge and tracer investigations to be conducted on the ESPA.

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INTRODUCTION

Purpose and Objectives

Groundwater levels in the ESPA have been declining and the Idaho Water Resource Board granted approval to proceed with the "W-canal" site for aquifer recharge. A pilot-scale project was implemented to determine the site feasibility for a potentially larger scale recharge effort. The primary purpose of the site was designed to allow canal water to fill a pond and allow it to infiltrate down to the aquifer. As an additional safeguard for protecting the public, a green colored fluorescent dye was added to the water in order to track flow paths for this source of water. The dye was detected four weeks after release in the nearest monitor well 150 away and the water table at 150 feet below ground surface but may have reached the aquifer earlier.

A query was made to determine if any tracer tests have been performed, documented and made available to the public on the Lower Eastern Snake Plain Aquifer (LESPA); none were found. If so, the tracer test completed at the W-canal Aquifer Recharge Site northeast of Wendell during the fall of 2008 would be the first documented successful tracer test in the LESPA that is available to the public. The primary purpose of the dye was to "tag" the recharge water for purposes of assisting with evaluation of human health and safety regarding water quality issues. The test was not designed specifically as a traditional tracer test would normally be for hydrologic or scientific purposes but yet some of this data was gleaned from the project.

Geographic Setting

The site is located about 90 miles southeast of Boise (Figure 1) and 2.5 miles northeast of the City of Wendell in Gooding County at T7S R15E, section 26, NE quarter. The elevation of the pond area is about 3,490 feet above MSL and it is located on state land with sagebrush vegetation traditionally used for grazing.

Geologic Setting

The Snake River Plain is a major late Cenozoic tectonic/volcanic feature in the northern portion of the Basin and Range geologic region. The plain extends across southern Idaho for roughly 300 miles in a crescent shape. It is divided into two main sections identified as the western and eastern Snake River Plain. The western portion is about 40 miles wide, bounded by normal faults and has a northwest-southeast trend. Malde and Powers (1958) recorded at least 9,000 feet of displacement between the highlands to the north and the elevation of the plain today and concluded about 5,000 feet of displacement occurred in the early and middle Pliocene. The displacement started about 17 million years ago by rifting and down warping of the plain. The subsequent stretching of the crust produced a basin that began filling with sedimentary and volcanic rocks of considerable thickness during the Miocene, Pliocene and Pleistocene (Malde, 1991).



Figure 1. General location of the dye tracer test at the W-canal Aquifer Recharge Site.

BACKGROUND OF DYE TESTING

Fluorescein was first synthesized by Adolf von Baeyer in 1871. It is a green colored dye that is the most commonly used dye for both surface and groundwater tracing studies (Figure 2). It is certified by ANSI/NSF for Standard 60 potable water and approved by the EPA. Sodium Fluorescein (Acid Yellow 73 – CAS # 518-47-8) can be detected in a fluorometer at very low concentrations of 0.1 parts per billion (ppb) even in water containing a high percentage of natural background fluorescence such as canal water, rivers or even raw sewage. Fluorescein is also known as Drug and Cosmetic Yellow 8 which is an ingredient in some consumer products. Fluorescein is widely used in medical treatments for humans in the US and is given to about a million people a year. Dye tracing has been used for the analysis of blood circulation within various parts of the human or animal body. For example, fluorescent angiography, a technique of analyzing the circulation in the retina is used for diagnosing various eye diseases. Human health and safety are addressed from the MSDS sheets provided in the appendices. The dye is EPA certified to conform to the ANSI/NSF Standard 60 for use in potable public water supplies as set forth by the Clean Water Act (see a copy of the certification in the appendices) up to 10 ppb.

Fluorescent dyes make excellent tracers for a variety of reasons, including:

- 1. There are no harmful effects (MSDS) and have extremely low toxicity ratings. The absence of toxicity from Fluorescein is documented as noted in the following reference by Smart (1984).
- 2. They are water soluble.
- 3. They are highly detectable (some below 1 part per trillion).
- 4. They are inexpensive.
- 5. They are fairly stable in a normal water environment.
- 6. They have been used successfully for tracing for over half a century even at locations where there are endangered or sensitive species and public drinking water supplies.
- 7. They are not naturally found in aquifer systems and therefore no background interference like other tracers can be like bromide.
- 8. Sampling procedure is simple and inexpensive.



Figure 2. Concentrated Fluorescein dye illuminated with a UV light (Wikipedia.com)

The type of tracer selected for a tracer test is dependent on many factors. One such factor includes the purpose of the study. For example, if information such as the velocity of the ground water, porosity, and the dispersion coefficient are of interest, then a conservative tracer should be used. Other factors include type of medium, available funds, the stability of the tracer, detectability of tracer, difficulty of sampling and analysis (availability of tracer, ease of sampling and availability of technology for analysis), physical/chemical/biological properties of tracer and public health considerations (Davis et. al., 1985). Various components go into the design of a tracer test. For tracer tests at springs in the Thousand Springs area, the following components were considered and evaluated: the conceptual design, down gradient receptors such as humans, aquaculture industry and endangered species, transient hydrologic barriers such as canal recharge, selection of initial mass of tracer or its concentration, observation wells, sampling schedule and locations, and monitoring.

The transport of a conservative tracer is primarily controlled by advection with effects of dispersion. Advection is the movement of the solute due to general ground water motion. Dispersion is a phenomenon by which a solute is mixed and becomes reduced in concentration at the pore level and different strata flow paths. The rate of the flowing ground water can be evaluated based on Darcy's Law. Tracer migration due to advection is assumed to occur at the same rate as the average linear velocity of the ground water (Fetter, 2001). It is important to realize that not all solute will travel at the same rate as the ground water. Some solute will move slower than the mean velocity and some will move faster than the mean velocity. This mechanical mixing together with ionic diffusion results in hydrodynamic dispersion and spreading of the solute. Dispersivity has been determined to be scale-dependent (Davis et.al., 1985), meaning that values of longitudinal dispersivity generally increase with increasing distance between the injection point and sampling locations (i.e. dispersivity increases as the plume migrates down gradient) (Anderson and Woessner, 1992). In fractured, non-soluble aquifers, Leibundgut and Wernli (1986) estimated about 1% of the dye introduced is typically recovered (Aley, 2002) but recovery of tracer can vary. For example, a tracer study performed in a basalt perched aquifer under the Bell Rapids Irrigation District in Twin Falls county by Dallas (2005) up to 28% of the dye was recovered.

PROCEDURE

On October 8th, 2008, 25 pounds of powder form dye was released into approximately 4.6 ac-feet (1,498,494 gallons) of water into Pond #2 at the W-canal Recharge Site northeast of Wendell and allowed to infiltrate into the subsurface (Figures 3 and 4). The initial dye concentration in the pond after mixing and filling with canal water up to the highest pool level (Figure 5) on October 9th was 1.49 parts per million (ppm) (Table 1) from the lab results. By October 21st (13 days) the dye concentration was essentially zero in the pond and most of the water had drained out with about 1-2 feet of water left in the pond. The weather at the time of dye release through Oct. 21 was cold and mostly cloudy which means that evaporation of water from the pond was minimal and degradation of the dye from ultraviolet light and bacteria was minimal. Therefore it is inferred that most of the water and dye from the pond infiltrated into the subsurface.

METHODS

Dye sampling design was implemented to be in alignment with the bacteria sampling procedure set forth by the project designers. The test was not designed as a tracer test but rather a 'tagging

test' assisting with potential human health issues. This means that the design was not optimal for a 'tracer test' but we still obtained some good results. Samples were collected every two weeks at 6 monitoring sites which include 3 monitor wells adjacent to the pond (ML-2, ML-3 and ML-4) and 3 domestic wells (Jax, Crumrine and Wert). For dye testing, both 50 mL water samples and charcoal packets were collected. An additional water sample was collected for bacteria testing only at the domestic wells. New charcoal packets were deployed every two weeks during sample retrieval and left in place for two weeks. Two other locations were randomly sampled once for a spot check and tested for both dye and bacteria at the 'Lamm' and 'Webb' domestic wells on December 16th with no positive detections in these wells for dye or bacteria.

Ozark Underground Laboratory, Inc. for

Idaho Dept. of Water Resources

W-Canal recharge
Neal Farmer
November 24, 2008
November 25, 2008
December 3, 2008

Table 1. Results for water samples analyzed for the presence of fluorescein dye. Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).								
OUL	Sta.	Station	Date/Time	Fluo	rescein			
#	#	Name	Collected	Results				
				Peak	Conc.			
S5029	1	W-canal Pond #2 water sample from where dye was released	10/9/08 1300	508.3	1,490			
S5030	2	W-canal Pond #2 water sample from where dye was released	10/12/08 1300	508.4	505			
S5031	3	W-canal Pond #2 water sample from where dye was released	10/21/08 1600	514.0 **	0.673			

Footnotes:

ND = No dye detected.

** = A fluorescence peak is present that does not meet all the criteria for this dye. However, it has been calculated as a positive dye recovery.

Table 1. Laboratory results for dye concentration in the W-canal Pond #2.

Charcoal packets serve as 'sentries' because they are constantly immersed in the water and absorb dye as it passes by the packet during the two week time period rather than an instantaneous water sample. This means the information gained from the charcoal packets are integrative over the two week time period.

Dye was absent from monitor well ML-3 at week 2 but present at week 4 so it is interpreted that the first time of arrival was week 3 (Figure 6). ML-3 is the closest well to the pond approximately 150 feet horizontal from the water's edge with a depth to the water table approximately 150 feet vertical from the base of the base of the pond. Since the well is 150 feet away from the pond, seepage probably reached the water table less than 3 weeks, and perhaps on the order of 2 weeks directly below the pond. This equates to an average vertical leakage rate of

approximately 7 to 10 feet per day. To date, dye has not been detected in any of the other monitor wells or domestic wells. Due to the distance from the site, the dye may be diluted below detection limits at the domestic wells.



Figure 3. USGS topographic map of the site northeast of Wendell by 2.5 miles in section 26. Wells are noted with green circles and the pond is the blue polygon.

Figure 4. Air photo showing land use patterns and desert state land west and southwest of the project site.

Figure 5. Fluorescein dye released into Pond #2 at W-canal Recharge Site (Dennis Owsley and Neal Farmer with IDWR).

ANALYTICAL RESULTS

All testing was performed by Ozark Underground Labs who specialize in dye tracing. The maximum dye concentration detected from water samples was 0.058 ppb and from charcoal packets it was 4.14 ppb (Figure 6). This type of quantitative information is useful for the ESPA groundwater model and additional aquifer recharge efforts. The tracer test cost under \$3,000 (direct costs) which demonstrates the feasibility. The project consumed about 24 hours per month.

Figure 6. Concentration of Fluorescein dye detected in monitor well ML-3.

COMMENTS

The greatest shortcoming for the dye tracer test was not having a monitor well drilled and placed to the southwest of the pond which is down gradient in the regional aquifer flow direction from the W-canal Site. One of the existing monitor wells, such as ML-2 or 4, would have been better suited to have been placed approximately 500 to 1,000 feet southwest (Figure 3) of where it was drilled or about halfway between the pond and the closet down gradient domestic well. This location would have provided monitoring at a location in between the recharge site and domestic

wells serving as early warning before potential bacteria arrive at domestic wells and better probability of detecting the dye in the aquifer as it flows to the southwest.

A second short coming is the measurement of water flowing into the recharge project from the canal was too inaccurate. Dye concentrations indicate that less water was diverted into Pond #2 compared to the reported volume from estimating flow rate diversion and volume of the Pond calculations. The caveat to this determination is that some of the canal water leaked from Pond #2 before dye was released which may account for the discrepancy. The results document the amount of dye needed was underestimated by about 30% because of the inaccurate estimate for the water. This would have provided a higher probability of detection of dye in the groundwater system and associated higher degree of safety for the domestic wells. Stated another way, we didn't use enough dye because of the inaccuracy associated with water volume and flow rate estimation. Regardless of the shortcomings, the test was successful and we gained a lot of information with results of unprecedented success which proved both viability and feasibility.

Additional aquifer recharge tracer tests are planned and one optimal site is the LSRARD recharge site north of Shoshone. The W-canal site tracer test has provided valuable quantitative information as a pilot scale test to implement larger scale tests. It seems appropriate and a prudent margin of safety to implement dye tests with aquifer recharge as an insurance to liability. I recommend that funding associated with the aquifer recharge program be used to support these low cost tracer tests not necessarily as a scientific study but to address the liability factor which would help take the place of paying for an aquifer recharge insurance policy. Other tracer tests recommended include locations near Malad Gorge State Park, Rangen Inc. spring, Thousand Springs, Crystal Springs and Clear Springs.

ACKNOWLEDGEMENTS

Tom Aley with Ozark Underground Laboratories (OUL) provided invaluable volunteer support for project planning with guidance and recommendations for implementation. Other Idaho Department of Water Resource staff that assisted with the project includes Bill Quinn, Dennis Owsley and Sean Vincent. Private homeowners were especially accommodating and without the public assistance the project would not have been as successful.

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APPENDIX A – LAB RESULTS

	A	В	C	D	E	F	G	H		
1	Table of resul	ts for the W-car	al Fluoresc	ein Tracer	Test in Pon	d #2				
2	Concentratior	n of dγe from ch	arcoal pack	ets in parts	s per billion					
3					Monitor W	ells		Domestic	Wells	
4	Date	Elapsed time	Pond #2	ML-3	ML-4	ML-2	Wert	Jax	Crumrine	
5	10/7/2008	(weeks)								
6	10/8/2008	0.0	25 pounds	0	0	0	0	0	0	
7	10/9/2008	0.1	1490							
8	10/10/2008	0.3								
9	10/11/2008	0.4								
10	10/12/2008	0.6	505							
11	10/13/2008	0.7								
12	10/14/2008	0.9								
13	10/15/2008	1.0								
14	10/16/2008	1.1								
15	10/17/2008	1.3								
16	10/18/2008	1.4								
17	10/19/2008	1.6								
18	10/20/2008	1.7								
19	10/21/2008	1.9	0.673	0	0	0	0	0	0	
20	10/22/2008	2.0								
21	10/23/2008	2.1								
22	10/24/2008	2.3								
23	10/25/2008	2.4								
24	10/26/2008	2.6								
25	10/2//2008	2.7								
26	10/28/2008	2.9								
27	10/29/2008	3.0								
28	10/30/2008	3.1								
29	10/31/2008	3.3								
30	11/1/2008	3.4								
31	11/2/2000	3.0								
32	11/3/2000	3.7								
33	11/4/2000	J.9 4.0		372	0	0	0	0	0	
34	11/6/2000	4.0		3.73	0	U	U	U	U	
38	11/7/2008	4.1								
37	11/8/2000	4.5								
38	11/9/2008	4.4								
39	11/10/2008	4.0								
40	11/11/2008	49								
41	11/12/2008	50								
42	11/13/2008	5.1								
43	11/14/2008	5.3								
44	11/15/2008	5.4								
45	11/16/2008	5.6								
46	11/17/2008	5.7								
47	11/18/2008	5.9		4.14	0	0	0	0	0	
48	11/19/2008	6.0			_				_	

	Δ	D	0	D	E	E	0	Ц		
4	A Table of record		al Elucionicia	oin Trans	Teet in Dee	L L L	G	П		
	Concentration	is for the VV-Car	iai Fluoresc	ein Tracer	Test in Pon	u #2				
4	Concentration	i of dye from ch	arcoai pack	ets in parts	s per billion	 		Description	V07-11-	
3	Data	Elsus est times	D	ML D	IVIONITOR VV	elis Mil D	107-04	Domestic	vveiis Ominerine	
4	Date	Elapsed time	Pond #2	IVIL-3	IVIL-4	IVIL-2	vven	Jax	Crumrine	
48	11/19/2008	6.0								
49	11/20/2008	6.1								
50	11/21/2008	6.3								
51	11/22/2008	6.4								
52	11/23/2008	6.6								
53	11/24/2008	6.7								
54	11/25/2008	6.9								
55	11/26/2008	7.0								
56	11/27/2008	7.1								
57	11/28/2008	7.3								
58	11/29/2008	7.4								
59	11/30/2008	7.6								
60	12/1/2008	7.7								
61	12/2/2008	7.9		2.11	0	0	0	0	0	
62	12/3/2008	8.0								
63	12/4/2008	8.1								
64	12/5/2008	8.3								
65	12/6/2008	8.4								
66	12/7/2008	8.6								
67	12/8/2008	8.7								
68	12/9/2008	8.9								
69	12/10/2008	9.0								
70	12/11/2008	9.1								
71	12/12/2008	9.3								
72	12/13/2008	9.4								
73	12/14/2008	9.6								
74	12/15/2008	9.7								
75	12/16/2008	9.9		2.36	0	0	0	0	0	
76	12/17/2008	10.0								
77	12/18/2008	10.1								
78	12/19/2008	10.3								
79	12/20/2008	10.4								
80	12/21/2008	10.6								
81	12/22/2008	10.7								
82	12/23/2008	10.9								
83	12/24/2008	11.0								
84	12/25/2008	11.1								
85	12/26/2008	11.3								
86	12/27/2008	11.4								
87	12/28/2008	11.6								
88	12/29/2008	11.7								
89	12/30/2008	11.9		1.79	0	0	0	0	0	
90	12/31/2008	12.0								

	A	B	C	D	F	F	G	Н	
1	Table of resul	ts for the W-car	al Eluoresc	ein Tracer	Test in Pon	d #2			
2	Concentration	of dye from ch:	arcoal nacki	ets in narts	s ner hillion	0.112			
3				oto ili parte	Monitor W	ells		Domestic	Wells
4	Date	Elapsed time	Pond #2	ML-3	MI -4	MI-2	Wert	Jax	Crumrine
	4 /4 /2000	40.4							
91	1/1/2009	12.1							
92	1/2/2009	12.3							
93	1/3/2009	12.4							
94	1/4/2009	12.6							
95	1/5/2009	12.7							
96	1/6/2009	12.9							
97	1/7/2009	13.0							
98	1/8/2009	13.1							
99	1/9/2009	13.3							
100	1/10/2009	13.4							
101	1/11/2009	13.0							
102	1/12/2009	13.7							
103	1/13/2009	13.9		1.20	0	0	0	0	0
104	1/14/2009	14.0		1.30	U	U	U	U	U
105	1/15/2009	14.1							
100	1/16/2009	14.3							
107	1/12/009	14.4							
100	1/10/2009	14.0							
110	1/15/2005	14.7							
111	1/20/2009	14.3							
112	1/27/2009	15.0							
113	1/22/2003	15.1							
114	1/23/2003	15.0							
115	1/24/2009	15.4							
116	1/26/2009	15.0							
117	1/27/2009	15.9							
118	1/28/2009	16.0							
119	1/29/2009	16.0							
120	1/30/2009	16.3							
121	1/31/2009	16.0							
122	2/1/2009	16.6							
123	2/2/2009	16.7							
124	2/3/2009	16.9							
125	2/4/2009	17.0							
126	2/5/2009	17.1							
127	2/6/2009	17.3							
128	2/7/2009	17.4							
129	2/8/2009	17.6							
130	2/9/2009	17.7							
131	2/10/2009	17.9							
132	2/11/2009	18.0							
133	2/12/2009	18.1							
101	0.40,0000	40.0							1

	A	В	C	D	E	F	G	Н	
1	Table of resul	ts for the W-can	al Fluoresc	ein Tracer i	Test in Pon	d #2			
2	Concentration) of dye from cha	arcoal pack	ets in parts	per billion				
3					Monitor W	ells		Domestic \	Wells
4	Date	Elapsed time	Pond #2	ML-3	ML-4	ML-2	Wert	Jax	Crumrine
5	10/7/2008	(weeks)							
6	10/8/2008	0.0	25 pounds	0	0	0	0	0	0
133	2/12/2009	18.1							
134	2/13/2009	18.3							
135	2/14/2009	18.4							
136	2/15/2009	18.6							
137	2/16/2009	18.7							
138	2/17/2009	18.9							
139	2/18/2009	19.0							
140	2/19/2009	19.1							
141	2/20/2009	19.3							
142	2/21/2009	19.4							
143	2/22/2009	19.6							
144	2/23/2009	19.7							
145	2/24/2009	19.9	0	1.52	0	0	0	0	0
146	2/25/2009	20.0							
147	2/26/2009	20.1							
148	2/27/2009	20.3							
149	2/28/2009	20.4							
150	3/1/2009	20.6							
151									

APPENDIX B – MISCELLANEOUS INFORMATION

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DATE PREPARED:

T. P. MULDOON (937) 886-9100 1/01/05

PRODUCT INFORMATION

MAUNFACTURED BY:

KINGSCOTE CHEMICALS 3334 S. TECH BLVD. MIAMISBURG, OHIO 45342

CHEMICAL NAME	NOT APPLICABLE
CHEMICAL FORMULA	NOT APPLICABLE
CHEMICAL FAMILY	AQUEOUS DYE PRODUCT

HAZARDOUS INGREDIENTS

NONE PER 29 CFR 1910.1200

PHYSICAL DATA

PHYSICAL STATE	LIQUID
ODOR AND APPEARANCE	YELLOW/GREEN, WITH NO APPARENT ODOR
SPECIFIC GRAVITY	APPROXIMATELY 1.05
VAPOR DENSITY (mm Hg @ 25 ° C)	~23.75
VAPOR DENSITY (AIR =1)	~0.6
EVAPORATION RATE (Butyl Acetate = 1)	~1.8
BOILING POINT	100 degrees C (212 degrees F)
FREEZING POINT	0 degrees C (32 degrees F)
рН	
SOLUBILITY IN WATER	HIGHLY SOLUBLE

FIRE HAZARD

CONDITION OF FLAMMABILITY	NON-FLAMABLE
MEANS OF EXTINCTION	WATER FOG, CARBON DIOXIDE, OR DRY CHEMICAL
FLASH POINT AND METHOD	NOT APPLICABLE
UPPER FLAMABLE LIMIT	NOT APPLICABLE
LOWER FLAMABLE LIMIT	NOT APPLICABLE
AUTO-IGNITION TEMPERATURE	NOT APPLICABLE
HAZARDOUS COMBUSTION PRODUCTS	NOT APPLICABLE
UNUSUAL FIRE HAZARD	NOT APPLICABLE

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EXPLOSION HAZARD

SENSITIVITY TO STATIC DISCHARGE _______NOT APPLICABLE SENSITIVITY TO MECHANICAL IMPACT ______NOT APPLICABLE

REACTIVITY DATA

PRODUCT STABILITY	STABLE
PRODUCT INCOMPATIBILITY	NONE KNOWN
CONDITIONS OF REACTIVITY	NOT APPLICABLE
HAZARDOUS DECOMPOSITION PRODUCTS	NONE KNOWN

TOXICOLOGICAL PROPERTIES

SYMPTOMS OF OVER EXPOSURE FOR EACH POTENTIAL ROUTE OF ENTRY:

INHALLATION, ACUTE	NO HARMFUL EFFECTS EXPECTED.		
INHALATION, CHRONIC	NO HARMFUL EFFECTS EXPECTED.		
SKIN CONTACT	WILL TEMPORARILY GIVE SKIN A YELLOW/GREEN COLOR.		
EYE CONTACT	NO HARMFUL EFFECTS EXPECTED.		
INGESTION	URINE MAY BE A YELLOW/GREEN COLOR UNTIL THE DYE		
	HAS BEEN WASHED THROUGH THE SYSTEM.		
EFFECTS OF ACUTE EXPOSURE	NO HARMFUL EFFECTS EXPECTED		
EFFECTS OF CHRONIC EXPOSURE	NO HARMFUL EFFECTS EXPECTED		
THRESHOLD OF LIMIT VALUE	NOT APPLICABLE		
CARCINOGENICITY	NOT LISTED AS A KINOWN OR SUSPECTED CARCINOGEN BY		
	IARC, NTP OR OSHA.		
TERATOGENICITY	NONE KNOWN		
TOXICOLOGY SYNERGISTIC PRODUCTS	NONE KNOWN		

PREVENTATIVE MEASURES

PERSONAL PROTECTIVE EQUIPMENT					
GLOVES	RUBBER				
RESPIRATORY	USE NISOH APPROVED DUST MASK IF DUSTY CONDITION:				
	EXIST.				
CLOTHING	PROTECTIVE CLOTHING SHOULD BE WORN WHERE				
	CONTACT IS UNAVOIDABLE.				
OTHER	HAVE ACCESS TO EMERGENCY EYEWASH.				

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PREVENTATIVE MEASURES (CONT.)

ENGINEERING CONTROLS	NOT NECESSARY UNDER NORMAL CONDITIONS, USE LOCAL		
	VENTILATION IF DUSTY CONDITIONS EXIST.		
SPILL OR LEAK RESPONSE	CLEAN UP SPILLS IMMEDIATELY, PREVENT FROM		
	ENTERING DRAIN. USE ABSORBANTS AND PLACE ALL		
	SPILL MATERIALS IN WASTE DISPOSAL CONTAINER. FLUSH		
	AFFECTED AREA WITH WATER.		
WASTE DISPOSAL	INCINERATE OR REMOVE TO A SUITABLE SOLID WASTE		
	DISPOSAL SITE, DISPOSE OF ALL WASTES IN ACCORDANCE		
	WITH FEDERAL, STATE AND LOCAL REGULATIONS.		
HANDELING PROCEDURES AND EQUIPMENT	NO SPECIAL REQUIREMENTS.		
STORAGE REQUIREMENTS	STORE AT ROOM TEMPERATURE BUT ABOVE THE FREEZING		
	POINT OF WATER.		
SHIPPING INFORMATION	KEEP FROM FREEZING		

FIRST AID MEASURES

FIRST AID EMERGENGY PROCEDURES

EYE CONTACT	FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES. GET
	MEDICAL ATTENTION IF IRRITATION PERSISTS.
SKIN CONTACT	WASH SKIN THOROUGHLY WITH SOAP AND WATER. GET
	MEDICAL ATTENTION IF IRRITATION DEVELOPS.
INHALATION	. IF DUST IS INHALED, MOVE TO FRESH AIR. IF BREATHING IS
	DIFFICULT GIVE OXYGEN AND GET IMMEDIATE MEDICAL
	ATTENTION.
INGESTION	DRINK PLENTY OF WATER AND INDUCE VOMITING. GET
	MEDICAL ATTENTION IF LARGE QUANTITIES WERE
	INGESTED OR IF NAUSEA OCCURS. NEVER GIVE FLUIDS OR
	INDUCE VOMITING IF THE PERSON IS UNCONSCIOUS OR
	HAS CONVULSIONS.

SPECIAL NOTICE

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END OF MATERIAL SAFETY DATA SHEET

Bulletin No. 103 Fluorescein

INTRODUCTION

Fluorescein was the first fluorescent dye used for water tracing work¹ and is still used for qualitative (visual) studies of underground contamination of wells. In recent years, Rhodamine WT has almost completely replaced fluorescein for flow measurements² and circulation, dispersion, and plume studies³. Nonetheless, fluorescein has a role in such studies, and can be used for masking, hydraulic model studies, and underground water studies.

ADVANTAGES

Fluorescein has the following advantages over other tracer dyes:

- Its low sorption rate is far better than Rhodamine B, and comparable to Rhodamine WT.
- It has a temperature coefficient of only -0.36% per degree C, about one-eighth of the temperature coefficient of rhodamine dyes^{2,4}.
- It emits a brilliant green fluorescence, which gives an excellent visual or photographic contrast against the backgrounds normally encountered in water transport studies. Therefore it is easy to visualize the progress of an experiment.
- It is more aesthetic than the red dyes. This is psychologically important, especially in ocean areas subject to the blooms of certain dinoflagellates, called "red tides." Less public resistance will be encountered using a dye that does not resemble red tide⁵.

DISADVANTAGES

Fluorescein has been replaced by other dyes, principally Rhodamine WT, for the following reasons:

- It is rapidly destroyed by sunlight. Reference 4 reports that a 50% loss occurred in three hours of sunlight exposure, with dye being held in an Erlenmeyer flask. Other tests in an flat, uncovered Pyrex dish showed an almost complete destruction in two hours⁶.
- Many naturally occurring fluorescent materials have similar characteristics and thus interfere with measurement. When carefully chosen optical filters are used, the situation is better than that reported in Reference 4, but higher concentrations are required to overcome the effect of higher and more variable "blank" fluorescence.
- Fluorescein is more pH-sensitive than rhodamine dyes. Fluorescence drops very sharply at pH values below 5.5. For optimum results, pH should be between 6 and 10.

MASKING TECHNIQUES

In river, harbor, and ocean tests, fluorescein can be used to mask the objectionable color of the rhodamine dyes. Tests show that Fluorescein is an effective mask, subject to the following conditions⁶:

- The concentration of fluorescein should be at least five times that of the active ingredients in the Rhodamine B or Rhodamine WT concentrate.
- Where the receiving water is shallow, clear, and in full sunlight, the dyes must be dispersed quite rapidly. With slow dispersion, the photosensitive fluorescein will be destroyed before the masking effect is complete.
- Masking is subjective. Lower (hence less costly) amounts of fluorescein may be effective, depending on water clarity, bottom color, wave action, etc. Small scale addition of the mixed dyes to the receiving water should be made in advance

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of a large scale test. This test should be made on a bright sunny day, if possible.

 Note that fluorescein is not the ingredient measured. The optical filter and light source in the fluorometer read only rhodamine dye⁷.

HYDRAULIC MODEL STUDIES

Fluorescein may be used in hydraulic model studies in exactly the same way that Rhodamine WT is used (See Refs. 2 and 3 for details).

The major advantage of using fluorescein is its visibility; the green color can be seen as the test proceeds. The major disadvantage is fluorescein's light sensitivity, It can be destroyed by light entering the test area, both from windows and from indoor lights, especially fluorescent ones.

Containers used for dye destruction tests must be transparent to light at shorter wavelengths. Clear borosilicate glass baking pans are handy, since they transmit light at shorter wavelengths than window glass or the glass envelopes of fluorescent lamps.

Test samples must be at low concentrations (around 0.2 PPM) so that the fluorescein in the bottom of the pan is not protected from the incident light by absorption of the fluorescein in the top of the pan.

In certain cases, deliberate destruction of the fluorescein by sunlight may be a convenience instead of a problem. Hydraulic models often recycle water. With the very stable Rhodamine WT, the concentration of dye in the entire system will build up over a sequence of several tests, requiring replacement of the water. If a shallow holding tank can be placed outdoors, the degradation of fluorescein by sunlight may eliminate the need to replace the water.

UNDERGROUND WATER STUDIES

Fluorescein can be used quantitatively for underground tests, subject to limitations imposed by the higher background of naturally occurring fluorescent materials.

An advantage of fluorescein in underground studies is its light sensitivity. Should it reach an

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open receiving body of water, the color will be less of a problem because it will disappear rapidly in the sunlight.

FILTER AND LIGHT SOURCE SELECTION

Using fluorescein, the following light sources and filters are recommended (referenced part numbers are specific to Turner Designs products):

	10-AU-005
Optical Kit	10-086
	(Lamp and all filters are included in this kit.)
Light Source	10-089 Blue Lamp
Reference	10-063
Excitation	10-105
Emission	10-109R-C

We have found that background fluorescence can be very high in natural systems with the fluorescein setup. In most cases, this background should be adequately suppressed using the 10-AU fluorometer. If, however, background cannot be suppressed, a mask (attenuator) may be added to the excitation filter holder to reduce its diameter and the amount of light scatter. Attenuation by a factor of 5 can be obtained with the 10-318R Attenuator Plate.

Fluorescein, known as "Acid Yellow 73", "Acid Yellow T", "DNC Yellow 7", etc., can be obtained from the following sources (addresses checked and confirmed June 1996):

Pylam Products Company, Inc. 1001 Stewart Avenue Garden City, NY 11530 516/222-1750 Tricon Colors, Inc. 16 Leliarts Lane Elmwood Park, NJ 07407 201/794-3800

LISSAMINE FF

The properties of uses of Lissamine FF are reported in Reference 9. Its spectral characteristics are similar to those of fluorescein, but it does not decompose as rapidly in sunlight. Use the fluorescein filters detailed above with Lissamine FF. Pylam Products (address shown above) offers

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Turner Designs Solutions

Lissamine FF as "Brilliant Acid Yellow 8G" or "Brilliant Sulphoflavine FFA".

REFERENCES

- Dole, R. B., Use of Fluorescein in the Study of Underground Waters, USGS Water Supply Paper 160, 73-85 (1906).
- A Practical Guide to Flow Measurement, monograph by Turner Designs, 845 W. Maude Avenue, Sunnyvale, CA 94086.
- Circulation, Dispersion, and Plume Studies, monograph by Turner Designs, 845 W. Maude Avenue, Sunnyvale, CA 94086.
- (0047) Feuerstein, D.L., Sellick, R.E., *Fluorescent Tracers for Dispersion Measurements*, Journal of Sanitary Engineering, ASCE 89 (SA4), 1-21 (1963).

 (0031) Murakami, Ken, Water Quality Section, Water Quality Control Division, Public Works Research Institute, 5-41-7, Shimo, Kita-Ku, Tokyo, 115, personal communication.

- Turner Designs Laboratory Tests conducted July 23, 1975.
- "Filter Selection Guide" for Turner Designs Fluorometers, by Turner Designs, 845 W. Maude Avenue, Sunnyvale, CA 94086.
- (0413) Smart, P.L., Laidlaw, I.M.S., An Evaluation of Some Fluorescent Dyes for Water Tracing, Water Resources Research, 13 (1), 15-33 (1977).

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FLT YELLOW/GREEN PRODUCTS

Division of Kingscote Chemicals

TECHNICAL DATA BULLETIN

Bright Dyes Yellow/Green products are specially formulated versions of Xanthene dye, certified by NSF International to ANSI/NSF Standard 60 for use in drinking water. This dye is the traditional fluorescent water tracing and leak detection material and has been used for labeling studies from the beginning of the century. It may be detected visually, by UV light and by appropriate fluoremetric equipment. Today it is most often used visually. This dye has been used by the military to mark downed pilots for search and rescue operations over large water bodies. Visually the dye appears yellow/green, depending on its concentration and under UV light as lime green.

Based on biochemical oxygen demand (BOD) studies, the dye is biodegradable with 65% of the available oxygen consumed in 7 days. The dye is resistant to absorption on most suspended matter in fresh and salt water. However, compared to Bright Dyes FWT Red products it is significantly less resistant to degradation by sunlight and when used in fluoremetry, stands out much less clearly against background fluorescence. As always the suitability of these products for any specific application should be evaluated by a qualified hydrologist or other industry professional.

General Properties	Tablets	Liquids	Powders
Detectability of active ingredient ¹	Visual <100 ppb	Visual <100 ppb	Visual <100 ppb
Maximum absorbance wavelength ²	490/520 nm	490/520 nm	490/520 nm
Appearance	Orange convex 1.6cm diameter	Reddish, brown aqueous solution	Orange fine powder
NSF (Max use level in potable water)	6.0 ppb	10.0 ppb	1.0 ppb
Weight	1.35 gms <u>+</u> 0.05		
Dissolution Time ³	50% <3 minutes 95% <6 minutes		50% < 3 minutes 95% < 6 minutes
Specific Gravity		1.05±0.05@25母C	
Viscosity ⁴		1.8 cps	
pH		8.5 <u>+0</u> .5 @ 25⊕ C	

Coverage of Products	One Tablet	One Pint Liquid	One Pound Powder
Light Visual	605 gallons	125,000 gallons	1,200,000 gallons
Strong Visual	60 gallons	12,500 gallons	120,000 gallons

Caution: These products may cause irritation and/or staining if allowed to come in contact wit the skin. The use of gloves and goggles is recommended when handling this product, as with any other dye or chemical.

To our best knowledge the information and recommendations contained herein are accurate and reliable. However, this information and our recommendations are furnished without warranty, representation, inducement, or license of any kind, including, but not limited to the implied warranties and fitness for a particular use or purpose. Customers are encouraged to conduct their own tests and to read the material safety data sheet carefully before using.

¹ In deionized water in 100 ml flask. Actual detectability and coverage in the field will vary with specific water conditions.

² No significant change in fluorescence between 6 and 11 pH.

³ (One tablet, 1 gram of powder), in flowing deionized water in a 10 gallon tank.

⁴ Measured on a Brookfield viscometer, Model LV, UL adapter, 60 rpm @ 25 & C.