Appendices

Appendix A. Oak Creek W.I.P. watershed investigation data

Appendix B. Oak Creek watershed social survey results

Appendix C. OCWIP Best Management Practices (BMP) Project Descriptions

Table A.1. *E. coli* and DNA results for samples collected in Oak Creek, adjacent springs and tributary washes Summer 2011.

													DNA Results					
strm_mi	Site_ID	Type	Date	Descript	East*	North*	Elev_m	Elev_ft	Accuracy	Hold_time	E_coli	E_co_dup	E_co_dil	MS**	S***	all296	human	bovine	dog
0.5	M13	Baseline	7/5/2011	West Fork	431602	3872890	1702	5584	18ft	2:41	9.7								
49.0	M08	Hot Spot	7/5/2011	Pine Flats	432976	3873836	1691	5549	7ft	5:00	10.5								
46.0	M09A	Hot Spot	7/5/2011	1/4 mi ds of Forest Houses	431432	3870005	1597	5241	18ft	0:28	8.5								
37.4	M45	Baseline	7/5/2011	Lomacasi	431532	3359813	1305	4280		1:04	5.2								
22.7	M32	Baseline	7/5/2011	Dry Creek Confluence	419367	3851286	1121	3678	4m	2:49	5.1								
17.0	M36	Hot Spot	7/5/2011	Page Springs Bridge	418422	3846869	1051	3448	6m	3:25	33.6								
8.9	M40	Baseline	7/5/2011	Cornville Bridge	416097	3842142	1009	3310	5m	2:53	74.9								
2.2	M41	Hot Spot	7/5/2011	Cornville Estates	416122	3838990	1012	3320	9m	4:54	37.9								
46.3	M09	Hot Spot	7/11/2011	Hoel's Wash/Forest Houses	-111.74748	34.97442			9m	1:50	19.5								
43.7	M44	Hot Spot	7/11/2011	Slide Rock	-111.75261	34.94470	1362	4469	9m	0:23	16.8								
40.5	M17	Hot Spot	7/11/2011	Indian Gardens	-111.72820	34.90914	1397	4584	5m	3:10	4.1								
40.0	M18	Hot Spot	7/11/2011	Living Springs	-111.72954	34.89975	1367	4485	6m	4:38	6.3								
34.0	M25	Hot Spot	7/11/2011	Chavez Crossing Campground	428890	3855894	1247	4092	11ft	1:14	44.1								
17.2	M36	Hot Spot	7/11/2011	Page Springs Bridge	418475	3847364	1065	3494	13ft	2:25	62.0								
12.6	M39A	Baseline	7/11/2011	below Spring Creek Confluence	416142	3845177	1007	3304	6m	1:29	70.8								
8.9	M40	Hot Spot	7/11/2011	Cornville Bridge	416102	3842149	1005	3297	6m	6:34	76.8								
0.4	M43	Baseline	7/11/2011	above Verde Confluence	413855	3837885	970	3182	3m	4:20	35.9								
0.1	M39	Hot Spot	7/11/2011	Spring Creek	-111.91485	34.74421	1023	3355	15 ft	1:13	32.8								
49.0	M08	Hot Spot	7/14/2011	Pine Flats	-111.73462	35.00505	1497	4911	7m	0:59	1.0								
37.4	M45	Baseline	7/14/2011	Lomacasi	-111.74924	34.87843	1305	4280		2:18	0.0								
22.7	M32	Baseline	7/14/2011	Dry Creek Confluence	-111.88151	34.80063	1121	3678		3:38	2.0								
2.2	M41	Hot Spot	7/14/2011	Cornville Estates	-111.91344	34.69084	1012	3320	4m	5:02	13.4								
40.5	M17	Hot Spot	7/19/2011	Indian Gardens	-111.72823	34.90922	1397	4584	13 ft	1:11	24.0								
22.7	M32	Baseline	7/19/2011	Dry Creek Confluence	-111.88151	34. 80063	1121	3678		2:36	54.7								
8.9	M40	Baseline	7/19/2011	Cornville Bridge	-111.91600	34.71806	1005	3297	6m	3:55	149.7								
0.5	M13	Baseline	7/28/2011	West Fork	-111.74952	34.99648	1625		6m	1:36	6.2								
43.7	M44	Hot Spot	7/28/2011	Slide Rock	-111.75210	34.94548	1362	4469	11m	3:29	21.8	11.0							
40.0	M18	Hot Spot	7/28/2011	Living Springs	-111.72955	34.89981	1367	4485	6m	4:56	13.4	22.8							
34.0	M25	Hot Spot	7/28/2011	Chavez Crossing Campground	-111.77778	34.84285	1247	4092	11ft	5:54	18.7								
17.2	M36	Hot Spot	7/28/2011	Page Springs Bridge	-111.89086	34. 76523	1060	3478	11 ft	2:14	63.7								
12.6	M39A	Baseline	7/28/2011	below Spring Creek Confluence	-111.91587	34. 74511	1021	3350	11 ft	2:46	48.8								
0.4	M43	Baseline	7/28/2011	above Verde Confluence	-111.94041	34.67934	973	3193	17 ft	4:33	9.4								
0.1	M39	Hot Spot	7/28/2011	Spring Creek	-111.91485	34.74421	1023	3355	15 ft	3:27	72.3								
	M49	Stormwater	8/1/2011	Jordan Pump	-111.75561	34.87486	1300	4264	20ft	2:08	1986.28								
	M48	Stormwater	8/1/2011	Arroyo Roble	-111.75704	34.86974	1289	4229	20ft	3:51	**2419.2**								
	M47	Stormwater	8/1/2011	Tlaquepaque	-111.76189	34.86247	1273	4176	16ft	4:21	435.2								
	M46	Stormwater	8/1/2011	Soldier's Wash	-111.76265	34.86061	1270	4168	16ft	4:09	110.3								
2.6	M26	Stormwater	8/1/2011	Carroll Canyon 3, trail (@Shelby)	-111.80097	34.85351	1299	4263	13ft	4:04	509.9								
0.6	M27	Stormwater	8/1/2011	Carroll Canyon 2, bridge	-111.80837	34.83286	1214	3983	15ft	4:23	222.1								
0.0	M51	Stormwater	8/1/2011	Carroll Canyon 1, mouth	-111.81006	34.82558	1206	3957	16ft	4:13	472.1								
8.9	M40	Baseline	8/1/2011	Cornville Bridge	416102	3842149	1005	3297	6m	3:04	49.6								
0.5	M13	Baseline	8/2/2011	West Fork	-111.74968	34.99650	1630			3:27	17.5								
49.0	M08	Hot Spot	8/2/2011	Pine Flats	-111.73493	35.00590	1707		6m	1:51	8.6								
46.3	M09	Hot Spot	8/2/2011	Hoel's Wash/Forest Houses	-111.74785	34.97377			4m	4:47	54.6								

														DNA Results					
strm_mi	Site_ID	Type	Date	Descript	East*	North*	Elev_m	Elev_ft	Accuracy	Hold_time	E_coli	E_co_dup	E_co_dil	MS**	S***	all296	human	bovine	dog
43.7	M44	Hot Spot	8/2/2011	Slide Rock	-111.75248	34.94530	1483		4m	5:58	21.6								
40.5	M17	Hot Spot	8/2/2011	Indian Gardens	-111.72832	34.90918	1394	4573	17 ft	2:12	12.5								
40.0	M18	Hot Spot	8/2/2011	Living Springs	-111.72956	34.89974	1365	4478	18 ft	2:54	26.3								
37.4	M45	Baseline	8/2/2011	Lomacasi	-111.74920	34.87845	1307	4288	13 ft	3:47	61.3								
34.0	M25	Hot Spot	8/2/2011	Chavez Crossing Campground	-111.77779	34.84282	1246	4087	10 ft	4:54	1732.87								
27.9	M29	Hot Spot	8/2/2011	below Red Rock State Park	-111.83756	34.81677	1159	3802	6m	2:10	**2419.2**								
22.7	M32	Baseline	8/2/2011	Dry Creek Confluence	-111.88068	34.80209	1121	3678	4m	3:12	**2419.2**								
17.2	M36	Hot Spot	8/2/2011	Page Springs Bridge	-111.89099	34.76459	1060	3478	5m	4:11	**2419.2**								
2.2	M41	Hot Spot	8/2/2011	Cornville Estates	-111.91575	34.68953	1012	3320	4m	5:20	86.5								
	S41	Focus	8/10/2011	Spring 41, upstream of SRSP	-111.75408	34.96543	1549	5081	16 ft	5:37	47.1								
	S52	Focus	8/10/2011	Spring 52, Indian Gardens	-111.72732	34.91336	1411	4629	16 ft	4:41	1.0								
	S49	Focus	8/10/2011	Spring 49 near source	-111.72690	34.91309	1391	4565	18 ft	4:28	86.0								
	S48	Focus	8/10/2011	Spring 48, Indian Gardens	-111.72687	34.91257	1384	4540	16 ft	4:16	0.0								
	S45	Focus	8/10/2011	Spring 45 waterfall	-111.72680	34.91192	1399	4589	16 ft	4:05	2.0								
	S42	Focus	8/10/2011	Spring 42, Munds Creek	-111.72667	34.91174	1400	4592	17 ft	3:56	0.0								
	S2	Focus	8/10/2011	Spring 2, South of IG bridge	-111.72786	34.91053	1390	4559	16 ft	3:23	0.0								
	S16	Focus	8/10/2011	Spring 16, Zane Grey's cabin	-111.74415	34.99123	1636	5369	16 ft	2:19	20.7								
	S16	Focus	8/24/2011	Spring 16, Zane Grey's cabin	-111.74419	34.99126	1631	5351	13 ft	5:19	105.0			*1*	*1*	3	1	0	na
	S41	Focus	8/24/2011	Spring 41, upstream of SRSP	-111.75405	34.96542	1551	5088	15 ft	4:40	19.5			*1*	3	3	3	0	na
	S52	Focus	8/24/2011	Spring 52, Indian Gardens	-111.72729	34.91330	1452	4763	16 ft	3:55	0			*1*	*1*	3	1	0	na
	S49	Focus	8/24/2011	Spring 49 near source	-111.72690	34.91310	1396	4580	15 ft	3:29	202.4	186.0		*1*	*1*	3	1	0	na
	S100	Focus	8/24/2011	Page Springs Source	-111.88918	34.76175	1069	3507	6m	2:55	0.0			6	*1*	3	3	0	na
	F3	Focus	8/24/2011	Spring Creek above WWT pond	-111.91182	34.74839	1024	3360	5m	5:40	46.7			*1*	*1*	3	0	0	na
	M39	Hot Spot	8/24/2011	Spring Creek	-111.91481	34.74415	1018	3340	8m	5:03	249.5			12	4	3	0	0	na
	S98	Focus	8/24/2011	Bubbling Ponds Spring	-111.90100	34.77334			6m	3:58	25.6			*1*	2	3	0	0	na
	F4	Focus	8/24/2011	Bubbling Ponds outfall	-111.89695	34.76559	1048	3438	6m	3:28	14.6			*1*	4	3	0	0	na
	S35	Spring	9/1/2011	Spring 35, West Fork	-111.74804	34.98176	1633	5358	5m	1:58	20.3								
	S36	Spring	9/1/2011	Spring 36, West Fork	-111.74792	34.98204				1:52	56.9								
	S39	Spring	9/1/2011	Walnut Spring, West Fork	-111.74649	34.98646	1619	5312	4 m	3:22	12.0								
	S1	Spring	9/1/2011	Spring 1, Indian Gardens	-111.72790	34.90980	1431	4695	8m	4:31	0.0								
	S3	Spring	9/1/2011	Spring 3, Indian Gardens	-111.72752	34.91114				4:51	0.0								
	F5	Focus	9/1/2011	Creek from Spring 59, Indian Gardens	-111.72728	34.90637				6:43	29.5								
	S58	Spring	9/1/2011	Spring 58 Pool, Indian Gardens	-111.72804	34.90982	1384	4541	6m	6:00	35.9								
	S67	Spring	9/1/2011	Spring 67, Indian Gardens	-111.72711	34.90614				6:31	18.1								
	S75	Spring	9/1/2011	Spring 75 Pool, Indian Gardens	-111.72769	34.91044	1382	4534	4m	5:44	0.0								
	S77	Spring	9/1/2011	Spring 77 Pool, Indian Gardens	-111.72741	34.91112	1398	4587	5m	5:20	0.0								
	S78	Spring	9/1/2011	Spring 78, Indian Gardens	-111.72987	34.91822	1420	4659	5m	3:52	0.0								
	M49	Stormwater	9/6/2011	Jordan Pump	-111.75561	34.87486	1300	4264	20ft	4:13	172.0			*1*	*1*	3	0	0	0
	M48	Stormwater	9/6/2011	Arroyo Roble	-111.75704	34.86974	1289	4229	20ft	4:40	**2419.2**			*1*	2110	3	0	0	0
	M46	Stormwater	9/6/2011	Soldier's Wash	-111.76265	34.86061	1270	4168	16ft	5:08	**2419.2**			*1*	19	3	0	0	0
	F1	Focus	9/6/2011	Chavez Ranch Day Use Area						2:44	727.0			19	35	3	0	0	na
	M26	Stormwater	9/6/2011	Carroll Canyon 3, trail (@Shelby)	-111.80097	34.85351	1299	4263	13ft	2:04	**2419.2**			*1*	610	3	0	0	na
	M27	Stormwater	9/6/2011	Carroll Canyon 2, bridge	-111.80837	34.83286	1214	3983	15ft	3:17	**2419.2**			*1*	*1*	3	3	0	0
37.4	M45	Baseline	9/7/2011	Lomacasi	-111.74920	34.87845	1307	4288	13 ft	1:31	18.1								

															DNA Results					
strm_mi	Site_ID	Type	Date	Descript	East*	North*	Elev_m	Elev_ft	Accuracy	Hold_time	E_coli	E_co_dup	E_co_dil	MS**	S***	all296	human	bovine	dog
34.0	M25	Hot Spot	9/7/2011	Chavez Crossing Campground	428890	3855894	1247	4092	11ft	1:56	57.1								
27.9	M29	Hot Spot	9/7/2011	below Red Rock State Park	-111.83798	34.81655	1165	3821	17 ft	2:35	30.5	40.2							
17.2	M36	Hot Spot	9/7/2011	Page Springs Bridge	418475	3847364	1065	3494	13ft	3:45	39.7								
8.9	M40	Hot Spot	9/7/2011	Cornville Bridge	416102	3842149	1005	3297	6m	4:25	25.3								
	M49	Stormwater	9/11/2011	Jordan Pump	-111.75561	34.87486	1300	4264	20ft	2:57	**2419.2**		**8200.7**						
	M48	Stormwater	9/11/2011	Arroyo Roble	-111.75704	34.86974	1289	4229	20ft	2:54	1986.2		1563.1						
	M46	Stormwater	9/11/2011	Soldier's Wash	-111.76265	34.86061	1270	4168	16ft	6:11	2419.2		2625.5						
	M26	Stormwater	9/11/2011	Carroll Canyon 3, trail (@Shelby)	-111.80097	34.85351	1299	4263	13ft	6:24	**2419.2**		6019.0						
	M27	Stormwater	9/11/2011	Carroll Canyon 2, bridge	-111.80837	34.83286	1214	3983	15ft	6:40	**2419.2**		3695.9						
49.0	M08	Hot Spot	9/11/2011	Pine Flats	432976	3873836	1691	5549	7ft	2:15	15.8		1101.7	*1*	2	3	2	0	na
40.5	M17	Hot Spot	9/11/2011	Indian Gardens	-111.72832	34.90918	1394	4573	17 ft	2:35	152.9		179.7	*1*	2	3	3	0	na
37.4	M45	Baseline	9/11/2011	Lomacasi	-111.74920	34.87845	1307	4288	13 ft	2:50	117.8		599.2	*1*	7	3	2	0	0
34.0	M25	Hot Spot	9/11/2011	Chavez Crossing Campground	428890	3855894	1247	4092	11ft	3:12	1413.6		8202.4	*1*	18	3	2	0	na
27.9	M29	Hot Spot	9/11/2011	below Red Rock State Park	-111.83798	34.81655	1165	3821	17 ft	3:49	2419.17		3170.4	*1*	81	3	2	0	0
22.7	M32	Baseline	9/11/2011	Dry Creek Confluence	-111.88068	34.80209	1121	3678	4m	4:24	344.8		354.2	*1*	15	3	1	0	na
17.2	M36	Hot Spot	9/11/2011	Page Springs Bridge	418475	3847364	1065	3494	13ft	4:21	816.4	727.0	459.1	*1*	14	3	3	0	na
2.2	M41	Hot Spot	9/11/2011	Cornville Estates	416122	3838990	1012	3320	9m	4:46	58.1		90.3	*1*	12	3	1	0	na
	F4	Focus	9/11/2011	Bubbling Ponds outfall	-111.89695	34.76559	1048	3438	6m	4:51	23.3		19.1						
49.0	M08	Hot Spot	9/15/2011	Pine Flats	432976	3873836	1691	5549	7ft	3:01	0.0		n/a						
40.5	M17	Hot Spot	9/15/2011	Indian Gardens	-111.72832	34.90918	1394	4573	17 ft	3:32	54.7		65.4						
37.4	M45	Baseline	9/15/2011	Lomacasi	-111.74920	34.87845	1307	4288	13 ft	3:16	517.2		426.0						
34.0	M25	Hot Spot	9/15/2011	Chavez Crossing Campground	428890	3855894	1247	4092	11ft	3:35	**2419.2**		1354.0						
27.9	M29	Hot Spot	9/15/2011	below Red Rock State Park	-111.83798	34.81655	1165	3821	17 ft	4:26	**2419.2**		2489.0						
22.7	M32	Baseline	9/15/2011	Dry Creek Confluence	-111.88068	34.80209	1121	3678	4m	5:10	**2419.2**		5794.0						
17.2	M36	Hot Spot	9/15/2011	Page Springs Bridge	418475	3847364	1065	3494	13ft	5:49	n/a		506.0						
8.9	M40	Baseline	9/15/2011	Cornville Bridge	416102	3842149	1005	3297	6m	6:22	**2419.2**		7270.0						
	S52	Focus	9/16/2011	Spring 52, Indian Gardens	-111.72729	34.91330	1452	4763	16 ft	2:05	16.1			*1*	*1*	3	0	0	na
	S49A	Focus	9/16/2011	Spring 49 source	-111.72700	34.91347	1394	4574	17 ft	2:35	2.0	4.1		6	*1*	3	1	0	na
	F6	Focus	9/16/2011	Spring ditch, AGFD	-111.90091	34.77384	1083	3552	18 ft	3:39	2419.17			*1*	*1*	3	0	0	na
	S107	Focus	9/16/2011	Spring ditch	-111.89752	34.77061	1063	3488	19 ft	4:07	**2419.2**			*1*	82	3	0	0	na
	S98	Focus	9/16/2011	Bubbling Ponds Spring	-111.90100	34.77334			6m	4:17	19.9			*1*	*1*	3	0	0	na
	F4	Focus	9/16/2011	Bubbling Ponds outfall	-111.89695	34.76559	1048	3438	6m	3:31	147.0			*1*	17	2	0	0	na
	S100	Focus	9/16/2011	Page Springs source	-111.88918	34.76175	1069	3507	6m	5:55	0.0			1	*1*	3	0	0	na
	F3	Focus	9/16/2011	Spring Creek above WWT pond	-111.91182	34.74839	1024	3360	5m	6:32	579.3			*1*	*1*	3	0	0	na
	M39	Hot Spot	9/16/2011	Spring Creek	-111.91482	34.74411	1025	3363	20 ft	7:03	686.7			2	39	3	1	0	na
	S9	Focus	9/20/2011	Pine Flat spring @ road						1:43	0.0								
	S41	Focus	9/20/2011	Spring 41, upstream of SRSP	-111.75408	34.96543	1549	5081	16 ft	2:30	16.4			4	3	3	0	0	na
	S49A	Focus	9/20/2011	Spring 49 source	-111.72700	34.91347	1394	4574	17 ft	2:57	20.1			2	*1*	3	0	0	na
	S49	Focus	9/20/2011	Spring 49 near source	-111.72690	34.91309	1391	4565	18 ft	3:10	15.5			6	*1*	3	3	0	na
	F7	Focus	9/20/2011	Lower Indian Gardens spring, upper end						3:40	27.8								
	S71	Focus	9/20/2011	Lower Indian Gardens spring, midway	-111.727733	34.90435				3:57	22.8			*1*	*1*	3	1	0	na
	S70	Focus	9/20/2011	Lower Indian Gardens spring, near fish runs	-111.727806	34.90273				4:13	18.5			*1*	3	3	3	0	na

													DNA Results					
strm_mi	Site_ID	Type	Date	Descript	East*	North*	Elev_m	Elev_ft	Accuracy	Hold_time	E_coli	E_co_dup	E_co_dil	MS**	S***	all296	human	bovine	dog
	F6	Focus	9/20/2011	Spring ditch, AGFD	-111.900909	34.77382				5:52	272.3		187.0	*1*	33	3	0	0	na
	S107	Focus	9/20/2011	Spring ditch	-111.897561	34.77068				5:25	116.9		86.0	*1*	19	3	1	0	na
	S109	Focus	9/21/2011	Lower Indian Gardens spring, down channel	-111.72854	34.90035	1373	4506	4m	1:21	0.0		0.0	*1*	*1*	3	3	0	na
	S45A	Focus	9/22/2011	Spring 45 source	-111.726331	34.91233				1:23	0.0								
	S45B	Focus	9/22/2011	Spring 45 water fountain on side of house						1:13	0.0								
	S71	Focus	9/22/2011	Lower Indian Gardens spring, midway	-111.727733	34.90435				2:14	27.8			*1*	4	3	3	0	na
	S70	Focus	9/22/2011	Lower Indian Gardens spring, near runs	-111.727806	34.90273				2:37	25.6			*1*	4	3	1	0	na
	S109	Focus	9/22/2011	Lower Indian Gardens spring, down channel	-111.72854	34.90035	1373	4506	4m	3:07	8.5			*1*	*1*	3	2	0	na

gray highlight denotessamples from tributary streams
green highlight denotes samples from springs
no highlighting denotes Oak Creek samples

bold numbers mean "greater than"
italic numbers mean "less than"
red font means "out of hold time" or other attention

* Eastings and northings are either in WGS 84 Decimal Degrees (eg. -111.727733 degrees E, 34.904349 degrees N) or in NAD 83 UTM zone 12N (eg. 418375 meters E, 3847364 meters N).
**MS = Male Specific Phage
***S = Somatic Phage

Table A.2. Basic water quality for sampling locations in Oak Creek, adjacent springs and tributary washes Summer 2011.

strm_mi	Site_ID	Date	Descript	turbid	PO4-P	NO2-	NO3-N	NH4+	Air_T_C	H2O_T_C	DO_mg/L**	DO_%sat	Cond***	TDS	pH	pH_T_C
0.5	M13	7/5/2011	West Fork						32.0	26	n/a	n/a	326	228	8.73	26
49.0	M08	7/5/2011	Pine Flats						24.0	14.5	n/a	n/a	270	195	8.1	14.5
46.0	M09A	7/5/2011	1/4 mi ds of Forest Houses						28.5	21.1	n/a	n/a	303	212	8.66	21.1
37.4	M45	7/5/2011	Lomacasi						28.0	22.1	6.14	94.4	276	192	9.41	
22.7	M32	7/5/2011	Dry Creek Confluence						32.0	28.4	5.62	96.6	314	214	9.05	
17.0	M36	7/5/2011	Page Springs Bridge						25.0	22.5	6.17	94.9	374	266	8.41	22.8
8.9	M40	7/5/2011	Cornville Bridge						34.0	27.8	9.16	133.1	451	314	7.86	27.8
2.2	M41	7/5/2011	Cornville Estates						34.0	27	7.54	115.3	462	320	8.3	27
46.3	M09	7/11/2011	Hoel's Wash/Forest Houses						32.0	19.1	10	118	286	203	8.54	19.1
43.7	M44	7/11/2011	Slide Rock						29.0	20.7	8.8	119.1	298	210	8.3	20.7
40.5	M17	7/11/2011	Indian Gardens						25.5	18.8	9.65	124	272	186	8.33	18.8
40.0	M18	7/11/2011	Living Springs						23.0	17.7	9.2	120	269	188	8.06	17.7
34.0	M25	7/11/2011	Chavez Crossing Campground						27.0	22.3	n/a	n/a	n/a	n/a	8.37	22.3
17.2	M36	7/11/2011	Page Springs Bridge						28.1	24.4	n/a	n/a	n/a	n/a	7.98	24.4
12.6	M39A	7/11/2011	below Spring Creek Confluence						30.5	26.3	6.22	103.38	394	270	9.32	26.2
8.9	M40	7/11/2011	Cornville Bridge						24.0	23.9	6.23	98.7	458	319	8.22	23.9
0.4	M43	7/11/2011	above Verde Confluence						29.0	27.2	6.47	110	456	320	9.23	27.2
0.1	M39	7/11/2011	Spring Creek													
49.0	M08	7/14/2011	Pine Flats						24.0	15.3	9.25	109.2	266	185	7.97	15.3
37.4	M45	7/14/2011	Lomacasi						28.9	17.9	9.12	116.6	283	193	8.47	17.9
22.7	M32	7/14/2011	Dry Creek Confluence						30.0	22.3	8.01	111.7	308	212	7.96	22.3
2.2	M41	7/14/2011	Cornville Estates						27.5	21.3	7.21	99.8	453	324	7.84	21.3
40.5	M17	7/19/2011	Indian Gardens						25.4	18.9	n/a	n/a	279	196	8.3	18.9
22.7	M32	7/19/2011	Dry Creek Confluence						33.0	24.7	n/a	n/a	310	216	8.21	24.7
8.9	M40	7/19/2011	Cornville Bridge						23.5	23	n/a	n/a	468	325	7.7	23
0.5	M13	7/28/2011	West Fork						26.0	23.6	n/a	n/a	315	219	8.68	23.6
43.7	M44	7/28/2011	Slide Rock						30.0	18.7	n/a	n/a	297	205	8.52	18.7
40.0	M18	7/28/2011	Living Springs						25.0	18.2	n/a	n/a	276	186	8.22	18.2
34.0	M25	7/28/2011	Chavez Crossing Campground						29.0	21.1	n/a	n/a	282	189	8.54	21.1
17.2	M36	7/28/2011	Page Springs Bridge						30.1	25.6	n/a	n/a	408	293	7.92	25.6
12.6	M39A	7/28/2011	below Spring Creek Confluence						32.0	23.3	n/a	n/a	476	333	7.88	23.3
0.4	M43	7/28/2011	above Verde Confluence						29.0	24.6	n/a	n/a	467	324	8.16	24.6
0.1	M39	7/28/2011	Spring Creek						28.0	21.9	n/a	n/a	653	455	7.62	21.9
	M49	8/1/2011	Jordan Pump													
	M48	8/1/2011	Arroyo Roble													
	M47	8/1/2011	Tlaquepaque													
	M46	8/1/2011	Soldier's Wash													
2.6	M26	8/1/2011	Carroll Canyon 3, trail (@Shelby)													
0.6	M27	8/1/2011	Carroll Canyon 2, bridge													
0.0	M51	8/1/2011	Carroll Canyon 1, mouth													
8.9	M40	8/1/2011	Cornville Bridge													
0.5	M13	8/2/2011	West Fork	0.83	*0.04*	*0.002*	0.05	0.01	28.0	24.5	7.24	116.6	337	235	9.64	24.5
49.0	M08	8/2/2011	Pine Flats	0.24	0.04	*0.002*	0.02	*0.01*	23.0	15.3	11.73	160.2	290	202	8.56	14.7
46.3	M09	8/2/2011	Hoel's Wash/Forest Houses	0.70	0.04	*0.002*	0.03	0.01	24.5	18.3	7.46	105.9	311	221	8.05	18.3

strm_mi	Site_ID	Date	Descript	turbid	PO4-P	NO2-	NO3-N	NH4+	Air_T_C	H2O_T_C	DO_mg/L**	DO_%sat	Cond***	TDS	pH	pH_T_C
43.7	M44	8/2/2011	Slide Rock	0.79	*0.04*	*0.002*	0.03	*0.01*	21.0	17.5	7.77	104.7	317	219	8.01	17.5
40.5	M17	8/2/2011	Indian Gardens	0.78	0.07	*0.002*	0.02	*0.01*	29.0	18.7	n/a	n/a	293	206	6.52?	18.7
40.0	M18	8/2/2011	Living Springs	1.05	0.04	*0.002*	0.03	0.01	30.0	19.3	n/a	n/a	279	193	8.38	19.3
37.4	M45	8/2/2011	Lomacasi	1.33	0.05	*0.002*	0.03	*0.01*	33.0	19.5	n/a	n/a	278	195	8.11	19.5
34.0	M25	8/2/2011	Chavez Crossing Campground	43.43	0.18	0.012	0.14	0.03	31.0	20.2	n/a	n/a	291	203	7.95	20.2
27.9	M29	8/2/2011	below Red Rock State Park	1537.00	*0.04*	*0.002*	*0.02*	0.17	34.0	24.4	n/a	n/a	200	140	7.64	24.4
22.7	M32	8/2/2011	Dry Creek Confluence						35.0	25.5	n/a	n/a	210	147	7.64	25.5
17.2	M36	8/2/2011	Page Springs Bridge	788.70	*0.04*	*0.002*	*0.02*	0.06	34.0	28	n/a	n/a	306	213	7.91	28
2.2	M41	8/2/2011	Cornville Estates	31.50	0.10	0.006	0.09	0.03	33.0	24.2	n/a	n/a	487	315	8.1	24.2
	S41	8/10/2011	Spring 41, upstream of SRSP	8.43	0.06	0.003	0.06	0.03	27.0	14.6	n/a	n/a	373	264	6.5	14.6
	S52	8/10/2011	Spring 52, Indian Gardens	0.74	0.12	*0.002*	0.07	0.06	23.6	15.7	n/a	n/a	n/a	n/a	n/a	n/a
	S49	8/10/2011	Spring 49 near source	0.62	0.07	*0.002*	0.05	0.01	25.0	13.3	n/a	n/a	255	188	7.4	13.3
	S48	8/10/2011	Spring 48, Indian Gardens	0.51	0.05	*0.002*	0.06	0.01	24.0	14.9	n/a	n/a	131	186	7.1	14.9
	S45	8/10/2011	Spring 45 waterfall	0.20	*0.04*	*0.002*	0.04	0.01	23.8	13.1	n/a	n/a	129	175	7.54	13.1
	S42	8/10/2011	Spring 42, Munds Creek	0.68	0.20	*0.002*	0.03	0.02	25.2	15.2	n/a	n/a	246	178	7.63	15.2
	S2	8/10/2011	Spring 2, South of IG bridge	0.27	*0.04*	*0.002*	0.10	0.03	28.0	13.8	n/a	n/a	259	191	7.95	13.8
	S16	8/10/2011	Spring 16, Zane Grey's cabin	2.58	0.04	0.002	0.04	0.04	29.0	12.7	n/a	n/a	432	301	7.34	12.7
	S16	8/24/2011	Spring 16, Zane Grey's cabin	2.09	0.10	*0.002*	0.02	0.03	23.8	13.2	n/a	n/a	422	294	8.06	13.2
	S41	8/24/2011	Spring 41, upstream of SRSP	2.81	0.07	0.002	0.06	0.02	23.0	17.6	n/a	n/a	346	247	7.41	17.6
	S52	8/24/2011	Spring 52, Indian Gardens	0.31	0.05	*0.002*	*0.02*	0.01	28.0	18.6	n/a	n/a	477	331	7.37	19
	S49	8/24/2011	Spring 49 near source	0.67	0.06	*0.002*	*0.02*	0.01	30.0	16	n/a	n/a	252	177	7.72	16.1
	S100	8/24/2011	Page Springs Source	0.21	0.04	*0.002*	0.02	0.02		20.3	n/a	n/a	333	228	7.37	20.3
	F3	8/24/2011	Spring Creek above WWT pond	n/a	n/a	n/a	n/a	n/a	33.0	22.4	n/a	n/a	525	362	8.45	22.4
	M39	8/24/2011	Spring Creek	10.45	0.14	0.006	0.09	0.05	33.5	23.3	n/a	n/a	626	429	7.77	23.3
	S98	8/24/2011	Bubbling Ponds Spring	0.24	*0.04*	*0.002*	0.06	0.02	33.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	F4	8/24/2011	Bubbling Ponds outfall	5.69	0.10	0.006	0.11	0.05	33.0	26.3	n/a	n/a	435	303	7.87	26.3
	S35	9/1/2011	Spring 35, West Fork	0.50	*0.04*	n/a	*0.02*	0.01		n/a	n/a	n/a	n/a	n/a	n/a	n/a
	S36	9/1/2011	Spring 36, West Fork	0.46	0.04	n/a	*0.02*	0.02		15.7	n/a	n/a	330	227	8.01	15.7
	S39	9/1/2011	Walnut Spring, West Fork	1.76	0.07	n/a	0.02	0.02	28.0	14.5	n/a	n/a	305	208	7.88	14.5
	S1	9/1/2011	Spring 1, Indian Gardens	2.97	0.06	n/a	*0.02*	0.02	29.0	15.3	n/a	n/a	298	206	6.94	15.3
	S3	9/1/2011	Spring 3, Indian Gardens	1.06	0.05	n/a	*0.02*	0.01	29.0	15.8	n/a	n/a	287	196	7.48	15.8
	F5	9/1/2011	Creek from Spring 59, Indian Gardens	1.01	0.05	n/a	*0.02*	0.02	28.5	16.7	n/a	n/a	260	182	7.81	16.7
	S58	9/1/2011	Spring 58 Pool, Indian Gardens	1.88	0.05	n/a	*0.02*	0.01	29.0	16.4	n/a	n/a	294	208	7.05	16.4
	S67	9/1/2011	Spring 67, Indian Gardens	59.30	0.09	n/a	0.03	0.01	29.0	16.7	n/a	n/a	260	183	7.38	16.7
	S75	9/1/2011	Spring 75 Pool, Indian Gardens	21.37	0.05	n/a	*0.02*	0.01	28.5	15.2	n/a	n/a	268	185	7.11	15.2
	S77	9/1/2011	Spring 77 Pool, Indian Gardens	0.84	*0.04*	n/a	*0.02*	0.01		14.9	n/a	n/a	274	182	6.33	14.9
	S78	9/1/2011	Spring 78, Indian Gardens	0.18	0.05	n/a	*0.02*	0.01		15.4	n/a	n/a	266	188	7.65	15.4
	M49	9/6/2011	Jordan Pump	597.00	>1.70	n/a	n/a	n/a								
	M48	9/6/2011	Arroyo Roble	51.60	0.84	n/a	n/a	n/a								
	M46	9/6/2011	Soldier's Wash	345.00	>1.70	n/a	n/a	n/a								
	F1	9/6/2011	Chavez Ranch Day Use Area	34.30	0.27	n/a	n/a	n/a								
	M26	9/6/2011	Carroll Canyon 3, trail (@Shelby)	22.30	0.35	n/a	n/a	n/a								
	M27	9/6/2011	Carroll Canyon 2, bridge	358.00	1.55	n/a	n/a	n/a								
37.4	M45	9/7/2011	Lomacasi						20.9	26.6	n/a	n/a	271	186	8.49	20.9
34.0	M25	9/7/2011	Chavez Crossing Campground						35.1	23.7	n/a	n/a	283	198	8.41	23.7
27.9	M29	9/7/2011	below Red Rock State Park						31.9	24.8	n/a	n/a	293	201	8.19	25.8

strm_mi	Site_ID	Date	Descript	turbid	PO4-P	NO2-	NO3-N	NH4+	Air_T_C	H2O_T_C	DO_mg/L**	DO_%sat	Cond***	TDS	pH	pH_T_C
17.2	M36	9/7/2011	Page Springs Bridge						n/a	24.3	n/a	n/a	424	277	8.06	24.3
8.9	M40	9/7/2011	Cornville Bridge						n/a	24.9	n/a	n/a	455	314	8.16	24.6
	M49	9/11/2011	Jordan Pump													
	M48	9/11/2011	Arroyo Roble													
	M46	9/11/2011	Soldier's Wash													
	M26	9/11/2011	Carroll Canyon 3, trail (@Shelby)													
	M27	9/11/2011	Carroll Canyon 2, bridge													
49.0	M08	9/11/2011	Pine Flats	0.30	0.07	*0.002*	*0.02*	*0.01*								
40.5	M17	9/11/2011	Indian Gardens	5.06	0.08	0.004	*0.02*	0.03								
37.4	M45	9/11/2011	Lomacasi	7.69	0.11	0.004	*0.02*	0.02								
34.0	M25	9/11/2011	Chavez Crossing Campground	40.07	*0.04*	0.002	*0.02*	0.02								
27.9	M29	9/11/2011	below Red Rock State Park	221.00	0.11	0.022	0.18	0.01								
22.7	M32	9/11/2011	Dry Creek Confluence	38.70	0.04	0.002	*0.02*	0.01								
17.2	M36	9/11/2011	Page Springs Bridge	10.80	0.09	0.006	0.04	0.01								
2.2	M41	9/11/2011	Cornville Estates	14.83	0.15	0.008	0.12	0.04								
	F4	9/11/2011	Bubbling Ponds outfall													
49.0	M08	9/15/2011	Pine Flats													
40.5	M17	9/15/2011	Indian Gardens													
37.4	M45	9/15/2011	Lomacasi													
34.0	M25	9/15/2011	Chavez Crossing Campground													
27.9	M29	9/15/2011	below Red Rock State Park													
22.7	M32	9/15/2011	Dry Creek Confluence													
17.2	M36	9/15/2011	Page Springs Bridge													
8.9	M40	9/15/2011	Cornville Bridge													
	S52	9/16/2011	Spring 52, Indian Gardens						22.0	16.1	n/a	n/a	254	177	7.39	16.1
	S49A	9/16/2011	Spring 49 source						24.0	15.8	n/a	n/a	260	179	7.69	15.8
	F6	9/16/2011	Spring ditch, AGFD						24.0	19.9	n/a	n/a	536	368	7.61	19.9
	S107	9/16/2011	Spring ditch						23.0	19.5	n/a	n/a	495	343	7.84	20.4
	S98	9/16/2011	Bubbling Ponds Spring						25.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	F4	9/16/2011	Bubbling Ponds outfall						26.0	21.0	n/a	n/a	452	308	7.8	21
	S100	9/16/2011	Page Springs source						23.0	20.1	n/a	n/a	349	240	7.42	20.1
	F3	9/16/2011	Spring Creek above WWT pond						22.5	19.1	n/a	n/a	585	406	8.27	19.1
	M39	9/16/2011	Spring Creek						20.0	18.9	n/a	n/a	677	470	7.8	18.9
	S9	9/20/2011	Pine Flat spring @ road						n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	S41	9/20/2011	Spring 41, upstream of SRSP	5.46	*0.04*	0.002	*0.02*	0.04	21.0	16.6	n/a	n/a	326	234	7.76	16.6
	S49A	9/20/2011	Spring 49 source	0.25	0.05	*0.002*	*0.02*	*0.01*	22.0	15.6	n/a	n/a	256	176	7.62	15.6
	S49	9/20/2011	Spring 49 near source	0.46	0.05	*0.002*	0.02	0.03	23.0	15.5	n/a	n/a	256	179	7.76	15.5
	F7	9/20/2011	Lower Indian Gardens spring, upper end						24.0	16.5	n/a	n/a	239	172	7.99	16.5
	S71	9/20/2011	Lower Indian Gardens spring, midway	5.12	0.05	0.003	*0.02*	0.05	28.5	17.1	n/a	n/a	253	175	8	17.1
	S70	9/20/2011	Lower Indian Gardens spring, near fish runs	0.69	0.08	0.010	0.08	0.15	27.0	17.5	n/a	n/a	248	159	7.91	17.5
	F6	9/20/2011	Spring ditch, AGFD	1.37	0.10	0.002	0.03	0.03	28.0	21.1	n/a	n/a	518	361	7.73	21.1
	S107	9/20/2011	Spring ditch	1.34	0.04	0.003	0.03	0.05	25.5	20.7	n/a	n/a	485	343	7.95	20.7
	S109	9/21/2011	Lower Indian Gardens spring, down channel	0.61	0.07	0.009	0.07	0.07	n/a	17.1	n/a	n/a	170	245	8.22	17.1
	S45A	9/22/2011	Spring 45 source	0.22	*0.04*	*0.002*	0.07	0.01								
	S45B	9/22/2011	Spring 45 water fountain on side of house													
	S71	9/22/2011	Lower Indian Gardens spring, midway	2.15	0.06	*0.002*	0.05	0.01	n/a	17.4	n/a	n/a	237	172	8.03	17.4

strm_mi	Site_ID	Date	Descript	turbid	PO4-P	NO2-	NO3-N	NH4+	Air_T_C	H2O_T_C	DO_mg/L**	DO_%sat	Cond***	TDS	pH	pH_T_C
	S70	9/22/2011	Lower Indian Gardens spring, near fish runs	1.17	0.05	0.008	0.13	0.08	n/a	17.4	n/a	n/a	253	175	7.83	17.4
	S109	9/22/2011	Lower Indian Gardens spring, down channel	0.58	0.08	0.009	0.15	0.08	24.7	17.2	n/a	n/a	244	164	8	17.2

gray highlight denotessamples from tributary streams
green highlight denotes samples from springs
no highlighting denotes Oak Creek samples

bold numbers mean "greater than"
italic numbers mean "less than"
red font means "out of hold time" or other attention

** The instrument used for measuring dissolved oxygen and temperature was the Extik DO600. Measurements of DO were discontinued after no noticeable trend was seen and two out three meters ceased to function properly.
*** The intrument used for measuring pH, conductivity, total dissolved solids and temperature was the Extik EC500.

Table A.3. Environmental conditions and streamflow during sampling of Oak Creek, adjacent springs and tributary washes Summer 2011.

strm_mi	Site_ID	Date	Descript	Weather	7-day weather	Flushing	Stream width	Depth (ft)	Velocity ft/s	ChanArea	Flow_cfs	Crew	Notes
0.5	M13	7/5/2011	West Fork	Partly cloudy	Rain	N	10.1	0.75	0.58	3.79	2.2	CW, KK, JL	Highly used recreation area downstream of sampling site, DO meter not properly functioning
49.0	M08	7/5/2011	Pine Flats	overcast	Rain	N	37.5	1.23	0.31	23.06	7.08	CW, KK, JL	DO meter not properly functioning
46.0	M09A	7/5/2011	1/4 mi ds of Forest Houses	overcast/rain	Rain	N	45.5	2.54	0.46	57.79	26.7	CW, KK	Random site; site will be moved 1/4 mile upstream, DO meter not properly functioning
37.4	M45	7/5/2011	Lomacasi	partly cloudy	rain	N						SML, LMP	
22.7	M32	7/5/2011	Dry Creek Confluence	clear	rain	N	23.0	1.7	0.7	19.6	13.7	SML, LMP	Abundant white bubbles on water surface. Occassional funky (dead animal) odor. No shade at cross-section
17.0	M36	7/5/2011	Page Springs Bridge	overcast	rain	N	45.5	1.8	0.75	41.0	30.7	SML, LMP	Diversion dam takes considerable flow at outfall into an irrigation ditch above this cross-section
8.9	M40	7/5/2011	Cornville Bridge	clear	rain	N	49.9	0.63	1.11	31.4	43.5	KJA, CJ	Semi turbid water, DO
2.2	M41	7/5/2011	Cornville Estates	Partly cloudy	rain	N	51.3	2.4	0.11	116.3	11.4	KJA, CJ	turbid appearance to water
46.3	M09	7/11/2011	Hoel's Wash/Forest Houses	clear	rain	N	29.5	1.23	0.32	36.5	10.9	KJA, LP	No biofilm, clear water
43.7	M44	7/11/2011	Slide Rock	clear	rain	N	51.5	1.94	0.11	100.7	14.04	KJA, CW	clear water, layer of loose brown colored algae
40.5	M17	7/11/2011	Indian Gardens	partly cloudy	rain	N	51.5	1.18	0.46	59.4	25.5	KJA, LP	Thin Layer diatoms, clear water
40.0	M18	7/11/2011	Living Springs	partly cloudy	rain	N	52.2	2.02	0.33	101.4	35.2	KJA, LP	White bubbles on water surface. Clear water. Thin layer diatoms
34.0	M25	7/11/2011	Chavez Crossing Campground	Partly cloudy	Rain	N	31	2.94	0.62	45.57	28.25	CW, KD	
17.2	M36	7/11/2011	Page Springs Bridge	overcast	Rain	N	48	3.24	0.54	77.76	41.99	CW, KD	
12.6	M39A	7/11/2011	below Spring Creek Confluence	clear	showers	N	74.7	2.85	0.4	106.4	42.6	SML, CTA	A lot of silt settled on bottom. Fairly turbid, but less than at Verde onfluence.
8.9	M40	7/11/2011	Cornville Bridge	partly cloudy	showers		40.0	1.9	1.66	38.0	63.1	SML, CTA	
0.4	M43	7/11/2011	above Verde Confluence	clear	showers	N	42.2	1.7	1.66	35.9	59.5	SML, CTA	Bottom is 1.6-1.7 for about 20 feet, starting 11.4' from LEW and going toward REW. Many dragonflies & damselflies. Water is turbid. Was also turbid on July 1, 2011 during recon.
0.1	M39	7/11/2011	Spring Creek										Collected *E coli* sample only in Spring Creek above path bridge. Sewer odor at Spring Creek.
49.0	M08	7/14/2011	Pine Flats	clear	partly cloudy		37.1	2.51	0.39	91.9	33.3	KJA,CW	No biofilm, clear water; Possible error in reading *E. coli* result. Overhead light not turned off. Disregard result.
37.4	M45	7/14/2011	Lomacasi	clear	partly cloudy		44.3	2.39	0.34	102.1	32.13	KJA,CW	No biofilm, clear water; Possible error in reading *E. coli* result. Overhead light not turned off. Disregard result.
22.7	M32	7/14/2011	Dry Creek Confluence	clear	clear		24.4	1.09	0.68	25.9	16.19	KJA, CJ,CW	No biofilm, clear water; Possible error in reading *E. coli* result. Overhead light not turned off. Disregard result.
2.2	M41	7/14/2011	Cornville Estates	clear	clear		50.9	2.28	0.31	108.7	34.71	KJA, CJ,CW	Possible error in reading *E. coli* result. Overhead light not turned off. Disregard result.
40.5	M17	7/19/2011	Indian Gardens	Clear	Rain	Y?	43	1.5	0.99	32.25	31.83	CW, CJ	Discharge was increased due to Rain on 7/18/11 afternoon
22.7	M32	7/19/2011	Dry Creek Confluence	Partly cloudy	Rain	Y?	30.2	1.16	0.94	17.51	16.41	CW, CJ	Discharge was increased due to Rain on 7/18/11 afternoon

strm_mi	Site_ID	Date	Descript	Weather	7-day weather	Flushing	Stream width	Depth (ft)	Velocity ft/s	ChanArea	Flow_cfs	Crew	Notes
8.9	M40	7/19/2011	Cornville Bridge	Cloudy	Rain	Y?	54.3	2.36	1.47	64.07	94.18	CW, CJ	Discharge was increased due to Rain on 7/18/11 afternoon
0.5	M13	7/28/2011	West Fork	Partly cloudy	partly cloudy		7.41	0.52	0.04	3.42	0.25	KJA, KM	clear water
43.7	M44	7/28/2011	Slide Rock	raining	partly cloudy		51.9	1.97	0.06	99.48	6.13	KJA, KM	clear water, benthic algal coverage, duplicate e.coli
40.0	M18	7/28/2011	Living Springs	cloudy	partly cloudy		52.3	1.66	0.29	84.16	32.02	KJA, KM	clear water
34.0	M25	7/28/2011	Chavez Crossing Campground	Partly cloudy	partly cloudy		35	2.07	0.39	70	30.39	KJA, KM	clear water
17.2	M36	7/28/2011	Page Springs Bridge	partly cloudy	showers	N	65.6	3.2	1.03	104.96	108.11	CW, CJ	
12.6	M39A	7/28/2011	below Spring Creek Confluence	partly cloudy	showers	N	63.5	3.41	0.36	108.27	38.49	CW, CJ	
0.4	M43	7/28/2011	above Verde Confluence	clear	showers	N	38.6	1.43	0.94	27.6	25.86	CW, CJ	
0.1	M39	7/28/2011	Spring Creek	partly cloudy	showers	N	13.1	1.42	n/a	9.3	n/a	CW, CJ	No discharge assessment method because flow was very inconsistent along a small area of channel
	M49	8/1/2011	Jordan Pump									CTA	
	M48	8/1/2011	Arroyo Roble									KHD	
	M47	8/1/2011	Tlaquepaque									KHD	
	M46	8/1/2011	Soldier's Wash									KHD	
2.6	M26	8/1/2011	Carroll Canyon 3, trail (@Shelby)									SH	Likely *E. coli* underestimation. Sample contained a great deal of sediment which filled the bottom row of small cells that consequently did not fluoresce.
0.6	M27	8/1/2011	Carroll Canyon 2, bridge									SH	Likely *E. coli* underestimation. Sample contained a great deal of sediment which filled the bottom row of small cells that consequently did not fluoresce.
0.0	M51	8/1/2011	Carroll Canyon 1, mouth									SH	Likely *E. coli* underestimation. Sample contained a great deal of sediment which filled the bottom row of small cells that consequently did not fluoresce.
8.9	M40	8/1/2011	Cornville Bridge									CJ	
0.5	M13	8/2/2011	West Fork	partly cloudy	rain		10	0.82	1.14	8.2	9.35	SML, JVS	
49.0	M08	8/2/2011	Pine Flats	partly cloudy	showers		40.7	1.16	1.03	47.21	48.63	SML, JVS	
46.3	M09	8/2/2011	Hoel's Wash/Forest Houses	clear	rain		33.2	1.88	n/a	62.42	n/a	SML, JVS	
43.7	M44	8/2/2011	Slide Rock	clear	rain		39.6	1.7	1.18	46.73	55.14	SML, JVS	
40.5	M17	8/2/2011	Indian Gardens	partly cloudy	Rain/Showers	N	45.6	2.21	n/a	50.39	n/a	CW, JL	Velocity (orange peel method) not done because of injured volunteer (recovering from knee surgery)
40.0	M18	8/2/2011	Living Springs	partly cloudy	Rain/Showers	N	44.2	3.42	n/a	75.58	n/a	CW, JL	Velocity (orange peel method) not done because of injured volunteer (recovering from knee surgery)
37.4	M45	8/2/2011	Lomacasi	partly cloudy	Storm/Rain	Y	41.9	3.27	0.68	68.51	46.65	CW, JL, JM	Some debris in water. Water was mostly clear.
34.0	M25	8/2/2011	Chavez Crossing Campground	clear	Storm	Y	35.7	3.08	1.18	54.98	64.87	CW, JL, JM	A lot of debris in water. Water was reddish-brown, opaque, and muddy.
27.9	M29	8/2/2011	below Red Rock State Park	clear	storm		21.2	1.45	1.25	30.74	38.43	KJA, KK, WJ	
22.7	M32	8/2/2011	Dry Creek Confluence	clear	storm		28.8	1.42	1.13	40.9	46.22	KJA, KK, WJ	
17.2	M36	8/2/2011	Page Springs Bridge	clear	storm		48	2.28	0.52	109.44	56.91	KJA, KK, WJ	Water was a medium brown color
2.2	M41	8/2/2011	Cornville Estates	clear	storm		52.1	2.91	0.8	151.61	121.29	KJA, KK, WJ	

strm_mi	Site_ID	Date	Descript	Weather	7-day weather	Flushing	Stream width	Depth (ft)	Velocity ft/s	ChanArea	Flow_cfs	Crew	Notes
	S41	8/10/2011	Spring 41, upstream of SRSP	partly cloudy	overcast	N						CW, AB	Forgot to take pictures
	S52	8/10/2011	Spring 52, Indian Gardens	clear	overcast	N						CW, AB	Forgot to take pictures; Flow was too small to take pH, cond, and TDS measurements
	S49	8/10/2011	Spring 49 near source	clear	overcast	N						CW, AB	Forgot to take pictures
	S48	8/10/2011	Spring 48, Indian Gardens	clear	overcast	N						CW, AB	Forgot to take pictures; Forgot to write down bacterial collection time, so I estimated
	S45	8/10/2011	Spring 45 waterfall	clear	overcast	N						CW, AB	Forgot to take pictures
	S42	8/10/2011	Spring 42, Munds Creek	clear	overcast	N						CW, AB	Forgot to take pictures
	S2	8/10/2011	Spring 2, South of IG bridge	clear	overcast	N						CW, AB	Forgot to take pictures
	S16	8/10/2011	Spring 16, Zane Grey's cabin	clear	overcast	N						CW, AB	Forgot to take pictures
	S16	8/24/2011	Spring 16, Zane Grey's cabin	clear	showers	N						CW, KK	Wasn't able to fill sample bottles to top because of shallow water
	S41	8/24/2011	Spring 41, upstream of SRSP	clear	showers	N						CW, KK	Compared to 8/10/2011, air temp is 4˚C cooler, but water temp is 3˚C warmer
	S52	8/24/2011	Spring 52, Indian Gardens	clear	showers	N						CW, KK	Took pH, cond, TDS, and temp measurements with water in sample bottle; compared to 8/10/2011 air and water temp are about 3-4˚C warmer
	S49	8/24/2011	Spring 49 near source	clear	showers	N						CW, KK	Compared to 8/10/2011, elevation difference is 134 ft higher?, air and water temp are about 3-5˚C warmer
	S100	8/24/2011	Page Springs Source	clear	showers	N						KA, MN	DO meter not working; DNA sample may haven been switched with Spring Creek M39A?
	F3	8/24/2011	Spring Creek above WWT pond	clear	showers	N						KA, MN	DO meter not working
	M39	8/24/2011	Spring Creek	clear	showers	N						KA, MN	DO meter not working. Exceeds *E. coli* standard. DNA sample may haven been switched with Page Springs S100.
	S98	8/24/2011	Bubbling Ponds Spring	clear	showers	N						KA, MN	DO meter not working. Not allowed to collect pH, conductivity, TDS at Bubbling Ponds Spring.
	F4	8/24/2011	Bubbling Ponds outfall	clear	showers	N						KA, MN	DO meter not working
	S35	9/1/2011	Spring 35, West Fork									KJA, MN	
	S36	9/1/2011	Spring 36, West Fork									KJA, MN	
	S39	9/1/2011	Walnut Spring, West Fork									KJA, MN	
	S1	9/1/2011	Spring 1, Indian Gardens									KJA, MN	
	S3	9/1/2011	Spring 3, Indian Gardens									KJA, MN	
	F5	9/1/2011	Creek from Spring 59, Indian Gardens									KJA, MN	
	S58	9/1/2011	Spring 58 Pool, Indian Gardens									KJA, MN	

strm_mi	Site_ID	Date	Descript	Weather	7-day weather	Flushing	Stream width	Depth (ft)	Velocity ft/s	ChanArea	Flow_cfs	Crew	Notes
	S67	9/1/2011	Spring 67, Indian Gardens									KJA, MN	
	S75	9/1/2011	Spring 75 Pool, Indian Gardens									KJA, MN	
	S77	9/1/2011	Spring 77 Pool, Indian Gardens									KJA, MN	
	S78	9/1/2011	Spring 78, Indian Gardens									KJA, MN	
	M49	9/6/2011	Jordan Pump									SML, KJA	
	M48	9/6/2011	Arroyo Roble									SML, KJA	
	M46	9/6/2011	Soldier's Wash									SML, KJA	
	F1	9/6/2011	Chavez Ranch Day Use Area									SML, KJA	
	M26	9/6/2011	Carroll Canyon 3, trail (@Shelby)									SML, KJA	
	M27	9/6/2011	Carroll Canyon 2, bridge									SML, KJA	
37.4	M45	9/7/2011	Lomacasi									CW	Normal clarity conditions
34.0	M25	9/7/2011	Chavez Crossing Campground									CW	Fairly clear, small amount of debris on waters surface
27.9	M29	9/7/2011	below Red Rock State Park									CW	E.coli Duplicate sample taken here; Muddy, partially opaque water, could barely see bottom of creek
17.2	M36	9/7/2011	Page Springs Bridge									CW	I smelled sewage at the sampling site
8.9	M40	9/7/2011	Cornville Bridge									CW	
	M49	9/11/2011	Jordan Pump									KJA	
	M48	9/11/2011	Arroyo Roble									KJA	
	M46	9/11/2011	Soldier's Wash									KHD	
	M26	9/11/2011	Carroll Canyon 3, trail (@Shelby)									KHD	
	M27	9/11/2011	Carroll Canyon 2, bridge									KHD	
49.0	M08	9/11/2011	Pine Flats									KJA	
40.5	M17	9/11/2011	Indian Gardens									KJA	
37.4	M45	9/11/2011	Lomacasi									KJA	
34.0	M25	9/11/2011	Chavez Crossing Campground									KJA	
27.9	M29	9/11/2011	below Red Rock State Park									SML, KHD	
22.7	M32	9/11/2011	Dry Creek Confluence									SML, KHD	
17.2	M36	9/11/2011	Page Springs Bridge									SML, KHD	
2.2	M41	9/11/2011	Cornville Estates									SML, KHD	
	F4	9/11/2011	Bubbling Ponds outfall									SML, KHD	
49.0	M08	9/15/2011	Pine Flats									KJA	Samples were too turbid to analyze for nutrients without filtering. Could not filter within the hold time, so nutrients were not analyzed.

strm_mi	Site_ID	Date	Descript	Weather	7-day weather	Flushing	Stream width	Depth (ft)	Velocity ft/s	ChanArea	Flow_cfs	Crew	Notes
40.5	M17	9/15/2011	Indian Gardens									KJA	Samples were too turbid to analyze for nutrients without filtering. Could not filter within the hold time, so nutrients were not analyzed.
37.4	M45	9/15/2011	Lomacasi									KJA	Samples were too turbid to analyze for nutrients without filtering. Could not filter within the hold time, so nutrients were not analyzed.
34.0	M25	9/15/2011	Chavez Crossing Campground									KJA	Samples were too turbid to analyze for nutrients without filtering. Could not filter within the hold time, so nutrients were not analyzed.
27.9	M29	9/15/2011	below Red Rock State Park									KJA	Samples were too turbid to analyze for nutrients without filtering. Could not filter within the hold time, so nutrients were not analyzed.
22.7	M32	9/15/2011	Dry Creek Confluence									KJA	Samples were too turbid to analyze for nutrients without filtering. Could not filter within the hold time, so nutrients were not analyzed.
17.2	M36	9/15/2011	Page Springs Bridge									KJA	Samples were too turbid to analyze for nutrients without filtering. Could not filter within the hold time, so nutrients were not analyzed.
8.9	M40	9/15/2011	Cornville Bridge									KJA	Samples were too turbid to analyze for nutrients without filtering. Could not filter within the hold time, so nutrients were not analyzed.
	S52	9/16/2011	Spring 52, Indian Gardens	overcast	storm	N						CW, MN	
	S49A	9/16/2011	Spring 49 source	overcast	storm	N						CW, MN	E.coli Duplicate sample taken
	F6	9/16/2011	Spring ditch, AGFD	overcast	storm	Y						CW, MN	Across from Bubbling Ponds source site
	S107	9/16/2011	Spring ditch	overcast	storm	Y						CW, MN	Oak Creek had a heavy sediment load at the ditch outfall, but ditch itself did not
	S98	9/16/2011	Bubbling Ponds Spring	overcast	stotrm	Y						CW, MN	Instruments not allowed in water
	F4	9/16/2011	Bubbling Ponds outfall	overcast	storm	N						CW, MN	
	S100	9/16/2011	Page Springs source	clear	storm	N						CW, MN	Sampled about 1-2 feet below metal gate
	F3	9/16/2011	Spring Creek above WWT pond	clear	storm	Y						CW, MN	Evidence of a recent large storm
	M39	9/16/2011	Spring Creek	clear	storm	Y						CW, MN	Evidence of a recent large storm
	S9	9/20/2011	Pine Flat spring @ road	clear	storm	N						CW, MN	
	S41	9/20/2011	Spring 41, upstream of SRSP	clear	storm	N						CW, MN	
	S49A	9/20/2011	Spring 49 source	clear	storm	N						CW, MN	
	S49	9/20/2011	Spring 49 near source	clear	storm	N						CW, MN	
	F7	9/20/2011	Lower Indian Gardens spring, upper end	clear	storm	N						CW, MN	
	S71	9/20/2011	Lower Indian Gardens spring, midway	clear	storm	N						CW, MN	
	S70	9/20/2011	Lower Indian Gardens spring, near fish runs	clear	storm	N						CW, MN	Water has a definite blue color in sample bottles

strm_mi	Site_ID	Date	Descript	Weather	7-day weather	Flushing	Stream width	Depth (ft)	Velocity ft/s	ChanArea	Flow_cfs	Crew	Notes
	F6	9/20/2011	Spring ditch, AGFD	clear	storm	N						CW, MN	
	S107	9/20/2011	Spring ditch	clear	storm	N						CW, MN	
	S109	9/21/2011	Lower Indian Gardens spring, down channel									KJA, MS	
	S45A	9/22/2011	Spring 45 source									CW, MN	
	S45B	9/22/2011	Spring 45 water fountain on side of house									CW, MN	
	S71	9/22/2011	Lower Indian Gardens spring, midway	overcast	overcast	N						CW, MN	
	S70	9/22/2011	Lower Indian Gardens spring, near runs	overcast	overcast	N						CW, MN	Water has a definite blue color in sample bottles
	S109	9/22/2011	Lower Indian Garden spring, down channel	overcast	overcast	N						CW, MN	

gray highlight denotessamples from tributary streams
green highlight denotes samples from springs
no highlighting denotes Oak Creek samples

bold numbers mean "greater than"
italic numbers mean "less than"
red font means "out of hold time" or other attention

March 24, 2012

To: Members of the Oak Creek Watershed Improvement Commission (WIC)

From: Barry Allan, OCWIP Grant Administrator

Re: Oak Creek Watershed Social Survey Results

In late December, 2011 we sent the Oak Creek Watershed Residents' Survey to you all for review and final comments. We also asked if you had the time, to fill out the Survey and let us know how long it took you to complete. Your feedback was invaluable and confirmed we needed to allow 15 minutes for residents to fill it out.

On February 9, 2012 we mailed 1,224 copies of the Oak Creek Watershed Residents' Survey through our distributor Hansen Light Works in Sedona. On March 20, 2012 we ended receipt of the Surveys from residents after entering the data from 265 replies or 21.6% of those sent out.

Methods used to create 10% random sample of addresses within the Oak Creek Watershed:

We used the parcel data provided by Coconino and Yavapai counties earlier in the project, and selected all parcels within the watershed boundary using a spatial intersection between the outline of the watershed and the map of parcel boundaries. There were 14,802 properties.

From the parcels within the watershed, we removed all parcels that did not contain information about the owner, and then removed all banks, credit unions, city properties, county properties, fire district properties, mortgage companies, and churches. We did not remove LLCs, trusts, or associations, but took a subset of all the owner addresses within Arizona, removing all international and out-of-state owners. The net total was 12, 241 addresses.

We then randomized the entries using Excel's RAND() function, generating random numbers and then removing the formula to convert the random numbers to values. The random numbers were sorted, smallest to largest, and the first 1224 entries selected to provide a 10% sample.

Prior to sending the list for distribution, we edited the names of owners to remove legal terminology such as the dates trusts were created. (Eg: An owner name listed as "Evans Jack Mercer & Marcia Anne Trustees ; Evans Jm & Ma Rvcbl Liv Trust Dtd 2/2/07" was reduced to "Evans Trust" for mailer purposes.)

The letter accompanying the Survey:

January 31, 2012

From: Barry Allan, Executive Director

Oak Creek Watershed COUNCIL

Dear Oak Creek Watershed Resident…

Oak Creek is the 50 mile thread that weaves together the fabric of our watershed community, as well as being vital to its economic, recreational and natural future. The Oak Creek Watershed Council is committed to preserving the integrity of Oak Creek and recognizes that its stewardship must be a part of the watershed community culture.

Funded by a grant from the Arizona Department of Environmental Quality (ADEQ) and the United States Environmental Protection Agency (EPA) our group has submitted a draft of the Oak Creek Watershed Improvement Plan, which will be ready for public review very soon. The Plan identifies problems associated with the impairment of Oak Creek by the fecal coliform *Escherichia coli (E. coli)*, as well as solutions to those problems.

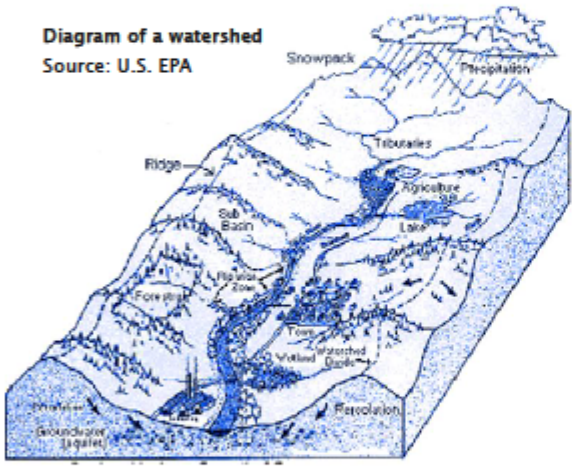

Diagram of a watershed
Source: U.S. EPA

We need your help discovering how best to inform other members of the public on ways to protect Oak Creek, and the health of people who recreate in it. Your household has been randomly selected to represent the view of Oak Creek watershed residents. This survey is designed to obtain residents' opinions on human behaviors that affect water quality. It will be used to guide projects to improve water quality in Oak Creek, and its five tributaries.

The enclosed survey takes approximately 15 minutes to fill out. Please take the time complete it, then fold and staple or tape, and return to the Oak Creek Watershed Council.

We highly value your opinion, and it matters a lot to us! Your time is very much appreciated, and every survey we receive back helps Oak Creek. ***Thank you for your participation!***

For more information about how you can help protect Oak Creek please visit our website at www.oakcreekwatershed.org. We also sponsor a website for visitors to Oak Creek Canyon at www.oakcreekcanyonaz.org in which we promote good stewardship and outdoor protocols.

Look for information on safe-guarding the water quality in Oak Creek through the Oak Creek Community Outreach Program in the spring of 2012 through radio, television, newspapers, as well as community groups. Your ideas at work along with hundreds of other watershed survey residents. *Together, we ARE making a difference!*

P.O. Box 732, Sedona, AZ 86339 • Tel: (928) 554-5460 • www.oakcreekwatershed.org

The Oak Creek Watershed Residents' Survey (2 pages) and Map of Watershed Zip Codes follows:

Oak Creek Watershed Residents' Survey

1) **Of the following, which best fits your definition of what a watershed is?**
   - ☐ Area that retains water like a swamp or a marsh
   - ☐ Water intake area that feeds a water treatment plant
   - ☐ The area of land where all of the water that drains off of it goes into a single creek, river or other water body
   - ☐ None of the above
   - ☐ Don't know

2) **How concerned are you with the health of the Oak Creek Watershed?**
   - ☐ Not concerned ☐ Somewhat
   - ☐ Concerned ☐ Very concerned

3) **How many times a year do you visit/recreate along Oak Creek?**
   - ☐ Never ☐ 1-5 ☐ 6-10
   - ☐ 11-15 ☐ 16-20 ☐ 20+

4) **What activities do you undertake while visiting Oak Creek? Please mark all that apply.**
   - ☐ Hiking ☐ Camping ☐ Fishing
   - ☐ Swimming ☐ Biking ☐ Dog walks
   - ☐ Equestrian ☐ Other:

5) **Which is the most important source of information affecting your perception of the Oak Creek Watershed's health?**
   - ☐ Personal observation
   - ☐ Newspaper ☐ Radio ☐ Internet
   - ☐ State or federal reports
   - ☐ Local environmental groups

6) **What sources do you think are the biggest contributors to creek contamination that can cause human illness?** Please number 1, 2 and 3 for your top choices.
   - ___ Litter
   - ___ Baby diapers
   - ___ Wildlife feces
   - ___ Septic systems
   - ___ Waste water treatment plants
   - ___ Other (specify)
   - ___ Dog feces
   - ___ Human feces
   - ___ Livestock waste
   - ___ Don't know

	Yes	No
7) Are you a pet owner? **If no please go to question 10.**		
8a) *If so,* does/do your pet(s) go outside?		
8b) Do you clean your yard of pet waste?		
9a) Do you own a dog? If **no please go to question 10.**		
9b) Do you walk your dog in the Oak Creek Watershed?		

9c) How often do you pick up your dog's waste when on a walk?
   - ☐ Never ☐ Rarely ☐ Sometimes
   - ☐ Most of the time ☐ Always

9d) If you pick up dog waste, how do you dispose of it?
   - ☐ Bag and leave it ☐ Trash
   - ☐ Toilet ☐ Compost ☐ Toss in ditch

9e) Would you use dog waste stations (plastic bag dispensers with or without trash can), if more were made available at parks and trails?
   - ☐ Yes ☐ No

10) Would you be willing to volunteer your time to help preserve Oak Creek and/or educate others about Oak Creek? (*If yes, provide contact information on next page.*)
   - ☐ Yes ☐ No

11) How old is the head of the household?
   - ☐ <34 ☐ 35-44 ☐ 45-54 ☐ 55-64
   - ☐ 65-74 ☐ 75+

12) How many people live in this household?
   - ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5+

13) Is this residence a second home?
   - ☐ Yes ☐ No

14) What is your approximate annual household income in thousands of dollars?
   - ☐ 0-20 ☐ 20-50 ☐ 50-100
   - ☐ 100-200 ☐ >200

Please complete the reverse side, then fold and staple or tape survey closed and mail to the Oak Creek Watershed Council.

For more information, please visit our website at www.oakcreekwatershed.org

15) In your opinion, how much do the following threaten Oak Creek water quality?

0 = not sure 1 = not a problem 2 = slight problem
3 = moderate problem 4 = large problem

	Please mark with an X				
	0	1	2	3	4
Agricultural runoff					
Livestock manure					
Fertilizers and pesticides					
Animals					
Dog feces that are not picked up and disposed properly					
Wildlife feces					
Wildlife attracted to water by discarded human food waste					
Erosion and sedimentation due to the following:					
Construction and maintenance of irrigation diversions					
Building and road construction					
Road maintenance					
Low water creek crossings					
Unmaintained "social" trails					
Jeep/ORV trails					
Other sources (specify)					
Recreation					
Human feces deposited outdoors					
Trash					
Used and improperly discarded baby diapers					
Lack of public toilet facilities near creek and at trailheads					
Lack of trash receptacles at recreation sites and trailheads					
Urban areas					
Stormwater runoff					
Lawn fertilizers and pesticides					
Pet feces not collected from yards					
Wastewater					
Inadequately maintained sewer system					
Improperly built or maintained residential septic systems					
Improperly built or maintained commercial septic systems					
Other					
Lack of riparian buffers (natural vegetation next to the water)					
Disturbance of "sediment reservoirs" on the bottom of Oak Creek that hold bacteria and viruses that can cause human illness					
Other (specify)					

Please, write any comments here:

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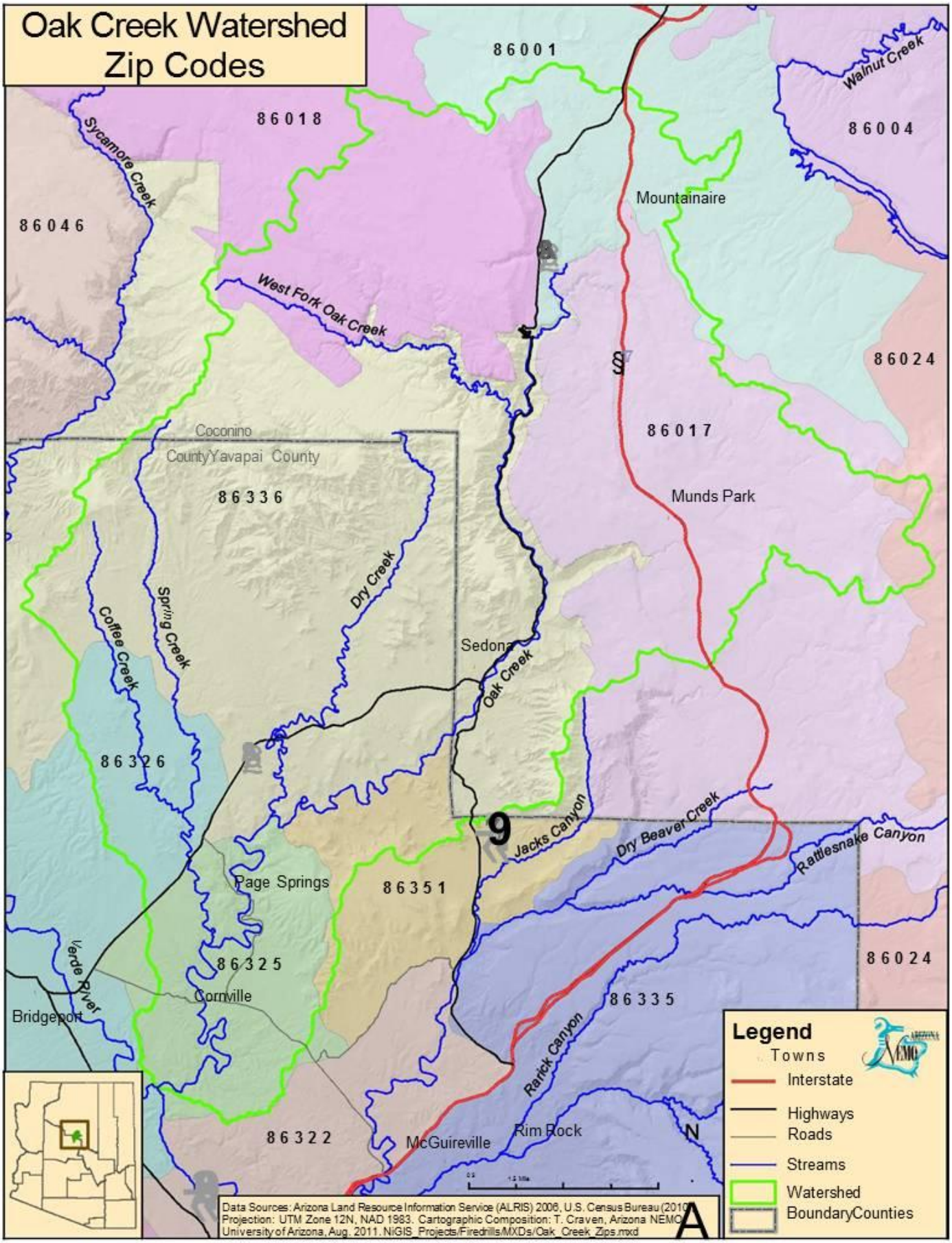
Oak Creek Watershed Council
P.O. Box 732, Sedona, AZ 86339

Oak Creek Watershed Council
P.O. Box 732
Sedona, AZ 86339


Oak Creek Watershed
Zip Codes
86001
86018
86004
86046
86024
86017
86336
86326
86351
86325
86322
86335
Walnut Creek
Sycamore Creek
West Fork Oak Creek
Mountainaire
Munds Park
Coconino
CountyYavapai County
Dry Creek
Spring Creek
Coffee Creek
Sedona
Oak Creek
Jacks Canyon
Dry Beaver Creek
Rattlesnake Canyon
Page Springs
Verde River
Cornville
Bridgeport
Rarick Canyon
McGuireville
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9
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Legend
Towns
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Roads
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Watershed
BoundaryCounties
Data Sources: Arizona Land Resource Information Service (ALRIS) 2006, U.S. Census Bureau (2010)
Projection: UTM Zone 12N, NAD 1983. Cartographic Composition: T. Craven, Arizona NEMO
University of Arizona, Aug. 2011. N:\GIS_Projects\Firedrills\MXDs\Oak_Creek_Zips.mxd
A

The results from the Social Survey are on a separate pdf attachments. Answers to questions 1 – 14 are in one pdf and answers to question 15 on the second. Three pages print out for all.

On the right side of each question's responses and tabulated data are some Take Away Notes that are meant to be summary observations. They assume that the collective answers from the 265 respondents are a fair sampling of all watershed residents and therefore the data can be extrapolated as such.

Our main use of the data and observations will be in developing the Oak Creek Community Outreach Program (OCCOP) as well as support in BMP decisions such as dog waste station installations.

We spent some time gathering some Census 2010 data regarding the ages of people living in watershed zip codes. We were hoping to compare that data with our own, relative to the age of the head of the household. Our reasoning was the low number of respondents under 45 years old (5.3%). Did younger people just not answer the survey or was it because there really are not a lot of younger people living in the watershed? The answer would be helpful in identifying our "audience" in the development of the OCCOP, but as it stands, it appears that middle aged and older watershed residents are in the majority.

<u>Highlights of the results from Questions 1 – 14 through direct answers and extrapolation are as follows</u>:

- 95% of property owners have some concern about the health of the Oak Creek Watershed.
- Each property owner visits/recreates along the Creek between 7 and 10 times a year.
- Hiking is almost 3 times as popular an activity as swimming.
- Personal observation & the newspaper were the choice of 74% as sources of information.
- Human feces, litter, baby diapers & septic systems were thought to be biggest contributors to creek contamination.
- Half of watershed property owners have pets & 90% of the pets go outside.
- 90% of watershed property owners clean their yard of waste
- 45% own a dog therefore there are at least 5400 dogs in the watershed.
- 45% of those who own a dog walk it (them) in the watershed extrapolating to almost 2500 dogs walked in the watershed annually.
- 64% always pick up their dog's waste. Approximate quantification of feces left behind is around 500 feces. Each gram of dog feces has 20 million *e. coli* bacteria colonies in it.
- 95% of dog owners who pick up the feces throw them into the trash.
- 89% of dog owners would use dog waste stations if provided.

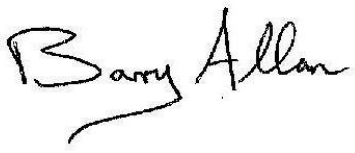
- 93% of respondents were over 45 years old, and 47% were over 65. 80% have 1 or 2 people living in the household, and for 62% it is their primary home.

Question 15 on the second page of the Survey had multiple choice answers to several questions within several categories, but all regarding the threat to Oak Creek water quality. Our percentages shown here are the total of 3 columns (slight problem, moderate problem and large problem):

- 69% believe that dog feces are a problem to some degree, and 48% wildlife feces. Almost 2/3 thought that wildlife attracted to water by human food waste threatens the water quality of Oak Creek.
- More than twice as many people than any other reason thought Jeep/ORV trails cause erosion and sedimentation which affects water quality of Oak Creek.
- The responses to recreation problems were the most significant of all categories: Totals: Human feces 67%; Trash 84%; Baby diapers 75%; Lack of public toilets 79%; Lack of trash receptacles 79%. There seems to be a consistency in these answers to those in Question 6.
- 60% thought there was some problem with stormwater runoff; lawn fertilizers & pesticides 71%; and pet feces in yards 66%.
- For wastewater: 62% inadequately maintained sewer system; 68% residential septic systems and 66% commercial septic systems.
- The lack of riparian buffers was 51% and disturbance of sediment 54%.

Thank you for reviewing this data and if you have any comments or feedback, please feel comfortable in dropping us a note at your earliest convenience. The Social Survey will be inserted into the Oak Creek Watershed Improvement Plan (OCWIP) and we highly value you're your opinion.

Sincerely,



Barry Allan
Grant Administrator/WIC Coordinator

OAK CREEK WATERSHED RESIDENTS' SURVEY

RESULTS FOR QUESTIONS 1 - 14

Prepared by Barry Allan Revised on March 23, 2012 Today is March 23, 2012

	# of responses	% of total	hi (1) to low		TAKE AWAY NOTES Question 1
1) Of the following, which best fits your definition of what a watershed is?					The survey based its sampling on 12,240 property owners with addresses in Arizona. The sampling of 1224 represents 10%, and the response was 265 or 21.65%. The cover letter sent with the Social Survey included a diagram of a typical watershed. This proved to be an effective education tool given the 90% of correct answers in the first question.
a) Area that retains water like a swamp or a marsh	5	1.9%			
b) Water intake area that feeds a water treatment plant	4	1.5%			
c) The area of land where all of the water that drains off of it goes into a single creek, river or other water body	240	90.6%	1		
d) None of the above	6	2.3%			
e) Don't know	6	2.3%			
NO RESPONSE	12	4.5%			

	# of responses	% of total	hi (1) to low		TAKE AWAY NOTES Question 2
2) How concerned are you with the health of the Oak Creek Watershed?					While 37% were very concerned then 70% were at least concerned. In total over 95% had concern in varying degrees.
a) Not concerned	7	2.6%			
b) Somewhat	68	25.7%	3		
c) Concerned	87	32.8%	2		
d) Very concerned	98	37.0%	1		
NO RESPONSE	11	4.2%			

	# of responses	% of total	hi (1) to low	minimum # visits	maximum # visits	TAKE AWAY NOTES Question 3
3) How many times a year do you visit/recreate along Oak Creek?						20% (2,448 watershed residents) visit Oak Creek over 20 times in a year which extrapolates to over 48,960 visits. 86% (10,531 watershed residents) collectively make between 76,000 and possibly over 108,000 visits to Oak Creek annually. This averages out to between 7 and 10 visits each a year.
a) Never	31	11.7%				
b) 1-5	122	46.0%	2	5635	28175	
c) 6-10	33	12.5%	3	9145	15242	
d) 11-15	10	3.8%	5	5081	6928	
e) 16-20	10	3.8%	4	7390	9238	
f) 20+	53	20.0%	1	48960	48960+	
NO RESPONSE	10	3.8%				
		86.0%	Totals>>	76211	108543	

	# of responses	% of total	hi (1) to low		TAKE AWAY NOTES Question 4
4) What activities do you undertake while visiting Oak Creek? Please mark all that apply.					Hiking is almost 3 times as popular an activity in the area of Oak Creek as swimming with watershed residents. Other activities are varied and include photography, picnics, walking, kayaking, canoeing, bird watching. 20% of watershed residents chose Dog Walks as an activity. This would extrapolate out to around 2500 a year or 7 every day.
a) Hiking	187	70.6%	1		
b) Camping	30	11.3%	6		
c) Fishing	44	16.6%	5		
d) Swimming	65	24.5%	2		
e) Biking	25	9.4%	7		
f) Dog walks	53	20.0%	4		
g) Equestrian	7	2.6%	8		
h) Other:	58	21.9%	3		
NO RESPONSE					

	# of responses	% of total	hi (1) to low		TAKE AWAY NOTES Question 5	TAKE AWAY NOTES Question 6
5) Which is the most important source of information affecting your perception of the Oak Creek Watershed's health?					Personal observation and the newspaper accounted for 74%. The newspaper, radio and internet media totalled 44%.	Litter and Septic Systems tied at 23.4% followed by Human Feces at 20%, and Baby Diapers at 11.7% were the top 3 in the #1 creek contamination choices of 78.5% of respondees. Tallying all 3 responses for each sources though indicated Human Feces to be prevalent with Litter in second place and Baby Diapers/Septic Systems tied for third.
a) Personal observation	113	42.6%	1			
b) Newspaper	84	31.7%	2			
c) Radio	21	7.9%	5			
d) Internet	11	4.2%	6			
e) State or federal reports	41	15.5%	4			
f) Local environmental groups	50	18.9%	3			
NO RESPONSE						

	#1	% of total	hi to low	#2	% of total	hi to low	#3	% of total	hi to low	Weighted for all 3 Lowest numbers are most popular
6) What sources do you think are the biggest contributors to creek contamination that can cause human illness? Please number 1, 2 and 3 for your top choices.										
a) Litter	62	23.4%	1	23	8.7%	7	40	15.1%	1	9 =2
b) Baby diapers	31	11.7%	3	38	14.3%	1	25	9.4%	6	10 =3
c) Wildlife feces	21	7.9%	6	25	9.4%	6	7	2.6%	9	21 =7
d) Septic systems	62	23.4%	1	35	13.2%	2	24	9.1%	7	10 =3
e) Waste water treatment plants	9	3.4%	8	12	4.5%	9	13	4.9%	8	25 =8
f) Dog feces	19	7.2%	7	28	10.6%	4	28	10.6%	5	16 =5
g) Human feces	53	20.0%	2	34	12.8%	3	37	14.0%	2	7 =1
h) Livestock waste	27	10.2%	4	27	10.2%	5	31	11.7%	3	12 =4
i) Don't know	24	9.1%	5	20	7.5%	8	30	11.3%	4	17 =6
j) Other (specify)	5	1.9%	9	1	0.4%	10	4	1.5%	10	29 =9
NO RESPONSE										

7) Are you a pet owner? If no please go to question 10.	# of responses	% of total			TAKE AWAY NOTES Question 7
Yes	139	52.5%			Over half of watershed residents have pets.
No	108				
8a) If so, does/do your pet(s) go outside?	# of responses	% of total			TAKE AWAY NOTES Question 8a
Yes	126	90.6%			90% of watershed residents' pets go outside
No	14				
8b) Do you clean your yard of pet waste?	# of responses	% of total			TAKE AWAY NOTES Question 8b
Yes	125	94.0%			90% of watershed residents whose pets go outside clean their yard of pet waste.
No	8				
9a) Do you own a dog? If no please go to question 10.	# of responses	% of total			TAKE AWAY NOTES Question 9a
Yes	118	44.5%			45% of watershed residents own a dog. Therefore there are at least 5400 dogs in the watershed.
No	20				
9b) Do you walk your dog in the Oak Creek Watershed?	# of responses	% responses			TAKE AWAY NOTES Question 9b
Yes	57	45.6%			45% of watershed residents who own a dog walk it in the watershed. That's almost 2500 dogs walked in the watershed annually. (See question 4 for
No	68	54.4%			
9c) How often do you pick up your dog's waste when on a walk?	# of responses	% responses		# dog walks	approx # feces unattended	TAKE AWAY NOTES Question 9c
a) Never	10	8.0%	3	200	200	64% of watershed residents always pickup their dog's waste which accounts for 1600 out of 2500 dog walks. Approximate quantification of those dog walks that feces may be left behind: rarely = 10%; Sometimes = 30%; most of the time = 70% The total is 500 feces (see table) left in the watershed. Each gram of dog feces has 20 million e. coli bacteria colonies in it.
b) Rarely	4	3.2%	5	80	72	
c) Sometimes	7	5.6%	4	140	84	
d) Most of the time	24	19.2%	2	480	144	
e) Always	80	64.0%	1	1600	0	
9d) If you pick up dog waste, how do you dispose of it?	# of responses	% dog owners			TAKE AWAY NOTES Question 9d
a) Bag and leave it	1	0.8%			95% of residents throw their dog's waste into the trash.
b) Trash	113	91.9%	1		
c) Toilet	2	1.6%			
d) Compost	5	4.1%			
e) Toss in ditch	0	0.0%			
NO RESPONSE	2	1.6%			
9e) Would you use dog waste stations (plastic bag dispensers with or without trash can), if more were made available at parks and trails?	# of responses	% dog owners			TAKE AWAY NOTES Question 9e
Yes	106	83.5%			89% of dog owners would use dog waste stations.
No	17	13.4%			
NO RESPONSE	4	3.1%			
10) Would you be willing to volunteer your time to help preserve Oak Creek and/or educate others about Oak Creek? (*If yes, provide contact information on next page.*)					TAKE AWAY NOTES Question 10
Yes	30	11.3%			11% of respondees would be willing to volunteer their time, and only a few left contact information.
No	204	77.0%			
NO RESPONSE	15	5.7%			
11) How old is the head of the household?					TAKE AWAY NOTES Question 11
a) <34	2	0.8%	6		Over 93% of respondees were over 45 years old, and 47% were over 65. These statistics could be compared with Census 2010 population counts if supplied by zip code or checked against the city of Sedona, for instance.
b) 35-44	12	4.5%	5		
c) 45-54	43	16.2%	4		
d) 55-64	80	30.2%	1		
e) 65-74	70	26.4%	2		
f) 75+	54	20.4%	3		
NO RESPONSE	12	4.5%			
12) How many people live in this household?					TAKE AWAY NOTES Question 12
1	38	14.3%	2		2/3 of respondees have 2 people living in the household. 80% of respondees have at 1 or 2.
2	173	65.3%	1		
3	16	6.0%	4		
4	23	8.7%	3		
5+	6	2.3%	5		
NO RESPONSE	7	2.6%			
13) Is this residence a second home?					TAKE AWAY NOTES Question 13
Yes	92	34.7%			62% of watershed residents are living in their primary home and for over 1/3 it is a second home.
No	163	61.5%			
NO RESPONSE	6	2.3%			
14) What is your approximate annual household income in thousands of dollars?					TAKE AWAY NOTES Question 14
a) 0-20	10	3.8%	5		62% of watershed residents make over $50,000 a year. A quarter of them earn $100,000 to $200,000. Relativity of age and income were not studied.
b) 20-50	41	15.5%	3		
c) 50-100	87	32.8%	1		
d) 100-200	65	24.5%	2		
e) >200	14	5.3%	4		
NO RESPONSE	32	12.1%			

OAK CREEK WATERSHED RESIDENTS' SURVEY

RESULTS FOR QUESTION 15

Prepared by Barry Allan Revised on March 23, 2012

Today is March 23, 2012

15) In your opinion, how much do the following threaten Oak Creek water quality?	not sure	not a problem	slight problem	moderate problem	large problem	not sure	not a problem	slight problem	moderate	large problem	TAKE AWAY NOTES
Please mark with an X	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	
Agricultural runoff						**Agricultural runoff**					Several respondees fumbled this section because they filled in the heading.
Livestock manure	52	40	58	59	32	20%	15%	22%	22%	12%	
Fertilizers and pesticides	41	24	46	65	50	15%	9%	17%	25%	19%	
Animals						**Animals**					69% believe that dog feces are a problem to some degree, and wildlife feces total 48%. Almost 2/3 think that wildlife attracted to water by human food waste threaten water quality to
Dog feces that are not picked up and disposed properly	27	32	74	59	51	10%	12%	28%	22%	19%	
Wildlife feces	36	75	58	46	24	14%	28%	22%	17%	9%	
Wildlife attracted to water by discarded human food waste	36	37	74	56	41	14%	14%	28%	21%	15%	
Erosion and sedimentation due to the following:						**Erosion and sedimentation due to the following:**					More than twice as many people than any other reason thought Jeep/ORV trails cause erosion and sedimentation which affects water quality of Oak Creek.
Construction and maintenance of irrigation diversions	56	45	74	46	15	21%	17%	28%	17%	6%	
Building and road construction	44	46	80	51	17	17%	17%	30%	19%	6%	
Road maintenance	44	54	91	39	8	17%	20%	34%	15%	3%	
Low water creek crossings	45	69	75	38	7	17%	26%	28%	14%	3%	
Unmaintained "social" trails	48	62	83	34	11	18%	23%	31%	13%	4%	
Jeep/ORV trails	41	43	57	55	35	15%	16%	22%	21%	13%	
Other sources (specify)	45	9	4	6	6	17%	3%	2%	2%	2%	
Recreation						**Recreation**					The responses to recreation problems were the most significant of all categories. Totals: Human feces 67%; Trash 84%; Baby diapers 75%; lack of public toilets 79%; lack of trash receptacles 79%. There is a consistency in these answers to those in Question 6.
Human feces deposited outdoors	34	34	69	47	61	13%	13%	26%	18%	23%	
Trash	13	9	53	85	85	5%	3%	20%	32%	32%	
Used and improperly discarded baby diapers	28	17	57	62	80	11%	6%	22%	23%	30%	
Lack of public toilet facilities near creek and at trailheads	21	12	48	76	85	8%	5%	18%	29%	32%	
Lack of trash receptacles at recreation sites and trailheads	24	11	66	67	78	9%	4%	25%	25%	29%	
Urban areas						**Urban areas**					Totals: stormwater 60%; lawn fertilizers & pesticides 71%; Pet feces in yards 66%
Stormwater runoff	30	54	54	68	36	11%	20%	20%	26%	14%	
Lawn fertilizers and pesticides	31	27	69	68	51	12%	10%	26%	26%	19%	
Pet feces not collected from yards	36	35	87	58	29	14%	13%	33%	22%	11%	
Wastewater						**Wastewater**					Totals: sewer system 62%; residential septic systems 68%; commercial septic systems 66%
Inadequately maintained sewer system	41	32	46	67	54	15%	12%	17%	25%	20%	
Improperly built or maintained residential septic systems	34	26	37	78	65	13%	10%	14%	29%	25%	
Improperly built or maintained commercial septic systems	34	29	43	66	65	13%	11%	16%	25%	25%	
Other						**Other**					Totals: lack of riparian buffers 51%; disturbance of sediment 54%
Lack of riparian buffers (natural vegetation next to the water)	55	48	66	41	30	21%	18%	25%	15%	11%	
Disturbance of "sediment reservoirs" on the bottom of Oak Creek that hold bacteria and viruses that can cause human illness	55	38	54	57	33	21%	14%	20%	22%	12%	
Other (specify)	35	4	1	3	6	13%	2%	0%	1%	2%	

Oak Creek Watershed Improvement Plan Appendix C: Best Management Practices (BMP) Project Descriptions

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Introduction

The following are project descriptions for proposed BMP implementation projects in the Oak Creek Watershed intended to reduce *E. coli* concentrations and related water quality problems, such as erosion and sedimentation. Each is a stand-alone project description that can be used for developing funding proposals and implementing projects. Each has an education and outreach component, but there are also stand- alone education and outreach projects that are supportive of the on-the-ground projects. These projects were developed based on the findings of the 2011 water quality investigation as well the findings of past studies and information provided by watershed residents both formally (through a social survey) and informally (anecdotal information). The projects have been reviewed and approved by the Oak Creek Watershed Improvement Commission. They are shown here in order of priority based on multiple lines of evidence that point to the greatest sources *E. coli* contamination of Oak Creek.

Project Prioritization

Project prioritization is described in the "Potential Future Projects" section in Chapter 2 of the Oak Creek Watershed Improvement Plan. There are two tiers of project prioritization. Tier 1are top priority projects and Tier 2 are lower priority projects. Within each tier projects priority is also ranked by project type and by project. The table below shows the tier 1 project priorities, with "1" being the top priority.

OCWIP Top Priority BMP Project

Priority	Project number	Project title
1	EO-2	Oak Creek Canyon Public Outreach Program
2	EO-5	"Even One" *E. Coli* Outreach Project
3	EO-6	Oak Creek Community Outreach Program (OCCOP)
4	SS-1	Oak Creek Commercial Septic System Improvement Incentive Project
5	SW-1	SW-1 Sedona Area Stormwater Improvement Project
6	RC-1	Oak Creek Canyon Public Toilet Access Project
7	RC-3	Keeping Oak Creek Beautiful – Trash Receptacle Access Project

The table below shows the Tier 2 project priorities:

OCWIP Second Tier BMP Project Priorities

Priority	Project number	Project title
8	EO-1	Sedona Dog Waste Reduction Outreach Project
9	EO-3	Lower Oak Creek Watershed Outreach Project
10	EO-4	Recreational Vehicle Proper Waste Disposal Outreach Project
11	SS-2	Oak Creek Residential Septic System Improvement Project
12	RC-2	Oak Creek Canyon Sediment Source Reduction Project
13	RC-4	Oak Creek Watershed Dog Waste Station Installation Project
14	AG-1	Animal Waste BMPs for Oak Creek Watershed
15	AG-2	Oak Creek Irrigation Diversion Erosion Reduction Project
16	AG-3	Lower Oak Creek Erosion Reduction Project

Top Priority Projects

EO-2 Oak Creek Canyon Public Outreach Program

Need

High recreation use of Oak Creek Canyon in the summer contributes to *E. coli* contamination of Oak Creek through several pathways: 1. dog feces, 2. used baby diapers, 3. human feces, 4. food waste that attrack wildlife that defecates near the stream, 5. soil disturbance and erosion that contribute sediment to *E. coli* sediment reservoirs, and 6. disturbance of sediment reservoirs by swimmers and waders causing *E. coli* and related fecal contaminants to enter the water column. Bilingual signage and oral communication are needed to reach both English- and Spanish-speaking recreators.

Description

Conduct a pre-summer and early summer media campaign with a public health awarement focus that includes public service announcements, kiosks, and volunteer contact with recreators at campground and day use areas to get the message out. The message should include health effects of fecal contamination, symptoms of infection due to fecal contamination, pictures of dirty diapers in the woods and blown up pictures of the germs that cause illness. Emphasize that July has the highest risk of contracting illness due to fecal contamination, because of high recreational use and the fact that flushing rains usually start later than July. Involve local businesses in an incentives/reward programs such as free frozen yogurt certificates or Red Rock day passes that volunteers hand out to visitors who pick up dog waste and/or properly dispose of used diapers. The success of this project relies on a presence of volunteers (preferably wearing official looking polo shirts with OCWC insignias) in the high recreational use areas interfacing with the public to convey information, solicit feedback, encourage the public through praise and incentives and generally promote a culture of caring for Oak Creek.

Estimated load reduction

Human feces

A University of North Dakota study for the U.S. Department of Agriculture regarding human waste distributions reveals the average stool produced is 95.5 grams per day, and 2066 ml of urine per day (Parker and Gallagher 1988). The average number of bowel movements per day was 2.54 (Parker and Gallagher 1988), but the number times a person urinates is variable based on the volume of fluid they consume, with a range of 4-10 times per day based on an Internet search. An urination rate of 7 per day will be used in this analysis.

The only access to and through the Oak Creek Canyon is Highway 89-A which carries about 7million visitors a year to Oak Creek and Sedona. Approximately one million of these visitors stop and utilize the publicly owned recreational sites, while 300,000 visit Slide Rock State Park (in Poff and Tecle 2002).

Assuming 60% of the potential visitors use the toilets once for urination and 30% of the potential visitors use the toilets for bowel movements, instead of relieving themselves into the environment, the load reductions for urine and fecal material are:

Urine (l) = 1 million visitors/year * 0.6 * 2066 ml/day * day/7 urinations * 1 liter/1000 ml = 177,086 liters

Fecal Material (kg) = 1 million visitors/year * 0.3 * 95.5 g/day * day/2.54 movements * 1 kg/1000 g = 11,280 kg

The Fecal Material estimate is more important in regard to *E. coli*. *E. coli*, as member of the intestinal flora, is part of the digestive process and is excreted in feces. Brandys (2007) found that human stool contained an average of 5 million CFU/gram of *E. coli* bacteria. Consequently, if 10% (11,280 kg) of fecal material that is now captured by the toilet facilities would have reached the river environment it would result in the potential *E. coli* load of 5.6×10^{12} CFU per year, representing a 100% load reduction compared to not having the toilet facilities.

In order estimate the actual load reduction a survey of rest room users should be conducted.

References:

Brandys, B. 2007. Quantifying Bacteria Levels in Water Categories 1-3. Occupational and Environmental Health Consulting Services, accessed July 11, 2012. Located at: http://www.bio-reveal.com/AdminWeb/userfiles/image/file/IICRC%20S520%20-%20IICRC%20S500/Quantifying-Levels-02-07.pdf

Parker, D. and S. Gallagher, 1988. Distribution of Human Waste Samples in Relation to Sizing Waste Processing in Space, accessed July 9, 2012. Located at http://www.nss.org/settlement/moon/library/LB2-611-WasteProcessing.pdf

Poff, B. and A. Tecle, 2002. Bacteriological Water Quality Trend Analysis in Oak Creek Canyon, Arizona. In: Ground Water/Surface Water Interactions, 2002 AWRA Summer Specialty Conference Proceedings, July 1-3, 2002, Keystone, CO. pp. 431-436.

Diapers

Peterson (1974) reported that feces-soiled diapers contained an average of 60 grams of feces. Brandys (2007) found that human stool contained an average of 5 million CFU/gram of *E. coli* bacteria. Assuming that the Trash Receptacle Access Project and the Outreach Program changes the behavior of 100 people per year (i.e. 100 diapers). The average annual load reduction would be 3×10^{10} CFU per year.

References:

Brandys, B. 2007. Quantifying Bacteria Levels in Water Categories 1-3. Occupational and Environmental Health Consulting Services, accessed July 11, 2012. Located at: http://www.bio-reveal.com/AdminWeb/userfiles/image/file/IICRC%20S520%20-%20IICRC%20S500/Quantifying-Levels-02-07.pdf

Peterson, M.L., 1974. Soiled disposable diapers: a potential source of viruses.. American Journal of Public Health: September 1974, Vol. 64, No. 9, pp. 912-914. doi: 10.2105/AJPH.64.9.912

Dog feces

E. coli bacteria are bacteria that are common to the intestinal tracts of humans and animals. Walker and Garfield (2008) found that a gram of fresh dog feces contained an average of 50 million CFU/gram with a range of 2 million to 200 million CFU/gram of *E. coli* bacteria. The average dog excretes 0.75 pounds (340 grams) of waste per day (Clear Choices Clean Water, 2012). That equates to an average 17 billion CFU of *E. coli* bacteria per day per dog. If the Sedona Dog Waste Reduction Outreach/Oak Creek Watershed Dog Waste Station Installation Projects prevents 100 dog/days from contaminating Oak Creek this would result in a load reduction 34 kg of dog feces and 17×10^{12} CFU of *E. coli* bacteria.

The goal of the Outreach Project is to improve community awareness on the role of dog waste in water quality impairment of Oak Creek. The Outreach Project should increase the use of the dog waste stations and the rate of dog waste removal. If the Outreach Project increases use of the dog waste stations from 100 to 300 dog/days the result would be a load reduction of 102 kg of dog feces and 5.1×10^{13} CFU of *E. coli* bacteria.

The actual load reduction will depend on the number of people that utilize the dog waste stations, before and after the Outreach Project. A monitoring program should be implemented to assess the use of the dog waste stations.

References:

Clear Choices Clean Water Organization, access on June 27, 2012 http://clearchoicescleanwater.org/wp-content/uploads/2011/08/pet-waste-FAQs_final.pdf

Walker, M. and L. Garfield, 2008. Dog wastes and water quality: Evaluating the connection at Lake Tahoe. University of Nevada Cooperative Extension, Fact Sheet-08-18.

Sediment

The project seeks to reduce the amount of erosion and sediment entering Oak Creek as a result of soil disturbance from people hiking into Oak Creek Canyon and Slide Rock State Park on unmaintained social trails.

Without knowing the locations of the BMPs that will be implemented, some assumptions must be made in order to formulate a reasonable estimation of load reduction. The Automated Geospatial Watershed Assessment tool (AGWA) with the SWAT model (ARS, 2012) was first run using land cover data downloaded from the SWReGAP server. Land cover was then modified starting at the bridge just below the public swimming area at Slide Rock S.P. upstream just over 0.5 miles to the Halfway Day Use Area in order to represent disturbed soils due to hiking off-trail. Assuming that twenty percent of the entire area could be considered disturbed by people going off the trails and making their own pathways to the stream, the Land Cover Modification Tool within AGWA allows for a partial change of landcover within an area, and the second model reflects that percentage.

The difference between the SWAT model run with normal landcover, and a model run with landcover that reflects 20% of disturbed soil within an area of approximately 50 acres is the reduction of sediment load as a result of trail engineering and maintenance.

Load Reduction: 7.02 tons of sediment per year

References:

Agricultural Research Service (ARS) Website, Access on June, 2012. Automated Geospatial Watershed Assessment Tool located at http://www.tucson.ars.ag.gov/agwa/.

Multiple effects

Because the project is a multi-faceted approach to overall watershed improvement, using different methods and making some assumptions of effectiveness of the BMP when modeling each facet separately is necessary in order to formulate a reasonable estimation of load reduction. The project seeks to reduce the amount of *E. coli* and sediment delivered to Oak Creek during summer stormflow events by first surveying and determining where there are concentrations of human and animal waste, and where erosion problems exist.

If the watershed survey reveals that jeep use is a significant cause of soil disturbance and sediment discharge, then BMP's will be implemented along trails and public outreach will promote practices that will reduce erosion. Each subwatershed with hiking or jeep trails was modeled assuming that the total area of the disturbance by humans was either 10%, 20% or 30% of the total area of subwatersheds with jeep and/or hiking trails, and that BMP's were utilized in the model in those proportions. The Automated Geospatial Watershed Assessment tool (ARS, 2012) with the SWAT model was used to estimate the sediment runoff of the areas of with landcover data that represents normal vegetation, then with landcover data that had been modified to reflect the disturbed areas near jeep and hiking trails within the six subwatersheds. If 10% of the areas were disturbed, recovered normal vegetation would be responsible for the reduction of 19.5 tons of sediment per year.

The STEP L Model (U.S. EPA, 2012) was used to estimate the effectiveness of installing water bars and bioretention ponds to slow runoff and reduce erosion, and the revegetation of areas denuded by erosion in areas near jeep and hiking trails. If humans and jeeps disturbed 10% of the area of subwatersheds with trails, the load reduction as a result of the installation of water bars, bioretention ponds, and native vegetation is 153.9 tons of sediment per year.

Dog waste stations will be installed at all trailheads. Walker and Garfield (2008) found that a gram of dog feces contained an average of 50 million CFU/gram of *E. coli* bacteria. The average dog excretes 340 grams per day (Clear Choices Clean Water, 2012). That equates to 17 billion CFU of *E.coli* bacteria per dog per day. If the project successfully prevents 100 dog/days per year from contaminating Oak Creek, the result would be a reduction of 34 kg of dog feces and 17 x 10^{12} CFU of *E. coli* bacteria.

Public outreach efforts aimed at eliminating human waste contributions to the watershed will be implemented. Brandys (2007) found that human stool contained an average of 5 million CFU/gram of *E. coli* bacteria. Parker and Gallagher (1988) found that the mean human waste in over 25,000 subjects was 95 grams per day of solid fecal matter. That equates to 475 million CFU of *E. coli* per person per day. If the project successfully prevents 100 people per day from

contaminating Oak Creek, the result would be a reduction of 9.5 kg of human feces and 4.75 x 10^{10} CFU of *E. coli* bacteria.

Average annual load reduction:

AGWA SWAT (Soil Disturbance and Normal Vegetation)
19.5 tons of sediment per year

STEP L (Water Bars, Bioretention Ponds, Revegetation)
153.9 tons of sediment per year

Combined Sediment Load Reduction: 173.4 tons of sediment per year

Dog Waste
34 kg (75 lbs) of feces and 17 x 10^{12} CFU per year of *E. coli* bacteria

Human Waste
9.5 kg (21 lbs) of feces and 4.75 x 10^{10} CFU per year of *E. coli.* bacteria

References:

Agricultural Research Service (ARS) Website, Access on June, 2012. Automated Geospatial Watershed Assessment Tool located at http://www.tucson.ars.ag.gov/agwa/.

Clear Choices Clean Water Organization Website, access June 27, 2012. Located at http://clearchoicescleanwater.org/wp-content/uploads/2011/08/pet-waste-FAQs_final.pdf

Walker, M. and L. Garfield, 2008. Dog Wastes and Water Quality; Evaluating the Connection at Lake Tahoe. University of Nevada Cooperative Extension, Fact Sheet-08-18.

Brandys, B. 2007. Quantifying Bacteria Levels in Water Categories 1-3. Occupational and Environmental Health Consulting Services, accessed July 11, 2012. Located at: http://www.bio-reveal.com/AdminWeb/userfiles/image/file/IICRC%20S520%20-%20IICRC%20S500/Quantifying-Levels-02-07.pdf

Parker, D. and S. Gallagher, 1988. Distribution of Human Waste Samples in Relation to Sizing Waste Processing in Space, accessed July 9, 2012. Located at http://www.nss.org/settlement/moon/library/LB2-611-WasteProcessing.pdf

U.S. EPA Website, Access June, 2012. Welcome to STEPL and Region 5 Model, http://it.tetratech-ffx.com/stepl/

Animal Waste

E. coli bacteria are bacteria that are common to the intestinal tracts of humans and animals. A 1000-pound horse will defecate from 4-13 times each day and produce 35 to 50 pounds of wet manure (feces

plus urine) daily, or approximately 9.1 tons per year. E. coli concentrations in fresh and dry manure from horses are 6.17×10^4 CFU per gram and 6.31×10^5 CFU per gram, respectively (NERA, 2012).

A mature cow weighting 1000 lbs produces an average of 8.7 lbs/day of manure (NRCS, 2012) or approximately 1.5 tons per year. Wang et al. (2004) showed that *E. coli* populations extracted from fresh cow manure ranging from 6.55×10^6 to 7.6×10^6 cfu per gram of manure (average of 7.1×10^6 cfu per gram).

If the fresh waste from one animal was dumped into the stream the potential average annual *E. coli* load would be:

Horse (CFU/year) = 9.1 tons/yr * 6.17×10^4 CFU per gram * 907,184.74 grams/ton = 5.1×10^{11} CFU per year

Cow (CFU/year) = 1.5 tons/yr * 7.1×10^6 CFU per gram * 907,184.74 gram/ton = 9.7×10^{12} CFU per year

The actual load reduction is based on the number of people currently dumping waste into the streams and the resulting number of people that stop dumped after the implementation of the Outreach Programs. A monitoring program would be implemented to assess the current rate of dumping and to evaluate the behavior changes after the implementation of Outreach Programs.

References:

Natural Resource Conservation Service (NRCS), access on June 25, 2012. Wyoming Comprehensive Nutrient Management Plan Workbook located at http://www.wy.nrcs.usda.gov/technical/wycnmp/

NERA Website, Access July 2012. NE1041: Environmental Impacts of Equine Operation located at http://lgu.umd.edu/lgu_v2/homepages/attachs.cfm?trackID=11196.

Wang, L., K.R. Mankin, and G.L. Marchin, 2004. Survival of Fecal Bacteria in Dairy Cow Manure. Transactions of the ASAE 47(4): 1239-1246.

Project schedule and milestones

<table>
<tr>
<td rowspan="2">Implementation schedule:
January 2012 through September 2014

Measurable milestones:
~ Outreach planning & coordination complete
~ Spring & early summer media campaign complete
~ ADOT approval for highway signs
~ Signs posted along Hwy 89 for public toilets
~ Educational materials posted at #? kiosks
~ Volunteers log recreators observed:
▪ using dog waste stations & trash receptacles</td>
<td>Resources and other support commitments:
ADEQ 319(h) grants
????
Commitment date(s):
<None at this time ></td>
</tr>
<tr>
<td>Pending commitments:
<Unknown at this time>
Estimated commitment date:
<None at this time ></td>
</tr>
</table>

▪ telling others to pick up waste ▪ using designated trails to reduce erosion ~ Volunteers distribute #? "thank you" gift certificates	

Education and Outreach Strategy

Findings of education needs survey:

At least 12% of residents do not think dog feces impact water quality.
At least 6% of residents do not think used baby diapers impact water quality.
At least 13% of residents do not think human feces impact water quality.
At least 23% of residents do not think soil erosion due to unmaintained trails impacts water quality.
At least 14% of residents do not think leaving food waste near the creek can attract wildlife that contribute to fecal contamination of the creek.
At least 14% of residents do not think that disturbing *E. coli* sediment reservoirs can cause water contamination.

Goals and target audiences:

~ Target audience is summer recreators in Oak Creek Canyon, both English language speakers and English language learners.
~ Inform them of risks to human health from unsanitary practices such as:
  - not picking up dog feces
  - improperly discarding used baby diapers
  - defecating near Oak Creek
  - causing erosion by accessing creek on unmaintained trails
  - leaving food waste near the creek
~ Inform recreators of risk of swimming/wading when water is turbid
~ Offer incentives to recreators for demonstrating and promoting healthy habits
~ Make information available in Spanish and English both orally and in writing

Priority education and outreach projects schedule:

~ Stage campaign to coordinate with completion of public toilets and dog waste station installations.
~ Early summer 2012 - media campaign: Let public know about health risks, expected behavior, availability of toilets, waste receptacles and dog waste stations, future availability of amenities.
~ Early summer 2013 - media campaign: Same as previous year with notice of new amenities.
~ 2013 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: The number of summer time *E. coli* exceedances at Slide Rock State Park decreases.

On-the-ground project effectiveness monitoring plan

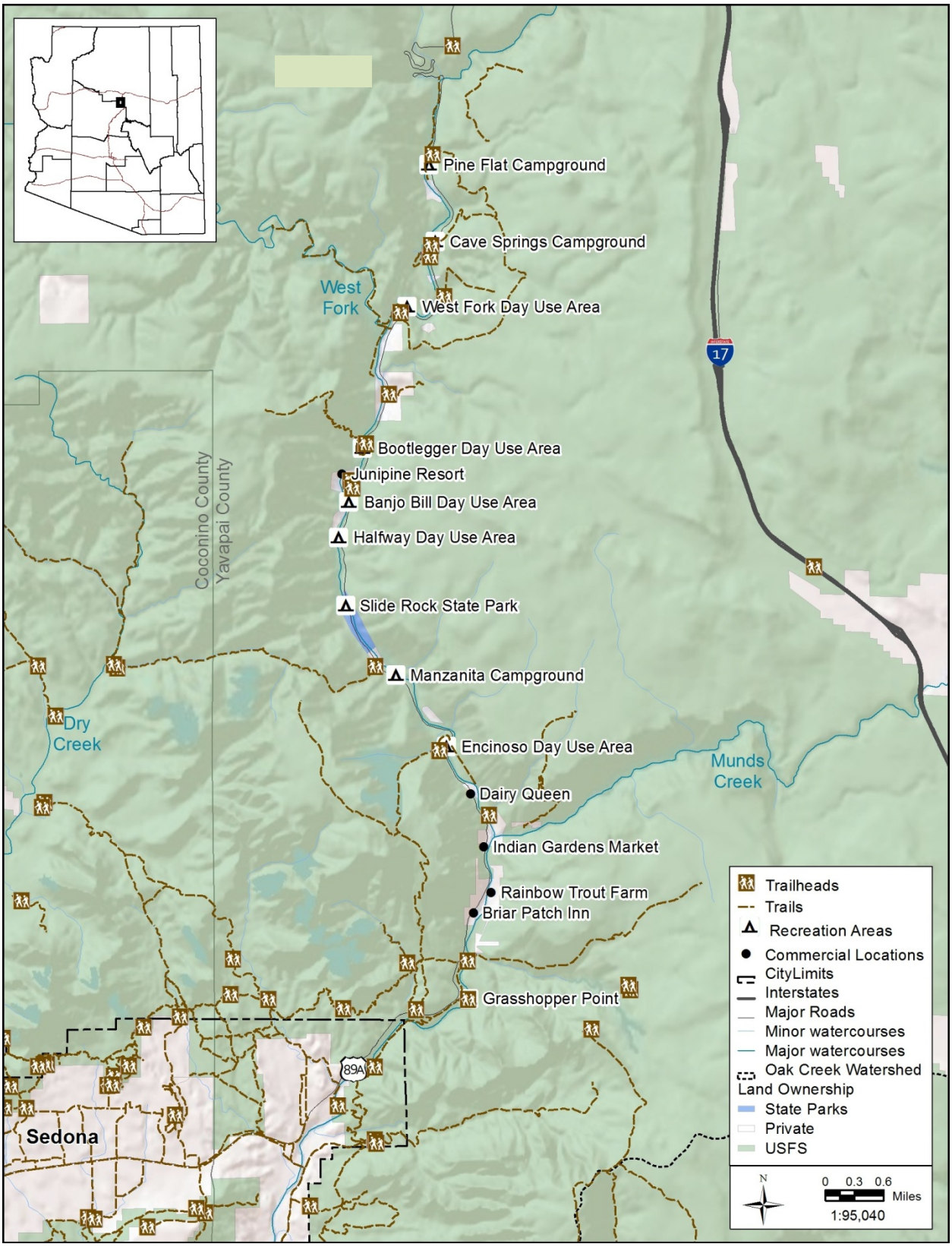
- *Monitoring and reference condition sites*:

Volunteers will observe recreator behavior at Slide Rock State Park and on Coconino National Forest at day use areas, campgrounds, and popular creek access points to determine whether desired behaviors are being exhibited.

- *Parameters & critical conditions:*
  - *E. coli* exceedences at Slide Rock State Park (>235 cfu/100 ml)
  - Observed behaviors
    - picking up dog feces
    - properly discarding used baby diapers
    - using public toilets
    - using maintained trails to avoid erosion
    - removing food waste near the creek
- *Schedule, frequency and duration*:
  Biweekly observations on the weekends throughout the summer, 2012-2014
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan:*
  Annual report in the fall of each year

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Recreators exhibit behaviors conducive to reducing *E. coli* contamination. The incidences of dog feces, used baby diapers, human feces, food waste, and soil erosion near the creek decrease.
- *Generation and implementation of second generation improvement projects:*
  Recreators provide feedback on the best locations for installing additional public toilets, trash receptacles, and dog waste stations.
- *Measurable reductions of pollutant loading:*
  Reduced *E. coli* exceedances at Slide Rock State Park
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan, how findings will be used:*
  Annual report in the fall of each year


Pine Flat Campground
Cave Springs Campground
West Fork
West Fork Day Use Area
17
Bootlegger Day Use Area
Junipine Resort
Banjo Bill Day Use Area
Halfway Day Use Area
Coconino County
Yavapai County
Slide Rock State Park
Manzanita Campground
Dry Creek
Encinoso Day Use Area
Munds Creek
Dairy Queen
Indian Gardens Market
Rainbow Trout Farm
Briar Patch Inn
Grasshopper Point
89A
Sedona
Trailheads
Trails
Recreation Areas
Commercial Locations
CityLimits
Interstates
Major Roads
Minor watercourses
Major watercourses
Oak Creek Watershed
Land Ownership
State Parks
Private
USFS
N
0 0.3 0.6
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1:95,040

EO-5 "Even One" *E. Coli* Outreach Project

Need

Recreators often do not grasp the consequences of their actions. Even one fece (dog, diaper or dump) can cause contamination of Oak Creek. This is known from past bacterial DNA studies in Oak Creek Canyon where it was discovered that a single animal (including human animals) can cause fecal contamination of the creek.

Description

Conduct a public outreach program to get the "Even one" message across that even one deposit of human or pet feces can cause contamination that threatens human health. Use fliers, presentations to schools, civic groups and campers, public service announcements and press releases to spread the message about personal responsibility for reducing *E. coli* contamination. Encourage residents and recreators in the watershed to speak up when they see someone polluting with used diapers, human feces, dog feces or food waste that attracts wild animals whose feces also contaminate Oak Creek. Be sure to emphasize that feces do not have to be right next to the creek to have an impact; feces on can be carried miles by stormwater and still cause contamination.

Estimated load reduction

A University of North Dakota study for the U.S. Department of Agriculture regarding human waste distributions reveals the average stool produced is 95.5 grams per day, and 2066 ml of urine per day (Parker and Gallagher 1988). The average number of bowel movements per day was 2.54 (Parker and Gallagher 1988), but the number times a person urinates is variable based on the volume of fluid they consume, with a range of 4-10 times per day based on an Internet search. An urination rate of 7 per day will be used in this analysis.

The only access to and through the Oak Creek Canyon is Highway 89-A which carries about 7million visitors a year to Oak Creek and Sedona. Approximately one million of these visitors stop and utilize the publicly owned recreational sites, while 300,000 visit Slide Rock State Park (in Poff and Tecle 2002). Assuming 60% of the potential visitors use the toilets once for urination and 30% of the potential visitors use the toilets for bowel movements, instead of relieving themselves into the environment, the load reductions for urine and fecal material are:

Urine (l) = 1 million visitors/year * 0.6 * 2066 ml/day * day/7 urinations * 1 liter/1000 ml = 177,086 liters

Fecal Material (kg) = 1 million visitors/year * 0.3 * 95.5 g/day * day/2.54 movements * 1 kg/1000 g = 11,280 kg

The Fecal Material estimate is more important in regard to *E. coli*. *E. coli*, as member of the intestinal flora, is part of the digestive process and is excreted in feces. Brandys (2007) found that human stool contained an average of 5 million CFU/gram of *E. coli* bacteria. Consequently, if 10% (11,280 kg) of fecal material that is now captured by the toilet facilities would have reached the river environment it would result in the potential *E. coli* load of 5.6×10^{12} CFU per year, representing a 100% load reduction compared to not having the toilet facilities.

In order estimate the actual load reduction a survey of rest room users should be conducted.

References:

Brandys, B. 2007. Quantifying Bacteria Levels in Water Categories 1-3. Occupational and Environmental Health Consulting Services, accessed July 11, 2012. Located at: http://www.bio-reveal.com/AdminWeb/userfiles/image/file/IICRC%20S520%20-%20IICRC%20S500/Quantifying-Levels-02-07.pdf

Parker, D. and S. Gallagher, 1988. Distribution of Human Waste Samples in Relation to Sizing Waste Processing in Space, accessed July 9, 2012. Located at http://www.nss.org/settlement/moon/library/LB2-611-WasteProcessing.pdf

Poff, B. and A. Tecle, 2002. Bacteriological Water Quality Trend Analysis in Oak Creek Canyon, Arizona. In: Ground Water/Surface Water Interactions, 2002 AWRA Summer Specialty Conference Proceedings, July 1-3, 2002, Keystone, CO. pp. 431-436.

Project schedule and milestones

<table>
<tr>
<td rowspan="2">Implementation schedule:
March 2012 through September 2014

Measurable milestones:
~ Design of literature, presentations, PSA scripts, and press releases
~ Spring/early summer media campaign completed
~ #? presentations to civic groups
~ Late summer “Thank you” message in media
~ Survey to gage any change in attitudes
~ Annual reports on activities and response from public</td>
<td>Resources and other support commitments:
ADEQ 319(h) grants
????
Commitment date(s):
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</tr>
<tr>
<td>Pending commitments:
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Estimated commitment date:
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Education and Outreach Strategy

Findings of education needs survey:

The opinions of watershed residents regarding whether feces from various sources pose a threat to the water quality of Oak Creek are as follows:

source	Not sure	Not a problem	Slight problem
Dog feces	10%	12%	28%
Human feces	13%	13%	26%
Wildlife feces	14%	28%	22%

Goals and target audiences:

~ Residents, visitors and school children who recreate in Oak Creek watershed.

~ Make it common knowledge that a single feces (human, pet or wildlife) can cause fecal contamination of Oak Creek that can cause human illness.
~ Affect people's behavior so that do not defecate outdoors, do not litter with used diapers or food waste, do pick up their dog's feces and do encourage others to do the same.

Priority education and outreach projects schedule:
~ Early 2012 - The Oak Creek Community Outreach program collaborative group designs elements of outreach project
~ Summers 2012-2014 – Volunteers give "campfire talks" at Coconino National Forest campgrounds; mix natural history with "Even one" message.
~ Summers 2012-2014 – PSAs with the "Even one" message.
~ School year 2012-2014 – Volunteers/ staff/consultants give presentations to area schools
    - "Deputize" students to bust people who pollute.
    - Provide examples of children who have gotten very ill because of fecal contamination of streams, rivers or lakes.
    - Tie into science learning about microbes and the spread of disease.
    - Provide English and Spanish literature (comic book/coloring book) to take home so parent might see the message.
    - Have a poster contest.
    - Encourage adoption of a reach of Oak Creek
~ Year round - Presentations to civic groups, eg. Chamber of Commerce, Rotary Club, etc.; Encourage adoption of a reach of Oak Creek
~ 2013-2014 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria:

- Reduced human and pet feces along trails and creek.
- Reduced *E. coli* concentrations in Oak Creek.
- Reduced percentage of human- and dog-sourced bacterial DNA.
- Survey results indicate a change in attitude about the importance of picking up dog waste, properly disposing of used diapers, not defecating outside (especially near water), and not littering in the riparian area with food waste that attracts wild animals whose feces can contaminate water.

On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  Fecal counts will be conducted once per month May through September along popular trails and at popular swim areas (sites to be determined by collaborative group). *E. coli* and bacterial DNA will be sampled at least 3 times per summer the day after storm events that can wash material into the stream.
- *Parameters & critical conditions:*
    - number of presentations given to civic groups
    - number of campfire talks
    - number of school presentations
    - number of PSA airings
    - feces counts (>20 feces per ¼ mile)

- *E. coli* (>90% of baseline average for reach; >235 cfu/100 ml exceedence)
- Bacterial DNA (greater than the historic average percentage of human or dog source.)
- percentage of people reporting desired attitude as determined by survey
- percentage of people exhibiting desired behavior as determined by volunteer observers

- *Schedule, frequency and duration*:
  - Monthly fecal counts, May-September, 2012 -2014
  - Early summer and late summer observations and surveys administered by volunteers in the watershed on busy weekends, 2012 and 2014

- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan:*
  - Annual accomplishments reports
  - Final report

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Residents exhibit an understanding and related behaviors regarding the importance of not depositing human or pet feces in the watershed or attracting wildlife with food litter to riparian areas where they may leave feces that contaminate Oak Creek.
- *Generation and implementation of second generation improvement projects:*
  Civic groups or schools may choose to adopt a reach of Oak Creek to patrol for pollution and carry the "Even one" message to recreators.
- *Measurable reductions of pollutant loading:*
  Fecal counts by volunteer monitors show decreased pollutant loading at recreation sites throughout the watershed. *E. coli* concentrations and the percentage of human- and dog-sourced bacterial DNA are reduced.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan, how findings will be used:*
  - Annual accomplishment reports and final report posted on OCWC website.
  - Feature stories in local media on project implementation and effectiveness.

EO-6 Oak Creek Community Outreach Program (OCCOP)

The Oak Creek Community Outreach Program (OCCOP) is a comprehensive program designed to promote better stewardship of Oak Creek by the watershed community, and reduce or eliminate trash and fecal contamination. The objective is to raise the awareness level, particularly of those living, working or recreating in the proximity of Oak Creek, regarding the consequences to littering and pollution, as well as changing the outdoor behavior of all visitors to Oak Creek. Framers of the program will coordinate all education and outreach projects described in the watershed improvement plan, with the OCCOP serving as an umbrella for these activities.

SS-1 Oak Creek Commercial Septic System Improvement Incentive Project

Need

Some septic systems in Oak Creek Canyon appear to contribute 20 to 200 cfu/100 ml (average = 72) to Oak Creek by way of spring discharge, whereas average *E. coli* concentrations in the creek are about 10 cfu/100ml based on 2011 monitoring. Also, in the Page Springs area discharge from a spring that is in the vicinity of a large commerical septic system has been found to exceed the *E. coli* standard for full body contact. These springs also tested postive for human DNA, indicating possible septic leakage. These more or less steady supplies of *E. coli* during the summer months may innoculate sediment reservoirs that are later disturbed by recreation or storm events to cause exceedences of *E. coli* in the water column. Evaluation and upgrade of septic systems is needed, particularly for commercial septic systems with seasonally large loads.

Description

Technical assistance will be offered to property owners for septic system evaluation and remediation design, and a subsidy will be offered for system upgrades.

Estimated load reduction

Approximately 10 springs in the Oak Creek Canyon area contain elevated concentrations of *E. coli.* Some failing septic systems in the watershed produce effluent that is intercepted by the springs and carried to the creek. These septic-influenced springs may provide a steady supply of *E. coli* to Oak Creek that may suffuse sediment reservoirs that can be later disturbed by recreational activity or a storm event causing exceedances of *E. coli* in the water column.

The project seeks to reduce the amount of effluent from failing septic systems by offering property owners technical assistance for septic system evaluation and remediation design. Upgrades to the failing septic systems will reduce contaminants from entering the springs, and improve water quality.

The STEPL model (U.S. EPA, 2012) is a spreadsheet tool that uses data inputs provided by the EPA to estimate nutrient and sediment loads. Best management practices can be incorporated into the model to determine the load reductions that would occur if the BMPs are implemented.

The numbers reflected in the load reduction results represent the remediation of all failing septic systems within the five subwatersheds adjacent to Oak Creek Canyon.

Using nitrogen and phosphorus as indicates for *E. coli* the average annual load reduction is:
Sediment – 77.9 tons per year (14.2%)
Nitrogen (N) – 3,506.5 lbs per year (10.3%)
Phosphorus (P) – 601.6 lbs per year (7.8%)

References:

U.S. EPA Website, Access June, 2012. Welcome to STEPL and Region 5 Model, http://it.tetratech-ffx.com/stepl/

Project schedule and milestones

Implementation schedule: January 2012 through December 2014 *Measurable milestones:* ~ Baseline springs monitoring complete ~ Septic upgrades identified & prioritized ~ Upgrade funding secured ~ Upgrades implemented ~ Implementation report ~ Follow-up monitoring complete ~ Follow-up report complete	*Resources and other support commitments:* ADEQ 319(h) grants ???? *Commitment date(s):* None at this time *Pending commitments:* Unknown at this time *Estimated commitment date:* None at this time

Education and Outreach Strategy

Findings of education needs survey:

Watershed residents' opinions about whether improperly functioning septic systems threaten water quality are as follows:

	Not sure	Not a problem	Slight problem	Moderate problem	Large problem
Improperly built or maintain residential septic systems	13%	10%	14%	29%	25%
Improperly built or maintain commercial septic systems	13%	11%	16%	25%	25%

Watershed residents rank septic systems as one of the top three biggest contributors to creek contamination that can cause human illness as follows:

#1 – 23.4%

#2 – 13.2%

#3 – 9.1%

There seems to be a pretty high awareness in the general population about the potential impacts of septic system on water quality. Outreach should be focused on owners of septic systems in locations of concern, such as where there is shallow groundwater.

Goals and target audiences:

~ Reach commercial septic system owners in Oak Creek Canyon.
~ Inform them of risks to human health from poorly functioning septic systems.
~ Offer incentives (technical assistance, evaluation, subsidy) for upgrading septic systems.
~ Work cooperatively with land owners to assure completion of upgrades.

Priority education and outreach projects schedule:

~ Early 2013 - outreach
~ Late 2013 - cooperative agreements
~ 2014 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: *E. coli* concentrations below 5 cfu/100 ml in spring discharge near septic systems.

On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  Five springs in Oak Creek Canyon with a history of elevated *E. coli* and suspected commercial septic system influence will be monitored along with one reference spring in each vicinity (one spring could serve as reference for multiple affected springs in close proximity). Springs to monitor are those that have shown elevated *E. coli* (greater than 2 cfu/100 ml) and tested positive for human DNA, including:
    - S41 upstream of Slide Rock State Park and
    - S70, S71 and S109 at lower Indian Gardens
    - S107 in the Page Springs area

  Other springs may be added to the monitoring list if areas of concern are identified through examination of septic system records, field reconnaissance, and/or sample testing.
- *Parameters & critical conditions:*
  - *E. coli:* >5 cfu/100 ml if sample is collected directly at a spring discharge point. This is a conservative threshold; the presence of any *E. coli* in spring water could be considered elevated *E. coli*, since the bacteria do not naturally occur in groundwater. The critical condition for samples collected away from the spring discharge point is >10 cfu/ml. In this situation it is important to confirm potential septic influence through DNA testing.
  - DNA: presence of human DNA
- *Schedule, frequency and duration*:
  Early and late summer samples for 1 year pretreatment and 2 years post-treatment.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan:*
  Project implementation report, 2-year follow-up monitoring report

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Residents exhibit an understanding and willingness to have properly functioning septic systems.
- *Generation and implementation of second generation improvement projects:*
  Residents seek additional assistance with septic system improvements.
- *Measurable reductions of pollutant loading:*
  Reduced *E. coli* concentrations
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan, how findings will be used:*
  Project implementation report, 2-year follow-up monitoring report. Feature stories in local media on project implementation and effectiveness.

SW-1 Sedona Area Stormwater Improvement Project

Need

Summer stormflow events in the Sedona area deliver large doses of *E. coli* to Oak Creek. Stormwater samples from Carroll Canyon Wash, Soldier Wash, a storm drain at Tlaquepaque, Arroyo Roble and Jordan Wash have yielded *E. coli* concentrations exceeding the water quality standard of 235 cfu/100 ml for full body contact on multiple occasions, with concentrations often greater than 2,419.2 cfu/100 ml and 2 samples greater than 6,000 cfu/100 ml in summer 2011. Although DNA testing was inconclusive (6 of 6 samples where negative for dog DNA; this is probably erronenous, since previous studies in Oak Creek Canyon regulary found dog DNA), it is still suspected that much of stormwater *E. coli* comes from dog feces, because there are obvious concentrations of dog feces deposited along trails within and adjacent to the city where residents and visitors walk their dogs. The City of Sedona and neighboring Coconino National Forest have a some dog waste "mitt" and collection stations and provide education/outreach, but these efforts need to be expanded to change dog owners attitudes and behaviors in order to reduce the loading of *E. coli* and other fecal pathogens in the watershed due to dog feces.

Human DNA was found in a water sample from Carroll Canyon Wash collected from a pool of standing water near the Chavez Crossing Road bridge on the morning of September 6, 2012 following a storm event the night before. The *E. coli* count for this sample was > 2,419.2. This results warrants further monitoring and investigation in the Carroll Canyon Wash watershed to determine if there are human fecal sources affecting water quality. Sources might include leaking sewer pipes, sewer overflows and human waste long trails. Whereas Carroll Canyon historically was a location to dump extra sewage in case of an overflow (Amina Sena personal communication), the City of Sedona has significantly reduced the number of overflows within the City over the last five years (Charles Mosely personal communication). Also the city has a sewer pipe inspection program; the City has inspected its gravity sewer pipe system once during the last five years and is preparing to begin the second round of inspections (Charles Mosely personal communication). Watershed stakeholders should stay engaged with City of Sedona and offer support for the sewer inspection program, as well as a potential study that would look at sewer system overflows, sewer lateral work (repair/replacement) on private property, and septic tank failure and repair records versus storm events and *E. coli* concentrations to look for correlations.

Finally, a tremendous amount of sediment is discharge to Oak Creek from Sedona Washes, especially Carroll Canyon. This sediment contributes to *E. coli* sediment reservoirs in Oak Creek which when disturbed cause increased *E. coli* concentrations in the water column. Erosion problems need to be identified and ammeliorated. Continued monitoring of turbidity and *E. coli* in stormwater from Sedona area washes is needed to more accurately identify source areas of sediment and bacteria, so that best management practices can be implemented accordingly. The City of Sedona has implemented a pro-active best management practices program under the MS-4 program relative to sediment. Stakeholders should work with the City to help ensure that BMPs are effective. The monitoring programshould endeavor to differentiate sediment that is part of natural background and sediment that is generated within and adjacent to the city due to human activity.

Description

To address the problems of dog feces, human waste, and sediment in Sedona stormwater loading Oak Creek with *E. coli* and promoting *E. coli* sediment reservoirs, the following actions will be taken:

1. Conduct surveys of smaller watersheds (eg. Dry Creek, Carroll Canyon, Soldier's Wash, Arroyo Roble, Jordan Pump) in Sedona to determine where there are concentrations of animal and human waste and where erosion problems exist,
2. To determine where best to focus efforts, sample stormwater at the boundary where washes pass from Yavapai County or national forest land into City of Sedona to determine the relative contributions of fecal contamination from outside and within the City's jurisdiction,
3. Interface with jeep tour companies to determine how they handle situations when customers need to defecate while on a tour. Is this a source of fecal material in the watershed? Encourage the use of ammo boxes or other small portable toilets to reduce loading in the watershed. Appeal to tourists protecting the fragile desert soils.
4. If the watershed survey reveals that jeep use appears to be a significant cause of erosion and sediment discharge, work with tour companies and use outreach to promote practices that reduce erosion,
5. Work collaboratively with City of Sedona to support inspection of sewer lines through pressure testing or other means to determine whether any leaks exist that could introduce untreated sewage to washes,
6. Establish dog waste stations and at all trailheads. Work collaboratively with City of Sedona, Arizona State Parks and Coconino National forest to establish a funding and staff to maintain waste stations,
7. Install erosion control measures such as waterbars on hiking and jeep trails to slow the flow of water and revegetation with native plants in areas that have been denuded,
8. If appropriate, install detention and settling basins to slow runoff for reducing erosion and to intercept fecal matter before it is carried by washes to Oak Creek.
9. Encourage the establishment of a city or regional stormwater utility or similar payment structure to fund upgrades and maintenance of the stormwater system to protect water quality and aquatic habitat of Oak Creek,
10. Monitor *E. coli* and turbidity in Sedona washes during stormflow before, during and after implementing best management practices.

Estimated load reduction

Because the project is a multi-faceted approach to overall watershed improvement, using different methods and making some assumptions of effectiveness of the BMP when modeling each facet separately is necessary in order to formulate a reasonable estimation of load reduction. The project seeks to reduce the amount of *E. coli* and sediment delivered to Oak Creek during summer stormflow events by first surveying and determining where there are concentrations of human and animal waste, and where erosion problems exist.

If the watershed survey reveals that jeep use is a significant cause of soil disturbance and sediment discharge, then BMP's will be implemented along trails and public outreach will promote practices that will reduce erosion. Each subwatershed with hiking or jeep trails was

modeled assuming that the total area of the disturbance by humans was either 10%, 20% or 30% of the total area of subwatersheds with jeep and/or hiking trails, and that BMP's were utilized in the model in those proportions. The Automated Geospatial Watershed Assessment tool (ARS, 2012) with the SWAT model was used to estimate the sediment runoff of the areas of with landcover data that represents normal vegetation, then with landcover data that had been modified to reflect the disturbed areas near jeep and hiking trails within the six subwatersheds. If 10% of the areas were disturbed, recovered normal vegetation would be responsible for the reduction of 19.5 tons of sediment per year.

The STEP L Model (U.S. EPA, 2012) was used to estimate the effectiveness of installing water bars and bioretention ponds to slow runoff and reduce erosion, and the revegetation of areas denuded by erosion in areas near jeep and hiking trails. If humans and jeeps disturbed 10% of the area of subwatersheds with trails, the load reduction as a result of the installation of water bars, bioretention ponds, and native vegetation is 153.9 tons of sediment per year.

Dog waste stations will be installed at all trailheads. Walker and Garfield (2008) found that a gram of dog feces contained an average of 50 million CFU/gram of *E. coli* bacteria. The average dog excretes 340 grams per day (Clear Choices Clean Water, 2012). That equates to 17 billion CFU of *E.coli* bacteria per dog per day. If the project successfully prevents 100 dog/days per year from contaminating Oak Creek, the result would be a reduction of 34 kg of dog feces and 17 x 10^{12} CFU of *E. coli* bacteria.

Public outreach efforts aimed at eliminating human waste contributions to the watershed will be implemented. Brandys (2007) found that human stool contained an average of 5 million CFU/gram of *E. coli* bacteria. Parker and Gallagher (1988) found that the mean human waste in over 25,000 subjects was 95 grams per day of solid fecal matter. That equates to 475 million CFU of *E. coli* per person per day. If the project successfully prevents 100 people per day from contaminating Oak Creek, the result would be a reduction of 9.5 kg of human feces and 4.75 x 10^{10} CFU of *E. coli* bacteria.

Average annual load reduction:

AGWA SWAT (Soil Disturbance and Normal Vegetation)
19.5 tons of sediment per year

STEP L (Water Bars, Bioretention Ponds, Revegetation)
153.9 tons of sediment per year

Combined Sediment Load Reduction: 173.4 tons of sediment per year

Dog Waste
34 kg (75 lbs) of feces and 17 x 10^{12} CFU per year of *E. coli* bacteria

Human Waste
9.5 kg (21 lbs) of feces and 4.75 x 10^{10} CFU per year of *E. coli.* bacteria

References:

Agricultural Research Service (ARS) Website, Access on June, 2012. Automated Geospatial Watershed Assessment Tool located at http://www.tucson.ars.ag.gov/agwa/.

Clear Choices Clean Water Organization Website, access June 27, 2012. Located at http://clearchoicescleanwater.org/wp-content/uploads/2011/08/pet-waste-FAQs_final.pdf

Walker, M. and L. Garfield, 2008. Dog Wastes and Water Quality; Evaluating the Connection at Lake Tahoe. University of Nevada Cooperative Extension, Fact Sheet-08-18.

Brandys, B. 2007. Quantifying Bacteria Levels in Water Categories 1-3. Occupational and Environmental Health Consulting Services, accessed July 11, 2012. Located at: http://www.bio-reveal.com/AdminWeb/userfiles/image/file/IICRC%20S520%20-%20IICRC%20S500/Quantifying-Levels-02-07.pdf

Parker, D. and S. Gallagher, 1988. Distribution of Human Waste Samples in Relation to Sizing Waste Processing in Space, accessed July 9, 2012. Located at http://www.nss.org/settlement/moon/library/LB2-611-WasteProcessing.pdf

U.S. EPA Website, Access June, 2012. Welcome to STEPL and Region 5 Model, http://it.tetratech-ffx.com/stepl/

Costs

????

Project schedule and milestones

<table>
<tr>
<td rowspan="2">Implementation schedule:
January 2012 through December 2014

Measurable milestones:
~ Tributary watershed surveys complete
~ Stormwater sampling complete
~ Cooperative agreement for funding and maintenance of dog waste stations complete
~ Dog waste station installed at all trailheads
~ Outreach and education for dog waste stations complete
~ Sewer system inspection complete
~ Erosion control measures installed
~ Retention basins installed
~ Follow-up monitoring complete
~ Project progress and completion reports</td>
<td>Resources and other support commitments:
ADEQ 319(h) grants
????
Commitment date(s):
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</tr>
<tr>
<td>Pending commitments:
City of Sedona??
<Unknown at this time>
Estimated commitment date:
<None at this time ></td>
</tr>
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Education and Outreach Strategy

(See also OCWIP Project #EO1 - Sedona Dog Waste Reduction Outreach Project)

Findings of education needs survey:

Watershed residents' opinions about potential sources of contamination in stormwater that could affect human health in Oak Creek are as follows:

	Not sure	Not a problem	Slight problem	Moderate problem	Large problem
Dog feces that are not picked up and disposed properly	10%	12%	28%	22%	19%
Human feces deposited outdoors	13%	13%	26%	18%	23%
Erosion and sediment due to the following:					
Building & road construction	17%	17%	28%	17%	6%
Road maintenance	17%	20%	34%	19%	6%
Low water creek crossings	17%	26%	28%	14%	3%
Unmaintained " social" trails	18%	23%	31%	13%	4%
Jeep/ORV trails	15%	16%	22%	21%	13%

Goals and target audiences:

~ Reach people who hike and walk dogs on trails in tributary watersheds in the Sedona area.
~ Reach home owners who might be prone to tossing dog feces into drainage ways.
~ Reach jeep tour company owners and drivers as well as others who use jeep trails for recreation.
~ Inform the public of risks to human health from dog and human feces left in the watershed.
~ Have volunteers offer incentives (eg. OCWC water bottles, gift certificates for frozen yogurt, etc.) for picking up dog feces and/or encouraging others to do so.
~ If increased taxes may be needed to cover the cost of stormwater and/or sewage improvements, work with City of Sedona to develop appropriate outreach campaign.

Priority education and outreach projects schedule:

~ 2012 - initial outreach;
~ 2013-2014 adapt and modify outreach and continue activities
~ 2013, 2014 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: *E. coli* concentrations below <235 cfu/100 ml and turbidity <50 NTU in Sedona washes during storm events.

On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  E. coli and turbidity should be monitored in Sedona washes during summer storm events before and after implementing best management practices. Process dilutions of *E. coli* samples to quantify concentrations >2,419.2 cfu/100 ml.
- *Parameters & critical conditions:*
  - *E.coli* (>235 cfu/100 ml)
  - Turbidity (>50 NTU)
  - DNA (presence of human DNA; dog DNA >10%)
- *Schedule, frequency and duration*:
  Two to four storm events during monsoon season 2012-2014. Try to capture "first flush" when rainfall is of great enough magnitude and intensity to move fecal material from uplands into washes.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; City of Sedona; Coconino National Forest
- *Reporting plan:*
  Produce an annual report of summer water quality results and interpretation by November.

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Residents, visitors, and tour drivers exhibit an understanding and willingness to reduce fecal contamination and erosion in Oak Creek tributary watersheds in the Sedona area.
- *Generation and implementation of second generation improvement projects:*
  City of Sedona considers establishing a stormwater utility to support ongoing outreach and improvement/maintenance of stormwater infrastructure to reduce pollutant loading in Oak Creek.
- *Measurable reductions of pollutant loading:*
  Reduced *E.coli* concentrations, turbidity and human and canine sources of fecal contamination in stormwater runoff in Sedona
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; City of Sedona; Coconino National Forest
- *Reporting plan, how findings will be used:*
  Quarterly and final reports to funding agencies. Progress reports on OCWC website. Feature stories in local media on project implementation and effectiveness.


Soldier Wash
Mormon Canyon
Sedona
Dry Creek
89A
Carroll Canyon Wash
Chavez Crossing Campground
179
Crescent Moon Day Use Area
Red Rock Crossing
Red Rock Loop Rd
Red Rock State Park
Oak Creek
Verde Valley School Rd
Exceeding E.coli
Trailheads
Trails
Arterial Road
Residential Road
CityLimits
Recreation Areas
Major Roads
Minor watercourses
Major watercourses
Oak Creek Watershed
Land Ownership
State Parks
Private
State
Fish and Game
USFS
N
0 0.25 0.5
Miles
1:63,360

RC-1 Oak Creek Canyon Public Toilet Access Project

Need

There is a shortage of public restrooms in Oak Creek Canyon, especially access that does not require a Red Rock Pass. Many people will park along the highway and hike into the creek rather than pay the fee. Because toilet and trash amenities on national forest land are associated with fee areas, but many recreators avoid the fee areas, they have limited options for sanitary toilet facilities. The public rest room at Indian Gardens is one available toilet. The others are primarily in a limited number of commerical sites, many of which are not available to general public. This shortage of public toilets sometimes results in people defecating near the stream where feces can wash into the channel during storm events, thereby contributing to fecal contamination of Oak Creek water that threatens human health. The shortage of public toilets is a long-standing problem that requires priority attention.

Description

Work with Coconino N.F., business owners, and ADOT to establish restrooms at intervals that will help ensure the public can conveniently access them rather than defecating near the stream. Post signs along the highway indicating public restrooms. Establish collaborative agreements and funding to maintain restrooms. This is a high priority, which was identified in the past and has not had enough action.

Estimated load reduction

A University of North Dakota study for the U.S. Department of Agriculture regarding human waste distributions reveals the average stool produced is 95.5 grams per day, and 2066 ml of urine per day (Parker and Gallagher 1988). The average number of bowel movements per day was 2.54 (Parker and Gallagher 1988), but the number times a person urinates is variable based on the volume of fluid they consume, with a range of 4-10 times per day based on an Internet search. An urination rate of 7 per day will be used in this analysis.

The only access to and through the Oak Creek Canyon is Highway 89-A which carries about 7million visitors a year to Oak Creek and Sedona. Approximately one million of these visitors stop and utilize the publicly owned recreational sites, while 300,000 visit Slide Rock State Park (in Poff and Tecle 2002). Assuming 60% of the potential visitors use the toilets once for urination and 30% of the potential visitors use the toilets for bowel movements, instead of relieving themselves into the environment, the load reductions for urine and fecal material are:

Urine (l) = 1 million visitors/year * 0.6 * 2066 ml/day * day/7 urinations * 1 liter/1000 ml = 177,086 liters

Fecal Material (kg) = 1 million visitors/year * 0.3 * 95.5 g/day * day/2.54 movements * 1 kg/1000 g = 11,280 kg

The Fecal Material estimate is more important in regard to *E. coli*. *E. coli*, as member of the intestinal flora, is part of the digestive process and is excreted in feces. Brandys (2007) found that human stool contained an average of 5 million CFU/gram of *E. coli* bacteria. Consequently, if 10% (11,280 kg) of fecal material that is now captured by the toilet facilities would have

reached the river environment it would result in the potential *E. coli* load of 5.6 x 10^{12} CFU per year, representing a 100% load reduction compared to not having the toilet facilities.

In order estimate the actual load reduction a survey of rest room users should be conducted.

References:

Brandys, B. 2007. Quantifying Bacteria Levels in Water Categories 1-3. Occupational and Environmental Health Consulting Services, accessed July 11, 2012. Located at: http://www.bio-reveal.com/AdminWeb/userfiles/image/file/IICRC%20S520%20-%20IICRC%20S500/Quantifying-Levels-02-07.pdf

Parker, D. and S. Gallagher, 1988. Distribution of Human Waste Samples in Relation to Sizing Waste Processing in Space, accessed July 9, 2012. Located at http://www.nss.org/settlement/moon/library/LB2-611-WasteProcessing.pdf

Poff, B. and A. Tecle, 2002. Bacteriological Water Quality Trend Analysis in Oak Creek Canyon, Arizona. In: Ground Water/Surface Water Interactions, 2002 AWRA Summer Specialty Conference Proceedings, July 1-3, 2002, Keystone, CO. pp. 431-436.

Costs

Item	**units**	**price/unit**	**cost**
full service restrooms with water well and septic system	#	$$	$$$
vault toilets	#	$$	$$$
portable toilets			
Purchased	#	$$	$$$
rented - # toilet x # months (2012-2014)	#	$$	$$$
highway pullouts and parking	#	$$	$$$
easement or purchase of land for toilets on private property	#	$$	$$$
Annual maintenance costs for first 3 years	#	$$	$$$
Signage along Hwy 89A	#	$$	$$$
Legal fees for permit processing, establishment of maintenance agreements, construction contracting, establishment of easements or property purchase contracts, etc. (some if this may count as inkind contribution from participating agencies?)	#	$$	$$$

Project schedule and milestones

Implementation schedule: January 2012 through December 2014	*Resources and other support commitments:* ADEQ 319(h) grants

Measurable milestones: ~ Meet with collaborators (USFS, SRSP, local business owners, ADOT) to discuss roles and responsibilities, cost-sharing, necessary permits and clearances, etc. ~ Make a complete inventory of available toilets, distance between toilets, ownership and accessibility; identify gaps that must be filled. ~ Select sites for additional toilets and types of toilets to be installed. ~ Complete all permits, clearances, construction contracting and maintenance agreements. ~ Construct flush toilets (including water wells and septic systems where needed) and necessary pull outs and parking ~ Place portable or vault toilets with adequate pull outs and parking ~ Signage installed along Hwy 89A. ~ Outreach activities complete ~ Monitoring complete ~ Reporting complete	???? *Commitment date(s):* <None at this time > *Pending commitments:* <Unknown at this time> *Estimated commitment date:* <None at this time >

Education and Outreach Strategy

Findings of education needs survey:

At least 13 % of watershed residents do not think human feces are a source of water contamination in Oak Creek.

Watershed residents think the lack of toilet facilities threatens Oak Creek water quality as follows:

	Not sure	Not a problem	Slight problem	Moderate problem	Large problem
Lack of public toilet facilities near creek and trailheads	8%	5%	18%	29%	32%

Goals and target audiences:

~ Swimmers, waders, hikers and fishermen in Oak Creek Canyon who need public access toilets
~ Stress how important it is for human and environmental health that they not defecate near the creek
~ Inform them of collaborators' efforts to increase public toilet access
~ Let them know where toilets are now and where they will be in the near future
~ Encourage them to tell others where to access toilets

~ Explain the health risks of discarded used diapers and encourage them to dispose of used diapers in trash receptacles at public toilets.
~ Have volunteers offer incentive items to people observed using public toilets
~ Have workers or volunteers (in uniform – polo shirt or T shirt) conducting fecal counts on the weekend to show a presence along the creek and interface with the curious public to offer information about reducing pollution, including directing them to available public toilets.

Priority education and outreach projects schedule:
~ Summer 2012 - radio PSA (including on the Slide Rock S.P. park information frequency) about available public toilets, the importance of using them, and upcoming additional toilets. Try to come up with something fun and catchy (eg. if not too distasteful or outdated, use a spin-off of the Cheech and Chong "What's that?" skit) or come up with a good catch phrase. Encourage public participation in siting of new toilets. Advertise public meeting.
~ Public meeting(s) July/August 2012 soliciting comment on siting of public toilets.
~ Feature stories in local media lauding the collaborative effort to increase toilet access in Oak Creek Canyon and soliciting input from the public.
~ 2014 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: Increased use of public toilets. Reduced human feces observed along Oak Creek in Oak Creek Canyon. Human-sourced DNA in fecal bacteria of Oak Creek reduced from an average of 16% in 1998-1999 samples.

On-the-ground project effectiveness monitoring plan

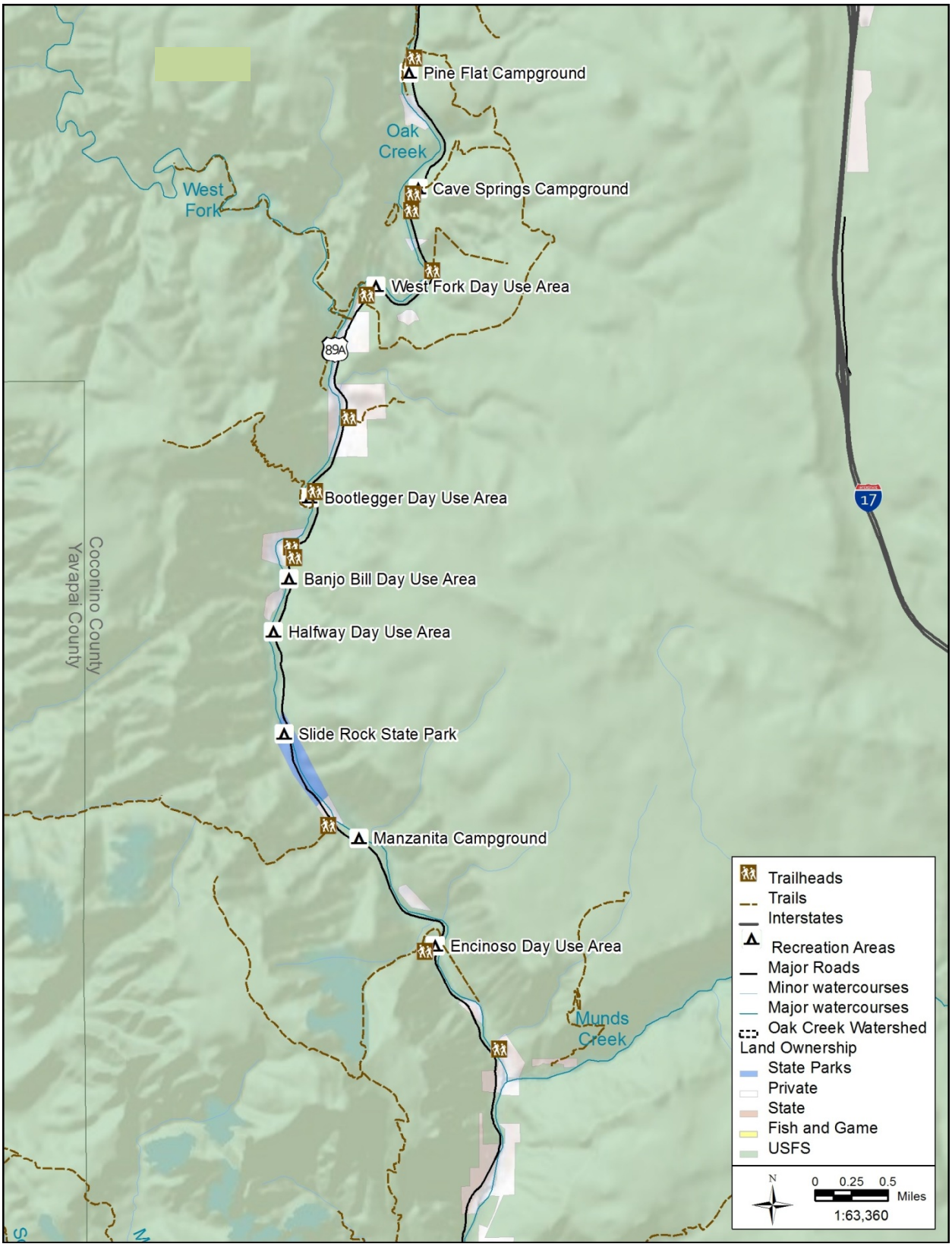
- *Monitoring and reference condition sites*:
  Volunteers will monitor the number of people utilizing public toilets. Approximately ## sites along the creek in Oak Creek Canyon will be monitored for *E. coli* and human-sourced bacterial DNA in proximity to new toilet installations and new signage for toilet access.
- *Parameters & critical conditions:*
  - Fecal counts along popular stretches of Oak Creek (>X human feces per ¼ mile); feces will be picked up and bagged so they are not double counted [Research degradation time for feces; if practical, space fecal count intervals so that previous feces would have decomposed, if volunteers are not wanting to pick up feces.]
  - *E.coli* (>10 cfu/100 ml for elevated values, >235 cfu/100 ml for exceedence)
  - DNA (average >15% human-sourced DNA in fecal bacteria)
- *Schedule, frequency and duration*:
  Public toilet use counts and fecal counts will be conducted twice per month May through September. *E. coli* and DNA sampling during high-use weekends in the early-, mid- and late summer and the day of or the day following a storm event that increases streamflow. Baseline monitoring will be accomplished in 2012 and effectiveness monitoring will be conducted in 2013-2014.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; Coconino National Forest; Coconino County Rural Environmental Corp [contract for services to conduct fecal counts and *E. coli* sampling? Require at least one Spanish speaking crew member to interface with the

public. Try to have crews along creek on the weekend for a presence to make visitors aware of the ramifications of their actions.]

- *Reporting plan:*
  Annual report on summer monitoring results and interpretation by November of each year. Final analysis report in Fall 2014.

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Recreators exhibit an understanding and willingness to use public toilets rather than defecating near the creek in order to reduce *E. coli* and other fecal contaminants that threaten human health.
- *Generation and implementation of second generation improvement projects:*
  The public may identify additional sites where portable or vault toilets may be appropriate, initiating future projects.
- *Measurable reductions of pollutant loading:*
  Reduced *E.coli* concentrations and human-sourced bacterial DNA
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; Slide Rock State Park; Coconino National Forest
- *Reporting plan, how findings will be used:*
  Annual accomplishments and monitoring report in the fall each year will be posted to OCWC website. Feature stories in local media will describe project implementation and effectiveness.


Pine Flat Campground
Oak Creek
West Fork
Cave Springs Campground
West Fork Day Use Area
89A
Bootlegger Day Use Area
17
Coconino County
Yavapai County
Banjo Bill Day Use Area
Halfway Day Use Area
Slide Rock State Park
Manzanita Campground
Encinoso Day Use Area
Munds Creek
Trailheads
Trails
Interstates
Recreation Areas
Major Roads
Minor watercourses
Major watercourses
Oak Creek Watershed
Land Ownership
State Parks
Private
State
Fish and Game
USFS
N
0 0.25 0.5
Miles
1:63,360

RC-3 Keeping Oak Creek Beautiful – Trash Receptacle Access Project

Need

Trash receptacles are lacking in many places along Oak Creek that are popular recreation sites, leading visitors to litter. Used diapers that are dumped contribute to *E. coli* pollution as does food waste that attracts wildlife whose feces add to *E. coli* concentrations.

Description

Work with Coconino N.F., business owners, and the state parks to place trash receptacles at convenient locations. Work out collaborative agreements and funding to maintain trash receptacles. Investigate the cost/value of bear-proof receptacles and install as appropriate.

Estimated load reduction

Diapers

Peterson (1974) reported that feces-soiled diapers contained an average of 60 grams of feces. Brandys (2007) found that human stool contained an average of 5 million CFU/gram of *E. coli* bacteria. Assuming that the Trash Receptacle Access Project and the Outreach Program changes the behavior of 100 people per year (i.e. 100 diapers). The average annual load reduction would be 3×10^{10} CFU per year.

References:

Brandys, B. 2007. Quantifying Bacteria Levels in Water Categories 1-3. Occupational and Environmental Health Consulting Services, accessed July 11, 2012. Located at: http://www.bio-reveal.com/AdminWeb/userfiles/image/file/IICRC%20S520%20-%20IICRC%20S500/Quantifying-Levels-02-07.pdf

Peterson, M.L., 1974. Soiled disposable diapers: a potential source of viruses.. American Journal of Public Health: September 1974, Vol. 64, No. 9, pp. 912-914. doi: 10.2105/AJPH.64.9.912

Costs ????

Project schedule and milestones

<table>
<tr>
<td rowspan="2">Implementation schedule:
January 2012 through December 2014

Measurable milestones:
~ Survey of popular recreation sites without trash receptacles
~ Coordination meetings with collaborators (USFS, services vendor for USFS, state parks, businesses, City of Sedona, OCWC, etc.) to discuss funding, permits, clearances, and maintenance
~ MOA regarding trash receptacle placement and maintenance</td>
<td>Resources and other support commitments:
ADEQ 319(h) grants
????
Commitment date(s):
<None at this time></td>
</tr>
<tr>
<td>Pending commitments:
<Unknown at this time>
Estimated commitment date:
<None at this time ></td>
</tr>
</table>

~ Purchase and installation of trash receptacles ~ Litter surveys before and after receptacle placement ~ Quarterly and final reports	

Education and Outreach Strategy

Findings of education needs survey:

Watershed residents reported the following opinions about litter and baby diapers as the biggest contributors to creek contamination that can cause human illness:

	#1 contributor	#2 contributor	#3 contributor
litter	23.4%	8.7%	15.1%
Baby diapers	11.7%	14.3%	9.4%

At least 14% of watershed residents did not think that leaving food waste at campgrounds or picnic sites attracts wild animals whose feces can contaminate Oak Creek.

Goals and target audiences:

~ Swimmers, waders, hikers and fishermen in Oak Creek Canyon.
~ Use signs next to trash receptacles and PSAs to inform recreators of the risks to human health from *E. coli* and how increased *E. coli* in water can be caused by littering food waste and used diapers
~ Have volunteers offer incentive items to people observed using waste receptacles rather than littering.

Priority education and outreach projects schedule:

~ Early summer 2012 - trash receptacles and signs in place
~ Summer 2012-2014 - radio PSA about risks of elevated *E. coli* and what people can do to reduce the risk, including reducing using trash receptacles rather than littering food waste and used diapers. Include PSA on Spanish language radio stations.
~ 2013 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: Reduced incidence of food waste and used diapers in recreation areas. Reduced *E. coli* concentrations in Oak Creek.

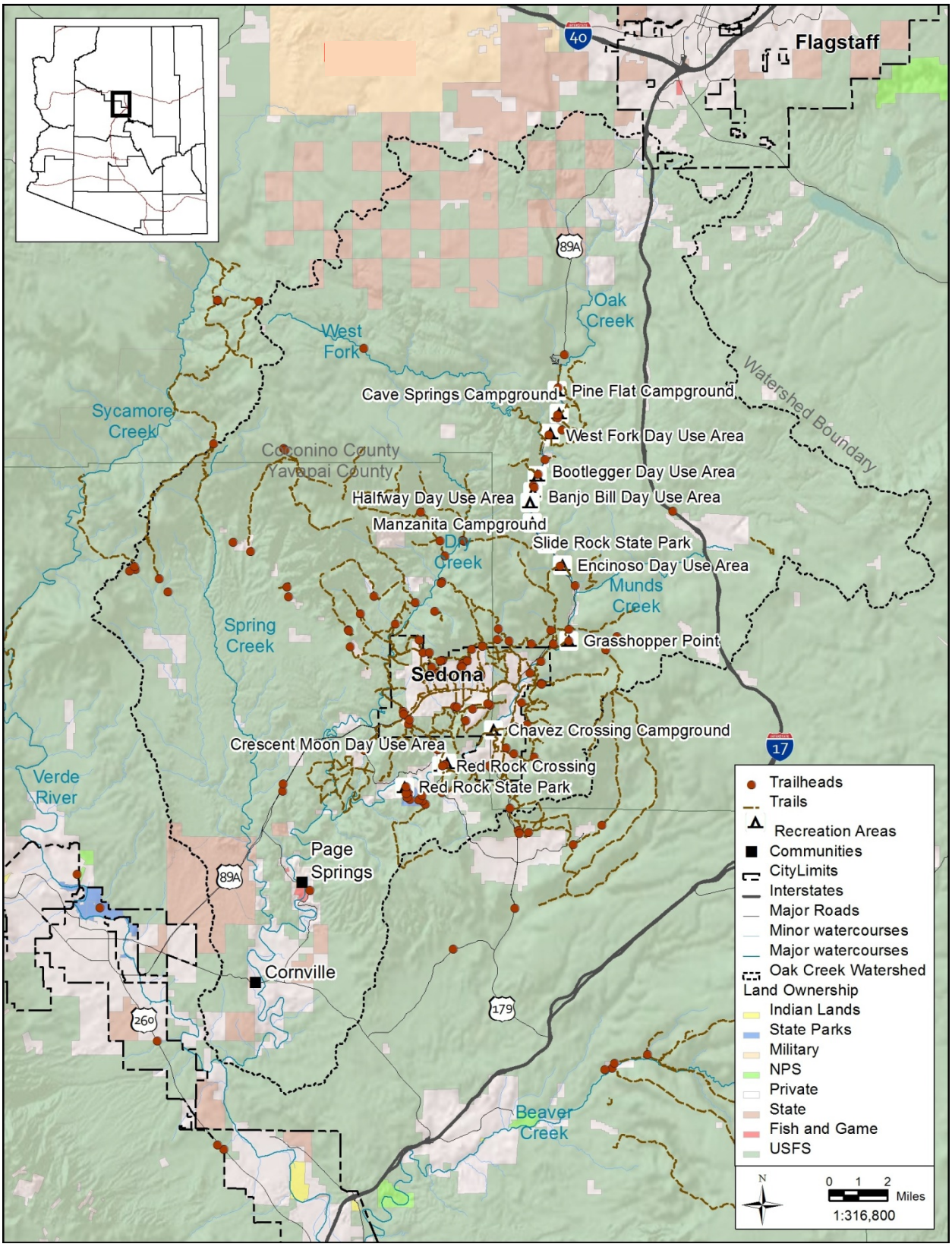
On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  Pre- and post-implementation litter counts in the vicinity of waste receptacle placement sites. *E. coli* monitoring in Oak Creek downstream of popular recreation sites, such as Midgely Bridge where trash receptacles have been added.
- *Parameters & critical conditions:*
  - Litter counts (average values $\geq$ to values prior to installation of receptacles)
  - *E. coli* (>235 cfu/100 ml during storm events; > 90% of average baseline concentration prior to installation of trash receptacles)

- *Schedule, frequency and duration*:
  Twice monthly litter counts during summer 2012-2013. *E. coli* monitoring in early, mid- and late summer during high use weekends and during or the day after at least 3 storm events.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; Coconino Rural Environmental Corp? [See if CREC be recruited to conduct litter counts and other monitoring activities. If OCWC subcontracts to have CREC provide services, make a requirement that the crew has at least one Spanish speaking member for interfacing with the public.]
- *Reporting plan:*
  Annual accomplishments and monitoring report in the fall of each year. Final report.

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Recreators exhibit an understanding and willingness to use trash receptacles rather than litter to reduce *E.coli* contamination of Oak Creek.
- *Generation and implementation of second generation improvement projects:*
  Recreators provide feedback on additional locations for waste receptacles to reduce litter that contributes to *E. coli* pollution.
- *Measurable reductions of pollutant loading:*
  Reduced *E.coli* concentrations. Reduced litter counts, including used diapers and food waste.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; Coconino National Forest; Coconino Rural Environmental Corp
- *Reporting plan, how findings will be used:*
  Annual accomplishments and monitoring report in the fall of each year posted to OCWC website. Feature stories in local media on project implementation and effectiveness.


Flagstaff
40
89A
Oak Creek
West Fork
Watershed Boundary
Cave Springs Campground
Pine Flat Campground
West Fork Day Use Area
Sycamore Creek
Coconino County
Yavapai County
Bootlegger Day Use Area
Halfway Day Use Area
Banjo Bill Day Use Area
Manzanita Campground
Slide Rock State Park
Dry Creek
Encinoso Day Use Area
Munds Creek
Spring Creek
Grasshopper Point
Sedona
Chavez Crossing Campground
Crescent Moon Day Use Area
Red Rock Crossing
Red Rock State Park
17
Verde River
Page Springs
89A
Cornville
260
179
Beaver Creek
Trailheads
Trails
Recreation Areas
Communities
CityLimits
Interstates
Major Roads
Minor watercourses
Major watercourses
Oak Creek Watershed
Land Ownership
Indian Lands
State Parks
Military
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Fish and Game
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Second Tier Priority Projects

EO-1 Sedona Dog Waste Reduction Outreach Project

Need

Stormflow events in Sedona deliver large doses of *E. coli* to Oak Creek, often > 2,419 cfu/100 ml, the maximum level measurable by Colilert ® without sample dilution, and as high as 8,202 cfu/100 ml as measured using sample dilution. Although dog DNA analysis of summer 2011 water samples was inconclusive (6 of 6 samples collected in the Sedona areas tested negative for dog DNA, which seems to be an errror, since dog DNA was found everywhere in Oak Creek Canyon in past studies), there is still reason to believe dog feces are a major source of fecal bacteria since significant concentrations are often seen along popular trails in the Sedona area. Dog owners need to know the seriousness of leaving dog waste along trails and in yards where it can wash into tributaries of Oak Creek during storms. They need to be encouraged to pick up and properly dispose of dog feces. While the City of Sedona does encourage pick-up of animal feces, through signage, information on their website, and the stocking of feces bag stations at some trailheads, and the the City tries to control of sediment from the Sedona Dog Park, additional actions can be taken to build on these efforts and more comprehensively address the dog waste problem.

Description

Implement an outreach program that includes radio and newspaper stories, public service announcements, and presentations to civic groups. Use brief motivational messages that get across 4 points: 1. the danger of *E.coli* and health effects on children, 2. causes of *E. coli* contamination, 3. pet-owner behaviors that reduce *E. coli* contamination, 4. "Deputizing the World", i.e. encouraging residents to speak up when they see others leaving dog waste unattended. Time outreach to correspond with establishment of dog waste stations. Before and after trailhead surveys will be conducted to determine effectiveness of outreach campaign.

Estimated load reduction

Dog waste

E. coli bacteria are bacteria that are common to the intestinal tracts of humans and animals. Walker and Garfield (2008) found that a gram of fresh dog feces contained an average of 50 million CFU/gram with a range of 2 million to 200 million CFU/gram of *E. coli* bacteria. The average dog excretes 0.75 pounds (340 grams) of waste per day (Clear Choices Clean Water, 2012). That equates to an average 17 billion CFU of *E. coli* bacteria per day per dog. If the Sedona Dog Waste Reduction Outreach/Oak Creek Watershed Dog Waste Station Installation Projects prevents 100 dog/days from contaminating Oak Creek this would result in a load reduction 34 kg of dog feces and 17 x 10^{12} CFU of *E. coli* bacteria.

The goal of the Outreach Project is to improve community awareness on the role of dog waste in water quality impairment of Oak Creek. The Outreach Project should increase the use of the dog waste stations and the rate of dog waste removal. If the Outreach Project increases use of the dog waste stations from 100 to 300 dog/days the result would be a load reduction of 102 kg of dog feces and 5.1 x 10^{13} CFU of *E. coli* bacteria.

The actual load reduction will depend on the number of people that utilize the dog waste stations, before and after the Outreach Project. A monitoring program should be implemented to assess the use of the dog waste stations.

References:

Clear Choices Clean Water Organization, access on June 27, 2012 http://clearchoicescleanwater.org/wp-content/uploads/2011/08/pet-waste-FAQs_final.pdf

Walker, M. and L. Garfield, 2008. Dog wastes and water quality: Evaluating the connection at Lake Tahoe. University of Nevada Cooperative Extension, Fact Sheet-08-18.

Multiple effects

Because the project is a multi-faceted approach to overall watershed improvement, using different methods and making some assumptions of effectiveness of the BMP when modeling each facet separately is necessary in order to formulate a reasonable estimation of load reduction. The project seeks to reduce the amount of *E. coli* and sediment delivered to Oak Creek during summer stormflow events by first surveying and determining where there are concentrations of human and animal waste, and where erosion problems exist.

If the watershed survey reveals that jeep use is a significant cause of soil disturbance and sediment discharge, then BMP's will be implemented along trails and public outreach will promote practices that will reduce erosion. Each subwatershed with hiking or jeep trails was modeled assuming that the total area of the disturbance by humans was either 10%, 20% or 30% of the total area of subwatersheds with jeep and/or hiking trails, and that BMP's were utilized in the model in those proportions. The Automated Geospatial Watershed Assessment tool (ARS, 2012) with the SWAT model was used to estimate the sediment runoff of the areas of with landcover data that represents normal vegetation, then with landcover data that had been modified to reflect the disturbed areas near jeep and hiking trails within the six subwatersheds. If 10% of the areas were disturbed, recovered normal vegetation would be responsible for the reduction of 19.5 tons of sediment per year.

The STEP L Model (U.S. EPA, 2012) was used to estimate the effectiveness of installing water bars and bioretention ponds to slow runoff and reduce erosion, and the revegetation of areas denuded by erosion in areas near jeep and hiking trails. If humans and jeeps disturbed 10% of the area of subwatersheds with trails, the load reduction as a result of the installation of water bars, bioretention ponds, and native vegetation is 153.9 tons of sediment per year.

Dog waste stations will be installed at all trailheads. Walker and Garfield (2008) found that a gram of dog feces contained an average of 50 million CFU/gram of *E. coli* bacteria. The average dog excretes 340 grams per day (Clear Choices Clean Water, 2012). That equates to 17 billion CFU of *E.coli* bacteria per dog per day. If the project successfully prevents 100 dog/days per year from contaminating Oak Creek, the result would be a reduction of 34 kg of dog feces and 17 x 10^{12} CFU of *E. coli* bacteria.

Public outreach efforts aimed at eliminating human waste contributions to the watershed will be implemented. Brandys (2007) found that human stool contained an average of 5 million

CFU/gram of *E. coli* bacteria. Parker and Gallagher (1988) found that the mean human waste in over 25,000 subjects was 95 grams per day of solid fecal matter. That equates to 475 million CFU of *E. coli* per person per day. If the project successfully prevents 100 people per day from contaminating Oak Creek, the result would be a reduction of 9.5 kg of human feces and 4.75 x 10^{10} CFU of *E. coli* bacteria.

Average annual load reduction:

AGWA SWAT (Soil Disturbance and Normal Vegetation)
19.5 tons of sediment per year

STEP L (Water Bars, Bioretention Ponds, Revegetation)
153.9 tons of sediment per year

Combined Sediment Load Reduction: 173.4 tons of sediment per year

Dog Waste
34 kg (75 lbs) of feces and 17 x 10^{12} CFU per year of *E. coli* bacteria

Human Waste
9.5 kg (21 lbs) of feces and 4.75 x 10^{10} CFU per year of *E. coli.* bacteria

References:

Agricultural Research Service (ARS) Website, Access on June, 2012. Automated Geospatial Watershed Assessment Tool located at http://www.tucson.ars.ag.gov/agwa/.

Clear Choices Clean Water Organization Website, access June 27, 2012. Located at http://clearchoicescleanwater.org/wp-content/uploads/2011/08/pet-waste-FAQs_final.pdf

Walker, M. and L. Garfield, 2008. Dog Wastes and Water Quality; Evaluating the Connection at Lake Tahoe. University of Nevada Cooperative Extension, Fact Sheet-08-18.

Brandys, B. 2007. Quantifying Bacteria Levels in Water Categories 1-3. Occupational and Environmental Health Consulting Services, accessed July 11, 2012. Located at: http://www.bio-reveal.com/AdminWeb/userfiles/image/file/IICRC%20S520%20-%20IICRC%20S500/Quantifying-Levels-02-07.pdf

Parker, D. and S. Gallagher, 1988. Distribution of Human Waste Samples in Relation to Sizing Waste Processing in Space, accessed July 9, 2012. Located at http://www.nss.org/settlement/moon/library/LB2-611-WasteProcessing.pdf

U.S. EPA Website, Access June, 2012. Welcome to STEPL and Region 5 Model, http://it.tetratech-ffx.com/stepl/

Project schedule and milestones

Implementation schedule: March 2012 through September 2014 *Measurable milestones:* ~ Design of literature, presentations, PSA scripts, and press releases ~ Pre-campaign trailhead survey ~ Spring media campaign completed ~ #? presentations to civic groups ~ Late summer follow-up trailhead survey ~ Late summer "Thank you" message in media ~ Report on year one and year two activities and results	*Resources and other support commitments:* <ADEQ 319(h) grants <????> *Commitment date(s):* <None at this time> *Pending commitments:* <Unknown at this time> *Estimated commitment date:* <None at this time>

Education and Outreach Strategy

Findings of education needs survey:

20% of watershed residents walk their dog near Oak Creek.

Dog feces were rated as 1st, 2nd and 3rd biggest contributors to creek contamination by 7.2%, 10.6%, and 10.6% or watershed residents respectively.

44.5 % of watershed residents own a dog.

Of those who own dogs 45.6% walk their dog in the watershed.

Most dog-owning residents (64%) said they always pick up their dog waste, while 19.2% said "most of the time", 5.6 % said "sometimes", 3.2% said "rarely", and 8.0% said "never".

83.5% of watershed residents with dogs say they would use dog waste stations if more were made available at parks and trails.

Watershed residents' opinion of whether dog feces threaten Oak Creek water quality is as follows:

	Not sure	Not a problem	Slight problem
Dog feces that are not picked up and disposed properly	10%	12%	28%

Goals and target audiences:
~ Outreach to residents of Sedona who walk their dogs on trails in and around the city.
~ Outreach to Sedona Humane Society.
~ Increase understanding of importance of picking up dog waste.
~ Affect behaviors so that more pet owners pick up and properly dispose of dog waste.

Priority education and outreach projects schedule:
~ Early 2012 - surveys and outreach
~ Late summer 2012 - follow-up surveys
~ Early 2013 - Year 2 surveys and outreach

~ Late summer 2013 - Year 2 follow-up surveys
~ 2013 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: Survey results indicate a change in attitude about the importance of picking up dog waste. At least 20% more people report picking up waste and telling others to do so.

On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  Fecal counts will be conducted once per month May through September on 4 popular trails in the Sedona area: Huckaby Trail, Baldwin Trail, West Fork Trail (all FS System trails) and Chavez Crossing trail (social trail). These trails all parallel significant reaches of Oak Creek and West Fork and have some tradition of dog use.
- *Parameters & critical conditions:*
  - number of presentations given to civic groups
  - feces counts (>20 feces per ¼ mile)
  - percentage of people reporting desired attitude
  - percentage of people exhibiting desired behavior
- *Schedule, frequency and duration*:
  - Monthly fecal counts, May-September, 2012 and 2013
  - Late spring and late fall hiker surveys, 2012 and 2013
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan:*
  - Year 1 accomplishments report.
  - Project implementation report

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Residents exhibit an understanding of the importance of proper dog feces disposal and willingness to pick-up dog waste and encourage others to do so.
- *Generation and implementation of second generation improvement projects:*
  Residents seek expansion of dog waste stations to trailheads that do not have them.
- *Measurable reductions of pollutant loading:*
  Fecal counts by volunteer monitors show decreases in pollutant loading along Sedona trails.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan, how findings will be used:*
  - Year 1 accomplishments report.
  - Project implementation report.
  - Feature stories in local media on project implementation and effectiveness.


Soldier Wash
Mormon Canyon
Sedona
Dry Creek
89A
Carroll Canyon Wash
Chavez Crossing Campground
179
Crescent Moon Day Use Area
Red Rock Crossing
Red Rock Loop Rd
Red Rock State Park
Oak Creek
Verde Valley School Rd
Trailheads
Trails
Arterial Road
Residential Road
CityLimits
Recreation Areas
Major Roads
Minor watercourses
Major watercourses
Oak Creek Watershed
Land Ownership
State Parks
Private
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Fish and Game
USFS
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Photos

Dog feces in drainage on national forest land upstream of Elf Neighborhood. This drainage is a tributary of Carroll Canyon Wash.

Multiple dog feces in the channel and on the bank. Little Elf drainage

EO-3 Lower Oak Creek Watershed Outreach Project

(aka The "Don't Put Crap in the Creek" Project")

Need

Dumping of animal waste into ditches or the creek may be increasing instream *E. coli* concentrations. Construction of irrigation diversion dams may cause sediment deposition that contributes to *E. coli* sediment reservoirs. *E. coli* concentrations were higher (56.4 cfu/100 ml average) at Page Springs and Cornville during July 2012 prior to the monsoon than upstream reaches of Oak Creek (eg. 31.4 cfu/100 ml at Chavez Crossing Campground in Sedona and 10.3 cfu/100 ml in Oak Creek Canyon on average). Turbidity was also noticeably greater. Increased sediment and sediment-water contact in these reaches seems to be the cause of higher *E. coli* concentrations. Although the July 2011 values did not exceed the Full Body Contact standard, there is a concern about *E. coli* loading in this reach that could contribute to exceedences during storm events that disturb sediments.

Description

Work collaboratively with Cooperative Extenstion Service to educate land owners about the impacts of animal waste dumping and provide technical assistance for implementing best management practices for animal waste management. Provide technical assistance to identify best practices for reducing erosion and sedimentation associated with annual earth moving for irrigation diversions. Outreach may involve best management practices workshops.

Estimated load reduction

E. coli bacteria are bacteria that are common to the intestinal tracts of humans and animals. A 1000-pound horse will defecate from 4-13 times each day and produce 35 to 50 pounds of wet manure (feces plus urine) daily, or approximately 9.1 tons per year. E. coli concentrations in fresh and dry manure from horses are 6.17×10^4 CFU per gram and 6.31×10^5 CFU per gram, respectively (NERA, 2012).

A mature cow weighting 1000 lbs produces an average of 8.7 lbs/day of manure (NRCS, 2012) or approximately 1.5 tons per year. Wang et al. (2004) showed that *E. coli* populations extracted from fresh cow manure ranging from 6.55×10^6 to 7.6×10^6 cfu per gram of manure (average of 7.1×10^6 cfu per gram).

If the fresh waste from one animal was dumped into the stream the potential average annual *E. coli* load would be:

Horse (CFU/year) = 9.1 tons/yr * 6.17×10^4 CFU per gram * 907,184.74 grams/ton = 5.1×10^{11} CFU per year

Cow (CFU/year) = 1.5 tons/yr * 7.1×10^6 CFU per gram * 907,184.74 gram/ton = 9.7×10^{12} CFU per year

The actual load reduction is based on the number of people currently dumping waste into the streams and the resulting number of people that stop dumped after the implementation of the Outreach Programs. A monitoring program would be implemented to assess the current rate of dumping and to evaluate the behavior changes after the implementation of Outreach Programs.

References:

Natural Resource Conservation Service (NRCS), access on June 25, 2012. Wyoming Comprehensive Nutrient Management Plan Workbook located at http://www.wy.nrcs.usda.gov/technical/wycnmp/

NERA Website, Access July 2012. NE1041: Environmental Impacts of Equine Operation located at http://lgu.umd.edu/lgu_v2/homepages/attachs.cfm?trackID=11196.

Wang, L., K.R. Mankin, and G.L. Marchin, 2004. Survival of Fecal Bacteria in Dairy Cow Manure. Transactions of the ASAE 47(4): 1239-1246.

Project schedule and milestones

<table>
<tr>
<td rowspan="2">Implementation schedule:
January 2012 through December 2014

Measurable milestones:
~ Enter into MOU with Cooperative Extension Service
~ Plan and implement a workshop or series of workshops to
o listen to landowners' concerns and needs
o teach BMPs for animal waste management and irrigation diversions and
~ Follow-up with assistance for implementing BMPs</td>
<td>Resources and other support commitments:
<ADEQ 319(h) grants
<????>
Commitment date(s):
<None at this time ></td>
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<tr>
<td>Pending commitments:
<Unknown at this time>
Estimated commitment date:
<None at this time ></td>
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</table>

Education and Outreach Strategy

Findings of education needs survey:

The educational needs survey showed that at least 15% of residents do not think livestock waste poses a threat Oak Creek water quality.

At least 17% of residents do not think irrigation diversions cause erosion and sedimentation that poses a threat Oak Creek water quality.

Goals and target audiences:

~ Reach private property owners who irrigate along Oak Creek and/or raise livestock along Oak Creek.
~ Inform them of risks to human health from dumping of animal waste into ditches or the Creek.
~ Educate them about *E. coli* sediment reservoirs and the importance of reducing sedimentation, such as through better practices when constructing irrigation diversion.
~ Offer incentives (technical assistance, evaluation, subsidy) for implementing best management practices.
~ Work cooperatively with land owners to assure implementation of BMPs.

Priority education and outreach projects schedule:

~ Fall 2012 - MOU or informal agreement with Cooperative Extension Service
~ Spring 2013 - BMP workshops; identify land owner needs and challenges; seek ways of helping to meet needs
~ 2013-2014 - Follow-up assistance to landowners for implementing BMPs
~ 2014 - Success stories coverage

Monitoring and Evaluating Effectiveness

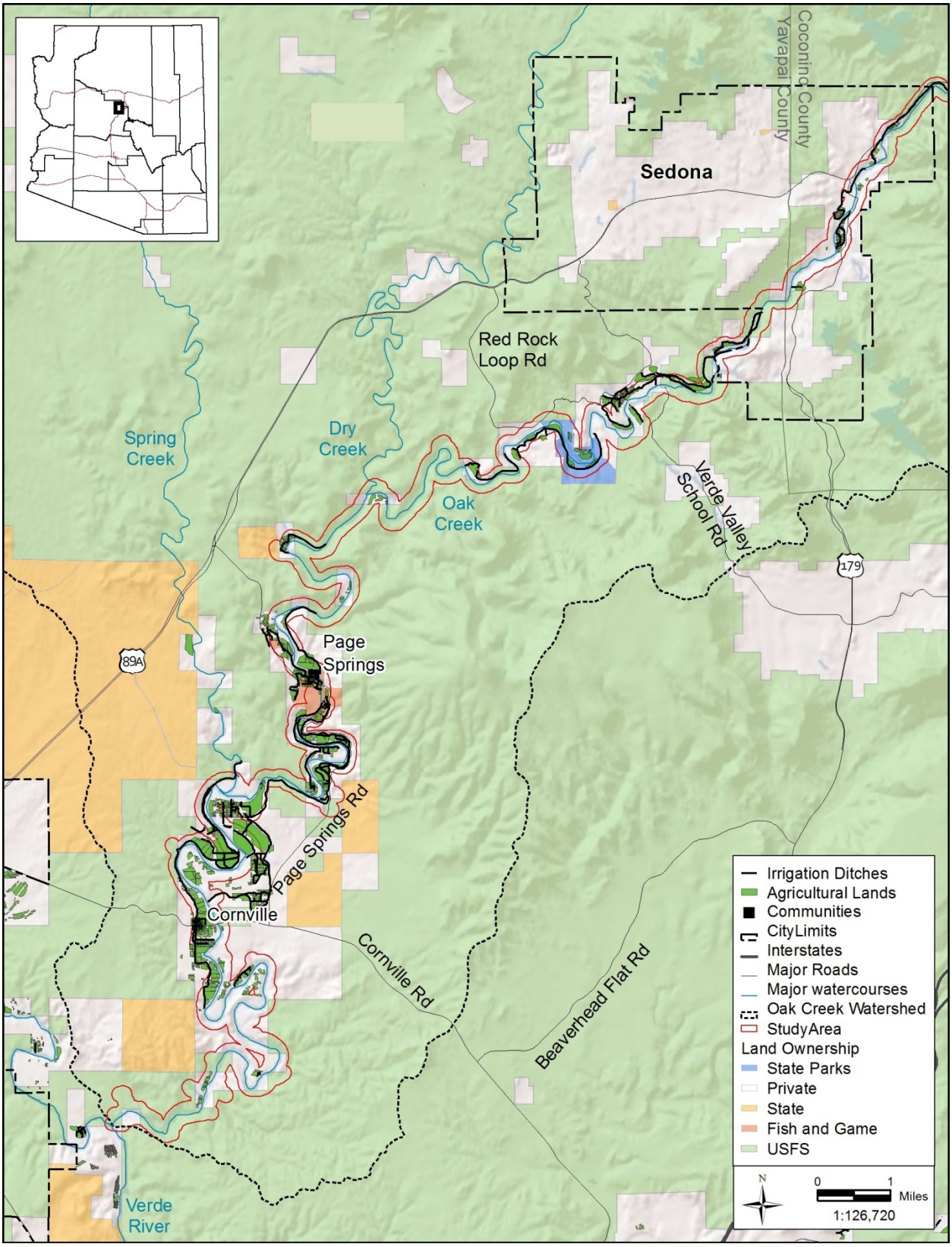
Long-term effectiveness criteria: Landowners at Page Springs and Cornville adopt the regular use of BMPs to reduce sedimentation and pollution by animal waste in Oak Creek.

On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  At least 3 sites each in Page Springs and Cornville will be selected to monitor sediment accumulation, turbidity and *E. coli* concentrations.
- *Parameters & critical conditions:*
  - turbidity (50 NTU)
  - sediment observed through aerial photography and/or field survey
  - *E. coli* (>60 cfu/100 ml)
- *Schedule, frequency and duration*:
  <Early and late summer samples for 1 year pretreatment and 2 years post-treatment.>
- *Volunteers and/or staff for monitoring and data analysis:*
  <OCWC volunteers, staff and consultants>
- *Reporting plan:*
  <Project implementation report, 2-year follow-up monitoring report>

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  At least 10 property owners attend workshop(s) hosted by Cooperative Extension Service and OCWC and learn animal waste management or irrigation diversion practices that reduce sedimentation and fecal pollution of Oak Creek.
- *Generation and implementation of second generation improvement projects:*
  Land owners may provide insight into projects needed to reduce erosion, sedimentation and animal waste inputs into lower Oak Creek.
- *Measurable reductions of pollutant loading:*
  Reduced *E. coli* concentrations
  Lower turbidity measurements during pre-monsoon
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan, how findings will be used:*
  Workshop outcomes report
  BMP implementation report
  Feature stories in local media on project implementation and effectiveness.


Sedona
Coconino County
Yavapai County
Red Rock
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Spring
Creek
Dry
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Verde Valley
School Rd
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Springs
Page Springs Rd
Cornville
Cornville Rd
Beaverhead Flat Rd
Verde
River
Irrigation Ditches
Agricultural Lands
Communities
CityLimits
Interstates
Major Roads
Major watercourses
Oak Creek Watershed
StudyArea
Land Ownership
State Parks
Private
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EO-4 Recreational Vehicle Proper Waste Disposal Outreach Project

(aka The "Don't Put Crap in the Creek" Project)

Need

RV owners may be dumping "black water" into ditches or the creek as evidenced by sewage odor at the Page Springs bridge adjacent to an RV park and past observance of dumping into Oak Creek at Pine Flat and at Cave Springs Crossing. Such dumping, although hopefully not common practice, poses an enormous health risk to downstream swimmers and waders when it occurs.

Description

Work with RV park owners and Coconino National Forest to inform campers of the health effects of dumping waste and assure that they know where to properly dispose of waste.

Estimated load reduction

A typical recreational vehicle holding tank is 40 gallons, although most people will discharge the tank before it is full due to odors. A University of North Dakota study for the U.S. Department of Agriculture regarding human waste distributions reveals the average stool produced is 95.5 grams per day, and 2066 ml of urine per day (Parker and Gallagher 1988). Assuming the average family size of 2.6 people and one week of use the amount of waste created would be:

Urine (l) = 2.6 people * 2066 ml/day * 7 days * 1 liter/1000 ml = 37.6 liters

Fecal Material (kg) = 2.6 people * 95.5 g/day * 7 days * 1 kg/1000 g = 1.7 kg

The Fecal Material estimate is more important in regard to *E. coli*. *E. coli*, as member of the intestinal flora, is part of the digestive process and is excreted in feces. Brandys (2007) found that human stool contained an average of 5 million CFU/gram of *E. coli* bacteria.

Assuming that the Outreach Project changes the behavior of 100 recreational vehicle users per year the average annual E coli load reduction would be 8.7×10^{11} CFU per year.

In order estimate the actual load reduction a survey of recreational vehicle users should be conducted.

Project schedule and milestones

<table>
<tr>
<td rowspan="2">Implementation schedule:
January 2013 through December 2014

Measurable milestones:
~ Engage RV park owners and CNF in discussions regarding the best approach to educating campers.
~ Design a simple, brief, punchy flier(s) that educates campers about health risks of RV waste dumping and a map of waste station</td>
<td>Resources and other support commitments:
ADEQ 319(h) grants
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Commitment date(s):
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<td>Pending commitments:
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Estimated commitment date:
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locations in the watershed. ~ Implement RV owner outreach through fliers and campground visits by volunteers.	

Education and Outreach Strategy

Findings of education needs survey:

The education needs survey targeted residents not campers, so we do not have data on educational needs. However, we will solicit information from RV park owners, the Forest Service and Forest Service's vendor to determine what prevailing attitudes and beliefs are among RV camper owners.

Goals and target audiences:

~ Recreational Vehicle (RV) owners camping in the Oak Creek Watershed
~ Educate RV owners about health risks of "black water" dumping into Oak Creek or its irrigation ditches
~ Provide locations of legitimate waste dump sites, including costs and contact information.
~ Amend attitudes and practices of some RV owners who do not think dumping is a problem.

Priority education and outreach projects schedule:

~ Early 2013 - Meet with CNF and RV park owners
~ Early 2013 - Develop flier
~ Summer 2013 and 2014 - Distribute flier through RV park managers and CNF staff and/or vendor
~ Mid-summer 2013 and 2014 – Volunteers check to see if fliers are being distributed and talk with RV owners in campgrounds to see if they have gotten the message and to survey attitudes, including soliciting input on where disposal stations are needed.

Monitoring and Evaluating Effectiveness

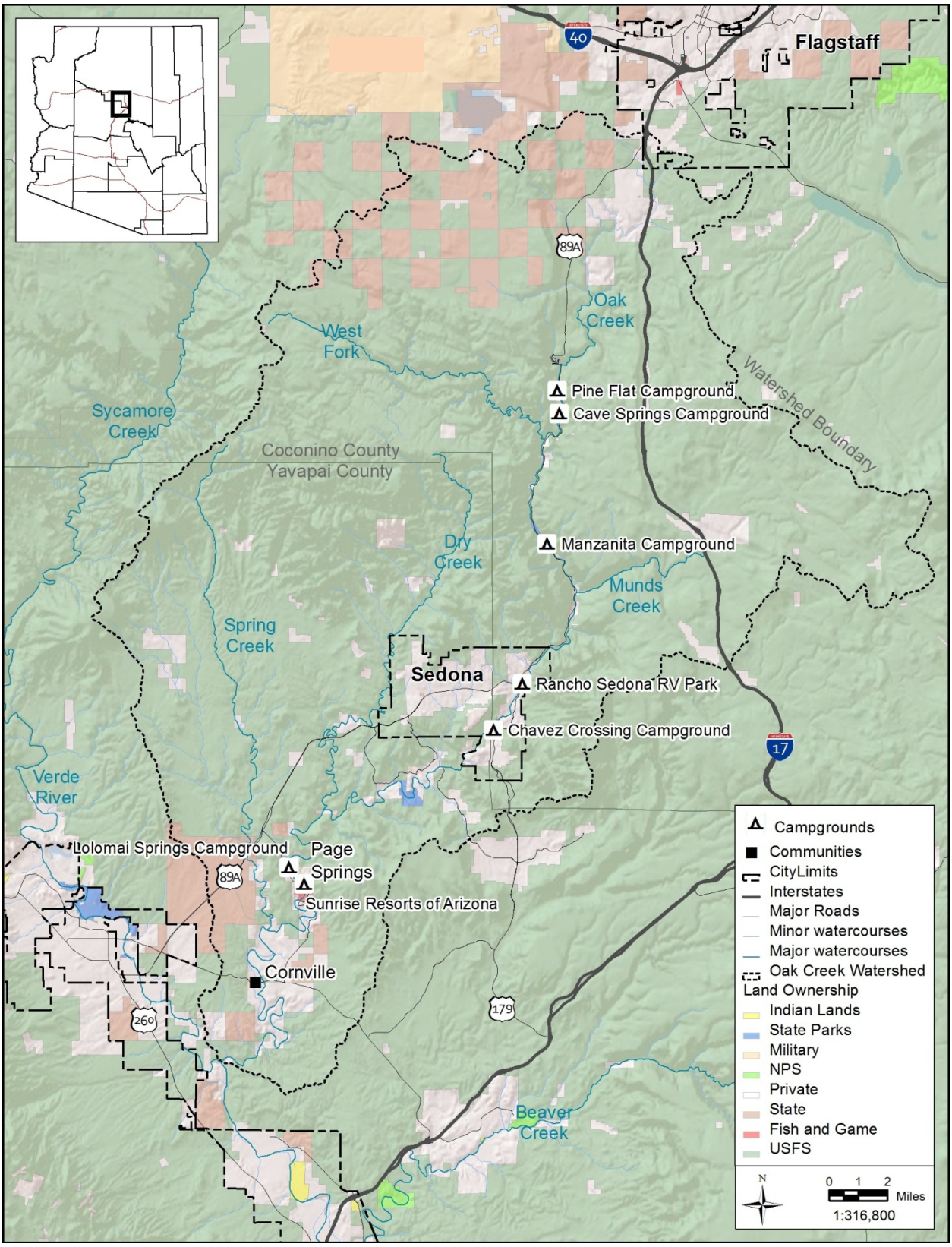
Long-term effectiveness criteria: Decreased observations of illegal dumping of RV black water

On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  The number of RVs using CNF campgrounds will be surveyed by volunteers. Use of dumping stations will be observed.
- *Parameters & critical conditions:*
  - Number of RVs in campground
  - Number of RV waste dumpings per weekend
  - Statements by RV owners regarding attitudes and practices related to waste
  - Statements by RV owners regarding places where RV waste stations are needed
- *Schedule, frequency and duration*:
  Volunteers conduct biweekly surveys of RV campground use, waste dumping, and RV owner attitudes and provide information during summer 2013 and 2014.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan:*
  Annual reports in the fall of 2013 and 2014

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  RV owners recognize health risks of dumping RV black water into Oak Creek or its ditches and modify behavior as evidenced by fewer incidences of dumping and expressions of RV owners' attitudes.
- *Generation and implementation of second generation improvement projects:*
  RV owners express outstanding needs for waste disposal stations so future projects can help support an adequate density of disposal stations.
- *Measurable reductions of pollutant loading:*
  Reduced incidences of black water dumping
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan, how findings will be used:*
  Annual reports in the fall of 2013 and 2014. Success story feature articles.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Pine Flat Campground
Cave Springs Campground
Sycamore Creek
Coconino County
Yavapai County
Dry Creek
Manzanita Campground
Munds Creek
Spring Creek
Sedona
Rancho Sedona RV Park
Chavez Crossing Campground
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Verde River
Lolomai Springs Campground
Page Springs
Sunrise Resorts of Arizona
Cornville
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Beaver Creek
Campgrounds
Communities
CityLimits
Interstates
Major Roads
Minor watercourses
Major watercourses
Oak Creek Watershed
Land Ownership
Indian Lands
State Parks
Military
NPS
Private
State
Fish and Game
USFS
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SS-2 Oak Creek Residential Septic System Improvement Project

Oak Creek Residential Septic System Improvement Project

Need

Some septic systems in the watershed appear to have effluent that is intercepted by springs that carry *E. coli* and/or other pathogens to the creek. During summer 2011 monitoring in Oak Creek Canyon, 20 to 200 cfu/100 ml (average = 72 cfu/100 ml) *E. coli* was found in spring water that emerges from underneath some properties with septic systems. By contrast, only an average *E. coli* concentrations of 9.5 cfu/100ml based was found in creek water. Although E. coli concentrations in spring discharge are below the water quality standard for *E. coli*, they are elevated compared to other spring water and compared to Oak Creek. Therefore, these possibly septic-influenced springs may provide more or less steady supplies of *E. coli* during the summer months that might innoculate sediment reservoirs that are later disturbed by recreation or storm events to cause exceedences of *E. coli* in the water column. Evaluation and upgrade of residential septic systems appears warranted, particularly for community systems with large loads or systems installed during the period of approximately the 1970s to 1980s when deep trenches were a preferred installation and may not have left adequate separation between the leachfield and spring beds.

Description

Technical assistance will be offered to property owners for septic system evaluation and remediation design, and a subsidy will be offered for system upgrades. OCWC will continue monitoring *E. coli* and nutrients in spring discharge, as well as other markers such as DNA and possible tracer dyes, to identify properties where septic system upgrades appear to be in order.

Estimated load reduction

Approximately 10 springs in the Oak Creek Canyon area contain elevated concentrations of *E. coli.* Some failing septic systems in the watershed produce effluent that is intercepted by the springs and carried to the creek. These septic-influenced springs may provide a steady supply of *E. coli* to Oak Creek that may suffuse sediment reservoirs that can be later disturbed by recreational activity or a storm event causing exceedances of *E. coli* in the water column.

The project seeks to reduce the amount of effluent from failing septic systems by offering property owners technical assistance for septic system evaluation and remediation design. Upgrades to the failing septic systems will reduce contaminants from entering the springs, and improve water quality.

The STEPL model (U.S. EPA, 2012) is a spreadsheet tool that uses data inputs provided by the EPA to estimate nutrient and sediment loads. Best management practices can be incorporated into the model to determine the load reductions that would occur if the BMPs are implemented.

The numbers reflected in the load reduction results represent the remediation of all failing septic systems within the five subwatersheds adjacent to Oak Creek Canyon.

Using nitrogen and phosphorus as indicates for *E. coli* the average annual load reduction is:
Sediment – 77.9 tons per year (14.2%)

Nitrogen (N) – 3,506.5 lbs per year (10.3%)
Phosphorus (P) – 601.6 lbs per year (7.8%)

References:

U.S. EPA Website, Access June, 2012. Welcome to STEPL and Region 5 Model, http://it.tetratech-ffx.com/stepl/

Costs ????

Project schedule and milestones

<table>
<tr>
<td rowspan="2">Implementation schedule:
January 2012 through December 2014

Measurable milestones:
~ Baseline springs monitoring complete
~ Septic upgrades identified & prioritized
~ Upgrade funding secured
~ Upgrades implemented
~ Implementation report
~ Follow-up monitoring complete
~ Follow-up report complete</td>
<td>Resources and other support commitments:
ADEQ 319(h) grants
????
Commitment date(s):
<None at this time></td>
</tr>
<tr>
<td>Pending commitments:
<Unknown at this time>
Estimated commitment date:
<None at this time ></td>
</tr>
</table>

Education and Outreach Strategy

Findings of education needs survey:

Watershed residents' opinions about whether improperly functioning septic systems threaten water quality are as follows:

	Not sure	Not a problem	Slight problem	Moderate problem	Large problem
Improperly built or maintain residential septic systems	13%	10%	14%	29%	25%
Improperly built or maintain commercial septic systems	13%	11%	16%	25%	25%

Watershed residents rank septic systems as one of the top three biggest contributors to creek contamination that can cause human illness as follows:

#1 – 23.4%

#2 – 13.2%

#3 – 9.1%

There seems to be a pretty high awareness in the general population about the potential impacts of septic system on water quality. Outreach should be focused on owners of septic systems in locations of concern, such as where there is shallow groundwater.

Goals and target audiences:

~ Reach private septic system owners in Oak Creek Canyon and the Page Springs area where spring underlie septic leachfields.
~ Inform them of risks to human health from poorly functioning septic systems.
~ Offer incentives (technical assistance, evaluation, subsidy) for upgrading septic systems.
~ Work cooperatively with land owners to assure completion of upgrades.

Priority education and outreach projects schedule:

~ Early 2012 - outreach
~ Late 2012 - cooperative agreements
~ 2013 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: *E. coli* concentrations below 5 cfu/100 ml in spring discharge near septic systems.

On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  Approximately 3 springs in Oak Creek Canyon with a history of elevated *E. coli* and suspected residential septic system influence will be monitored along with one reference spring in each vicinity (one spring could serve as reference for multiple affected springs in close proximity).
- *Parameters & critical conditions:*
  - *E. coli* (>5 cfu/100 ml)
  - DNA (presence of human DNA)
- *Schedule, frequency and duration*:
  Early and late summer samples for 1 year pretreatment and 2 years post-treatment
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan:*
  Project implementation report, 2-year follow-up monitoring report

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Residents exhibit an understanding and willingness to have properly functioning septic systems.
- *Generation and implementation of second generation improvement projects:*
  Residents seek additional assistance with septic system improvements.
- *Measurable reductions of pollutant loading:*
  Reduced *E.coli* concentrations in spring discharge where *E. coli* was previously elevated
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan, how findings will be used:*
  Report on outreach effort. Feature stories in local media on project implementation and effectiveness.

RC-2 Oak Creek Canyon Sediment Source Reduction Project

Need

Past studies have noted that sediment reservoirs of *E. coli* buildup at Slide Rock throughout the summer. These reservoirs are composed of fine sediment. Some fine sediment may be yielded from the upper watershed due to hundreds of miles of minimally maintained forest roads, timber harvest by heavy equipment, ATV use, fire scars, soil sculpting actions, and/or grazing. Other sediment is likely generated locally due to soil disturbance from people hiking into the Oak Creek on unmaintained social trails. While Coconino National Forest has done some work to stabilize slopes where social trails have caused erosion, a comprehensive evaluation of erosion problems and implementation of solutions may be needed, in both the riparian areas and the larger watershed.

Description

Evaluate erosion problems upstream of Slide Rock S.P. and within the park, as well as at other high use areas in Oak Creek Canyon where recreators hike down steep slopes from the highway to the creek. Couple this localized evaluation with a more comprehensive study of sediment production and transport in Oak Creek watershed to determine the relative sediment contributions from streamside erosion and erosion in the uplands. Implement best management practices to reduce erosion. Establish well engineered and maintained trails where feasible. Work within national forest trail system guidelines to enable volunteers to perform trail maintenance work. Post signs regarding importance of avoiding erosion to reduce *E. coli* sediment reservoirs that contribute to water quality problems that can close Slide Rock State Park and cause human illness. Have volunteers interface with recreators to discuss the importance of reducing erosion as well as other practices for reducing pollution. Work with Coconino National Forest to develop a plan for addressing sediment source areas in the uplands.

Estimated load reduction

The project seeks to reduce the amount of erosion and sediment entering Oak Creek as a result of soil disturbance from people hiking into Oak Creek Canyon and Slide Rock State Park on unmaintained social trails.

Without knowing the locations of the BMPs that will be implemented, some assumptions must be made in order to formulate a reasonable estimation of load reduction. The Automated Geospatial Watershed Assessment tool (AGWA) with the SWAT model (ARS, 2012) was first run using land cover data downloaded from the SWReGAP server. Land cover was then modified starting at the bridge just below the public swimming area at Slide Rock S.P. upstream just over 0.5 miles to the Halfway Day Use Area in order to represent disturbed soils due to hiking off-trail. Assuming that twenty percent of the entire area could be considered disturbed by people going off the trails and making their own pathways to the stream, the Land Cover Modification Tool within AGWA allows for a partial change of landcover within an area, and the second model reflects that percentage.

The difference between the SWAT model run with normal landcover, and a model run with landcover that reflects 20% of disturbed soil within an area of approximately 50 acres is the reduction of sediment load as a result of trail engineering and maintenance.

Load Reduction: 7.02 tons of sediment per year

References:

Agricultural Research Service (ARS) Website, Access on June, 2012. Automated Geospatial Watershed Assessment Tool located at http://www.tucson.ars.ag.gov/agwa/.

Costs

????

Project schedule and milestones

<table>
<tr>
<td rowspan="2">Implementation schedule:
January 2012 through December 2014

Measurable milestones:
~ Comprehensive study of sediment production and transport in Oak Creek watershed complete, including recommendations to Coconino N.F.
~ Streamside soil stability survey complete
~ Trail improvement and erosion control measures planned
~ All USFS permits and clearances acquired
~ Trail improvement and erosion control measures installed
~ Outreach activities complete
~ Reporting complete</td>
<td>Resources and other support commitments:
ADEQ 319(h) grants
<????>
Commitment date(s):
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</tr>
<tr>
<td>Pending commitments:
<Unknown at this time>
Estimated commitment date:
<None at this time ></td>
</tr>
</table>

Education and Outreach Strategy

Findings of education needs survey:

Watershed residents' opinions of whether erosion and sediment related to recreational activities threaten water quality are as follows:

Activity	Not sure	Not a problem	Slight problem	Moderate Problem	Large 3Problem
Low water creek crossings	17	26	28	14	3
Unmaintained "social" trails	18	23	31	13	4
Jeeps/ORV trails	15	16	22	21	13
Other sources	17	3	2	2	2

Goals and target audiences:

~ Swimmers, waders, hikers and fishermen in Oak Creek Canyon.
~ Inform them of risks to human health from *E. coli* sediment reservoirs in the stream that are partly due to erosion along way trails.
~ Have volunteers offer incentive items to people observed using proper trails rather than cutting across steep slopes and causing erosion.

Priority education and outreach projects schedule:

~ Early summer 2012 - outreach
~ July 2012 - radio PSA about risks of elevated *E. coli* and what people can do to reduce the risk, including reducing erosion, and protect themselves (eg. not swimming in turbid water).
~ 2013 - success stories coverage

Monitoring and Evaluating Effectiveness

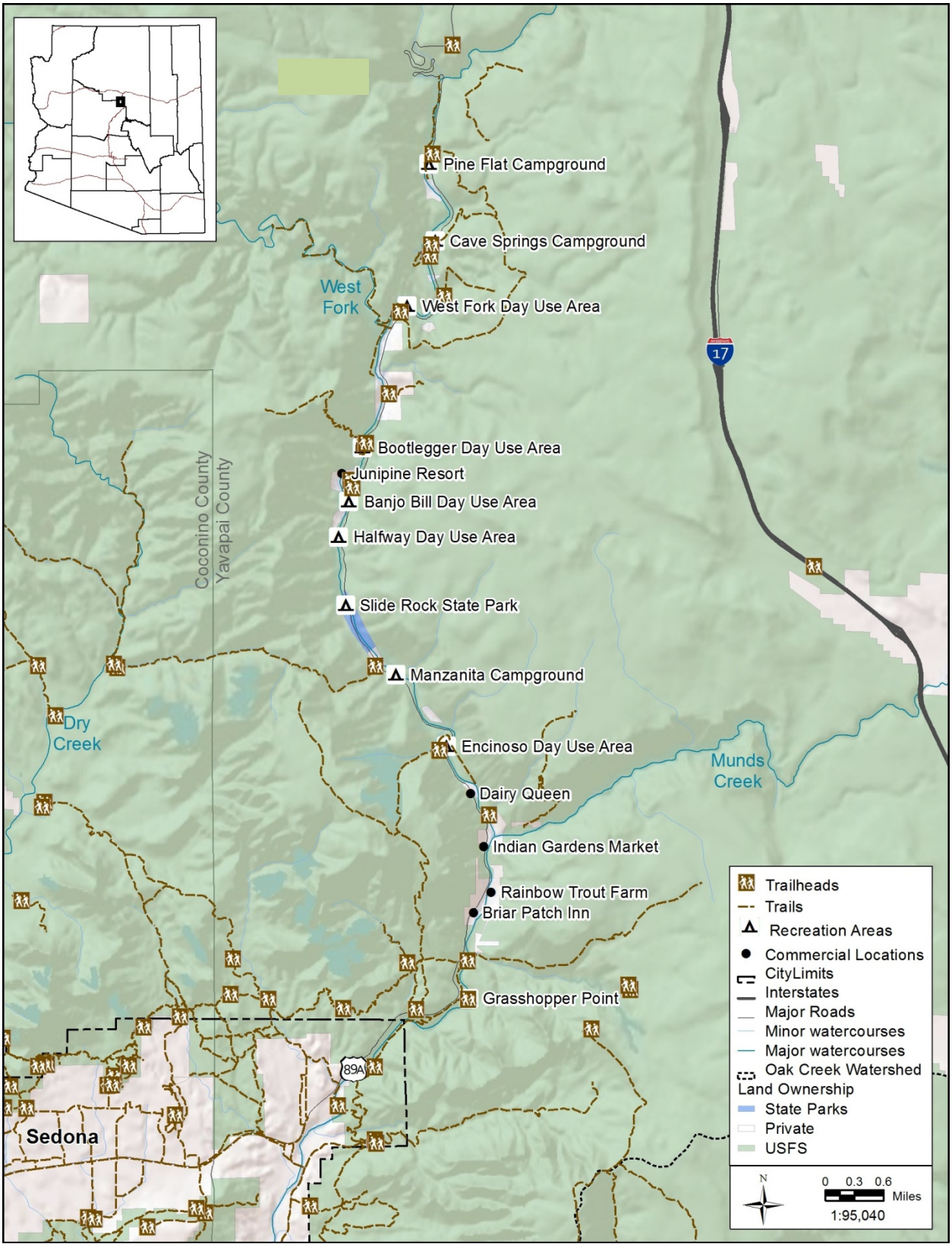
Long-term effectiveness criteria: Reduced *E. coli* exceedances at Slide Rock State Park. Turbidity during peak visitation at S.R.S.P. reduced.

On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  Approximately #? sites along the creek in Oak Creek Canyon will be monitored for *E. coli* and turbidity where soil erosion due to unmaintained way trails (ie. "social trails") is apparent.
- *Parameters & critical conditions:*
  - *E. coli* (>10 cfu/100 ml for elevated values, >235 cfu/100 ml for exceedence)
  - turbidity (>10 NTU for elevated values, >50 NTU for values associated with *E. coli* exceedences)
- *Schedule, frequency and duration*:
  Sampling will occur during high-use weekends in the early-, mid- and late summer. Baseline monitoring will be accomplished in 2012 and effectiveness monitoring will be conducted in 2013-2014.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; Slide Rock S.P. and Coconino National Forest
- *Reporting plan:*
  Annual report on summer monitoring results and interpretation by November of each year. Final analysis report in Fall 2014.

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Recreators exhibit an understanding and willingness to reduce erosion when accessing the creek on way trails in order to reduce *E. coli* sediment reservoirs that can contribute to water contamination and human illness.
- *Generation and implementation of second generation improvement projects:*
  Volunteer organizations, such as Friends of the Forest, provide access trail maintenance and outreach to continue reduced sediment loads.
- *Measurable reductions of pollutant loading:*
  Reduced *E.coli* concentrations and turbidity
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; Slide Rock S.P. and Coconino National Forest
- *Reporting plan, how findings will be used:*
  Implementation accomplishments and monitoring results will be included in an annual report that will be posted to the OCWC website. Feature stories in local media will describe project implementation and effectiveness. Utilize any local hotel/restaurant/campground/chamber of commerce publications to run a small advertisement or mini-feature on protecting Oak Creek.


Pine Flat Campground
Cave Springs Campground
West Fork
West Fork Day Use Area
17
Bootlegger Day Use Area
Junipine Resort
Banjo Bill Day Use Area
Halfway Day Use Area
Coconino County
Yavapai County
Slide Rock State Park
Manzanita Campground
Dry Creek
Encinoso Day Use Area
Munds Creek
Dairy Queen
Indian Gardens Market
Rainbow Trout Farm
Briar Patch Inn
Grasshopper Point
89A
Sedona
Trailheads
Trails
Recreation Areas
Commercial Locations
CityLimits
Interstates
Major Roads
Minor watercourses
Major watercourses
Oak Creek Watershed
Land Ownership
State Parks
Private
USFS
N
0 0.3 0.6
Miles
1:95,040

RC-4 Oak Creek Watershed Dog Waste Station Installation Project

Need

As evidenced by historic and recent investigations that have included DNA source testing of fecal bacteria, dog feces contribute to *E. coli* contamination in Oak Creek. This is especially true in the Sedona area where residents regularly walk their dogs on trails and often do not pick up their dog's feces. Picking up dog feces would be greatly encourage if pet owners had bags readily available for waste and an appropriate trash receptacle at the trailhead instead of having to put bagged feces in their vehicle to carry it home and dispose.

Description

In conjunction with the Sedona Dog Waste Reduction Outreach Project which will encourage social pressure to pick up dog waste, this project will establish dog waste stations at as many trailheads as possible within 3 miles of Oak Creek. OCWC will work collaboratively to secure funding for establishment and maintenance of dog waste stations. Prior to the selection of sites and installation of waste stations, meetings will be convened with collaborators to discuss roles and responsibilities, cost-sharing, necessary permits and clearances, etc. One topic of discussion will be the issue of whether USFS policy allows establishing dog waste stations where there are not official national forest system trails, such as at the Chavez Ranch area that is heavily used for exercising dogs.

Estimated load reduction

Dog feces

E. coli bacteria are bacteria that are common to the intestinal tracts of humans and animals. Walker and Garfield (2008) found that a gram of fresh dog feces contained an average of 50 million CFU/gram with a range of 2 million to 200 million CFU/gram of *E. coli* bacteria. The average dog excretes 0.75 pounds (340 grams) of waste per day (Clear Choices Clean Water, 2012). That equates to an average 17 billion CFU of *E. coli* bacteria per day per dog. If the Sedona Dog Waste Reduction Outreach/Oak Creek Watershed Dog Waste Station Installation Projects prevents 100 dog/days from contaminating Oak Creek this would result in a load reduction 34 kg of dog feces and 17×10^{12} CFU of *E. coli* bacteria.

The goal of the Outreach Project is to improve community awareness on the role of dog waste in water quality impairment of Oak Creek. The Outreach Project should increase the use of the dog waste stations and the rate of dog waste removal. If the Outreach Project increases use of the dog waste stations from 100 to 300 dog/days the result would be a load reduction of 102 kg of dog feces and 5.1×10^{13} CFU of *E. coli* bacteria.

The actual load reduction will depend on the number of people that utilize the dog waste stations, before and after the Outreach Project. A monitoring program should be implemented to assess the use of the dog waste stations.

References:

Clear Choices Clean Water Organization, access on June 27, 2012 http://clearchoicescleanwater.org/wp-content/uploads/2011/08/pet-waste-FAQs_final.pdf

Walker, M. and L. Garfield, 2008. Dog wastes and water quality: Evaluating the connection at Lake Tahoe. University of Nevada Cooperative Extension, Fact Sheet-08-18.

Costs

Item	Units	price/unit	cost
Permits and clearances for waste station installation	#	$$	$$$
Dog waste stations	#	$$	$$$
Legal fees for permit processing, establishment of maintenance agreements, installation contracting (inkind?)	#	$$	$$$

Project schedule and milestones

Implementation schedule:
January 2012 through December 2014

Measurable milestones:
~ Meeting with collaborators (USFS, State Parks) to discuss roles and responsibilities, cost-sharing, necessary permits and clearances, etc.
~ Completed inventory of trails with dog waste stations and those without; identify gaps that must be filled and prioritize the sequence of installations
~ Completed permits, clearances, construction contracting and maintenance agreements
~ Installation of dog waste stations and sign explaining the importance of using them to reduce fecal contamination of Oak Creek and human health risks
~ Effectiveness monitoring complete
~ Reporting complete

Resources and other support commitments:
ADEQ 319(h) grants
????
Commitment date(s):
<None at this time >

Pending commitments:
<Unknown at this time>
Estimated commitment date:
<None at this time >

Education and Outreach Strategy

Findings of education needs survey:

20% of watershed residents walk their dog near Oak Creek.

Dog feces were rated as 1st, 2nd and 3rd biggest contributors to creek contamination by 7.2%, 10.6%, and 10.6% or watershed residents respectively.

44.5 % of watershed residents own a dog.

Of those who own dogs 45.6% walk their dog in the watershed.

Most dog-owning residents (64%) said they always pick up their dog waste, while 19.2% said "most of the time", 5.6 % said "sometimes", 3.2% said "rarely", and 8.0% said "never".

83.5% of watershed residents with dogs say they would use dog waste stations if more were made available at parks and trails.

Watershed residents' opinion of whether dog feces threaten Oak Creek water quality is as follows:

	Not sure	Not a problem	Slight problem
Dog feces that are not picked up and disposed properly	10%	12%	28%

Goals and target audiences:

~ Pet owners who walk dogs on trails within 3 miles of Oak Creek.
~ Work collaboratively with the Sedona Human Society.
~ Increase understanding of importance of picking up dog waste.
~ Affect behaviors so that more pet owners pick up and properly dispose of dog waste.
~ See "Sedona Dog Waste Reduction Outreach Project" for complete details of outreach activities

Priority education and outreach projects schedule:

~ Early 2012 - outreach; trailhead surveys of pet owner attitudes and behaviors
~ Late summer 2012 - follow-up surveys
~ 2013-2014 - continued outreach and follow-up surveys
~ 2013-2014 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: Reduced dog feces counts along trails in Oak Creek watershed. Reduced *E. coli* concentration in Oak Creek, especially *E. coli* with dog-sourced bacterial DNA.

On-the-ground project effectiveness monitoring plan

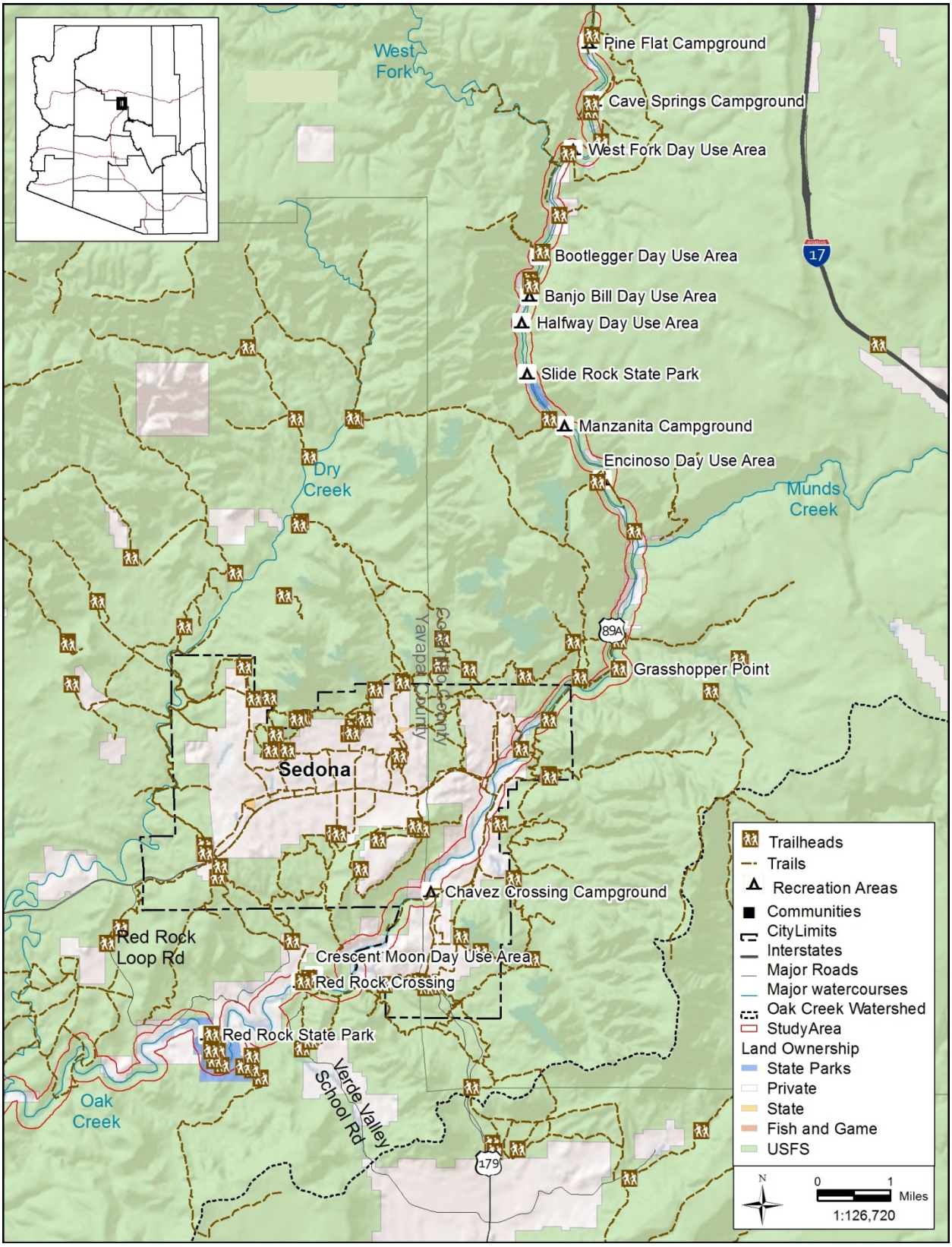
- *Monitoring and reference condition sites*:
  Conduct regular dog feces counts in the summer along trails with a large volume of dog walking, especially Huckaby Trail, Baldwin Trail, West Fork Trail (all FS System trails) and Chavez Crossing trail (social trail). Monitor *E. coli* concentrations and bacterial DNA in Oak Creek during storm events or the day after storm events downstream of the mouths of tributary watersheds with a large volume of dogs walking on trails, including Jordan Pump, Soldier Wash, and Carroll Canyon.
- *Parameters & critical conditions:*
  - Fecal counts along popular trails (>20 dog feces per ¼ mile); feces may be picked up and bagged so they are not double counted.
  - Volume of dog feces collected at waste stations (number of bags dispersed and weight of collection at the waste station)

- *E.coli* (> 90% of average past background or stormflow concentrations; >235 cfu/100 ml for exceedence)
- DNA (seasonal average equal to or greater than baseline or past percentages of dog-sourced DNA in fecal bacteria)

- *Schedule, frequency and duration*:
  Dog fecal counts twice per month in summer. *E. coli* and DNA sampling at least 3 times per summer during or the day after stormflow events.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; Coconino National Forest; Coconino County Rural Environmental Corp. [Try to contract CREC for services to conduct fecal counts and *E. coli* sampling. Require at least one Spanish speaking crew member to interface with the public. Try to have crews along trails on the weekend for a presence to make dog walkers aware of the ramifications of their actions.]
- *Reporting plan:*
  Annual report on summer monitoring results and interpretation by November of each year. Final analysis report in Fall 2014.

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Pet owners exhibit an understanding and willingness to use dog waste stations rather than leaving dog waste on the ground where it can wash into Oak Creek and cause fecal contamination that threaten human health.
- *Generation and implementation of second generation improvement projects:*
  Pet owners may identify additional sites where dog waste stations may be appropriate, initiating future projects.
- *Measurable reductions of pollutant loading:*
  Reduced *E. coli* concentrations and dog-sourced bacterial DNA in Oak Creek water. Reduced dog feces along trails.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants; Slide Rock State Park; Coconino National Forest; Coconino Rural Environmental Corp
- *Reporting plan, how findings will be used:*
  Annual accomplishments and monitoring report in the fall each year will be posted to OCWC website. Feature stories in local media will describe project implementation and effectiveness.


West Fork
Pine Flat Campground
Cave Springs Campground
West Fork Day Use Area
Bootlegger Day Use Area
Banjo Bill Day Use Area
Halfway Day Use Area
Slide Rock State Park
Manzanita Campground
Encinoso Day Use Area
Dry Creek
Munds Creek
Yavapai County
Coconino County
89A
Grasshopper Point
Sedona
Chavez Crossing Campground
Red Rock Loop Rd
Crescent Moon Day Use Area
Red Rock Crossing
Red Rock State Park
Oak Creek
Verde Valley School Rd
179
17
Trailheads
Trails
Recreation Areas
Communities
CityLimits
Interstates
Major Roads
Major watercourses
Oak Creek Watershed
StudyArea
Land Ownership
State Parks
Private
State
Fish and Game
USFS
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1:126,720

AG-1 Animal Waste BMPs for Oak Creek Watershed

Need

Some livestock owners have reportedly dumped animal waste into irrigation ditches that drain into Oak or into Oak Creek directly. Elevated *E. coli* concentrations in Oak Creek in areas where livestock are kept appears to corroborate waste dumping and its impacts. For example, from Page Springs to the Verde Confluence the average baseline *E. coli* concentration in summer 2011 was 56.4 cfu/100 ml, compared to 31.4 cfu/100 ml at Chavez Crossing Campground in the City of Sedona and 10.3 cfu/100 ml in Oak Creek Canyon. Concentrated doses of fecal matter can cause spikes in *E. coli* and other related pathogens as well as innoculate *E. coli* sediment reservoirs that later contaminate water when disturbed by storm flows or recreation activities. The resulting pathogen loads may threaten the health of people wading and swimming in Oak Creek. The excess nutrients and organic matter can also have a deleterious impact on aquatic life. Perhaps some livestock owners do not know the serious environmental impacts of dumping animal waste into water bodies. Outreach, education and technical support are needed to help landowners initiate best management practices for animal waste.

Description

OCWC will collaborate with Cooperative Extension Service, the Verde Natural Resources Conservation District, local ditch assocations and any livestock organizations in the watershed. The location of all livestock owners will be determined through aerial and driveby surveys and any available databases related to livestock producers and horse, goat, sheep, llama etc. owners. A focused outreach effort will be made to educate livestock owners on the water quality impacts of dumping animal waste into water. Assistance will be provided to implement best management practice alternatives to dumping, such as those listed on the Cooperative Extension Service website: http://ag.arizona.edu/animalwaste. Demonstration workshops will be held in the watershed to teach BMP background and techniques to livestock owners. Workshop presenters should appeal to landowners environmental ethics but also emphasize if there is an economic advantage to proper waste management, such use of waste for improving soil fertility or selling composted waste to farmers and gardeners. Material and technical assistance will be provided to operators as they initiate BMPs. USFS hydrologist Amina Sena recommends pursuing a grant to fund a pick up for livestock waste at no cost for one year to quantify exactly how much people may potentially be dumping in the creek

Estimated load reduction

E. coli bacteria are bacteria that are common to the intestinal tracts of humans and animals. A 1000-pound horse will defecate from 4-13 times each day and produce 35 to 50 pounds of wet manure (feces plus urine) daily, or approximately 9.1 tons per year. E. coli concentrations in fresh and dry manure from horses are 6.17×10^4 CFU per gram and 6.31×10^5 CFU per gram, respectively (NERA, 2012).

A mature cow weighting 1000 lbs produces an average of 8.7 lbs/day of manure (NRCS, 2012) or approximately 1.5 tons per year. Wang et al. (2004) showed that *E. coli* populations extracted from fresh cow manure ranging from 6.55×10^6 to 7.6×10^6 cfu per gram of manure (average of 7.1×10^6 cfu per gram).

If the fresh waste from one animal was dumped into the stream the potential average annual *E. coli* load would be:

Horse (CFU/year) = 9.1 tons/yr * 6.17 x 10^4 CFU per gram * 907,184.74 grams/ton = 5.1 x 10^{11} CFU per year
Cow (CFU/year) = 1.5 tons/yr * 7.1 x 10^6 CFU per gram * 907,184.74 gram/ton = 9.7 x 10^{12} CFU per year

The actual load reduction is based on the number of people currently dumping waste into the streams and the resulting number of people that stop dumped after the implementation of the Outreach Programs. A monitoring program would be implemented to assess the current rate of dumping and to evaluate the behavior changes after the implementation of Outreach Programs.

References:

Natural Resource Conservation Service (NRCS), access on June 25, 2012. Wyoming Comprehensive Nutrient Management Plan Workbook located at http://www.wy.nrcs.usda.gov/technical/wycnmp/

NERA Website, Access July 2012. NE1041: Environmental Impacts of Equine Operation located at http://lgu.umd.edu/lgu_v2/homepages/attachs.cfm?trackID=11196.

Wang, L., K.R. Mankin, and G.L. Marchin, 2004. Survival of Fecal Bacteria in Dairy Cow Manure. Transactions of the ASAE 47(4): 1239-1246.

Costs

????

Project schedule and milestones

<table>
<tr><td rowspan="2">Implementation schedule:
January 2012 through December 2014

Measurable milestones:
~ Collaboration agreement with Cooperative Extension Service and the Verde Natural Resources Conservation District
~ Map of irrigation 22 irrigation ditches and contact information for each
~ Survey of livestock properties including location, livestock type and estimated number of animals
~ #? BMP workshops
~ #? livestock owners provided material and technical assistance for initiating BMPs
~ Quarterly and final reports</td><td>Resources and other support commitments:
ADEQ 319(h) grants
????
Commitment date(s):
<None at this time ></td></tr>
<tr><td>Pending commitments:
<Unknown at this time>
Estimated commitment date:
<None at this time></td></tr>
</table>

Education and Outreach Strategy

Findings of education needs survey:

The following reflects watershed residents' views on the whether livestock waste threatens water quality:

Ag. Runoff	Not sure	Not a problem	Slight problem
Livestock manure	20%	15%	22%

Goals and target audiences:

~ Owners of warm-blooded livestock in Oak Creek watershed
~ Advertise workshops in local specialty publications (eg. 4H newsletter), bulletin boards at feed stores, NRCD list serve or newsletter, etc.
~ Inform livestock owners of risks to human health from dumping livestock excrement into water, because of pathogens and dosing of *E. coli* sediment reservoirs that later cause water contamination when reservoirs are disturbed by stormflows or recreation activity.
~ Provide educational workshops and hands-on demonstrations while assisting livestock owners with the initiation of BMPs.

Priority education and outreach projects schedule:

~ Spring 2012 - Establish collaboration with other natural resources professionals who can provide expert instruction
~ Fall through Spring 2012-2014 – BMP workshops and demonstrations
~ 2014 - success stories coverage

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: Reduced *E.coli* concentrations in reaches of Oak Creek where livestock are common.

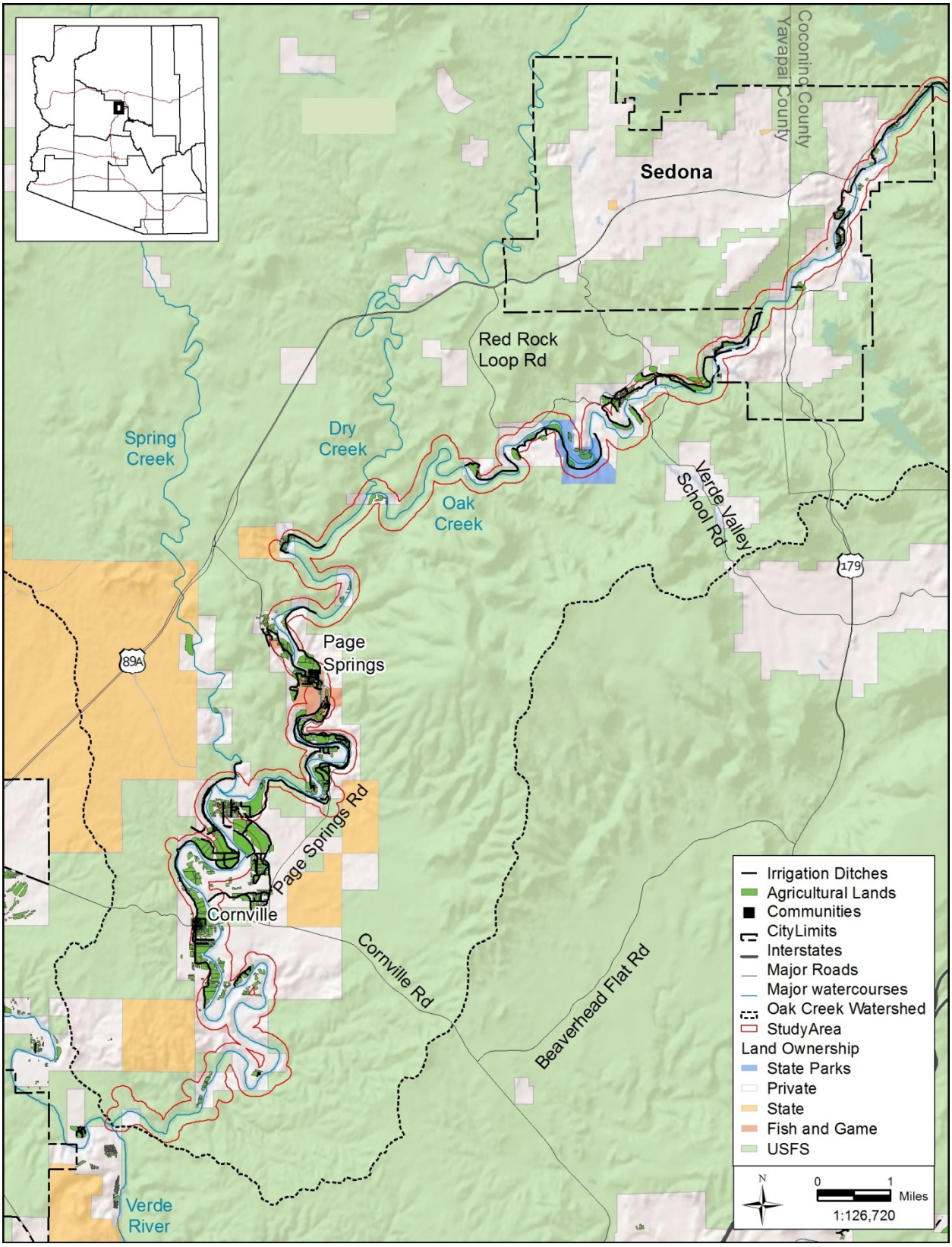
On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  Continue monitoring *E. coli* and DNA at OCWIP monitoring sites during summer months in reaches where livestock are common, from below Red Rock State Park (M29) to Cornville Estates (M41).
- *Parameters & critical conditions:*
  - *E. coli* (greater than average baseline concentration for each site in 2011)
  - DNA, if practical and affordable (% horse-, sheep-, etc.-sourced bacterial DNA greater than percentages found in Oak Creek Canyon by Southam in 1999) University of Arizona could test bovine DNA and forward water samples or extracted DNA to other lab(s) for testing of other livestock species.
- *Schedule, frequency and duration*:
  At least 3 samples each during baseline and stormflow conditions throughout the summer months, 2012-2014. Sampling may be combined with sampling efforts for other projects.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants, University of Arizona and other contracted genetics laboratories

- *Reporting plan:*
  Annual report on sampling, data analysis and interpretation. Assessment of BMP effects on water quality in project final report.

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Livestock owners exhibit an understanding and willingness to use animal waste management BMPs to reduce fecal contamination of Oak Creek.
- *Generation and implementation of second generation improvement projects:*
  Local ditch associations seek grant funding for projects to improve animal waste management to maintain quality of irrigation tail water.
- *Measurable reductions of pollutant loading:*
  Reduced *E.coli* concentrations. Reduced percentage of bacterial DNA attributed to livestock species.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants, University of Arizona and other contracted genetics laboratories
- *Reporting plan, how findings will be used:*
  Annual reports on workshop and demonstration attendance. Feature stories in specialty publications for livestock owners regarding progress of project and results of monitoring. Success stories in local media.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AG-2 Oak Creek Irrigation Diversion Erosion Reduction Project

Need

Annual earth moving activities to build or restore irrigation diversion structures may be introducing large quantities of sediment to creek, which can contribute to *E. coli* sediment reservoirs, which in turn cause water contamination when sediments are disturbed by stormflows or recreation activities. This is evidenced by anecdotal accounts, aerial photo interpretation and *E. coli* concentrations that have been found higher in reaches with irrigation diversions that appear to be contributing sediment to the stream channel. Also, irrigation tailwater that enters ditches may deliver sediment to the creek from fields with unstable soils. Besides sediment inputs potentially increasing *E. coli* in to Oak Creek water, sediment is also disruptive to benthic organisms that are essential to the stream's food web. Most of the sediment problems associated with irrigation appear to be in the lower reaches of Oak Creek where stream bed and bank material is finer grained and usually must by reworked on an annual basis for maintenance of diversion structures. In Oak Creek Canyon there are several diversion structions, but the coarseness of the material and the infrequency with which it is disturbed may mean there is less erosion and sedimentation.

Description

Map all irrigation diversions and ditches. Have volunteers float/wade the creek with a GPS unit, camera, and notebook to inventory irrigation infrastructure (diversion dams, gates, ditch starts, ditch outfalls, etc.). Work collaboratively with Yavapai County GIS, ADWR, NRCD and Cooperative Extension on mapping ditches. Engage local ditch associations. Interface with Army Corp of Engineers to ascertain whether there are current 404 permits for diversions or whether some diversions predate the 404 rules and are thereby exempt due to a grandfather clause. For any diversions that do require a 404 permit, evaluate structures to see if excavations may be out of compliance. Identify problem areas and provide incentives to implement Best Management Practices, such as using larger diameter material for diversion dams, as recommended by NRCD, Cooperative Extension Service or others, to reduce erosion and sedimentation associated with irrigation diversions. Develop a plan for at least 3 diversion structures to reduce erosion/sedimentation and provide assistance in applying for grants to fix problems.

Estimated load reduction

The StepL modeling tool was used to estimate the load reductions by reducing sediment caused by irrigation structures. It was assumed that the BMPs would have a load reduction efficiency of 50%. The estimated average annual load reduction is:
Sediment – 10.2 tons per year
Nitrogen (N) – 267.6 lbs per year
Phosphorus (P) – 30.2 lbs per year

References:

U.S. EPA Website, Access June, 2012. Welcome to STEPL and Region 5 Model, http://it.tetratech-ffx.com/stepl/

Costs

????

Project schedule and milestones

<table>
<tr>
<td rowspan="2">Implementation schedule:
January 2012 through December 2014

Measurable milestones:
~ Collaboration agreement with Cooperative Extension Service and the Verde Natural Resources Conservation District
~ Map of irrigation 22 irrigation ditches and contact information for each
~ Survey of irrigation infrastructure condition and erosion/sedimentation trouble spots
~ #? 404 permits identified as out of compliance (if relevant)
~ #? diversion renovation plans/grant proposal frameworks
~ Quarterly and final reports</td>
<td>Resources and other support commitments:
ADEQ 319(h) grants
????
Commitment date(s):
<None at this time></td>
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<td>Pending commitments:
<Unknown at this time>
Estimated commitment date:
<None at this time (Sept 2011)></td>
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Education and Outreach Strategy

Findings of education needs survey:

The following reflects watershed residents' views on the whether irrigation diversions can cause erosion and sedimentation that may threaten water quality:

Activity	Not sure	Not a problem	Slight problem
Construction and maintenance of irrigation diversions	21%	17%	28%

Goals and target audiences:

~ Irrigation association members along Oak Creek
~ Contact association administrators (ie. ditch bosses or similar) and invite them to a round table discussion about irrigation infrastructure on Oak Creek and how it might be affecting water quality. Dangle the carrot of assistance with writing grant proposals to obtain funds for system upgrades. Establishing a friendly working relationship with ditch administrators is critical.
~ After irrigation systems have been surveyed and problem spots are identified, go on a "show me" tour of the good, the bad and the ugly with interested members of irrigation associations. Advertise and/or invite though contact information provided by ditch administrators.
~ Solicit volunteers among ditch associations to participate in demonstration projects and collaboratively write grant proposals with volunteers for further system upgrades.
~ Host demonstrations of BMPs to reduce erosion and sedimentation associated with irrigation diversions.

Priority education and outreach projects schedule:

~ Fall 2012 to Spring 2013 – Round table discussions
~ Spring 2013 – Show me tour(s)
~ Fall 2014 to Spring 2014 - Demonstration projects (might be combined with animal waste BMP demonstration projects in a 2-day conference, maybe rent the Dancing Apache?)

Monitoring and Evaluating Effectiveness

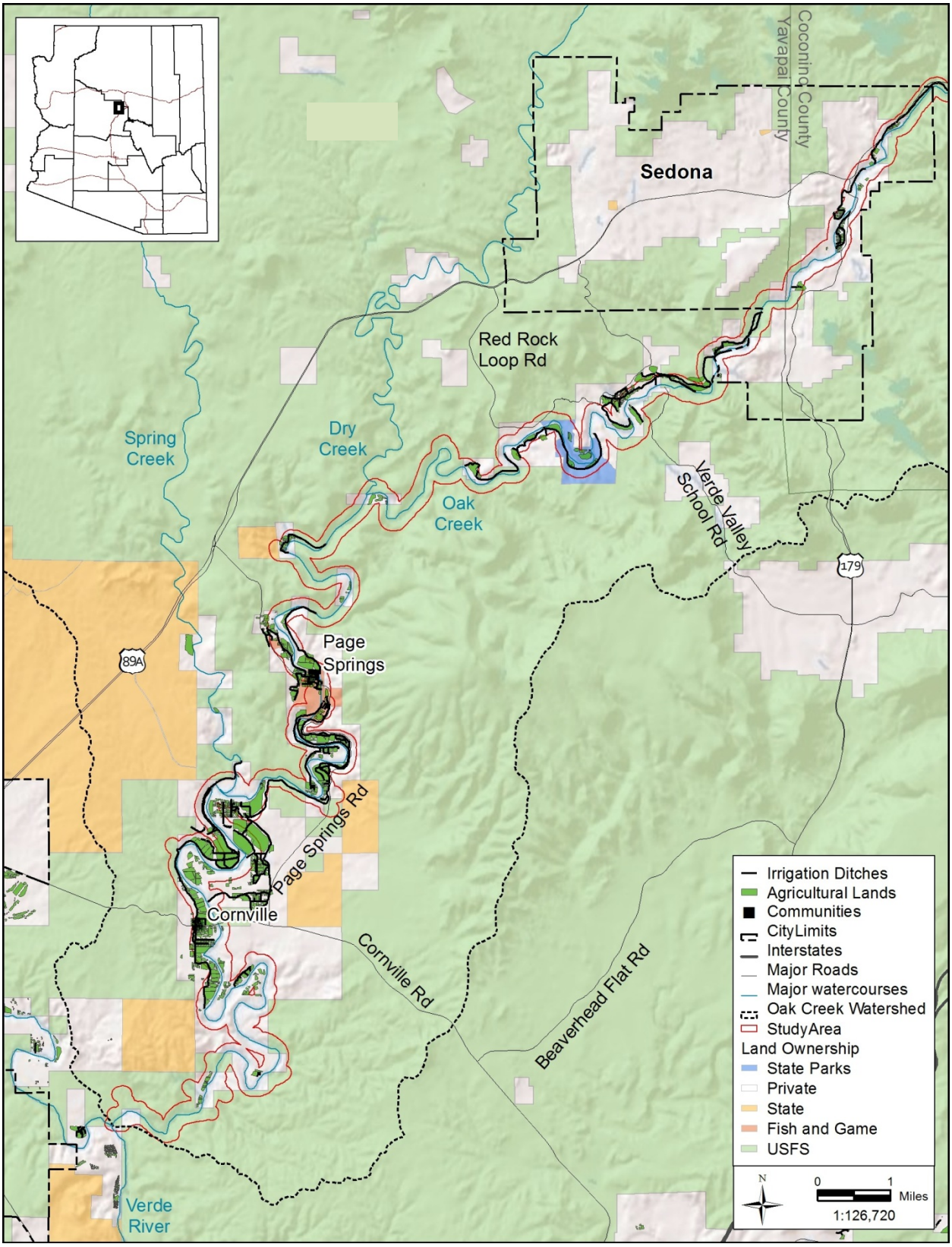
Long-term effectiveness criteria: Reduced *E. coli* concentrations and sediment in reaches of Oak Creek where irrigation diversions correspond with erodible materials.

On-the-ground project effectiveness monitoring plan

- *Monitoring and reference condition sites*:
  Continue monitoring *E. coli* and turbidity at OCWIP monitoring sites during summer months in reaches where irrigation diversions correspond with erodible materials, from below Red Rock State Park (M29) to Cornville Estates (M41).
- *Parameters & critical conditions:*
  - *E. coli* (greater than average baseline concentration for each site in 2011)
  - Turbidity (>50 NTU)
- *Schedule, frequency and duration*:
  At least 3 samples each during baseline and stormflow conditions throughout the summer months, 2012-2014. Sampling may be combined with sampling efforts for other projects.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan:*
  Annual report on sampling, data analysis and interpretation. Assessment of the adoption irrigation diversion BMPs and potential effects on water quality in project final report.

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Irrigators exhibit an understanding and willingness to use BMPs to reduce erosion and sedimentation associated with irrigation diversions in Oak Creek.
- *Generation and implementation of second generation improvement projects:*
  Local ditch associations seek grant funding for projects to upgrade irrigation diversions so that annual maintenance is less disruptive and generates less sediment.
- *Measurable reductions of pollutant loading:*
  Reduced *E.coli* concentrations. Reduced turbidity.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan, how findings will be used:*
  Annual reports on show me tour and demonstration attendance. Feature stories in specialty publications for livestock owners regarding progress of project and results of monitoring. Success stories in local media.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Photos

Examples of how excavation of fine-grained material can be very disruptive to the channel. These photos are from the Verde River upstream of Deadhorse Ranch State park.

AG-3 Lower Oak Creek Erosion Reduction Project

Need

Turbidity is persistent in the lower reaches of Oak Creek – Page Springs through Cornville to Verde River confluence – even during dry weather when upper reaches of Oak Creek are clear, indicating multiple sources of sediment in the lower reaches. These same reaches have baseline *E. coli* concentrations higher that upper reaches (56.4 cfu/100ml average compared to 31.4 cfu/100 ml in Sedona area and 10.3 cfu/100 ml in Oak Creek Canyon). Reportedly there is a least one low-water crossing (a.k.a. ford) across Oak Creek downstream of Cornville that may be contributing sediment to the creek. Sediment is a problem because it causes turbidity which has been strongly correlated with *E. coli* in Oak Creek, probably because *E.coli* on sediment particles transfers to the water when the particles are suspended in the water column. Low water crossings need to be mapped and evaluated and alternatives explored to reduce erosion and sedimentation. Also, erosion has been observed after summer monsoon rain along roadways in the Cornville area, eg. along Sexton Ranch Road, which is likely delivering sediment to Oak Creek. Sediment production from roadways, properties under development, and recently developed needs to be evaluated to determine whether Yavapai County should revise policies, road mainteance procedures, regulations or building codes to limit erosion and sedimentation.

Description

Map all low-water crossings on Oak Creek. Have volunteers float/wade the creek with a GPS units, camera, and notebook to inventory low water crossings and notes locations with apparent elevated turbidity. (Field work can be combined with inventory of irrigation infrastructure.) Assess road network conditions for adequate drainage to avoid erosive flows along road beds or ditches. Inspect recently developed properties that are without established vegetation to see whether stormwater BMPs are needed to slow runoff and reduce erosion. Work collaboratively with property owners and/or Yavapai County to explore implementing improvements to reduce sediment inputs. Improvements may include cement fords or bridges (depending on resources available) terracing, additional culverts, improved road prisms and so forth. Offer to help write grant proposals to secure funding to upgrade low-water crossings and road drainage.

Estimated load reduction

The project will map low-water crossing on Oak Creek which in itself will not produce a load reduction in sediment. The project will provide information for the formulation of future BMPs to reduce sedimentation.

Costs

????

Project schedule and milestones

Implementation schedule: January 2012 through December 2014 *Measurable milestones:* ~ Meet with Roads Division of Yavapai County Public Works to discuss road	*Resources and other support commitments:* ADEQ 319(h) grants ???? *Commitment date(s):* <None at this time >

maintenance and improvements that could reduce erosion and sedimentation ~ Low-water crossings inventoried ~ Roadway inspections complete ~ Meet with property owners regarding low-water crossings and any properties with overt erosion problems ~ Report with recommendations and grant proposal frameworks ~ Quarterly and final reports	*Pending commitments:* <Unknown at this time> Approach SRP; they may be interested in erosion control projects to reduce sedimentation of water storage reservoirs *Estimated commitment date:* <None at this time >

Education and Outreach Strategy

Findings of education needs survey:

The following reflects watershed residents' view on the impacts of road construction and road maintenance on erosion and sedimentation which can affect water quality:

Activity	Not sure	Not a problem	Slight problem
Road construction	17%	17%	30%
Road maintenance	17%	20%	34%

Goals and target audiences:

~ Property owners in the lower reaches of Oak Creek watershed
~ Contact property owners and/or Yavapai County regarding low-water crossings, roadways or building sites that appear to be contributing to erosion and sedimentation and discuss options for improving the road network and overall soil stability. Keep in mind that Yavapai County has a very strong property rights ethic and may not welcome any strangers who appear on their door step regardless of your intentions. Send a post card in advance of visit to inform property owner about the project, give them a link to the OCWC website, and provide a contact phone number.
~ Take interested property owners on a "show me" trip to see erosion problems. Pitch idea of helping with grant proposals and/or lobbying the county for upgrades to reduce erosion. Also sell the idea of better access to their properties during storm events.

Priority education and outreach projects schedule:

~ Winter/spring 2013 – post cards and site visits
~ Summer 2013 – Show me tour(s)
~ Fall 2013 to Spring 2014 – Writing grant proposal and holding forums with Yavapai County and residents to seek funding and develop a plan for improving roadways to reduce erosion.

Monitoring and Evaluating Effectiveness

Long-term effectiveness criteria: Reduced turbidity and *E. coli* concentrations in the lower reaches of Oak Creek

On-the-ground project effectiveness monitoring plan

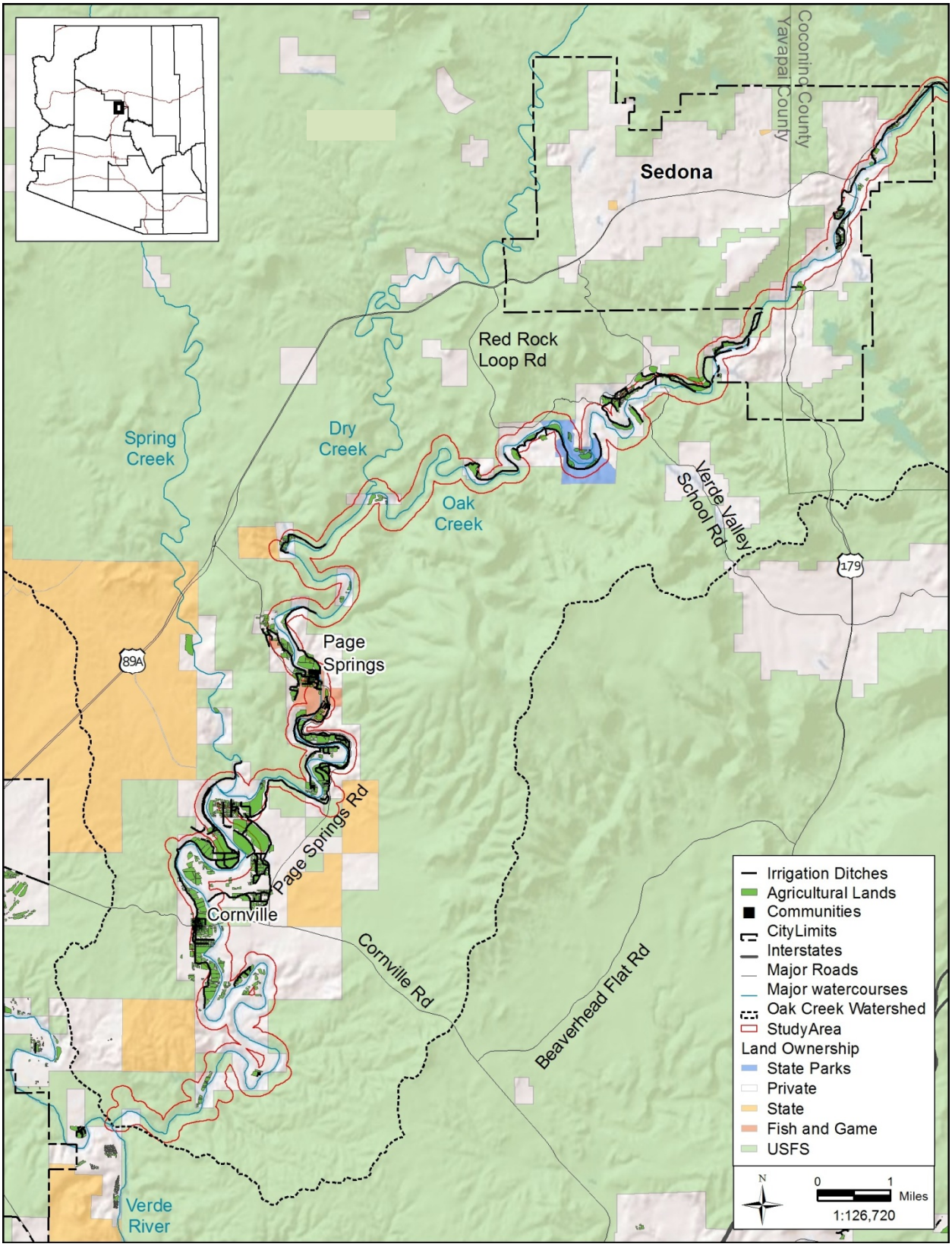
- *Monitoring and reference condition sites*:

Continue monitoring *E. coli* and turbidity at OCWIP monitoring sites during summer months in reaches where turbidity is usually elevated compared to upstream reaches, from Page Springs down to the Verde River confluence.

- *Parameters & critical conditions:*
  - *E.coli* (greater than average baseline concentration for each site in 2011)
  - turbidty (>50 NTU)
- *Schedule, frequency and duration*:
  At least 3 samples each during baseline and stormflow conditions throughout the summer months, 2012-2014. Sampling may be combined with sampling efforts for other projects.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan:*
  Annual report on sampling, data analysis and interpretation. Assessment of possible correlations between road conditions and turbidity in project final report.

Education effectiveness monitoring

- *Long-term behavior change criteria:*
  Property owners appreciate the importance of reducing sedimentation through proper roadway design, construction and maintenance to help reduce water quality impacts and take action to improve road conditions.
- *Generation and implementation of second generation improvement projects:*
  Property owners seek grant funding and/or Yavapai County support for projects to upgrade roadways and low-water crossing to reduce sedimentation.
- *Measurable reductions of pollutant loading:*
  Reduced turbidity. Reduced *E.coli* concentrations.
- *Volunteers and/or staff for monitoring and data analysis:*
  OCWC volunteers, staff and consultants
- *Reporting plan, how findings will be used:*
  Annual reports on show me tours. Feature stories in local media.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