Water Quality in Deer Creek and its Tributaries:

An analysis of samples collected by Stream Team 2760

Deer Creek at the LREC horse trail site

Danelle Haake
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Executive Summary

Staff and volunteers at the Litzsinger Road Ecology Center (LREC) in Ladue, Missouri, monitor water quality in Deer Creek. Monitoring results presented in this report represent three years of water chemistry data collection at seven sites along Deer Creek and its tributaries as well as six years of benthic macroinvertebrate study at LREC.

Water chemistry parameters are sampled monthly using Missouri Stream Team methods: dissolved oxygen, air temperature, water temperature, nitrate, conductivity, turbidity, flow rate, pH, and chloride. Data show that pH is periodically lower than desired at the upstream sites. Dissolved oxygen concentrations fluctuate fairly widely, often falling below the 5 mg/l that is vital to support a healthy fish and macroinvertebrate community. Chloride concentrations are often very high in winter, reaching levels that are considered toxic to fish and invertebrates; this chloride is associated with runoff of water containing road salt during snow melt.

Benthic macroinvertebrate samples are collected annually in both the spring and the fall. Monitoring has shown that populations in Deer Creek are generally more diverse in the fall than in the spring. The presence of fish is noted in May through September, but they are rarely seen October through April.

Stream flow data is collected by the U.S. Geological Survey (USGS) at the Litzsinger Road bridge at the downstream end of the LREC property, as well as several other sites in the watershed. Considering the urban setting of Deer Creek and the high variability of flow in the stream, the ecology of the stream seems fairly intact.

Introduction

Deer Creek is a fourth order stream in St. Louis County, Missouri (Figure 1). It is a tributary to the River Des Peres. The stream length is 10.8 miles (CARES, 2008). Contributing streams include Two-Mile Creek, Sebago Creek, Shady Grove Creek, and Black Creek. The watershed of Deer Creek is located in the heart the St. Louis suburbs and drains approximately 37 square miles, including large portions of the municipalities of Brentwood, Creve Coeur, Frontenac, Glendale, Ladue, Maplewood, Richmond Heights, Rock Hill, Webster Groves, and others.

Members of Stream Team 2760, Litzsinger Road Ecology Center (LREC) Stream Team, have been collecting water quality data since 2005. Originally, this effort was intended to provide an opportunity for members of the LREC community to learn about water quality, to practice their monitoring skills, and to generate some baseline information on the ecology of Deer Creek. Beginning in 2008, water chemistry data has been collected as well. This baseline data was to be used by the staff at LREC as well as members of the St. Louis County Department of Health who were working to fill the needs of a multi-watershed 319 water quality improvement grant.

More recently, the 319 water quality improvement grant has been transferred to the Missouri Botanical Garden. A nine-point watershed plan has been submitted to EPA and a new 319 grant has been awarded to continue the implementation of the plan. The administrators of the grant are utilizing the data set collected by the LREC Stream Team as part of their monitoring requirements.

Sampling Plan and Results

Regular monitoring commenced on February 28, 2008. Water chemistry samples were collected at seven sites in the Deer Creek watershed on 30 or 31 occasions; some sites were not sampled on one occasion due to weather. In addition, 14 sets of aquatic macroinvertebrate samples have been collected at two sites on LREC property since 2005. Water quality sampling is expected to continue approximately once per month through the grant period with two biological samples collected per year. The level of interest of the Stream Team Volunteers for additional sampling beyond the period of the grant will be evaluated at that time.

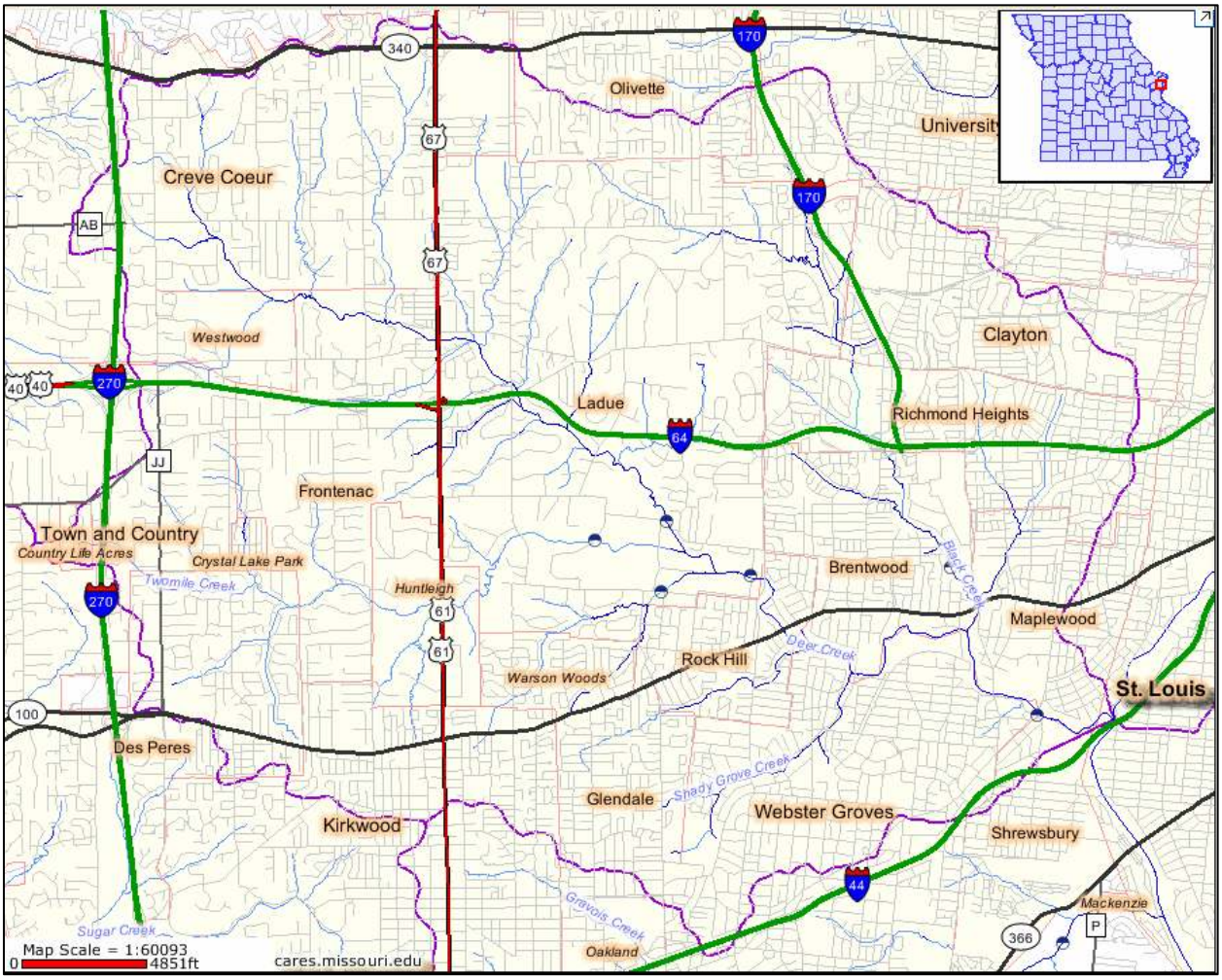

Figure 1. The watershed (boundary marked in purple) of Deer Creek in St. Louis County, Missouri. Circles represent USGS gauges (developed using CARES, 2008).

Physical and Chemical Sampling:
Data has been collected from seven sites for this project (Figure 2). See Table 1 for characteristics of each of these sites and Appendix 1 for information on the U.S. Geological Survey (USGS) gauges associated with four of these sites. The sites are:

- Malcolm Terrace Park – Deer Creek approximately 320 meters upstream of the pedestrian bridge in Malcolm Terrace Park (Creve Coeur),
- Chaminade – Tributary to Deer Creek approximately 20 meters upstream of the pedestrian bridge that connects the Chaminade campus to Chaminade Drive,
- Log Cabin – Deer Creek approximately 40 meters upstream of Log Cabin Lane,
- LREC – approximately 150 meters upstream of USGS gauge 07010055 at Litzsinger Road at the Litzsinger Road Ecology Center,
- Overbrook – Two-Mile Creek approximately 40 meters upstream of Overbrook Lane and 750 meters downstream of USGS gauge 07010061,
- Old Warson – Sebago Creek approximately 30 meters upstream of USGS gauge 07010070 at Old Warson Road, and
- McKnight – approximately 50 meters downstream of McKnight Road 200 meters downstream of USGS gauge 07010075 at North Rock Hill Road.

Table 1. Descriptions of the seven sampling sites on Deer Creek.

Site	Drainage Area	Latitude	Longitude	Stream Mile
Malcolm Terrace	1 to 2 mi^2	38^O 39' 08.9"	90^O 26' 02.5"	9.6
Chaminade (Tributary)	1 to 2 mi^2	38^O 39' 00.3"	90^O 24' 42.9"	0.5 (8.4*)
Log Cabin	10 to 11 mi^2	38^O 37' 47.1"	90^O 23' 07.1"	5.9
LREC	12.0 mi^2	38^O 37' 25.7"	90^O 22' 32.0"	5.1
Overbrook (Two-Mile)	6.4 mi^2	38^O 37' 11.7"	90^O 22' 38.1"	0.2 (4.9*)
Old Warson (Sebago)	1.9 mi^2	38^O 36' 52.9"	90^O 22' 35.8"	0.5 (4.8*)
McKnight	21.4 mi^2	38^O 36' 57.3"	90^O 21' 43.5"	3.9

* Distance from mouth of Deer Creek

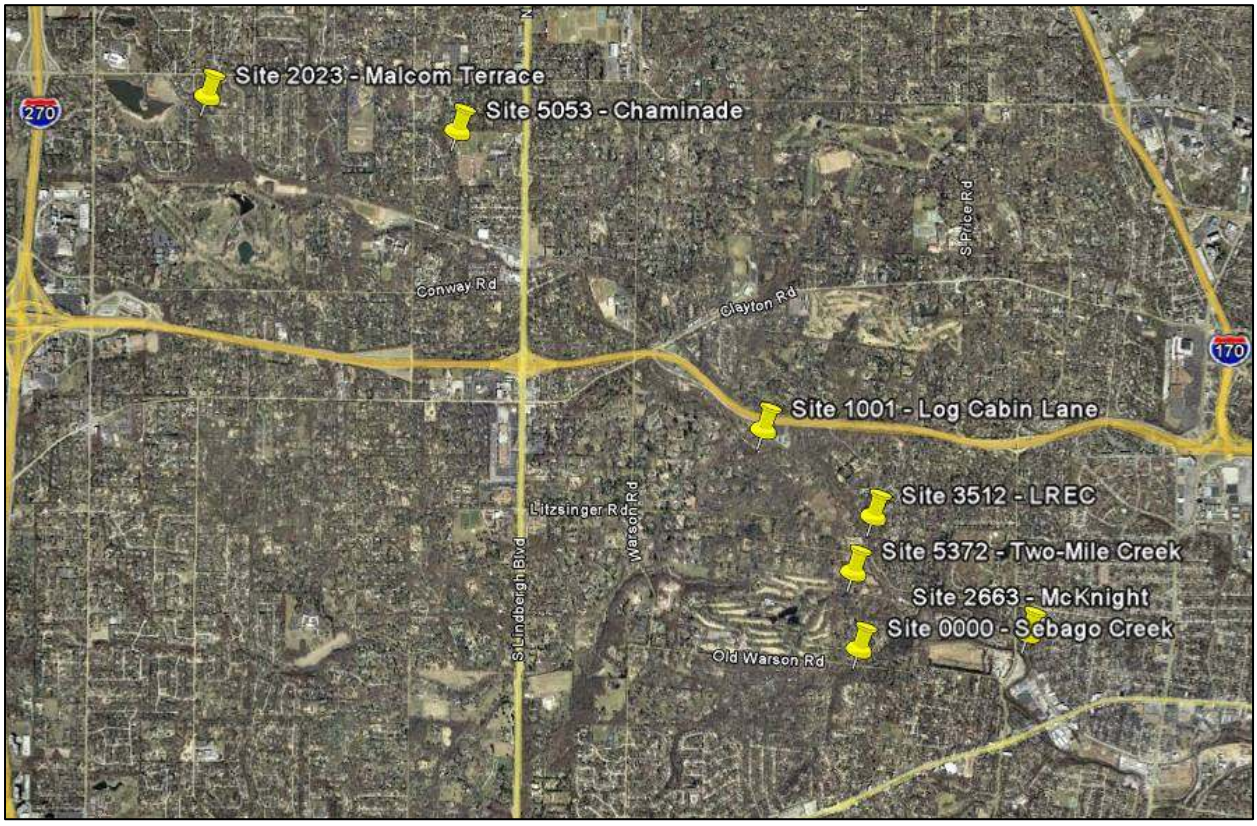

Figure 2. Locations of the seven sites monitored by the LREC Stream Team.

The following parameters are sampled on a monthly basis: dissolved oxygen, air temperature, water temperature, nitrate, conductivity, turbidity, flow rate, pH, and chloride. The sampling protocol has followed the methods prescribed by the Missouri Stream Team. The data are summarized in Table 2.

At the four downstream sites, instantaneous flow rates at the time of sampling were recorded from the USGS web site. At the upstream sites, flow was generally noted as present or absent, or sometimes estimated by an experienced team member.

Table 2. Summary of water chemistry in Deer Creek as measured by Stream Team 2670. Red values indicate potential cause for concern.

	Malcolm Terrace	Chamin-ade	Log Cabin	LREC	LREC*	Over-brook	Old Warson	Mc-Knight
Water temperature (^{O}C) (range)	1-29	0.5-27	0.5-29	1-28	0-28	1-27	0-27	0.5-28
pH (range)	6.3-8.9	6.3-8.2	6.4-8.6	6.6-8.5	6.6-8.5	6.6-8.3	6.6-8.3	6.9-8.5
DO (mg/L) (range)	4-24	1-23	5-28	2-26		3-18	3-21	3-21
DO (% sat) (range)	69-186	11-166	54-346	17-236		25-169	22-209	27-222
Nitrate (mg/L) (max)	4.0	2.0	2.0	1.0		2.0	2.0	2.0
Chloride (mg/L) (max, median)	2214, 162	3514, 161	2904, 100	2904, 92	3927, 172	911, 40	1116, 141	2029, 93
Conductivity (uS/cm) (range)	490-6200	280-8600	440-7300	410-7600	410-9000	360-1780	370-3600	460-6300
Turbidity (NTU) (max, median)	80, <10	350, <10	70, <10	54, <10		38, <10	35, <10	52, <10

* Includes fifteen additional winter samples collected at LREC in January and February of 2010 and 2011 by staff in order to better determine the extent of chloride pollution caused by salting of roads.

Biological Sampling:
Since 2005, sampling for benthic macroinvertebrates has been conducted at the LREC site in the "mulch pile woods" as well as a second location further upstream at the "horse trail." Invertebrates were collected in flowing water using a kick net and in pooled conditions using a D-frame net. On each sampling date, three net sets were collected and all invertebrates found were identified.

The results of the three net sets were compiled to determine the water quality score; an invertebrate score of <12 is poor, 12-17 is fair, 18-23 is good, and >23 is excellent. Summary results may be viewed in Table 3.

Benthic macroinvertebrates found at both LREC locations during at least one sampling event since 2005 fall into the following categories mayfly, riffle beetle, other beetle, crayfish, dragonfly, damselfly, scud, sowbug, aquatic worm, blackfly, leech, midge, and pouch snail. Caddisflies were only collected at the mulch pile woods site. Gilled snail and crane fly were recorded only at the horse trail site.

In addition to seasonal sampling of macroinvertebrates, the presence and absence of fish was noted, beginning in March of 2009. While live fish were rarely seen in Deer Creek and its tributaries between October and April, schools of 50 fish or more are seen regularly at all seven sites in June through September.

Habitat Measurements:
The standard Missouri Stream Team Visual Stream Survey Data Sheet was filled out on February 24, 2011, at each of the sever water chemistry sites. Results of the survey are summarized in Table 4.

The land uses in the floodplains of each site are variable, but do not include any commercial or industrial developments. All except the LREC site have at least a 50% residential component. The riparian zones of all seven sites include trees, grasses and forbs, and bare ground. None of the sites had buildings in the riparian zone and only three of the seven sites had pavement (limited to 10% of the riparian zone).

Table 3. Summary of A) invertebrate scores and B) number of individual invertebrates.

A	Horse Trail			Mulch Pile Woods			Combined		
SCORE	max	mean	min	max	mean	min	max	mean	min
Spring	20	11.6 (n=5)	4	18	12.3 (n=4)	8	20	11.9 (n=9)	4
Fall		17 (n=1)		22	16.8 (n=5)	12	22	16.8 (n=6)	12
Overall	20	12.5 (n=6)	4	22	14.8 (n=9)	8	22	13.9 (n=15)	4

B	Horse Trail			Mulch Pile Woods			Combined		
INDIV.	max	mean	min	max	mean	min	max	mean	min
Spring	490	172	19	228	121	47	490	153	19
Fall		95		189	98	36	189	97	36
Overall	490	159	19	228	107	36	490	129	19

Table 4. Summary of the visual stream survey.

		Malcolm Terrace	Chamin -ade	Log Cabin	LREC	Overbrook	Old Warson	Mc-Knight
Flood-plain Land Use	Industrial							
	Commercial							
	Residential	85%	50%	90%		50%	80%	70%
	Pasture/Hay	5%						
	Woods	10%		10%	60%		20%	30%
	Other		50% school		40% prairie	50% golf course		
Riparian Cover	Trees	90%	65%	80%	50%	60%	30%	60%
	Grass/Weeds	5%	15%	10%	28%	30%	50%	15%
	Bare	5%	20%	10%	2%	10%	10%	15%
	Pavement		10%				10%	10%
	Buildings							
	Other				20% shrubs			
Stream-bank Condi-tions	Trees	80%	60%	65%	40%	50%	20%	30%
	Grass/Weeds		10%	5%	20%	35%	25%	20%
	Bare		20%	10%		5%	10%	20%
	Bedrock				40%	10%	5%	
	Pavement	20%	10%	20%			40%	30%
	Other							
Bed Composi-tion	Silt/Mud	20%	10%	5%		5%		
	Sand	10%	10%	5%			10%	10%
	Gravel	10%	40%	10%	5%	5%	15%	60%
	Cobble	60%	40%	75%	90%	80%	25%	30%
	Bedrock			5%	5%	10%	50%	
Percent Embeddedness					43%	30%	27%	56%
Signs of Human Use		Plastic bags, medicine bottle, cut logs, large tire	Plastic trash	Plastic bags, trash	Trash, elimina-tion of non-natives	Trash, bridge	Trash	Trash, bridge
Algae	% Covered	0%	0%	20%	70%	75%	90%	20%
	% Close			60%	100%	100%	100%	100%
	% Filamentous			40%				
Water Color		Clear	Mostly clear	Clear	Greenish brown		Clear	Slightly brown
Water Odor		None	None	None		None	None	None
Fish Present		No	No	No	No	Yes (dead)	No	No

At least 70% of the stream bed at each site is made of gravel or cobble, with the exception of the Old Warson site which is dominated by bedrock. Algal growth was minimal at sites upstream of LREC, though it was abundant at the sites along both Two-Mile Creek (Overbrook) and Sebago Creek (Old Warson). No odors were detected and no live fish were seen.

Analysis and Discussion

pH:

Measurements of pH in the Deer Creek watershed were mostly within normal parameters; levels above 9.0 or below 6.5 are outside the range allowed by the State of Missouri (CSR, 2007). The three sites upstream of LREC had pH levels periodically below 6.5. These levels were not associated with any particular season. However, comments made by the team members when four of the six samples of low pH were taken include mention of the unusually large amount of leaves or other organic material that was present.

The decomposition of organic matter and respiration by plants, animals and bacteria can result in the creation of CO_2 which contributes to the acidity of water (Hem, 1985). Such decomposition and respiration can also be indicated by low concentrations of dissolved oxygen which is consumed to create the CO_2. Low concentrations of oxygen were also found on four of the six occasions.

Based on research by Robertson-Bryan, Inc. (2004), the level of variability and range of values found in Deer Creek seem unlikely to have a substantial health effect on the organisms founding the stream system. However, there may be behavioral or breeding consequences, depending on how rapidly the pH is changing.

Flow Duration:

Flow duration curves are a useful tool for understanding the hydrology of a site. A flow duration curve shows graphically what percent of the time streamflow meets or exceeds a certain volume. This can be used to understand the dynamics of floods and droughts in the stream. (EPA, 2007) For example, a flow duration curve was developed using USGS gauge data at LREC (Figure 3). We can see that flow is greater than or equal to 0.05 cfs about 60% of the time, but flow is only 11 cfs or higher 10% of the time.

In the flow duration curve for Deer Creek at LREC, it is notable that the flow record indicates that detectable flow exists in the stream channel approximately 75% of the time. The other 25% of the time, Deer Creek at LREC is either sustained as pools, left as dry streambed, or flows through the gravel or in underground natural channels.

The understanding of hydrology, combined with water quality data offers unique ways of understanding environmental data. With the flow duration curve as a basis, water quality parameters may be examined in terms of either concentration (amount in a given volume, often as milligrams per liter) or load (amount present in the stream as a whole at one time, often as pounds or tons per day). (EPA, 2007)

Nitrate:

Nitrate is a naturally occurring component of aquatic ecosystems. This nutrient is generally not considered to be at a level to cause concern until it reaches 10 mg/L. (Murdoch and Cheo, 1996) In the sampling we conducted, the highest measured value in Deer Creek has been 4 mg/L and the vast majority of samples had concentrations of 1.0 mg/L or lower.

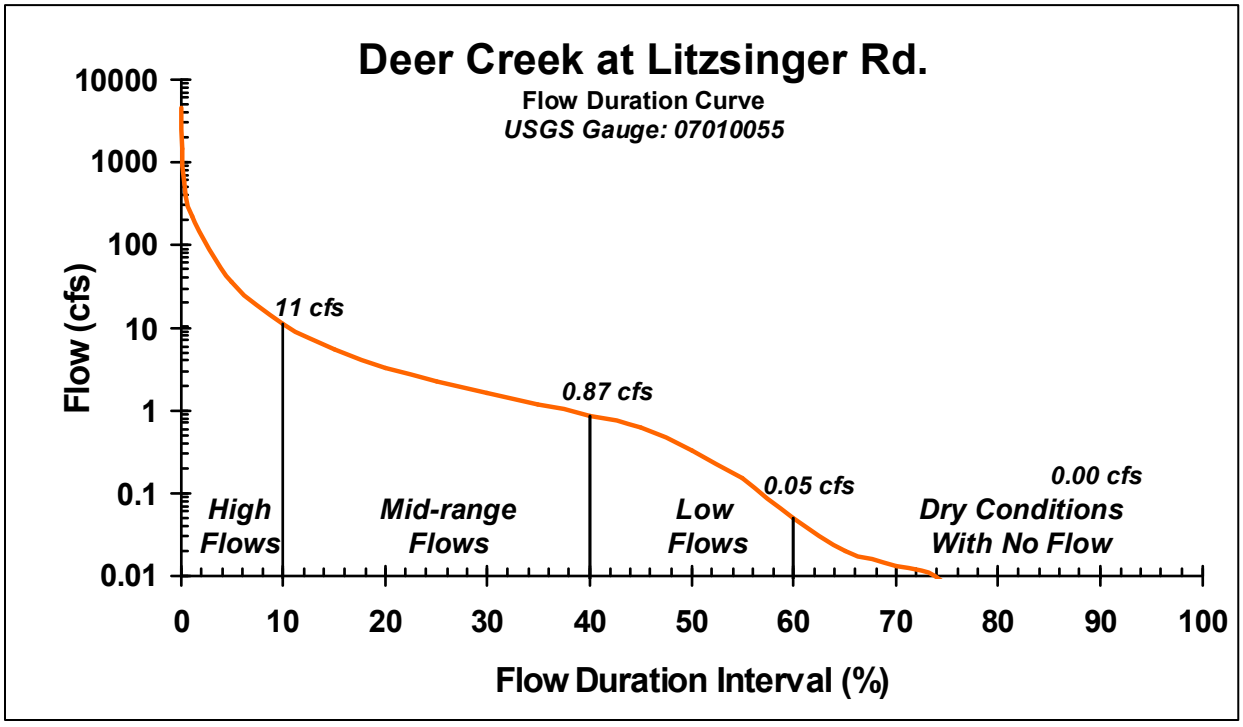

Figure 3. Flow duration curve for Deer Creek at the Litzsinger Road Ecology Center. The period of record for this sub-hourly (about 20 minute intervals) data is 12/29/2008 to 2/2/2011.

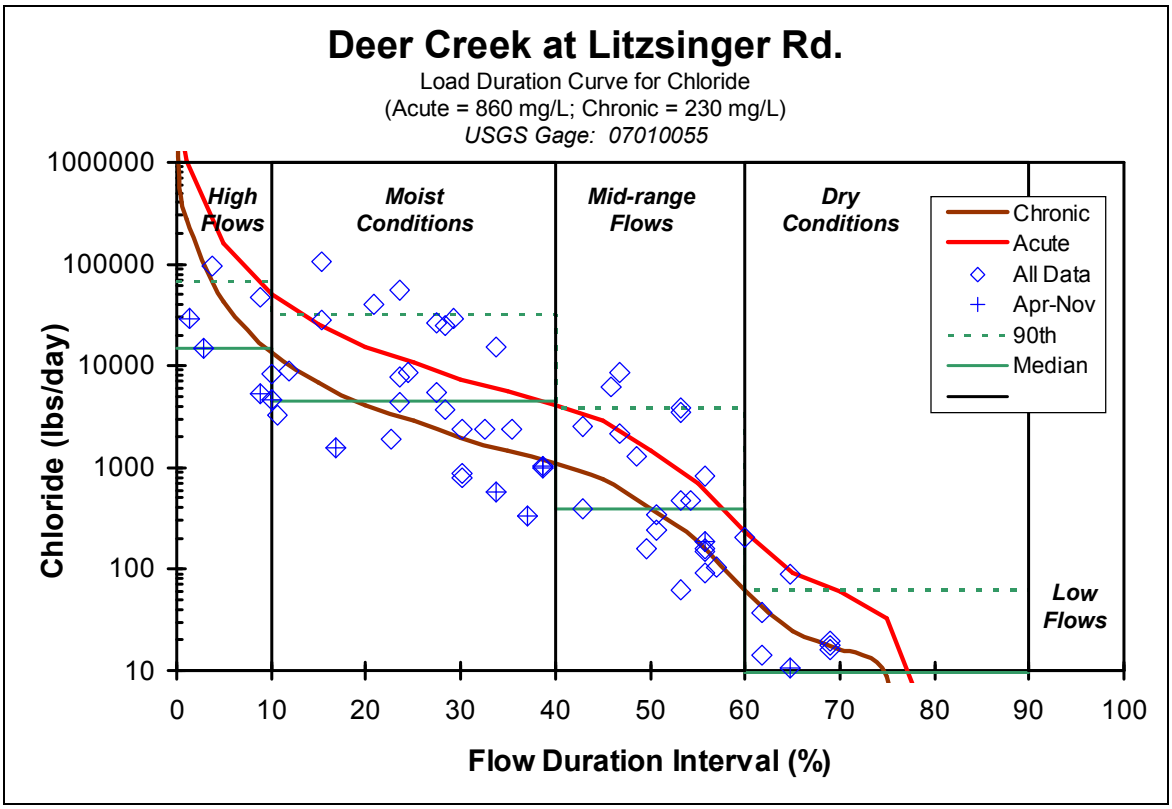

Figure 4. Load duration curve for chloride in Deer Creek at Litzsinger Road.

Chloride:

Chloride is a component of the aquatic system that is found at high concentrations in saltwater (about 19,000 mg/L), but at low concentrations in freshwater (Hem, 1985). In the State of Missouri, the water quality standard for chloride is based on the chronic toxicity level of 230 mg/L and an acute toxicity of 860 mg/L (CSR, 2007). A material's chronic toxicity is the concentration at which long-term exposure will cause death while concentrations that are acutely toxic will cause death with short-term exposure.

Using the flow data and the chloride concentration, it is possible to calculate the load of chloride passing the LREC, Overbrook, Old Warson, and McKnight sites in units of lbs/day. Using the standard values and the flow data, it is also possible to determine the maximum allowable load under a given flow condition. Once the target maximum load has been charted, it is possible to plot the sampled values and compare them to the target (Figure 4).

It is notable that the target maximum concentration of chloride was approached and even exceeded, primarily between December and March (diamond symbols without a cross). This may be attributed to the application of road salt within the watershed. At the highest flows during the winter, the loads of chloride remained high, but not high enough to violate the acute standard. This could be the result of dilution of the chloride or of storms for which no road salt was applied.

Due to concerns about the effects of road salt application, frequent winter sampling for chloride was conducted from February 2009 to March 2011 at the LREC site (Figure 5). A majority of the samples collected in February were above the acute toxicity limit set by the State of Missouri (CSR, 2007). Though not part of the original sampling plan, this extra monitoring will be continued for the foreseeable future.

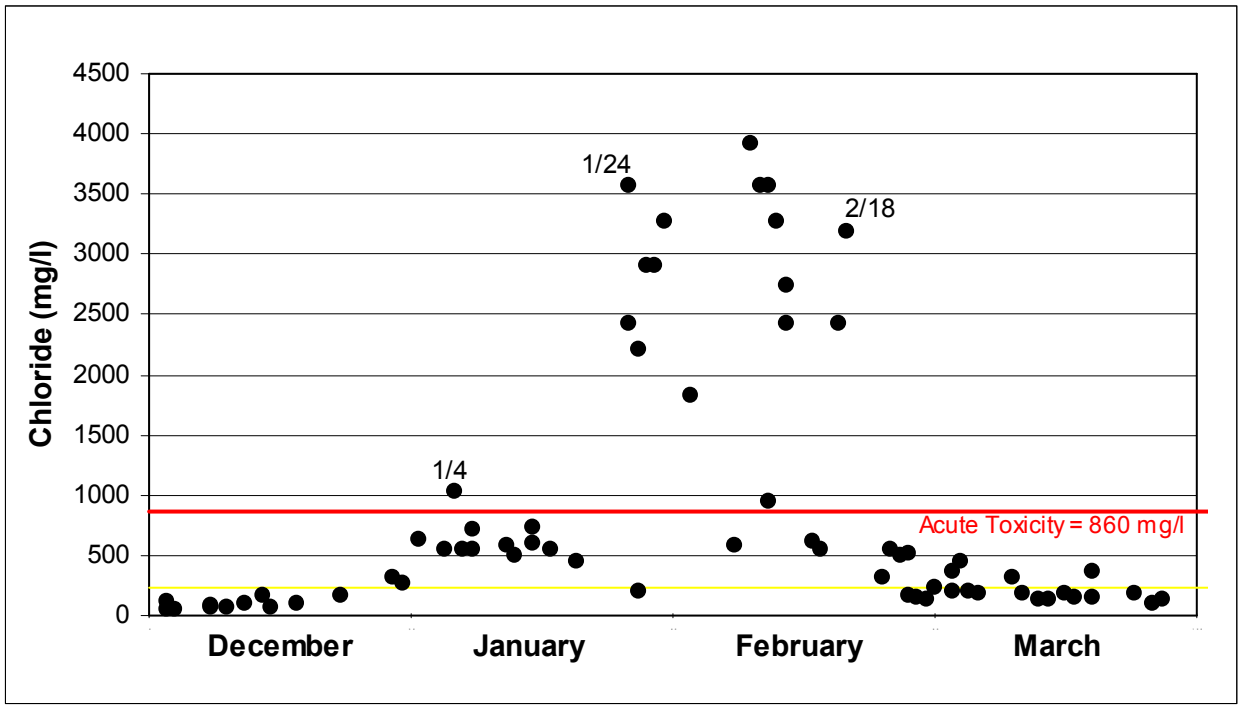

Figure 5. Chloride concentrations during the winter in Deer Creek at Litzsinger Road.

Dissolved Oxygen:

Concentrations of dissolved oxygen (DO) were examined using a target minimum value of 5 mg/L. This is the concentration at which some of the more sensitive fish and aquatic invertebrate species show signs of stress. It is also the concentration that the U.S. EPA has suggested and the State of Missouri has adopted as the minimum standard for warm-water aquatic life use classification (CSR, 2007).

As shown in Figure 6, the DO concentration was below the target value of 5 mg/L several times at various sites within the watershed, both in the mainstem of Deer Creek (filled circles) and the tributaries (open circles). When examined using an annual cycle, the seasonal variability of DO concentrations becomes clear. While concentrations vary widely in the winter (from 7 to over 25 mg/L), spring concentrations of DO are consistently between 5 and 15 mg/L. Concentrations remain below 15 mg/L for most of the summer and fall, but begin to dip below the 5 mg/L threshold in August and September.

During the summer and fall, multiple factors contribute to decreases in dissolved oxygen. Often, lower flows occur during this period, decreasing diffusion of oxygen into the water. In addition, higher temperatures decrease oxygen solubility in the water. The lower solubility limits diffusion even further by decreasing the amount of oxygen the water is capable of holding. A third factor that may impact dissolved oxygen concentrations in the summer and fall are respiration rates. Both plants and animals have higher rates of respiration during the warmer months. This depletes the oxygen supplies more rapidly, particularly at night when photosynthesis by plants and algae cannot occur.

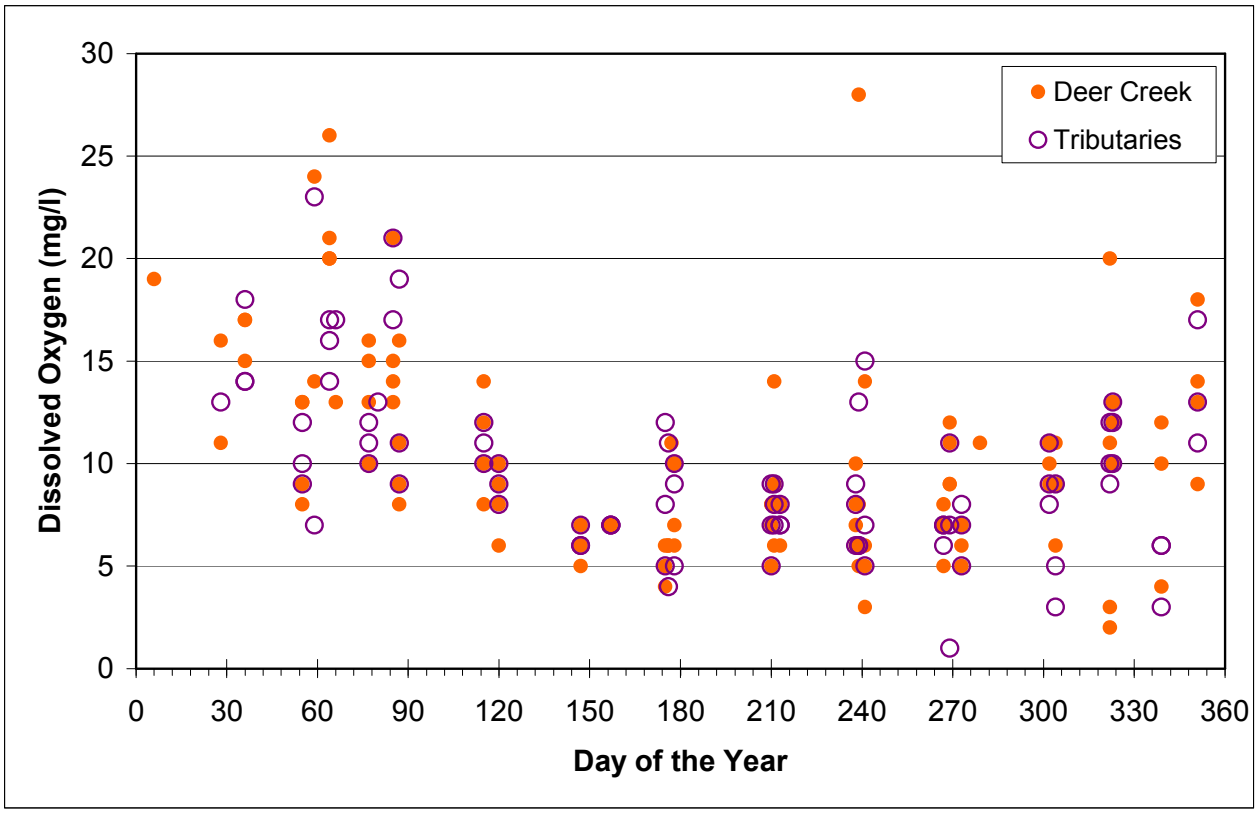

Figure 6. Concentrations of dissolved oxygen by day of the year in Deer Creek and its tributaries; data collected from 2/2008 to 2/2011.

Hydrology:

The hydrology, or flow patterns, of Deer Creek are typical of an urban watershed. Flow volumes are closely linked to recent rainfall and snowmelt events due to the runoff from impervious surfaces like rooftops, roads, and driveways, as well as from semi-pervious surfaces like mown lawns. These impervious and semi-pervious surfaces drain water quickly into the urban stormwater system which conveys the water directly to the nearest stream. Therefore, the more impervious surfaces there are in a watershed, the greater the volume of stormwater that rapidly reaches the stream, and the greater the 'flashiness' of the stream. This flashiness, the rapid rise and fall of water levels, translates into increased flash flooding.

Data collected from the USGS gauge along Deer Creek at Litzsinger Road show examples of this flashiness (Figure 7). On June 15, 2009 (pink curve), the water rose 8.5 feet in less than 30 minutes and peaked another 2.5 feet higher. Four hours after the water began to rise, the stream was back to within 3 feet of where it had started. As seen in the figure, this pattern of rapid rise and fall is relatively common in Deer Creek. It may be initiated by rainfall of less than one inch.

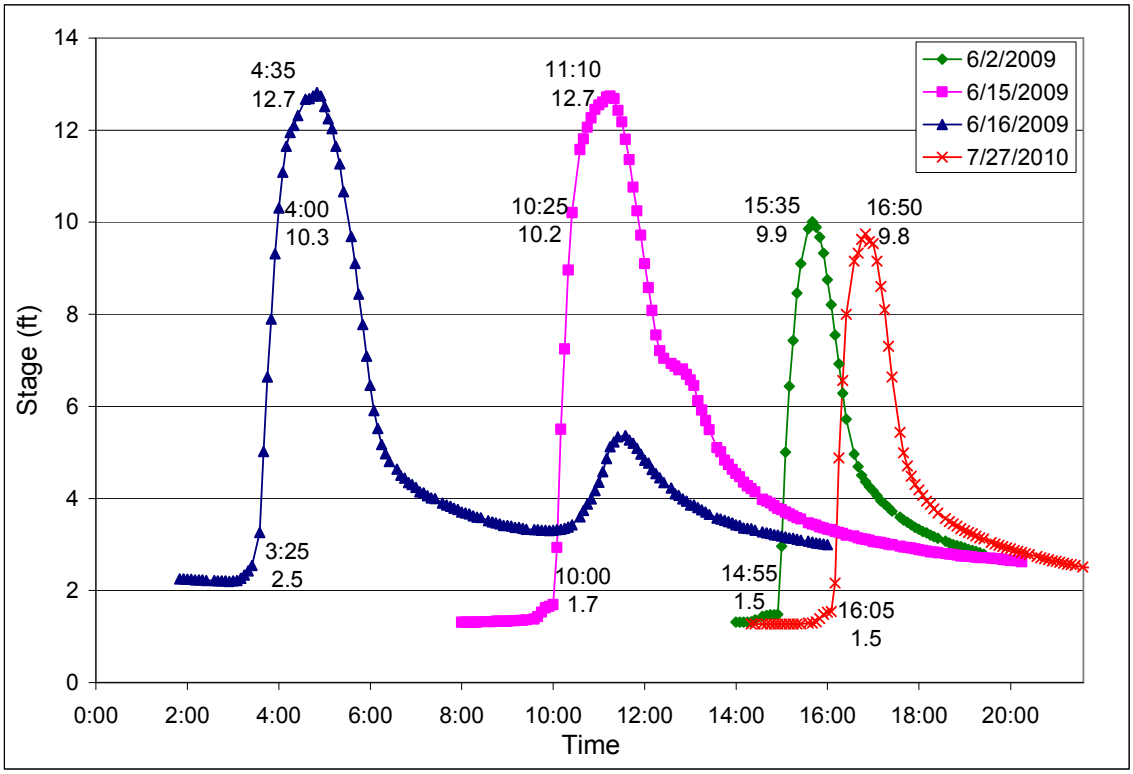

Figure 7. Hydrology of Deer Creek at LREC. The peaks shown here were caused by storms generating 0.85 inches of rain on 6/2/09, a total of 3.0 inches causing both peaks on 6/15/09 and 6/16/09, and 1.7 inches on 7/27/10.

Biological:

The benthic macroinvertebrate community at the LREC site is highly variable. This appears to manifest itself in two ways; overall diversity of invertebrates is greater in the fall, but there are a greater number of invertebrates in the spring (Table 3).

The seasonal change in diversity may be related to the chloride concentration. If the overwintering invertebrates are exposed to high chloride concentrations, potentially several times the concentration that is acutely toxic, it would not be surprising to learn that the more sensitive invertebrates are dying during

the winter. Over the course of the spring and summer, adult invertebrates may emerge from nearby streams that have not been so heavily impacted by chloride and leave their offspring in Deer Creek. These offspring may be the organisms that are found in the fall that were not present in the spring.

Overall, samples collected at the mulch pile woods site tended to have slightly higher scores than those collected at the horse trail site, though the minimum score at each is in the poor range (<12) while the maximum score is in the good range (18-23). The differences between the two sites may be due in part to the seasonality of the sampling; only one fall collection was made at the horse trail site.

Within the mulch pile woods data, there appears to be a seasonal trend. The maximum spring score is an 18, at the bottom of the good range, with a minimum score of 8. Meanwhile the minimum fall score is 12 with a maximum of 22; in both cases this is a difference of 4 which requires the collection of at least two additional species. This supports the link between invertebrate diversity and the potential for chloride impacts.

Despite the low invertebrate score at the mulch pile woods site in spring, there are certainly a larger number of invertebrates captured in the spring than in the fall (mostly scuds, sowbugs, and midges). Likewise, at the horse trail site, spring fauna was dominated by scuds, midges, and aquatic worms. However, this abundance is not necessarily a good thing and, in fact, somewhat supports the belief that chloride is having an impact on Deer Creek. Midges and aquatic worms are among the aquatic organisms that are most tolerant of pollution (Murdoch and Cheo, 1996). Scuds are known to be tolerant of exposure to chloride concentrations of 5,000 mg/L for at least 4 days (Blasius and Merritt, 2002)

The chloride concentrations may also be effecting the fish population; the distinct lack of fish in winter and into spring points in this direction. However, the fish population begins to disappear in October, before salt operations begin for the winter and before chloride concentrations peak. This indicates that there is another force at work, either completely independently or in conjunction with the later increase in chloride concentration. It is possible in some instances, particularly when temperatures drop and fish seek refuge in the deeper pools, that the water may be too cloudy or turbid to see the fish.

Habitat:

The riparian habitats within the Deer Creek watershed are somewhat variable. While there are no industrial or commercial developments at any of the sites, there is substantial residential development in the area. While all seven sites included a bare ground component, it should be noted that this information was collected during February. It is likely that the bare ground coverage would decrease in spring and summer as annual vegetation begins to grow.

The in-stream character of Deer Creek changes substantially as you move downstream. The amounts of silt, mud, and sand forming the stream bed drop while cobble and bedrock increase. The percent of the stream bank and riparian zone that are wooded also tend to decrease in downstream areas while algal coverage tends to increase.

Complications

Monitoring in Deer Creek has been complicated by a number of factors. On several occasions, weather has impacted the ability of the LREC Stream Team to complete sampling. For example, an incomplete data set was collected in January 2010 when temperatures were so cold that volunteers were beginning to experience moderate frost bite. In addition, on some occasions, severe weather (either strong storms or extreme temperatures) during the designated sampling time caused the delay or cancellation of scheduled sampling.

Summary

The physical and chemical data and the biological samples that have been collected show a variety of urban influences on the system.

- The pH at sites in this study is highly variable and, in the upper parts of the watershed, at times is below the range considered acceptable for Missouri streams.
- Flow peaks at over 1,000 cubic feet per second; however, there is no detectible, above surface flow in Deer Creek at LREC approximately 25% of the time.
- High concentrations of chloride and associated high conductivity during the winter are indicative of the heavy use of road salt during winter storms. Peak concentrations were over 3,500 – more than four times the amount that is considered toxic to aquatic life.
- Dissolved oxygen concentrations reach unhealthy extremes, dropping below 5 mg/L and reaching over 25 mg/L.
- The flashiness of Deer Creek is not unexpected for an urban stream, but considering the low density of development in the upstream reaches, it is somewhat severe.
- The biological diversity in Deer Creek at LREC is relatively good, particularly considering the chemical conditions in the water during the winter.
- The habitat along the locations sampled is relatively good. Most of the riparian areas and streambanks are wooded which will slow erosion.

Data has been and will continue to be analyzed regularly. Any major changes in Deer Creek or its tributaries during the grant period will be reported immediately to the Missouri Botanical Garden's grant coordinator, the Missouri Stream Team, and any other appropriate entities.

Acknowledgements

This report would not be possible without the dedication of the LREC Stream Team volunteers and the participation other members of the LREC staff, both past and present:

Volunteers		Staff
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Julie Nicolai	Theodore Smith	Emily Lopez
Ron Nimer		Malinda Slagle
		Anne Wamser

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Appendix 1: USGS Gauge Data

USGS data available:

McKnight: Deer Creek at N. Rock Hill Road in Ladue
http://waterdata.usgs.gov/nwis/nwisman/?site_no=07010075&agency_cd=USGS

This real-time gauge site has daily data from May 31, 2001 to the present. The data includes discharge in cubic feet per second. In addition, water quality samples have been collected on several occasions for a wide variety of organic and inorganic parameters.

LREC: Deer Creek at Litzsinger Road in Ladue
http://waterdata.usgs.gov/nwis/nwisman/?site_no=07010055&agency_cd=USGS

This real-time gauge site has daily data from June 6, 2001 to the present. The data includes discharge in cubic feet per second. The gauge was taken off-line in late September 2007 during bridge repairs and was re-started in January 2008; daily flow during this period has been estimated by the USGS.

Overbrook: Two Mile Creek at Overbrook Drive in Ladue
http://waterdata.usgs.gov/nwis/nwisman/?site_no=07010061&agency_cd=USGS

This real-time gauge site has daily data from May 31, 2002 to the present. The data includes discharge in cubic feet per second.

Old Warson: Sebago Creek at Old Warson Road near Rock Hill
http://waterdata.usgs.gov/nwis/nwisman/?site_no=07010070&agency_cd=USGS

This real-time gauge site has daily data from July 26, 2001 to the present. The data includes discharge in cubic feet per second.