
Lower Bull Creek District Park Contact Recreation Use Assessment



Prepared by a joint task force of:

Watershed Protection & Development Review Department
Austin/Travis County Health and Human Services Department
Austin Water Utility
Parks and Recreation Department

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1.0 Summary of Findings

Lower Bull Creek District Park, near the intersection of Lakewood Drive and RM 2222 in northwest Austin, frequently exhibits indicator bacteria concentrations that exceed State of Texas water quality standards for contact recreation. The impairment is localized in the lower (most southern) portion of the park.

A joint task force consisting of representatives from the City of Austin Watershed Protection and Development Review Department, Austin/Travis County Health and Human Services Department, the Austin Water Utility and the Parks and Recreation Department was formed to identify the source of the water quality impairment and recommend potential solutions that would reduce the further degradation of the water body and risk to human health.

The task force identified that the most likely source of the impairment is recreational use of the park; specifically, off-leash dogs within the park that are entering the water, functioning as a vector for dog excrement in the park and/or agitating potentially contaminated bottom sediments.

One immediate and verifiable if unpopular solution to the impairment while maintaining the human contact recreation use of the park is to prohibit or limit dog access to the creek within park boundaries through park regulation. Alternatively, a two-pronged public education campaign is proposed to: 1) educate citizens about the health risks associated with swimming in areas where bacteria is elevated *and* 2) reduce bacterial contamination through a focused effort to promote the collection and disposal of pet waste by park users.

This type of water quality problem may not be localized to Bull Creek District Park, as there may be other locations in the City with similar human/dog recreational use of natural waters. To maintain full recreational use of water bodies including human contact recreation where appropriate, the development of a City-wide policy is proposed, addressing monitoring, notification and signage.

2.0 Background

Bull Creek District Park

Bull Creek District Park is located in northwest Austin, near the intersection of Lakewood Drive and RM 2222 (Figure 2.1). The 48 acre park contains picnic facilities, an indoor restroom and 3 miles of hiking trails. The park, which was acquired by the City of Austin in 1971, is a part of the publicly accessible greenbelt along the lower reach of Bull Creek and the most southern portion of the park is an off-leash dog area.

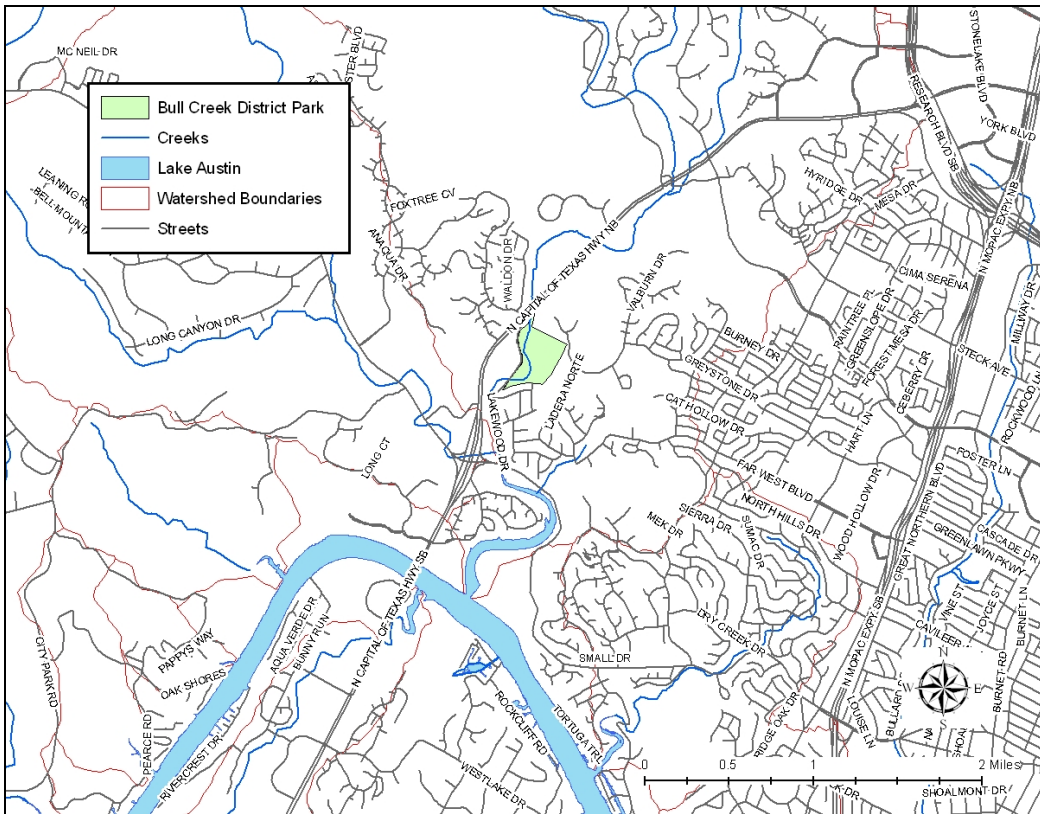


Figure 2.1. Bull Creek District Park location.

Bull Creek Sewage Spill—August 2007

On 28 August 2007, the Austin Water Utility, the Watershed Protection and Development Review Department (WPDR), and the Environmental and Consumer Health Unit (ECHU) of the Austin/Travis County Health & Human Services Department (HHS) received a report that a sanitary sewer overflow into Bull Creek had occurred between West Rim Cove and Spicewood Springs Road. The Spill Response team of WPDR collected water samples in the vicinity of the spill site as well as upstream and downstream locations of Bull Creek.

On 30 August 2007, HHS Epidemiology and Surveillance Unit (EPI) received a call from a concerned parent reporting a cluster of gastrointestinal illnesses in children who swam in Bull Creek Park on 28 August 2007. Children reported having symptoms of nausea, vomiting and diarrhea. The EPI unit began an epidemiologic investigation to determine potential causes of the outbreak. The ECHU also began water sampling at 7 different locations along Bull Creek in the southern most portion of Bull Creek District Park on 31 August 2007. The purpose of water quality sampling was to determine whether the reported sanitary sewage overflow might be influencing water quality further downstream within Bull Creek Park, and to address the parent’s concerns about Bull Creek water quality.

While conducting the sampling, ECHU posted warning signage in collaboration with the Parks and Recreation Department (PARD) to notify park visitors that the water body was potentially contaminated and to prohibit swimming. ECHU’s plan of action was to continuously monitor and sample the water at Bull Creek District Park and maintain warning signage until bacteria levels fell below contact recreation standards defined by the Texas Commission on Environmental Quality (TCEQ) (see below for discussion of state contact recreation standards).

The ECHU continued sampling at multiple locations (Sites BC1 thru BC5, Figure 2.2) in the park twice per week (on weekdays). The Water Resource Evaluation Section (WRE) of the Watershed Protection and Development Review Department maintains a long-term monitoring site near the southernmost Loop 360 crossing of Bull Creek (BC8, Figure 2.2) that was also monitored by ECHU during this study period.

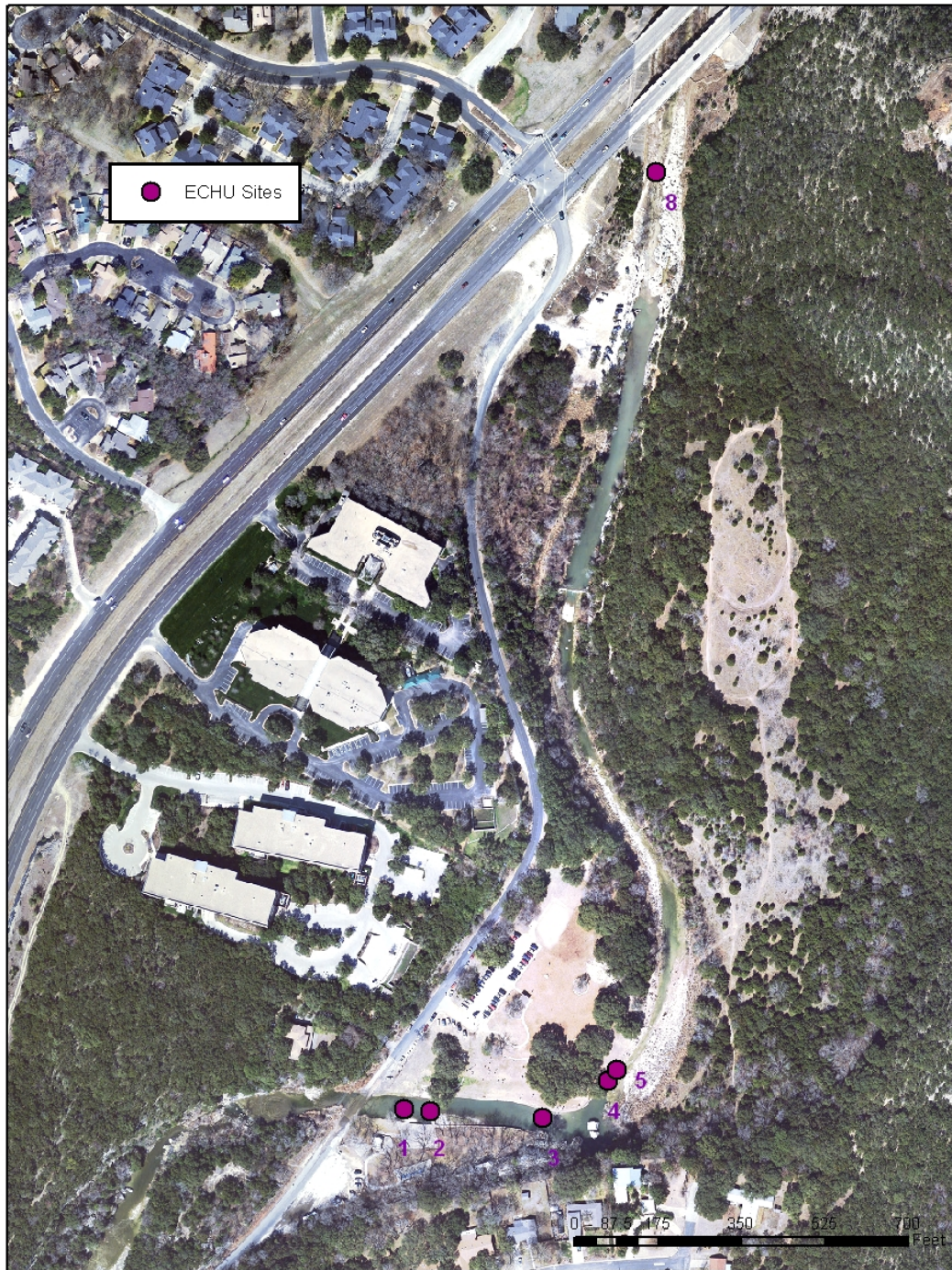


Figure 2.2. ECHU sampling locations within the park.

Bacteria Sources in Water

Pathogenic bacteria and viruses are released to the environment in the feces of warm-blooded animals. Because the identification and enumeration of all pathogenic bacteria that pose a health risk to humans would be difficult and expensive, selected indicator bacteria are used as a surrogate to determine the potential health risk associated with swimming in or drinking from a water body.

Indicator bacteria are selected on the basis of ease of measurement, persistence in the environment, and correlation to sources of pathogenic organisms (APHA 1995). Currently, *Escherichia coli* are the preferred indicator bacteria (TCEQ 2008). Although the type of *E. coli* used in water testing may not directly cause illness, *E. coli* bacteria originate in the intestinal track of warm-blooded organisms and the presence of *E. coli* in natural waters are thus considered indicators of the presence of pathogenic microorganisms.

Fecal bacteria are most commonly delivered to creeks by several methods. Leaking sanitary sewers or septic tanks may release bacteria directly to creeks, or sewage from leaking wastewater infrastructure may be washed into creeks during rain events. These sources can also contaminate shallow groundwater, where direct conduit springs or seeps can carry high bacteria loads during baseflow conditions. Excrement from wild and domestic animals can be directly deposited into creeks, or may also be washed into creeks during storms. Fecal bacteria concentrations in creeks are expected to be significantly higher during storm flow conditions in any urban setting.

Contact Recreation Standard

The Texas Commission on Environmental Quality (TCEQ) assesses contact recreation safety using the preferred indicator bacteria *Escherichia coli* (TCEQ 2008). The contact recreation criteria for *E. coli* currently used by TCEQ is a long-term geometric mean of 126 colonies/100 mL or 394 colonies/100 mL for individual samples. The recreational use of a water body is not supported if the geometric mean of two or more years of temporally-representative data (at least 10 samples with no more than $\frac{2}{3}$ of samples in any one year) or the individual sample criteria is exceeded more than 25% of the time using the binomial method (TCEQ 2008). The contact recreation standard is assigned to all water bodies, except for water bodies where ship and barge traffic makes contact recreation unsafe or waterfowl refuge results in high levels of bacteria (TCEQ 2007).

The geometric mean is the back-transformed (antilog) mean of the logarithmically transformed measurements (Sokal and Rohlf 1995). The geometric mean of 126 colonies/100 mL was selected on the basis of an acceptable level of risk, which is the concentration of indicator bacteria correlating to 8 illnesses per 1,000 swimmers (EPA 1986). The geometric mean is an extremely protective standard, and is intended to be used in situations where humans can immerse in a water body so that incidental oral ingestion of water is likely. Bathwater can reasonably be expected to exceed the contact recreation standard, although the standard is not intended to be applied in that way.

Analysis Methods

E. coli is analyzed by the City of Austin using two comparable U.S. Environmental Protection Agency (EPA) approved laboratory methods. The Watershed Protection Department uses the IDEXX method (SM 9223B) while the Health Department utilizes a membrane filtration method (SM 9222D). Both methods require an 18-24 hour incubation time after sample collection and processing before bacteria concentrations may be determined.

Long-term Monitoring Data

WRE has conducted long-term quarterly monitoring of multiple sites on Bull Creek including measurement of indicator bacteria concentrations since 1995. Based on WRE *E. coli* data collected since 2003 (when WRE followed TCEQ policy recommendations and switched from fecal coliform bacteria to *E. coli*), Bull Creek has historically been fully supporting contact recreation (Table 2.1) in the area of the park.

Table 2.1. Summary of WRE data for *E. coli* collected upstream and downstream of the lower Bull Creek District Park since 2003.

WRE Site	Location relative to park	# Samples Since 2003	Geometric Mean (col/100mL)	% Single Sample Exceedances
Bull Creek @ Loop 360 first crossing (#350)	Upstream	28	46.4	0.0%
Bull Creek Above West Bull Creek (#347)	Downstream	13	75.6	7.6%

Following the initial ECHU investigation, data was obtained from the Colorado River Watch Network (CRWN) volunteer monitoring program coordinated by the Lower Colorado River Authority via the CRWN website (lcra.org/water/quality/crwn/index). Since October 2003, 14 *E. coli* analyses have been obtained from samples collected near the Lakewood Drive low-water crossing at the downstream end of the park. Although CRWN data exceed the single sample contact recreation criteria for only 7% of samples, the geometric mean (159 col/100 mL) slightly exceeds the contact recreation criteria. Temporal trend analysis yields no statistically significant trends in CRWN *E. coli* concentrations over time (df=13, $r^2=0.001$, $Pr>F=0.906$), indicating the bacteria problem in the park has been on-going and occurred prior to the August 2007 sewage spill (Figure 2.3).

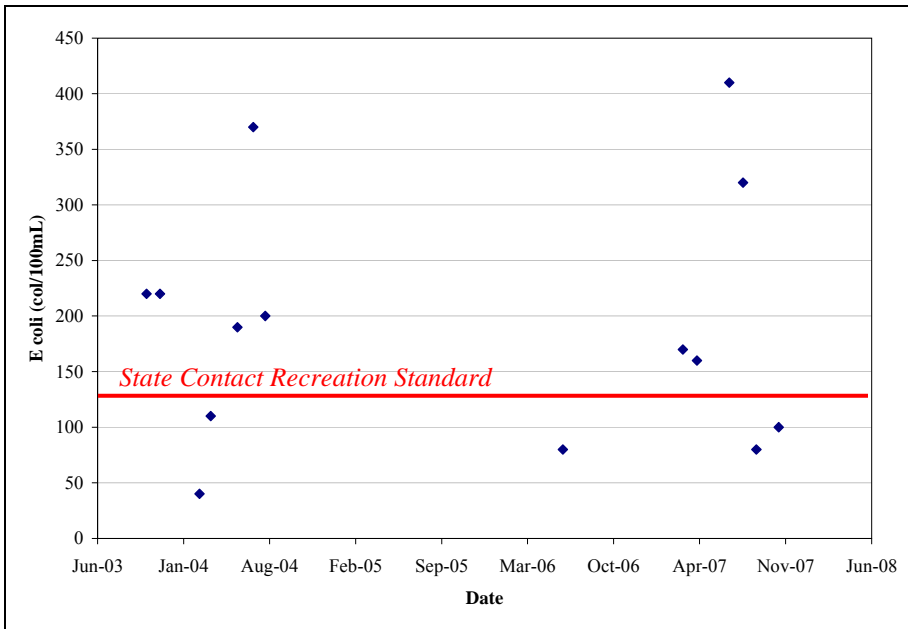


Figure 2.3. Colorado River Watch Network volunteer monitoring data for *E. coli* over time. Data indicate no consistent temporal trend.

3.0 Monitoring Results

Bull Creek District Park Contact Recreation Status

Data were collected by ECHU staff at least twice per week on weekdays (Monday through Friday) from 31 August 2007 to 3 December 2007 (when weekend/weekday testing began, see Section 5.0) at five sites (BC1 through BC5). Multiple sample dates were affected by antecedent storm events, and would not be representative of non-storm conditions.

Based on all ECHU data from August to December 2007 including storm-influenced data, Bull Creek District Park is not supporting contact recreation at any of the five monitoring locations based on geometric means compared to the 126 col/100 mL *E. coli* criteria (Table 3.1)*. Geometric means exceed the 126 col/100 mL criteria even when non-storm data are excluded from the analysis.

Table 3.1. Bull Creek District Park Contact Recreation Assessment (August-December 2007).

Assessment	BC1	BC2	BC3	BC4	BC5
Geometric Mean (col/100mL)	191.0	218.9	269.0	386.8	284.8
% Exceeds Single Sample (%)	21.4	25.0	28.6	50.0	32.1

*Contact recreation criteria using City of Austin data were not calculated using strict TCEQ methodology and should be used for comparison, illustrative purposes only.

Although site BC4 exhibits higher geometric mean *E. coli* concentrations than other sites, each of the five sites has yielded the maximum concentration of bacteria for a given sample date at least once (Table 3.2) and there is no obvious spatial pattern (Figure 3.1).

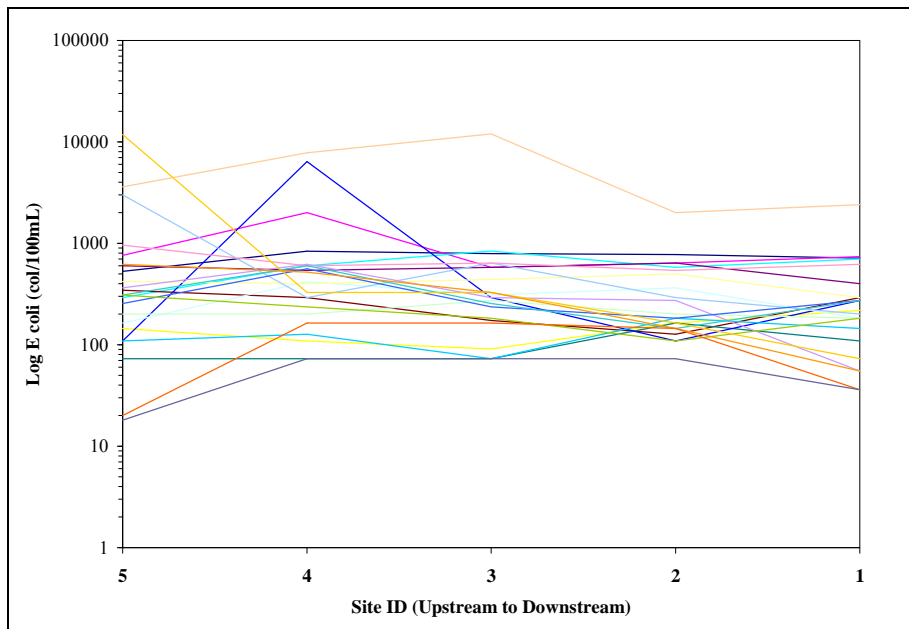


Figure 3.1. *E. coli* concentrations at sites BC1 through BC5, August-December 2007. Individual lines represent unique sample dates.

The more upstream sites BC3, BC4 and BC5 are not significantly different from each other by all combinations based on Wilcoxon signed-rank test comparisons (Table 3.3). The downstream sites, BC1 and BC2, are also not significantly different from each other by Wilcoxon signed-rank test. Although there were significant site differences observed (i.e BC1 is lower than BC4) no

consistent upstream to downstream pattern was observed. The Wilcoxon signed-rank test (Sokal and Rohlf 1995) is used to evaluate statistically significant differences between sites based on paired observations (e.g., observations collected on the same day) to remove other sources of variability from the analysis.

Table 3.2. Percentage of samples by site with highest bacteria concentration for a given sampling day.

Site ID	% of Days with Highest Concentration
BC1	3.0
BC2	12.1
BC3	21.2
BC4	39.4
BC5	24.2

Table 3.3. Wilcoxon signed-rank test result output ($Pr > |S|$) for pairwise comparisons between sites (n=28) using ECHU data from August-December 2007. Probability values ≥ 0.05 indicate no statistically significant difference between sites.

	BC1	BC2	BC3	BC4	BC5
BC1					
BC2	0.9348				
BC3	0.0071	0.0308			
BC4	<0.0001	0.0017	0.1082		
BC5	0.0585	0.1512	0.7346	0.1538	

Over short periods of time (or short distances in flowing waters), bacteria concentrations may be considered as conservative constituents and are generally not expected to change unless additional water is introduced to the system with a lower or higher concentration of bacteria. Field observation suggests that there are no significant seeps or springs and no tributary inflows that would add flow in the approximately 500 feet reach between the most downstream BC1 and most upstream BC5 site within the park. Flow observations yield water velocity measurements that suggest hydraulic residence times within the park are on the order of minutes to hours whereas bacteria decay rates at ambient temperatures may be on the order of 50% per day (Easton et al 2005). Substantial decreases in bacteria concentrations between sites within the park, some only 50 feet apart, suggest that bacteria sources are extremely local (i.e., are not well-mixed within the creek).

The elevated bacteria levels in Bull Creek District Park as determined by ECHU monitoring from August to December 2007 are clearly anomalous relative to long-term WRE monitoring (2004-2007) of multiple locations in Bull Creek (Figure 3.2). *E. coli* concentrations in the park may actually be decreasing over time (Figure 3.3). Although there is no statistically significant linear temporal trend in measured concentrations ($df=27$, $r^2=0.07$, $Pr > F=0.19$), log-transformed *E. coli* measurements do yield a statistically significant decreasing temporal trend. Bull Creek flow, as measured at the United States Geological Survey (USGS) gage near site BC8, over the study period has also declined (Figure 3.4). While a point source for bacteria may yield increasing bacteria concentrations under low flow conditions due to decreasing dilution, the decreasing temporal trend in bacteria may not be due to a non-point source as the decrease in bacteria concentrations may be simply a seasonal effect.

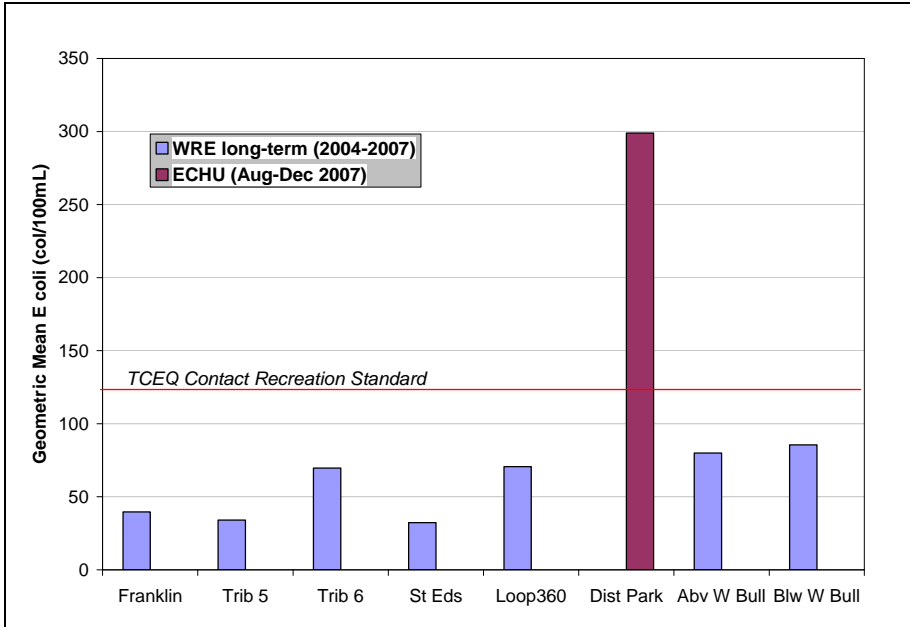


Figure 3.2. Comparison of Bull Creek District Park bacteria levels from ECHU monitoring to long-term WRE monitoring of Bull Creek. Sites presented in upstream to downstream order, from the headwaters to the confluence with Lake Austin (left-to-right).

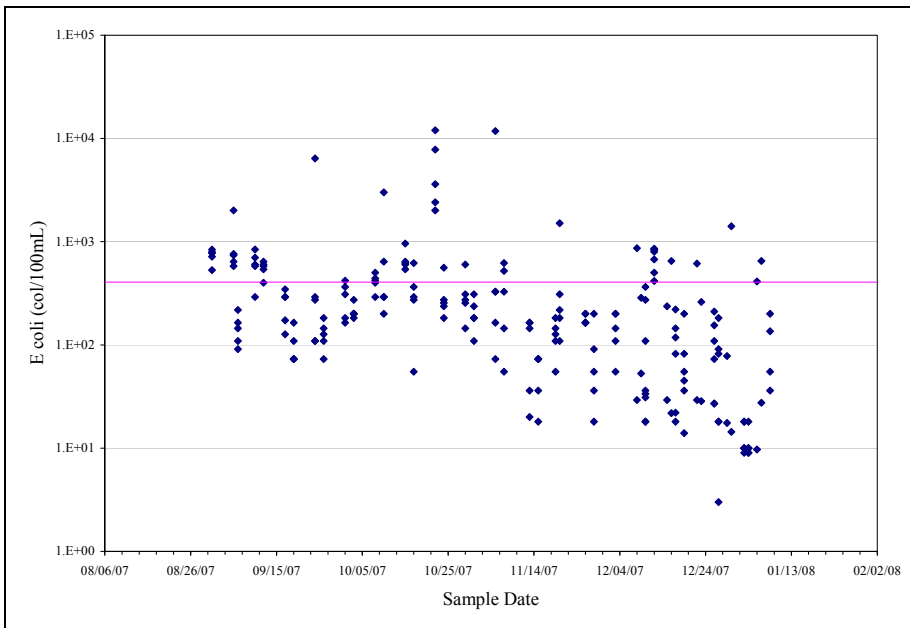


Figure 3.3. Log *E. coli* concentrations at all District Park sites since 31 August 2007 compared to TCEQ single sample exceedence criteria.

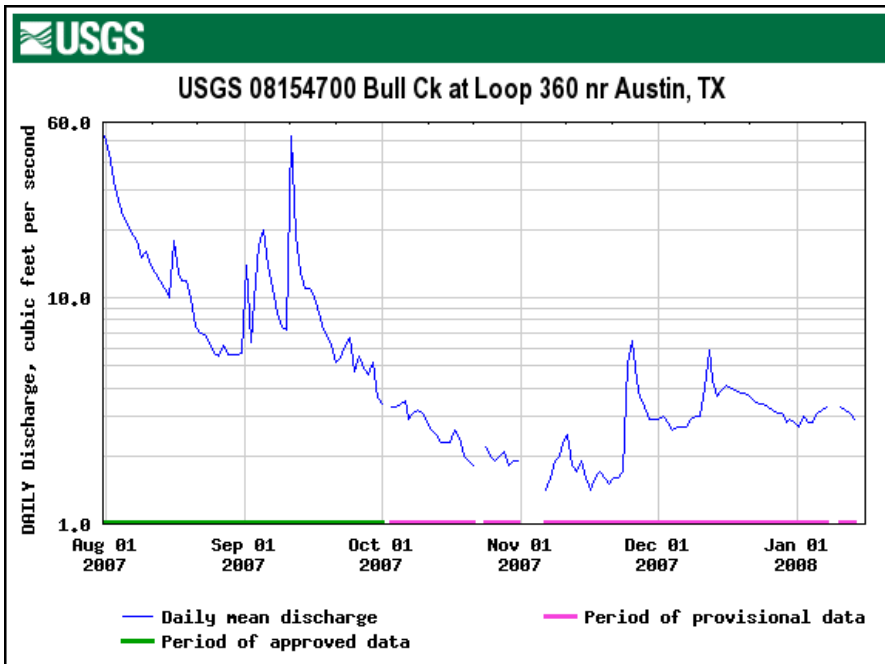


Figure 3.4. Flow at the USGS gage upstream of the park over the study period.

A bacterial load duration curve (EPA 2007) may be used as a method for determining whether bacterial contamination is related to non-point or point sources, and has been used in the development of a Total Maximum Daily Load for bacteria impairments in the Gilleland Creek Watershed (TCEQ 2007). A load duration curve for Bull Creek District Park was generated using ECHU data from August to mid-November 2007 (Figure 3.5). Results are inconclusive as exceedence of the contact recreation standard occurs at both high and low flows. Although this is a limited data set, high flows do not explain all bacteria peaks that occurred, indicating a more local, point source phenomenon.

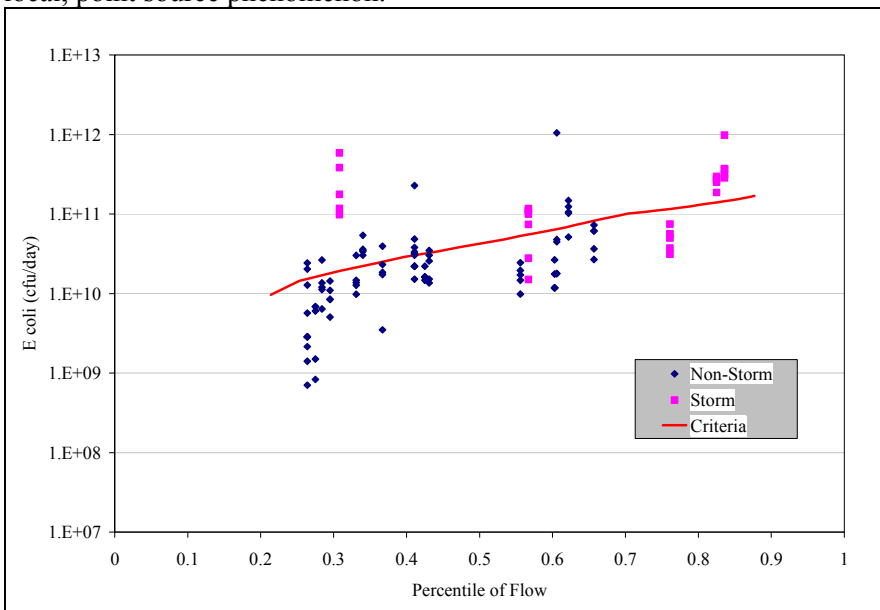


Figure 3.5. Load duration curve for *E. coli* in Bull Creek District Park relative to TCEQ standard (red line).

Identification of Potential Sources

Data collected by ECHU in the park, along with historic WRE data collected throughout the watershed were used to develop a series of hypotheses as to the source of the elevated *E. coli* values found in the lower section of Bull Creek District Park. These hypotheses were evaluated by staff using field investigations, monitoring studies and statistical analyses.

Potential Source Hypotheses:

- a. Individual on-site sewage treatment or septic systems are known to fail and after a central sewage system is established, older septic systems are sometime abandoned and can be a chronic source of bacterial contamination. Age, location and proximity of septic systems to the park were investigated to assess this potential source.
- b. Leaking wastewater lines from a central sewage system is often the source for both episodic and chronic contamination of streams with raw sewage and associated bacterial load. Location and integrity of all central sewage lines in the vicinity of the Bull Creek District Park were assessed as a potential source of bacterial contamination.
- c. Stormwater, and the non-point pollution that it carries from overland flows is often very high in bacterial load, due to both anthropogenic and natural, or non-human sources of fecal matter. Although high bacterial values were found during non-storm related flow periods, it is possible that storms brought in heavy bacteria loads that remained viable in the sediments at the bottom of the stream, in areas with low flow velocities. This source could be released slowly into the water column or disturbed by agitation and raise bacteria concentrations in the water column. Relationships of bacteria loads to rain, flow and temporal extent of high values were investigated to assess this potential source.
- d. Observations by staff and citizens confirmed the relatively high intensity use of the lower portion of the Bull Creek District Park by dog owners, both on and off leash. Associated dog excrement was observed throughout the park and this source to the creek was posited (Figure 3.6). Dog use in the park is centered around the creek, with dogs running in and through the creek regularly. The potential of this bacterial source, dog feces tracked in to the stream by recreational use of the park, was investigated by sampling during low use periods during the week and high use periods on the weekends.



Figure 3.6. Dog excrement noted on banks of Bull Creek in District Park.

Task Force Development

Due to the potential health risks associated with the elevated *E. coli* levels documented by ECHU in September and October 2007, signs were posted in the lower section of the Bull Creek District Park alerting users of potentially “contaminated water”. The COA sewage overflow that occurred in the headwaters of a tributary of Bull Creek in late August and the known relationship between sewage spills and *E. coli* contamination spurred the Austin Water Utility to take a strong interest in this issue and initiate an infrastructure investigation. Staff in the Watershed Resource Evaluation (WRE) section of the Watershed Protection and Development Review Department have had extensive experience monitoring water quality on Bull Creek and were asked to coordinate a collaborative effort between the interested COA departments in addressing contact recreation in the Bull Creek District Park. Representatives from the Austin/Travis County Health Department, the Austin Water Utility and the Watershed Protection Department met on November 27, 2007 to initiate this effort and to develop a monitoring strategy.

4.0 Source Analysis: Leaking wastewater infrastructure

Field observation by WRE and AWU staff yielded none of the expected indicators of wastewater contamination, such as excessive algal growth, odor, turbidity, low dissolved oxygen levels or presence of anoxic sediments. Data analysis (see Section 3.0) suggested no consistent point source type spatial pattern in the bacteria concentrations that might be expected in the presence of the continuous source from a leaking wastewater line, or stormwater – only spikes from wet

weather manhole or lift station overflows. The only wastewater main actually crossing Bull Creek in the vicinity of the park crosses the creek upstream of the routine WRE monitoring site (BC8, a.k.a. Bull Creek at Loop 360 southernmost crossing) which does not exhibit elevated bacteria levels.

To ensure the absence of a wastewater source, AWU initiated a series of contamination and sewage leak tests in the Bull Creek area. AWU reviewed the flow data of the wastewater lines and found flows to be fairly low with no surcharging. Smoke and dye testing, which are used to locate sewer connections and can be used to identify sewage leaks are scheduled to be conducted from late January through March 2008. Smoke testing is used for locating illegal connections, cross connections or leaks in a sealed system by forcing smoke-filled air through a sewer line. The smoke fills the main sewer and connection lines and indicates the source of any leaks. Crews smoke tested all sewer main segments on Lakemoore Drive, Marblewood Drive and Laurelwood Drive in January 2008, and results show no indication of leakage to Bull Creek. AWU has also worked with WPDR staff to develop a dye testing program that began in late February 2008 and will be conducted for several weeks. Dye testing is used to locate active service connections in main lines and trace existing lines as well as to determine which lines may be leaking fluids.

AWU reviewed the vicinity above the dog park and determined that the septic tanks near the area were abandoned approximately 20 years ago and are no longer considered to be potential point sources. During the smoke testing conducted in January 2008, field crews discovered two septic tanks in the area of which they were previously unaware. This often happens during sanitary surveys in older developments at the edges of wastewater service areas. AWU will smoke test these septic systems as well.

Further analysis of the source of contamination was also performed in the form of caffeine testing, which AWU designed and conducted for the first time for this report. Because caffeine is not a naturally occurring chemical in natural water bodies (streams, rivers, etc), positive results could indicate the presence of human sewage contaminaton while negative results would indicate that the presence of human sewage is unlikely. All water samples taken from Bull Creek showed non-detectable levels of caffeine (less than 0.50 ppb; see Appendix). It should be noted that while this test was adapted from USGS methods, these samples were analyzed using a modification designed solely for screening purposes by AWU. The results are not conclusive but do corroborate the other evidence that the contamination found in Bull Creek was very likely not a result of leaking wastewater infrastructure.

5.0 Source Analysis: Recreational use of park

Weekend versus Weekday Sampling Results

Following a preliminary review of available data and a field investigation of the park, the primary hypothesis of the source of the bacteria impairment within the park was recreational use of the park. Dogs are allowed to be off-leash within the park and frequently are encountered in the water. Although both humans and dogs are present in the park throughout the week, field observations and general park use patterns around Austin suggested a large increase in the use of the park on weekends.

Comparison of weekend and weekday bacteria levels was initiated in December 2007 (Table 5.1) based on the assumption that if recreational use of the park was a source of the bacteria impairment, bacteria concentrations should be higher on weekends during periods of peak use. ECHU staff collected two samples per week on weekday mornings for approximately 5 weeks.

WRE staff collected samples on weekend afternoons on both Saturday and Sunday. Both teams sampled above the park at the WRE routine monitoring site (BC8, a.k.a. Bull Creek at Loop 360 southernmost crossing #350), which served as background or reference condition, and immediately below the park (BC1, a.k.a. Bull Creek 90 ft upstream of Lakewood Drive #4187) which represented the lower section of the Bull Creek District Park.

Table 5.1. Calendar of sampling days in December 2007 and January 2008 that were used for weekend versus weekday analysis. One sample (December 12, 2007) was strongly influenced by an antecedent storm event and was excluded from the analysis.

December 2007						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

	Sample Date
	Storm influenced

January						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Based on all measurements during the study period from 8 December 2007 to 8 January 2008, Bull Creek District Park was not supporting contact recreation for both the geometric mean and percent single sample exceedence at site BC1 downstream of the park (Table 5.2). The monitoring site upstream of the park, BC8, was fully supporting contact recreation for both measures during this time period. This pattern suggests that the impairment is most likely spatially related to the park and is consistent with assessment of data collected prior to this time period.

Table 5.2. Assessment of Bull Creek District Park contact recreation (12/08/2007-01/08/2008), excluding storm influenced samples.

Assessment	Site BC1	Site BC8
Geometric Mean (col/100mL)	138.0	21.8
% Exceeds Single Sample	33.3	0.0

The TCEQ contact recreation standard was compared to weekend and weekday samples (Table 5.3). During the December 2007 study period, BC8 was fully supporting contact recreation on both weekends and weekdays. BC1, downstream of the park, was not supporting contact recreation on weekends but fully supporting contact recreation on weekdays.

Table 5.3. Assessment of contact recreation using TCEQ standard by weekend/weekday.

Site Name	Weekend/Weekday	Geometric Mean (col/100mL)	% Exceeds Single Sample (%)
BC1	weekend (Sat-Sun)	421.6	60.0
BC1	weekday (Mon-Fri)	34.2	0.0
BC8	weekend (Sat-Sun)	23.7	0.0
BC8	weekday (Mon-Fri)	17.4	0.0

Verification of the study design shows that by the non-parametric paired Wilcoxon signed-rank test (Sokal and Rohlf 1995), there is no significant difference between weekdays (e.g., Monday is not different from Wednesday) sampled during the same week ($p=0.50$) and there is no significant difference between weekends (e.g., Saturday is not different from Sunday) sampled during the same week ($p=1.00$). The study design is valid for testing the hypothesis of differential bacteria concentrations between weekends and weekdays.

Data results support the hypothesis that increased use of the park on weekends is correlated to an increase in bacteria concentrations (Figure 5.1). Mean weekend bacteria levels are significantly higher than mean weekday bacteria concentrations at site BC1 by Wilcoxon signed-rank test ($p=0.0078$) using paired weekly data from the December 2007 study period. Weekend concentrations during the December 2007 study period are on average 98% higher than weekdays by average relative percent difference. This is not a natural pattern as there is no significant difference between weekday and weekend bacteria levels at the reference site (BC8, Bull @ 360/Lakewood), upstream of park influences. Since WRE staff collected on weekends and ECHU staff collected on weekdays, there is the potential for observer/collector bias. However, our reference site data was consistent among observers, so this is very unlikely.

Weekday geometric means in the park (BC1) during December were lower than during the August-November sampling period (as collected by ECHU), indicating the presence of some seasonality in bacteria levels. This follows as recreational use of the park is expected to be higher during warmer months of the year and *E. coli* viability in the environment increases as temperatures approach mammal gut temperatures (70-100 ° F).

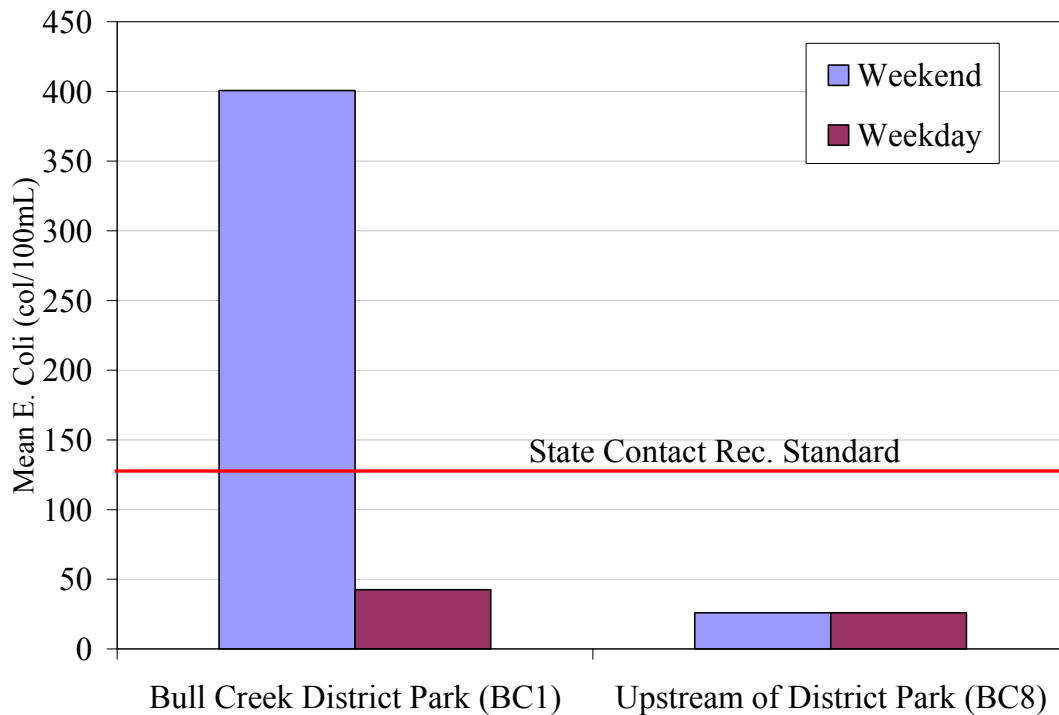


Figure 5.1. Geometric means of *E. coli* on Bull Creek during the December 2007 study period by site and day of week (weekend/weekday). Geometric means on weekends in the Bull Creek District Park (BC1) exceeded even the single sample exceedence limit during the December 2007 study period, while means upstream of the park (BC8) remained well below contact recreation criteria.

6.0 Summary/Conclusions

In response to a sewage spill and a citizen complaint of a gastrointestinal illness outbreak, the Austin/Travis County Health Department initiated indicator bacteria sampling in Bull Creek within the lower Bull Creek District Park. Sample results from August through November 2007 indicated elevated concentrations of the indicator bacteria *E. coli*, above State of Texas criteria for contact recreation. The HHSD conducted an epidemiologic investigation of the children reporting gastrointestinal illness after swimming in Bull Creek District Park. The investigation, which evaluated a variety of exposures in both ill and non-ill children, found that exposure to water in Bull Creek increased the risk of becoming ill.

The bacteria problem is spatially limited to the park, and is not evident in long-term routine Watershed Protection and Development Review Department monitoring upstream or downstream of the park. Volunteer monitoring data conducted by the Lower Colorado River Authority Colorado River Watch Program indicates that the problem is not recent, and most likely has been on-going since at least 2003. Bacteria in the park may be decreasing over time, although the observed decrease may be the result of a seasonal effect and additional monitoring over a longer period of time would be necessary to verify.

Wastewater from either a leaking wastewater main or a septic system is not a likely source of elevated bacteria in the park. There is no spatially consistent pattern that would indicate sewage

contamination and no other typical wastewater indicators (algae, odor, anoxic sediments) were observed during Austin Water Utility field inspections. AWU has reviewed the flow data of the wastewater lines and found flows to be fairly low with no surcharging. Smoke test results indicate that contamination from wastewater lines is highly unlikely. Further source analysis using caffeine as a wastewater indicator corroborate the other evidence that the contamination found in Bull Creek was very likely not a result of leaking wastewater infrastructure. AWU has also worked with WPDR staff to develop a dye testing program that began in late February 2008 and will be conducted for approximately two weeks.

Non-storm-related bacteria concentrations in the park are highest on weekends, when use of the park was at a maximum. Paired comparison of weekend versus weekday samples indicates that weekend concentrations are significantly higher than weekday concentrations. During the December 2007 study period, Bull Creek within the park was fully supporting contact recreation during the week but not on weekends. The elevated weekend bacteria levels do not appear to be a natural phenomenon as they are not observed at the reference site upstream of the park (BC8).

Based on these preliminary findings, recreational use of the park - specifically, dogs entering the water and/or agitating bottom sediments - is the most probable source of the bacteria impairment. This phenomenon was documented during cooler weather periods (September-November), but during summer months it is predicted that the problem will be compounded by more park users/dogs and more swimming. It should also be noted that under high-use periods, human feces, in the form of diapers or other vectors are likely a significant source of bacteria to the creek.

Continual, high-frequency monitoring of bacteria to determine real-time closure policy of water bodies to swimming may not be the most effective method for assessing contact recreation safety. Bacteria tests require 18-24 hour incubation times in addition to the time required to inform the public or post notices of closure to swimming (Eleria and Vogel 2005, Herrington 2007). It is also not possible to identify and frequently monitor all possible locations where contact recreation may be occurring. No economical surrogate for bacteria testing has proven reliable enough to use as an instantaneous or rapid assessment method. While regular (e.g., monthly or quarterly) sampling of water bodies could be sufficient to identify new or increased chronic sources of bacterial contamination (e.g., a new wastewater line leak), the data indicate that a more prudent approach to addressing contact recreation in Austin would be a stated City-wide policy regarding the general safety of swimming in natural water bodies in combination with public education campaigns including a focus on the potential impact that dogs may have on the safety of swimming in natural waters.

Austin is unique among other urban environments for the accessibility and quality of our natural creeks and parks and the high value they hold with our citizenry. The proposed public outreach campaign is an effort to maintain the maximum resource value of Austin creeks by continuing to allow full recreational use of all appropriate water bodies.

8.0 Recommendations

- 1. Develop a pilot program for maintaining contact recreation use of Bull Creek District Park. This should include signage and an intensive on-site public information campaign that directly addresses the new findings that dog excrement is a source of bacteria problems in this park.*

- Signage should be directed specifically at the dog excrement problem, but also educate citizens about the health risks associated with swimming in areas where bacteria may be elevated.
 - Brochures/flyers should be developed that present new findings and specific actions that need to occur to address contact recreation issues. These should be actively distributed during the launch of this campaign, be available on the web, and be generally available to all stakeholders.
 - Park users should be involved in this campaign, both as educators, eyes and stewards in the park (code, pet waste patrols, etc.).
2. *Conduct a City-wide public education campaign to inform citizens about the significance of dog excrement as a bacteria source and how to manage it, as well as the risks associated with contact recreation in natural waters that may have elevated bacteria levels.*
- This campaign should be informed directly from the lessons learned at the Bull Creek District Park pilot and from a targeted monitoring effort in other contact recreation areas in the City (see item #3).
 - A policy task force with representatives from multiple departments (WPDR, PARD, AWU and HHSD) will create appropriate signage and materials for this larger scale approach to contact recreation safety in natural waters around Austin.
3. *Develop a new contact recreation monitoring program that will expand the findings of this report to a city-wide scale, evaluating all significant sources of bacteria that could threaten contact recreation.*
- A multi-department bacteria monitoring task force (WPDR, HHSD, AWU, PARD) will coordinate data collection and analysis efforts to efficiently and effectively inform a citywide approach to protecting contact recreation in our waters.

9.0 References

- American Public Health Association (APHA). 1995. Standard methods for the analysis of water and wastewater.
- Easton, J. H., and J. J. Gauthier, M. L. Lalor, R. E. Pitt. 2005. Die-off of pathogenic *E. coli* O157:H7 in sewage contaminated waters. *Journal of the American Water Resources Association*. 41(5):1187-1193.
- Eleria, A., and R. M. Vogel. 2005. Predicting fecal coliform bacteria levels in the Charles River, Massachusetts, USA. *Journal of the American Water Resources Association*. 41(5):1195-1209.
- Herrington, C. 2007. McKinney Falls State Park contact recreation assessment. City of Austin Watershed Protection and Development Review Department, Water Resource Evaluation Section. SR-07-07
- Sokal, R. R., and F. J. Rohlf. 1995. *Biometry, the principles and practice of statistics in biological research*. 3rd edition. Freeman and Company, New York.
- Texas Commission on Environmental Quality (TCEQ). 2007. One Total Maximum Daily Load for Bacteria in Gilleland Creek, Segment 1428C. Chief Engineer's Office, Water Programs, TMDL Division, TCEQ.
- Texas Commission on Environmental Quality (TCEQ). 2008. DRAFT 2008 Guidance for Assessing and Reporting Surface Water Quality in Texas in compliance with Section 305(b) and 303(d) of the Federal Clean Water Act. Prepared by Surface Water Quality Monitoring Program.
- U.S. Environmental Protection Agency (EPA). 1986. Ambient Water Quality Criteria for Bacteria. EPA 440/5-84-002.
- U.S. Environmental Protection Agency (EPA). 2007. An approach for using load duration curves in the development of TMDLs. EPA 841-B-07-006.

10.0 Appendix

WPDR and HHSD *E. coli* results from monitoring associated with this report.

Date	Day	BC1	BC2	BC3	BC4	BC5	BC8
09/06/07	Thu	218	164	91	109	145	.
09/10/07	Mon	700	580	840	600	291	.
09/17/07	Mon	291	127	173	291	345	.
09/19/07	Wed	109	164	73	73	73	.
09/26/07	Wed	145	182	73	127	109	.
10/01/07	Mon	182	364	309	418	164	.
10/03/07	Wed	182	200	273	200	200	.
10/08/07	Mon	291	500	440	400	420	.
10/10/07	Wed	200	291	640	291	3000	.
10/15/07	Mon	620	540	640	600	960	.
10/17/07	Wed	55	273	291	620	364	.
10/24/07	Wed	273	182	236	560	255	.
10/29/07	Mon	273	145	255	600	309	.
10/31/07	Wed	182	109	182	236	309	.
11/05/07	Mon	73	164	327	327	11800	.
11/07/07	Wed	55	145	327	520	620	.
11/13/07	Tue	36	145	164	164	20	.
11/15/07	Thu	36	73	73	73	18	.
11/19/07	Mon	55	127	145	182	109	.
11/20/07	Tue	182	109	309	1509	218	.
11/26/07	Mon	164	164	164	200	200	.
11/28/07	Wed	91	36	18	55	200	.
12/03/07	Mon	109	145	200	200	55	.
08/31/07	Fri	715	775	793	838	530	.
09/05/07	Wed	740	640	580	2000	760	.
09/12/07	Wed	400	640	580	540	600	.
09/24/07	Mon	273	109	291	6400	109	.
10/22/07	Mon	2400	2000	12000	7800	3600	.
12/08/07	Sat	866.4	.	.	.	.	29.2
12/09/07	Sun	285.1	.	.	.	.	52.9
12/10/07	Mon	18	36	109	273	364	18
12/10/07	Mon	33.6	.	.	.	.	30.9
12/12/07	Wed	800	855	836	673	500	415
12/13/07	Thu	.	.	.	.	.	<100
12/14/07	Fri	.	.	.	.	.	<100
12/15/07	Sat	235.9	.	.	.	.	29.2
12/16/07	Sun	648.8	.	.	.	.	21.8
12/17/07	Mon	82	118	145	220	18	22
12/19/07	Wed	82	55	45	200	36	14
12/22/07	Sat	613.1	.	.	.	.	29.2
12/23/07	Sun	260.3	.	.	.	.	28.5
12/26/07	Wed	210	155	109	73	27	27
12/27/07	Thu	3	82	182	91	18	18
12/29/07	Sat	78	.	.	.	.	17.5

Date	Day	BC1	BC2	BC3	BC4	BC5	BC8
12/30/07	Sun	1413.6	.	.	.	.	14.4
01/02/08	Wed	18	<10	9	18	<10	<10
01/03/08	Thu	<10	<10	9	<10	9	18
01/05/08	Sat	410.6	.	.	.	.	9.7
01/06/08	Sun	648.8	.	.	.	.	27.5
01/08/08	Tue	136	.	200	55	36	.

AWU Caffeine Screening Results

Sample ID	Concentration (ppb)	Comments
30247	90.7	Man Hole Sample.
30249	< 0.50	Caffeine was not detected at or above the estimated method detection limit of 0.10 ppb. (Field Blank Sample)
30277	< 0.50	Caffeine was not detected at or above the estimated method detection limit of 0.10 ppb.
30278	< 0.50	Caffeine was not detected at or above the estimated method detection limit of 0.10 ppb.
30279	< 0.50	Caffeine was not detected at or above the estimated method detection limit of 0.10 ppb.
30280	< 0.50	Caffeine was not detected at or above the estimated method detection limit of 0.10 ppb.
30281	< 0.50	Caffeine was not detected at or above the estimated method detection limit of 0.10 ppb.
30282	< 0.50	Caffeine was not detected at or above the estimated method detection limit of 0.10 ppb.
Lab Blank # 1	< 0.50	Caffeine was not detected at or above the estimated method detection limit of 0.10 ppb.
Lab Blank # 2	< 0.50	Caffeine was not detected at or above the estimated method detection limit of 0.10 ppb.
30282, MS	0.84 (84 % recovery)	Matrix Spike sample,spiked at 1.0 ppb
LCS	0.78 (78 % recovery)	Lab Control Sample, (Milli-Q water), spiked at 1.0 ppb

1. These samples were not analyzed using an approved method for caffeine but by a method designed for screening purposes only and these results are not of the same level of quality as those produced by a proven analytical method such as USGS TMS-B4_508 or EPA 625. This screening method was based on USGS method TM5-B4_508 "Determination of Wastewater Compounds in Whole Water by Continuous Liquid-Liquid Extraction and Capillary-Column Gas Chromatography/Mass Spectrometry".