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Bacteria Monitoring for Mill Creek and Associated Reaches of Buffalo River

Status and Trends for 2010

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INTRODUCTION

Mill Creek has been and is impacted by numerous point and non-point sources of organic pollution (Maner and Mott, 1991; Mott, 1994). In late summer of 2009, staff of Buffalo National River (BNR) observed higher than normal *Escherichia coli* (*E. coli*) concentrations in Mill Creek. Simultaneously, local staff from Arkansas Department of Environmental Quality (ADEQ) alerted BNR of a raw sewage leak from a local sewer improvement district at the head of Mill Creek near Marble Falls, Arkansas. Subsequent to those events, during the fall of 2009, dye tracing work was performed by a professional hydrogeologist who confirmed that that raw sewage was entering the Buffalo River (Aley, 2010). Concerned about the risk to public health and to the environment, BNR formulated a plan to monitor the water quality conditions and associated risk to public health for recreational exposure (Usrey, 2009). This report concludes the first year of water quality monitoring, documents the general water quality conditions during 2010, and discusses water quality trends to help interpret the possible pollution sources and the risk to humans and aquatic environment of Buffalo River.

The goals of the 2009 Mill Creek monitoring plan were to 1) monitor recreational waters of Mill Creek and Buffalo River to determine whether water quality is sufficient to protect public health, 2) communicate health risk to recreational users of Buffalo National River (BNR), and 3) monitor water quality conditions to provide for preservation of the aquatic environment within Buffalo River. This report will present and discuss findings related to the first and third goals within the monitoring plan. The second goal was established early in the 2010 sampling period, and consists of weekly or bi-weekly notification system of *E. coli* levels in Lower Mill Creek, Buffalo River at Pruitt and Buffalo River at the Crow Hole swimming area. Official signs warning the public of potential risks associated with raw sewage contamination were posted at these areas. To date there have been no reported cases of human illness associated with sewage contamination in these locations.

BACKGROUND

The community of Marble Falls, Arkansas is located within the headwaters of Mill Creek, a major tributary to Buffalo River. Marble Falls' Sewage Improvement District (SID) operates a sewage treatment plant (STP) that discharges into upper Mill Creek. In winter of 2009, a major lift station became inoperable and raw sewage began to flow over the ground surface into upper Mill Creek. Intermittent pumping of the lift station was discontinued in spring of 2009, and during this period, approximately 6000 gallons of raw sewage a day was leaking into the sub-surface, cave system of upper Mill Creek's recharge area. In early 2010 the SID installed a new pump in the disabled lift station. Additionally, they commissioned an engineering review (Engineering Services, Inc., 2010). The resultant report found that many locations within the sewage collection system leaked and little of the sewage was being pumped to the sewage treatment facility, nor being processed. For these reasons, BNR felt it was necessary to monitor Mill Creek until the entire system was rehabilitated and/or replaced and the system was fully permitted by the ADEQ and all discharge into state waters met the their waste water permit requirements.

In the fall of 2009, dye tracing of the leaking sewage observed that the time of travel from the leaking lift station to the confluence area of Mill Creek and Buffalo River (a distance of six miles) was approximately 28 hours. Within a 3-day period, post dye release, approximately 30 % of the dye was accounted. This suggests that raw sewage travels quickly to Buffalo River via Mill Creek and significant amounts of the sewage was flowing into Buffalo River each day (Aley, 2010).

Recreational use of BNR occurs year-round with visitation dramatically increasing during the float season; typically April to August. An estimate of canoe usage in this reach of river is approximately 4000 canoes per season (park concession records). Other significant recreational uses include jon boats, tube floating, swimming, wading and fishing.

E. coli is a commonly used indicator of fecal contamination of fresh water (U. S. EPA, 1986) because it constitutes greater that 90 percent of the bacteria found in human and animal excrement. These bacteria can become pathogenic to humans when they contact tissues outside the intestinal tract, particularly the urinary and biliary tracts, lungs, peritoneum, and meninges. *E. coli* is recommended over other indicators such as fecal coliforms and e*nterococci* because they exhibit less correlation to illness associated with swimming. Other microorganism pathogens (protozoa) such as cryptosporidium and *Giardia lamblia* are also sources of water-borne illness. These protozoa do not function well as monitoring devices for detection of point and non-point sources of pollution because they are difficult and expensive to process in field and laboratory settings and their detection times are too long for a public notification process. However, many of these other pathogens are understood to be present in association with *E. coli*, and *E. coli* can generally be used to effectively represent the risk of these other pathogens as they are associated.

The Arkansas Pollution Control and Ecology Commission (APCEC) is tasked with setting the water quality standards for the State of Arkansas and the agency Arkansas Department of Environmental Quality (ADEQ) administers and enforces those regulations, and regulations are outlined in Regulation Number 2 (2007). Within this regulation, Section 2.507 assigns "*the Arkansas Department of Health with the responsibility of approving or disapproving surface waters for public water supply and for approving or disapproving the suitability of specifically delineated outdoor bathing places for body-contact recreation, and as such has issued rules and regulations pertaining to such uses*". Section 2.507 of Arkansas Regulation 2 states that "*all streams with watersheds less than 10 square miles shall not be designated for primary contact unless and until site verification indicates that such use is attainable*" and within Primary Contact Waters, between May 1 and September 30, the maximum allowable *E. coli* criteria or level is calculated either as a geometric mean of 126 colonies per 100ml or a single-sample maximum of 298 colonies per 100ml in lakes, reservoirs, Extraordinary Resource Waters (ERWs) and Natural and Scenic Waterbodies (NSW). Additionally the regulation states that "*During the calendar year, these criteria may be exceeded, but at no time shall these counts exceed the level necessary to support secondary contact recreation.*" Secondary Contact Waters criteria states that the maximum allowable *E. coli* as a geometric mean of 630 colonies per 100ml and a single-sample maximum of 1490 colonies per 100ml.

Arkansas water quality Regulation 2.509 deals with nutrient levels and state nutrient levels "*shall not be present in concentrations sufficient to cause objectionable algal densities or other nuisance aquatic vegetation or otherwise impair any designated waterbody*". Since no maximum nutrient threshold exists, and quantification of impairment of the biology of Mill Creek is not within the scope of this investigation, information on nutrients will be presented for comparison of Mill Creek to that of the Buffalo River and other tributaries of similar size. Nutrients will be presented as nitrate (NO^3 mg/L).

Regulation 2.203 describes Outstanding Resource Waters (ORW) as "*high-quality waters which constitute an outstanding state or national resource, such as those waters designated as extraordinary resource waters, ecologically sensitive or natural and scenic waterways, those uses and water quality for which the outstanding waterbody was designated shat be protected by 1) water quality controls, 2) maintenance of natural flow regime, 3) protection of instream habitat, and 4) encouragement of land manage practices protection of the waters.*" The Buffalo River is listed as an ERW and as an ORW.

Mill Creek has approximately 19.4 square miles of drainage area. Whether or not Arkansas Department of Health has ruled that lower portions of Mill Creek is considered - an "*outdoor bathing place for body contact recreation*" is unknown to the author at time of document release. However, it reasonable to assume that the lower portion of Mill Creek, within the boundaries of BNR, experiences recreational use by the visiting public for wading, fishing, swimming, and other types of full body contact use. Therefore, the water quality criteria included in Regulation 2 will be used in this report to apply to this portion of Mill Creek. Furthermore, due to the type of public use the Buffalo River receives, primary contact should also be assumed as being year round, and primary contact regulations should be adhered to throughout the year to ensure public safety for recreational users of the park.

METHODS

The selection of water quality monitoring sites (Table 1) were based upon their hydrologic setting, results of past monitoring in Mill Creek (Maner and Mott, 1991), results of dye tracing within the system (Aley, 2010), initial project data collection (Usrey, 2009), and dependable, long-term access to sampling sites (right-of-ways, private landowner permission, etc.). Figure 1 shows locations of all water quality monitoring sites relative to the Buffalo River.

Table 1. Selected water quality monitoring sites for the Mill Creek Project.

Site Identification	Site Name	Northing	Easting
BUFR03	Buffalo River at Pruitt Access (aka Pruitt)	3990351.48	487697.59
BUFR0304	Buffalo River at Crow Hole (aka Crow Hole)	3991181.16	488479.84
BUFT04	Mill Creek At County Road Crossing Near Pruitt Access (aka Lower Mill Creek)	3991050.85	487700.77
BUFT0401	Mill Creek Downstream of Campground (aka Campground)	3992817.89	487725.21
BUFT0402	Mill Creek at Spring Valley Road	3994696.83	488357.83
BUFT0405	Harp Creek	3993112.79	487585.05
BUFT0406	Flatrock Creek	3992030.33	487601.99
BUF04S02	Boiling Spring Upstream of Mill Creek Confluence	3991145.53	487605.07

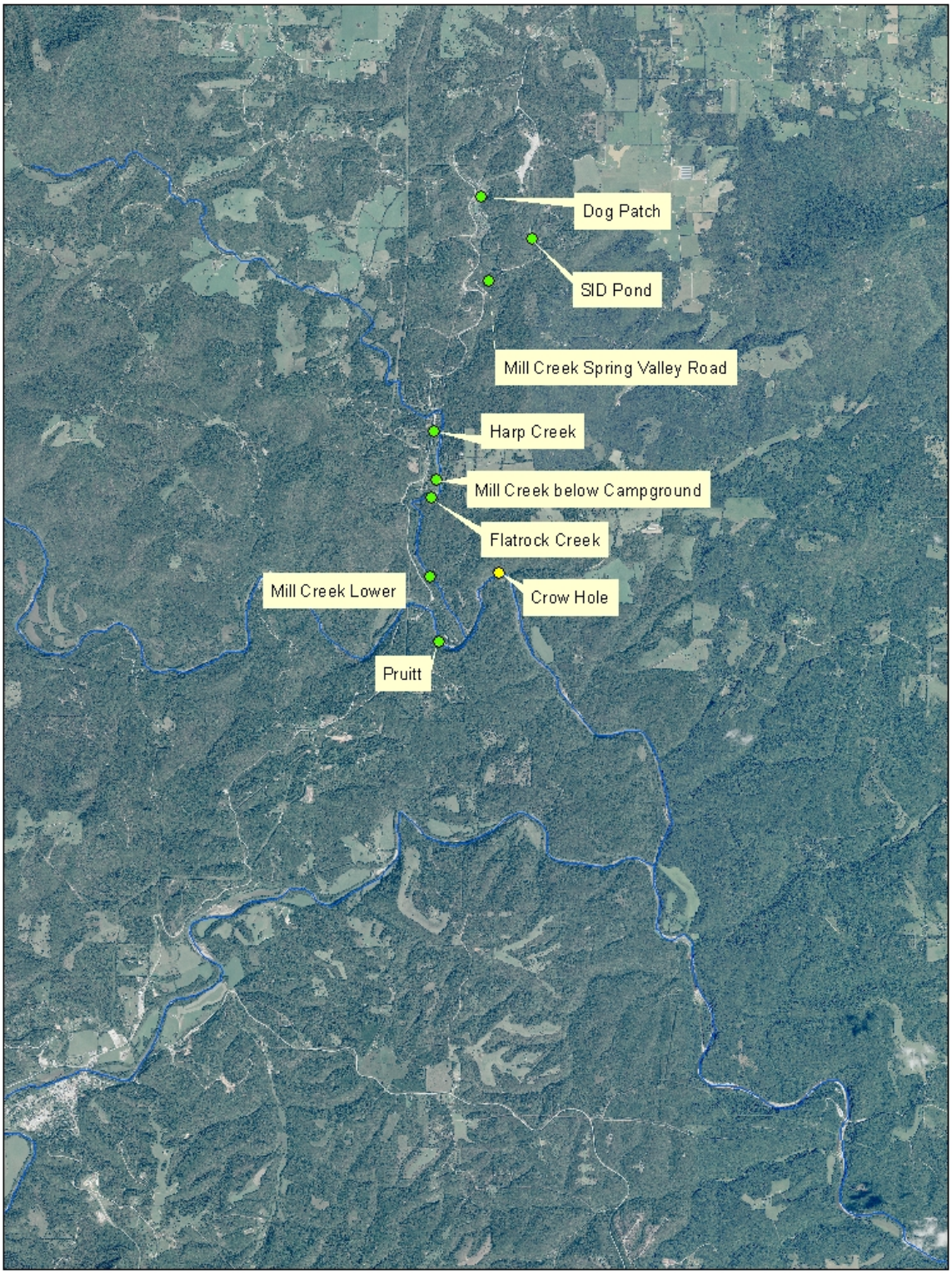

Figure 1. Map of Mill Creek area with sampling sites and Marble Falls sewage outfall.

E. coli Sampling Methodology

E. coli sample collection and all physicochemical measurements follow the guidelines found in *Standard Methods for the Examination of Water and Wastewater* (1985) for surface water collection in streams and rivers. *E. coli* samples are collected in the center flow of the stream using collection bottles from the IDEXX Colilert-18 system (http://www.idexx.com). Samples are taken just below the surface of the river by holding the bottle near its base with a gloved hand and plunging it, neck downward, below the surface. Turning the bottle until neck points slightly upward and mouth is directed toward the current. Once sufficiently filled to 100-ml, the bottles are tightly capped. The bottle were marked with site ID, date, and time of arrival at the sampling site.

All bacteria samples are placed on ice (below 10°C) and transported to the lab for processing within a maximum 6-hour holding time. Sample processing strictly follows the IDEXX Coliert-18 methodology in its entirety, using only IDEXX equipment and supplies. The IDEXX Coliert-18 method is EPA approved and is widely accepted as a reliable *E. coli* enumeration procedure. More details on procedures can be found on the IDEXX website listed above. See Appendix A for general IDEXX procedures.

Associated Water Quality Sampling

The following physicochemical parameters were measured at each site from the center flow of the stream: water temperature (^{o}C), conductivity (µS/cm), pH, dissolved Oxygen (mg/L and % saturated), and turbidity (NTU). All these measurements were taken using an YSI 6000 multi-parameter water quality measurement, and data logging system. Calibrations were made following the manufacturer's direction using calibration standards suitable for expected environmental conditions. All calibrations were entered into a calibration log book assigned to the meter. When field measurements were taken at the first site of the day, the meter was allowed to equilibrate for 10 minutes prior to readings being recorded. Periodically within the primary season, the meter was deployed within lower Mill Creek (BUFT04) for a three day period in unattended sampling mode to collect 24-hour water quality trends. While the meter was deployed or when the meter was broken or dysfunctional, single probe meters were used to collect data. These individual backup meters were each calibrated according to manufacturer's procedures and a calibration log book was kept with each meter. A data notation was made when these meters were being used.

Discharge was measured using a Marsh-McBirney model 2000 flow meter. A cross-section at each of the water quality monitoring sites was selected with the cross-section being relatively uniform in depth and flow. The cross-section width was divided into equal width increments (1-foot intervals or at 2-intervals, depending upon width) and depth and velocity were measured at each interval. An engineered, metered, depth rod was used to measure velocity at 60% depth; depth at average vertical flow. Flow rates were calculated using the conversion formula; $Q = \Sigma w_n * d_n * v_n$; where W_n = mean width at a particular station, D_n = mean depth at a particular station, and V_n = mean velocity at a particular station. Calculations resulted in Q being reported in cubic feet per second (cfs).

Discharge was physically measured at all sites within Mill Creek, and instantaneous discharge estimates collected from the USGS gauge at Pruitt (07055680, R03) was used for all Buffalo River sites. Since the Buffalo River at Crow Hole (R0304) is only a short distance downstream from Pruitt and the confluence of Mill Creek (3 riffle/pool series in distance), discharge at Crow Hole was estimated by adding the discharge measurement at lower Mill Creek (T04) to that of the instantaneous estimate from Pruitt.

Data Processing and Quality Assurance

Data collected from the field or generated within the laboratory was entered into the BNR's Water Quality Database as is typically done for each monitoring site within the system. Each data point entry was double checked for input error, and a preset entry criterion was used for each data entry type to limit data input errors. Downloaded data were formatted similar to other routine water quality data being collected at BNR, and the data was checked again for error prior to being released or used with statistical or graphing software.

Quality assurance was conducted with each sampling and processing event. Duplicates (side by side sample collection), trip blanks, replicates (sequential collections), and positive control indicator samples were obtained at a 1 to 10 ratio; 1 quality assurance sample to 10 environmental samples. Although the BNR water quality laboratory was not an EPA certified laboratory, the lab adhered to EPA standards. Controlled samples were purchased from IDEXX at quantification levels expected from site conditions and at levels near the contact threshold (http://www.idexx.com) .

RESULTS

Water quality samples were collected during late 2009 throughout 2010 in Buffalo River and Mill Creek (see Table 1). Four hundred (400) *E. coli* samples (see Appendix A), and 40 nutrient samples were collected as part of routine water quality monitoring along lower Mill Creek and other Buffalo River and tributary sites (see Appendix B).

Single-Sample Maximum

During the period of study, Buffalo River at Pruitt did not exceed the single sample maximum (298 colonies/100ml; Figure 2, Table 2); however, only a short distance downstream, below Mill Creek, Buffalo River at Crow Hole exceeded the single-sample maximum 2 times (Figure 4), which equates to 5% of the sampling events exceeding state standards (Table 2). On 7/13/2010 Buffalo River was at base-flow, and Mill Creek had a discharge of 79 cfs and an *E. coli* concentration of 1733 with a falling hydrograph, post flood. Concentration and discharge in Mill Creek were sufficient to elevate Buffalo River from 42 *E. coli* colonies/100ml at Pruitt to 1986 *E. coli* colonies/100ml at Buffalo River at Crow Hole. Averages of single-sample *E. coli* estimates for Pruitt, Mill Creek Lower, and Buffalo River at Crow Hole were compared (Figure 5), and contributions of Mill Creek increase *E. coli* loading in Buffalo River by 3 times the concentrations observed in Buffalo River upstream of Mill Creek. In both cases, a single event and the average load, Buffalo River is negatively affected by the quality of water flowing from Mill Creek.

Sites within the Mill Creek drainage typically are as high as or higher in *E. coli* concentrations than observed in Mill Creek, Lower site (Figure 6). Within Mill Creek, average concentrations of *E. coli* increase upstream, until above of the Harp Creek confluence. Spring Valley Road, the uppermost collection site, is lowest in concentration among the sites tested, and Spring Valley Road is the closest site to the Marble Falls SID.

Of all Mill Creek sites, the frequency of samples in excess of the single-sample maximum is highest in Harp Creek. Harp Creek had the highest percentage of sampling events over the maximum and was at 28% of samples (Table 2). Mill Creek Lower had the next highest with 18% of the samples being over maximum, and Mill Creek at Campground was similar at 17%. The site with the lowest percentage of sampling events exceeding the maximum was Mill Creek at Spring Valley Road; again this is the uppermost sampling site nearest the Marble Falls SID.

E. coli concentrations were compared with discharge for each site within the Mill Creek drainage. In Lower Mill Creek concentrations of *E. coli* generally increased with increasing discharge (Figure 7), and *E. coli* concentrations could be quite high (maximum 2530, Table 3). Mill Creek at Campground is approximately a half mile upstream from Mill Creek Lower (Figure 1), and Flatrock Creek is the only tributary between the Lower site and Campground. Flatrock Creek was dry most of the 2010 period of study and was not included in the data analysis. Maximum *E. coli* levels at Mill Creek Campground were somewhat less than Lower Mill Creek (maximum 700, mean 200), although the mean was similar (Table 3). At Mill Creek Campground, comparison of *E. coli* and discharge (Figure 9) found that *E. coli* concentrations were higher at lower discharges. This suggests that base-flow concentrations were

higher than runoff concentrations in general for E coli at Mill Creek Campground. Harp Creek had high levels of *E. coli* at maximum (1986 colonies/100ml) and on average (mean 273 colonies/100ml), and as with Campground, Harp Creek (Figure 9) also exhibited higher *E. coli* concentrations at lower discharge levels. This suggests that both Harp Creek and Mill Creek Campground, which are located immediately adjacent to one another, have *E. coli* contamination originating from a local source and not as much of the *E. coli* loading is associated with non-point source runoff. The uppermost site within the Mill Creek system is at Spring Valley Road, and it had the lowest maximum single-sample result along with the lowest mean (maximum 687, mean 72). *E. coli* concentrations increased with discharge (Figure 10) which indicates contamination is more associated with non-point source runoff than with a local point source.

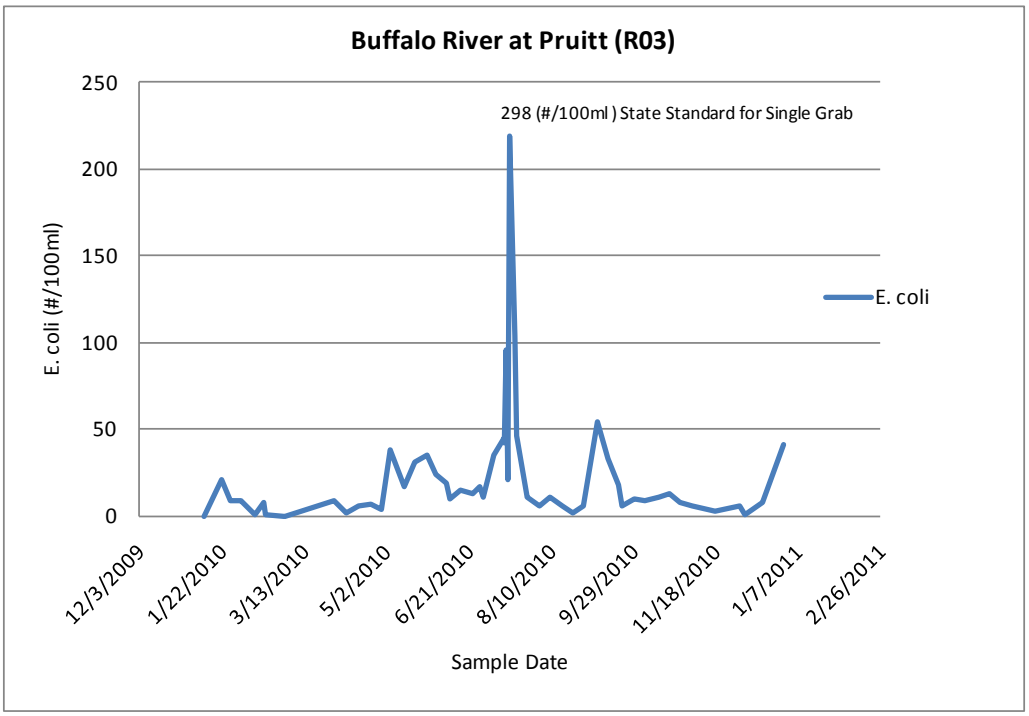

Figure 2. Single sample results for *E. coli* in Buffalo River at the Pruitt Access.

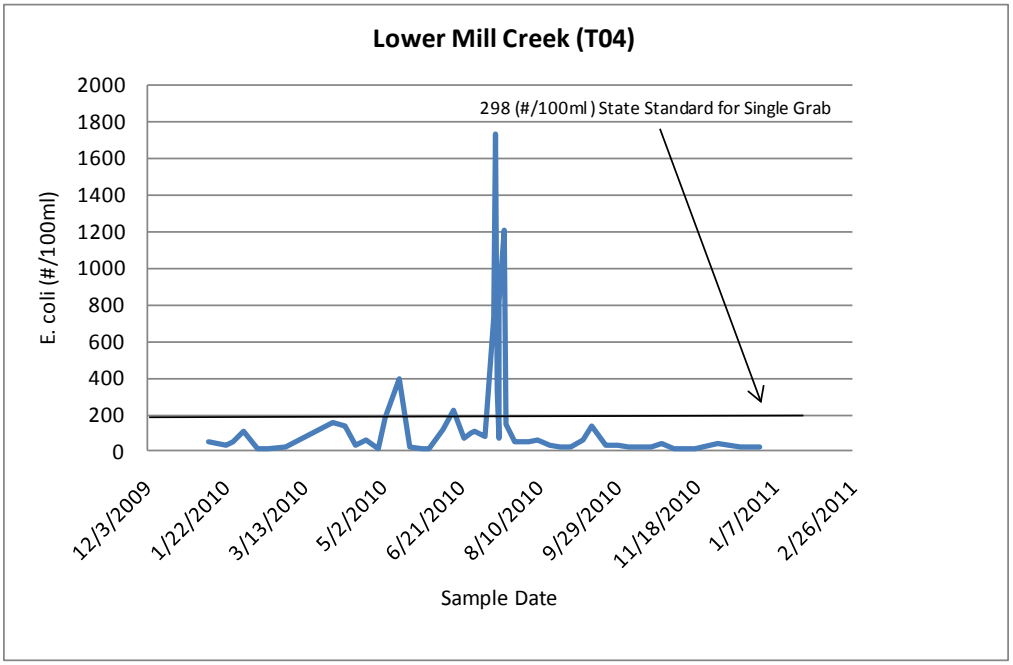

Figure 3. Single sample results for *E. coli* in Mill Creek at the Newton County Road crossing within Buffalo National River.

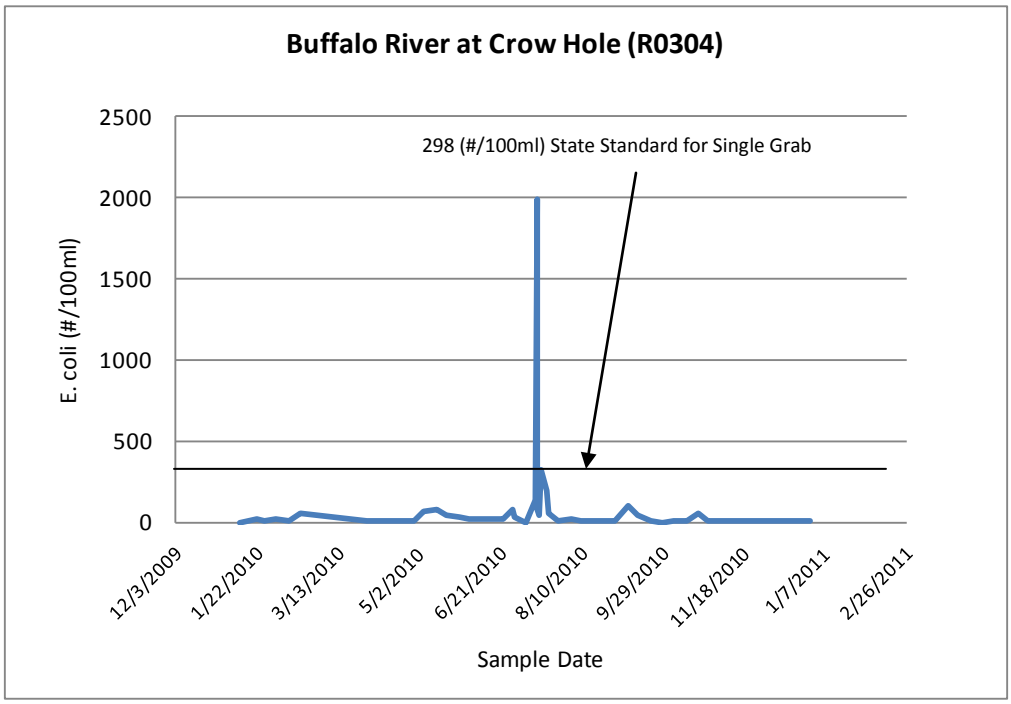

Figure 4. Single sample results from Buffalo River below Mill Creek confluence at the Crow Hole Swimming Area.

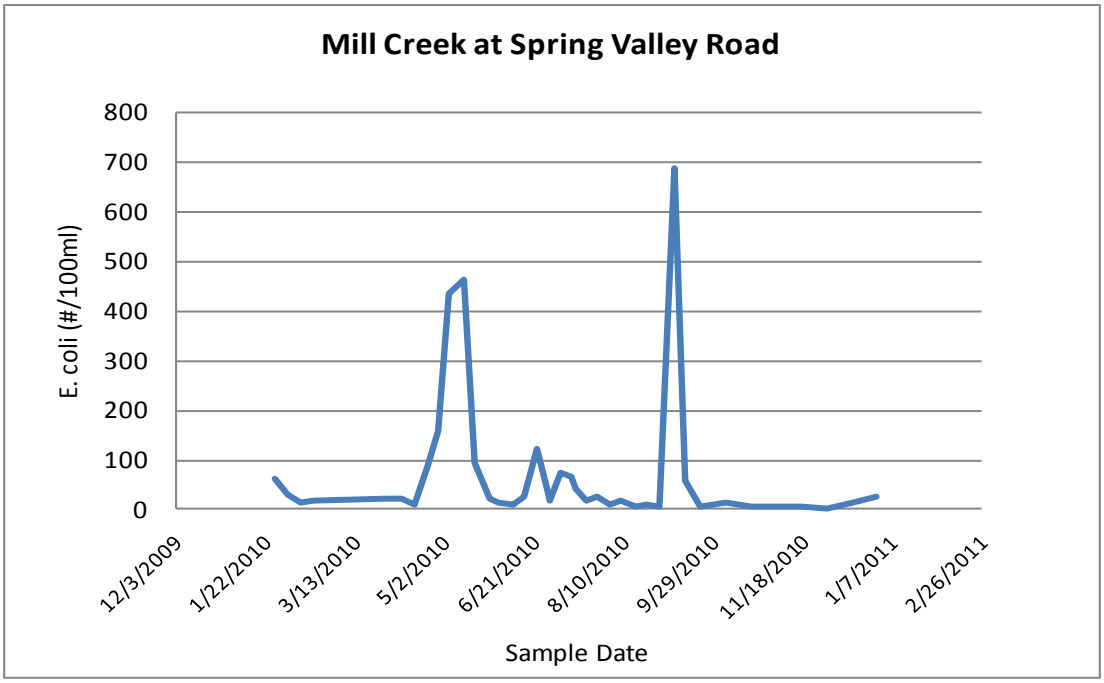

Figure 5. Single sample results of *E. coli* through time in Mill Creek at Spring Valley Road.

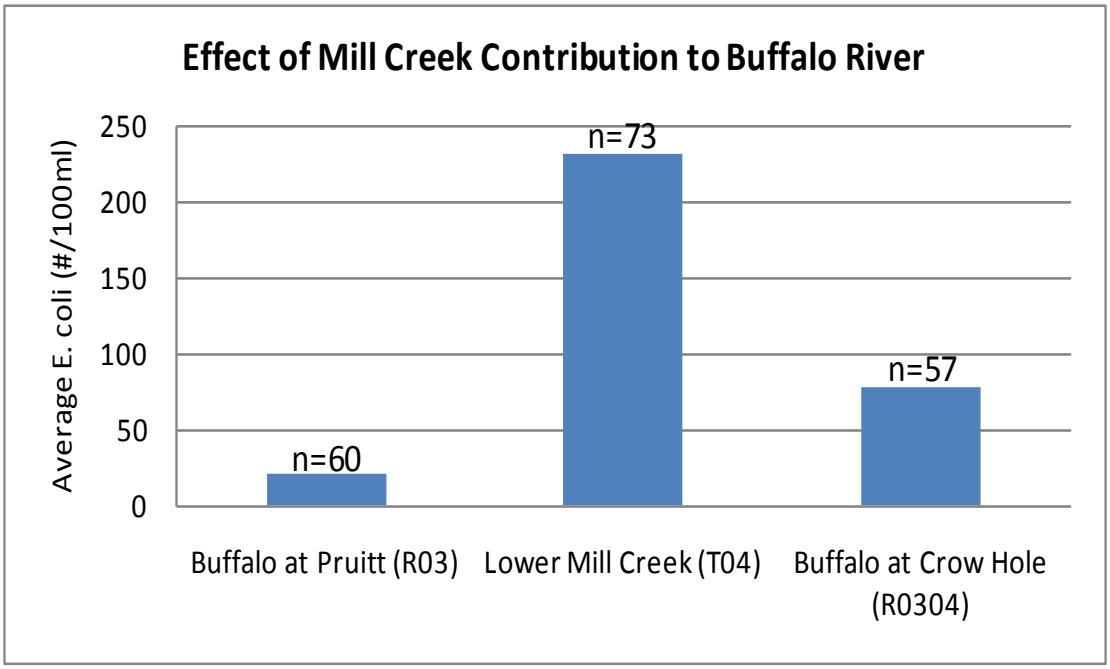

Figure 6. Site average of single-sample, shows Mill Creek's effects on Buffalo River at Crow Hole. Site averages include all data available from early 2009 until the end of 2010; therefore, sample sizes are not equal.

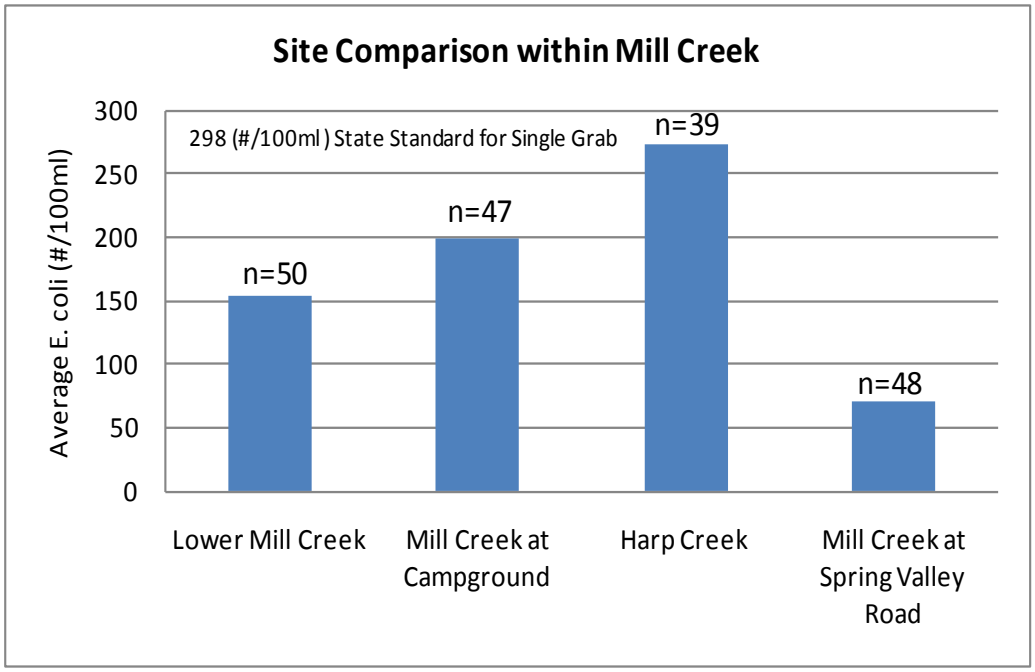

Figure 7. Average single-sample *E. coli* concentrations from sites within Mill Creek drainage. Samples were collected in unison during 2010; sample size was not equal due to dry conditions or sample loss.

Table 2. Percent of time sites sampled were in excess to state standard for single sample criteria.

Percentage of Single-Sample Maximum Exceeding f State Standards			
	Percent Exceeding	Number Exceeding	Number Samples
Buffalo River at Pruitt (BUFR03)	0	0	60
Buffalo River at Crow Hole (BUFR0304)	5	3	58
Mill Creek Lower (BUFT04)	**18**	13	74
Mill Creek at Campground (BUFT0401)	**17**	8	48
Harp Creek (BUFT0405)	**28**	11	40
Mill Creek at Spring Valley Road (BUFT0402)	6	3	49

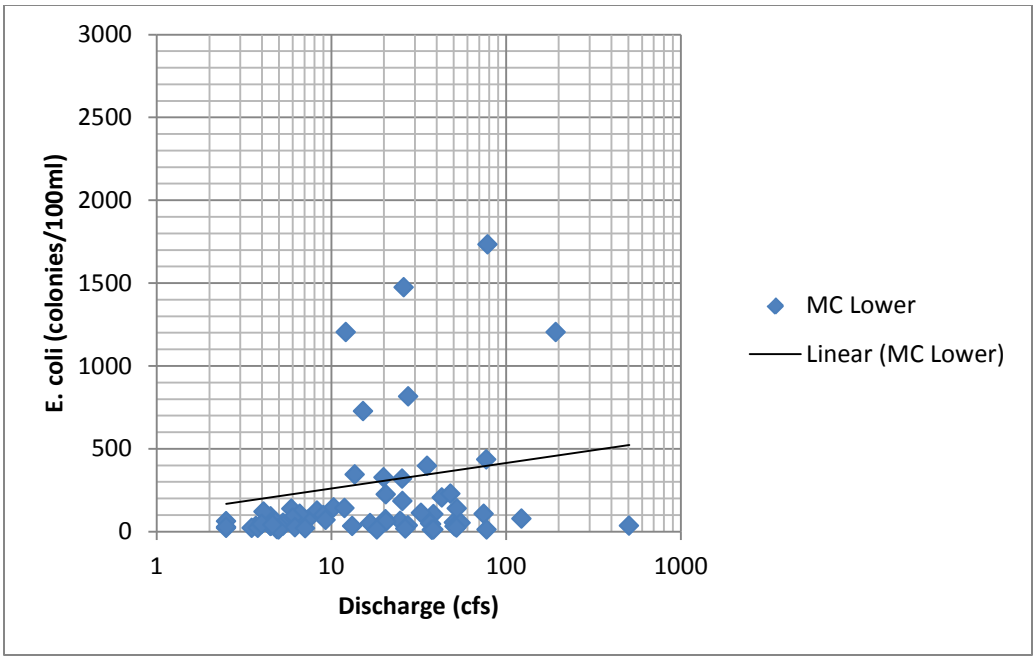

Figure 8. *E. coli* concentrations by discharge at Mill Creek Lower.

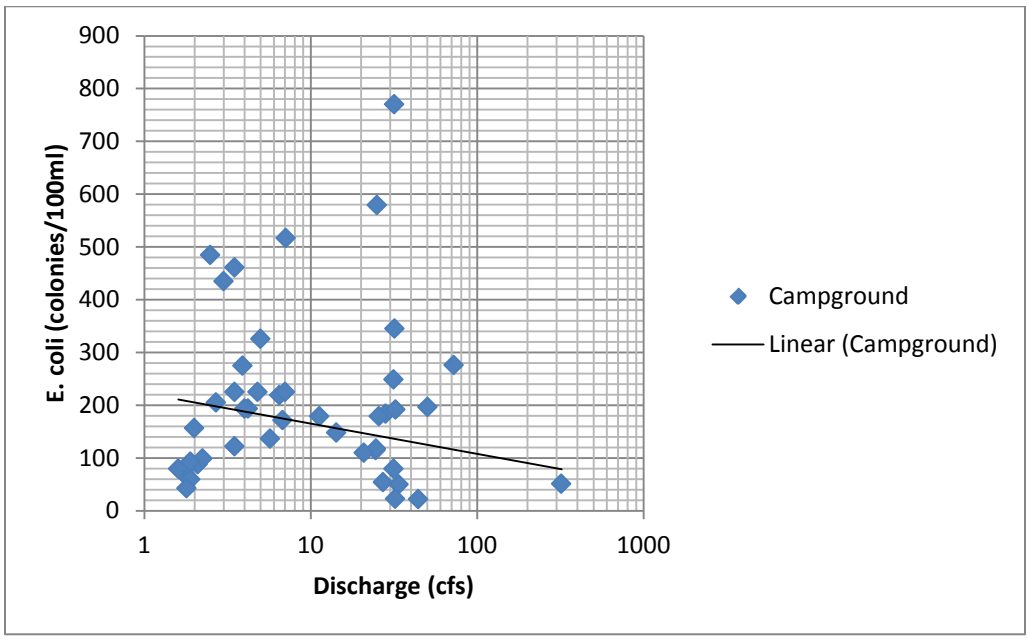

Figure 9. *E. coil* concentrations by discharge at Mill Creek Campground.

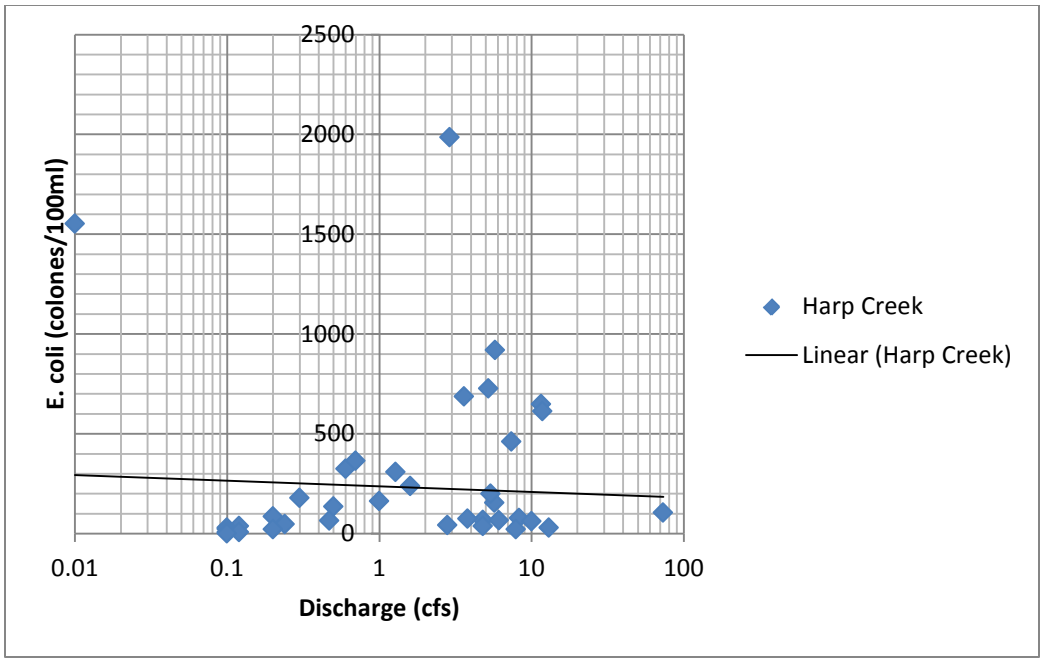

Figure 10. *E. coli* concentrations by discharge at Harp Creek.

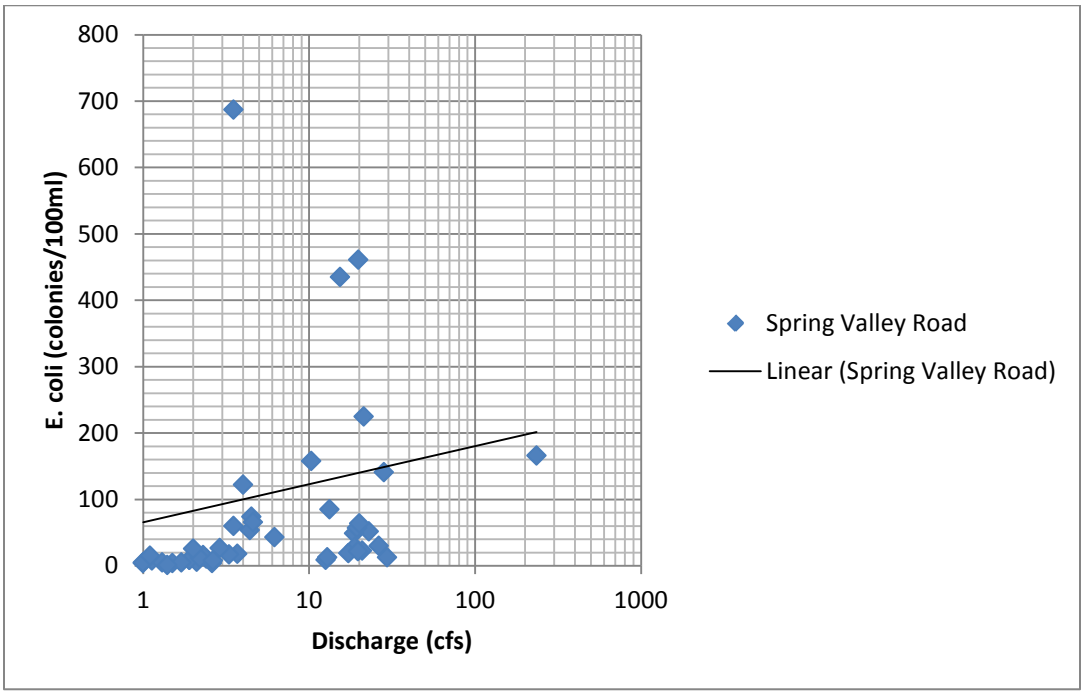

Figure 11. *E. coli* concentrations by discharge at Mill Creek at Spring Valley Road

Geometric Mean Maximum

Geometric mean is similar to the arithmetic mean but it is more conservative when dealing with data that is typified by variation in distribution and attenuates data extremes, such as is typical with surface water bacteria. The geometric mean was calculated for approximately a 30 day period of time within 2010 (Table 4), and all periods were based upon a sample size of 5, with the exception of Buffalo River at Crow Hole, Pruitt, and Lower Mill Creek having more than 5 samples within period 1. A state water quality standard for E. coli is a geometric mean maximum of 126 colonies/100ml. Lower Mill Creek, Mill Creek at the Campground, and Harp Creek are the only sites which exceed this standard during the study period (Table 4, Figures 11 and 12). Since the geometric mean reflects the condition of the site for an extended period of time and the majority of samples were collected at base-flow, in general, these sites were contaminated with *E. coli* most of the time. Chronically high concentrations were at observed at low discharge conditions which would indicate a nearby presence of a point source, rather than a distant non-point source.

Table 3. Periods of time during 2010 when geometric mean maximums were exceeded.

	Collection Dates		**BR at Pruitt**	**BR at Crow Hole**	**MC Lower**	**MC Campground**	**MC Spring Valley**	**Harp**	**Flatrock**
Period	**Begin**	**End**	**R03**	**R0304**	**T04**	**T0401**	**T0402**	**T0405**	**T0406**
1	1/12/2009	10/19/2009	13	84	**225**				
2	10/22/2009	1/27/2010	6	18	82			**152**	
3	2/3/2010	4/8/2010	3	14	44	83	22	80	24
4	4/15/2010	5/13/2010	10	19	74	**207**	119	**214**	
5	5/19/2010	6/16/2010	20	29	44	**256**	23	**178**	51
6	6/23/2010	7/12/2010	23	57	**208**	**258**	57	89	
7	7/14/2010	8/9/2010	33	50	**165**	**231**	20	87	
8	8/17/2010	9/13/2010	11	19	42	**194**	24	**135**	
9	9/22/2010	10/21/2010	9	10	29	**148**	7	6	
10	10/27/2010	12/29/2010	6	7	24	69	6		

Abbreviations: Buffalo River (BR), Mill Creek (MC)

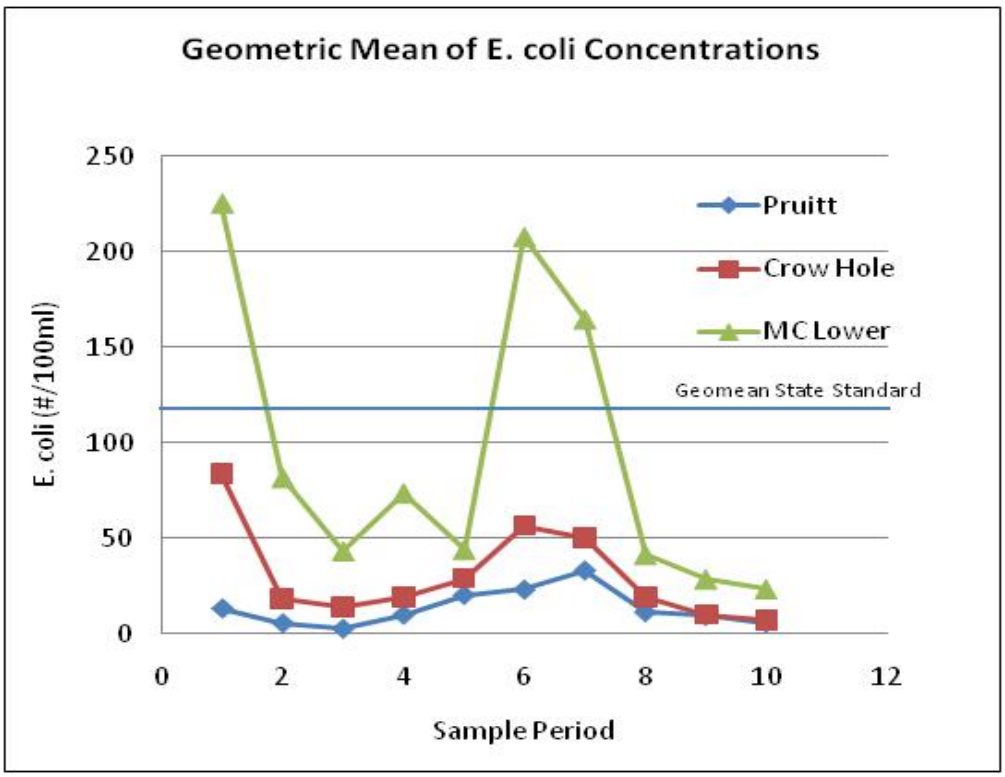

Figure 12. Geometric mean by period of study at Buffalo River sites and Mill Creek Lower.

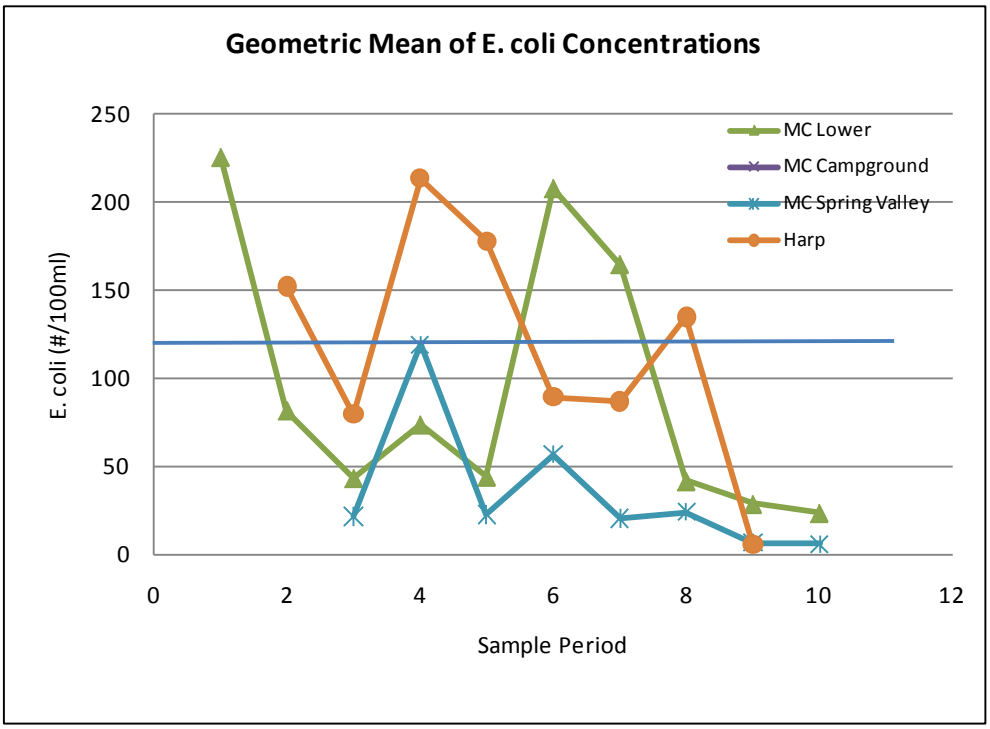

Figure 13. Geometric mean by period of study at sites within Mill Creek drainage.

Nutrient Standards

Nutrient samples were taken during mid to late summer 2010, which corresponds to sample periods 6, 7, and 8 (Table 4). Three nutrient samples were taken from each of the Mill Creek monitoring sites and selected Buffalo River sites, including a not previously discussed site BUFR04, which is at the Hasty River Access. The highest mean nitrate concentration was from Mill Creek at Spring Valley Road (T0402; 1.207 mg/L; Table 5), which is the closest site to the Marble Falls SID. Concentrations of nitrate declined in Mill Creek in a downstream order, Mill Creek near Campground (T0401; 0.901 mg/L), and then Mill Creek Lower (T04; 0.694 mg/L). Harp Creek was the lowest in nitrates (T0405; 0.334 mg/L).

In order to compare the nutrient concentrations of Mill Creek to that of other Buffalo River tributaries, a single sample was gathered for all the tributaries from the same time as Mill Creek was sampled for nitrates. The three highest tributaries were Brush Creek (T13), Mill Creek (Figure 14) Davis Creek (T07). All three of these tributaries have historically high levels of nitrates, and those nitrates were generally contributed by non-point source runoff.

Table 4. Basic statistics for nutrient samples for Mill Creek and selected Buffalo River sites.

	NO3(mg/L)			
	Mean	Max	Min	Number
BUFR03	0.016	0.036	0.005	4
BUFR0304	0.135	0.204	0.044	3
BUFR04	0.095	0.182	0.049	4
BUFT04	0.694	0.816	0.612	3
BUFT0401	0.901	1.070	0.811	3
BUFT0402	1.207	1.390	1.110	3
BUFT0405	0.334	0.468	0.224	3

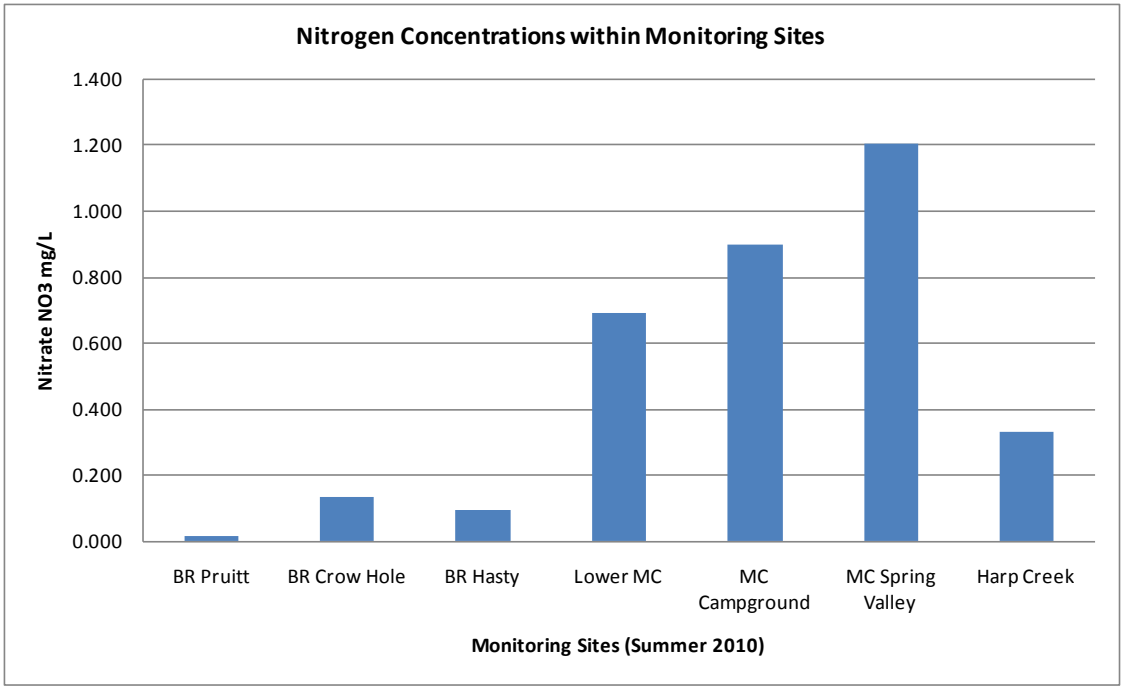

Figure 14. Mean nitrate concentrations from Buffalo River and Mill Creek sites for mid-summer 2010, sample size was n=3.

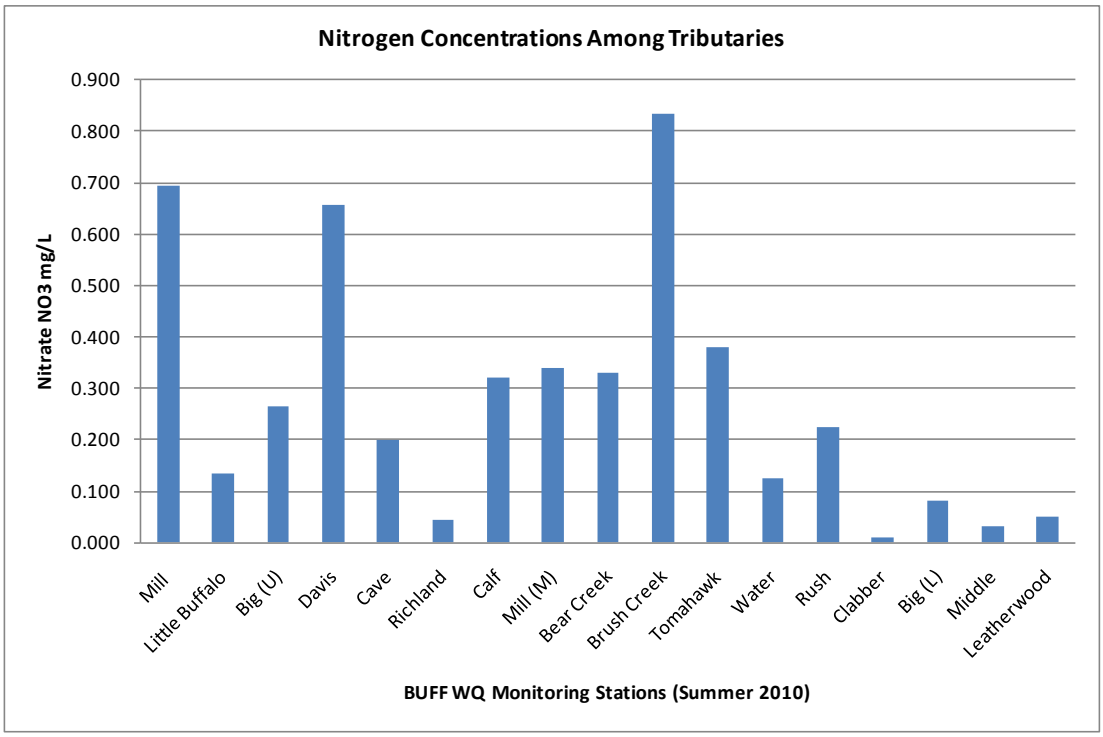

Figure 15. Nitrate concentrations from most tributaries sampled as part of the Buffalo National River's Water Quality Program, values represent only an n=1 and all samples were taken during summer 2010. BUFT07 is Davis Creek, BUFT13 is Brush Creek.

CONCLUSIONS

Within the administrative boundary of Buffalo National River, *E. coli* concentrations in Lower Mill Creek and within Buffalo River at Crow Hole reached levels above the state maximum for single-sample during 2010. Lower Mill Creek reached levels above the geometric mean maximum for an extended period of 2010. Elevated levels of *E. coli* in these areas increase the risk from water-borne pathogens to park visitors and staff, and continued monitoring to inform visitors of risk of recreation within these areas should continue.

Outside the boundary of Buffalo River, Mill Creek near the Campground and Harp Creek exceeded levels for single-sample maximums, and geometric means for extended periods of time during 2010. The drainage area of Mill Creek near the Campground is greater than 10 square miles. Therefore, it is considered as Primary Contact Waters of the State (APCEC , 2007), and it is reasonable that it is utilized as recreational waters as it is located adjacent to a private campground. Harp Creek, just upstream of the Campground, is not greater than 10 square miles, and it is unclear just how much recreational use occurs there. These two sites are within the jurisdiction of ADEQ and the Arkansas Department of Health, and data concerning these sites is available for their use in formulating mitigation strategies.

Numeric criteria developed by ADEQ for *E. coli* were patterned after earlier work done by the U. S. Environmental Protection Agency (1986). Numeric standards were initially derived by relating the concentrations of water-borne pathogens such as *E. coli* to that of the number of people in a 1000 that would become sick at various concentrations of *E. coli*. Much debate, litigation, and argument has occurred on the subject of direct cause and effect. However, State regulations have set concentration values for *E. coli*, and two sites within the park were over those values during times when recreation by the public was expected. Given this situation, it is likely that if conditions in Mill Creek continue, and *E. coli* concentrations remain high, the public will remain at increased risk. The amount of risk is linked to the flow ratio of Mill Creek to that of the Buffalo River. When Mill Creek is at higher flows and Buffalo River is at lower flow, *E. coli* concentrations can reach unsafe levels within Buffalo River relatively quickly below the confluence of Mill Creek. People visiting this area of the river would then be at greater risk to contract water borne illness. If an increase in flow at Mill Creek increases the ability to canoe certain areas of Buffalo River, then that would further increase the probability that the public would choose to float within that area of Buffalo River and increase their personal risk. Communication with the public about this risk should continue and creation of better and more dynamic communication with the public and visitor concessions should occur.

The ideal environment for *E. coli* is in the intestinal tracts of warm-blooded animals. Surface water conditions are not generally hospitable environs for *E. coli*. Because of this, concentrations of *E. coli* are generally higher near the source and dissipate with distance during base flow conditions in streams. Comparisons of *E. coli* concentrations versus discharge identified several sites that had negative relationships between these two variables and concentrations of *E. coli* were higher at lower flows. This suggests that at Harp Creek and Mill Creek Campground the source of the *E. coli* is near the collection site and indicates that origin is a point source. A similar finding was also observed in 1991 (Maner and Mott, 1991). Channel sediments within the confluence of Harp Creek and Mill Creek at Campground are

primarily bedrock, the soil horizons are shallow and domestic developments within the area are only a couple meters above that bedrock layer. Wastes from septic systems might be moving down through surface soils, and when intersecting the bedrock layer, moving laterally into the stream. Therefore, septic systems within this area are likely to be a significant contributing source of chronic contamination, particularly as older housing developments found are immediately adjacent to Mill Creek.

All other sites within Mill Creek exhibited a positive correlation with *E. coli* concentrations and discharge, suggesting non-point sources or a combination there of as an origin of the *E. coli*. Generally, as heavy rains fall on watersheds, the resulting runoff carries fecal matter from human developments and agricultural facilities within the watershed to the receiving stream. As stream flow increases, the concentration of fecal matter, *E. coli*, increases as well. The site having the highest magnitude of *E. coli* concentrations by flow was Mill Creek Lower. As the site having the largest watershed area, it is logical that the catchment would have a higher probability of non-point sources due to size alone. Mill Creek at Spring Valley Road was the next site exhibiting this relationship. At this site, increases in *E. coli* and discharge were generally positive in relationship; however, as seen in Figure 5, there were instances in May and September where *E. coli* concentrations increased to above the legal maximum and this increase was not associated with an increase in discharge. These instances suggest that although the *E. coli* concentrations at this site are primarily non-point source, this site does receive highly concentrated pulses of *E. coli* from a nearby point source, and the closest site is the Marble Falls SID. Certainty of the point source is inconclusive, but the samples with the highest concentrations from Spring Valley Road were collected after the 2010 Labor Day holiday, following a large biker rally and convention at Marble Falls Convention Center.

Nutrient water quality standards are based upon the impairment of stream biota (APCEC 2007), and while stream biota was not the focus of this investigation, nutrients are also an indicator of organic pollutions analogous to *E. coli*. Nutrient values were highest at Spring Valley Road, and dissipated downstream. Generally, during summer months, most Ozark streams are nitrate limited (Matthews, 2007) as algae, periphyton, aquatic plants, and riparian plant communities quickly utilize dissolved nutrients. The stream valley width in the upper portions of Mill Creek is narrow and shaded. As it progresses downstream, the valley width increases and more light penetrates the stream. So, it is not unexpected that this trend of lowering levels of nitrates would emerge as more uptake by plants occurs. However, an average concentration of 1.2 mg/L of nitrate is much higher than one could expect from a small, first order stream.

The dichotomy of lower *E. coli* and higher nitrates during base flows at the site closest the Marble Falls SID could be interpreted that *E. coli* concentrations are not an exclusive tool to identify point source locations. Assuming that Lower Dogpatch Spring is receiving untreated sewage, *E. coli* in that water must travel through Dogpatch Lake, over the dam spillway, over Mable Falls, and then travel approximately 0.8-km to the site on Spring Valley Road. This process could act as a natural waste water treatment pathway for *E. coli*. Aeration of the water throughout this pathway is extensive; light penetrates the water column killing *E. coli*, and temperature changes are not beneficial for *E. coli* existence. Therefore, *E. coli* concentrations would no longer be as high when reaching Spring Valley

Road, although nutrient concentrations are saturated in this zone and values would remain high. This logic is also reinforced by the positive relationship between discharge and *E. coli* density, as velocity increases there is little time for the natural elimination of E. coli over the distance from the perceived source to the uppermost sampling site at Spring Valley Road. Therefore, the Marble Fall SID may indeed impact the Mill Creek system, although *E. coli* alone may not fully explain the magnitude of that affect.

The ultimate sources for nutrients and *E. coli* in the upper Mill Creek basin, at the conclusion of this study, are still not clearly understood. Aley and Aley (2000) found that the recharge area for Upper Dogpatch Spring (the spring closest to the dysfunctional lift station) is 4.82 square miles, and of that area, 3.43 square miles (71%) is located in the Crooked Creek topographic basin to the north of Marble Falls. The total area which contributes water to Lower Dogpatch Spring (the spring below the SID's collection infrastructure) is 10.90 square miles. While Lower Dogpatch Spring is within the Mill Creek topographic basin, 8.76 square miles (80%) of the recharge area for this spring is located in the Crooked Creek topographic basin. The Crooked Creek basin is typified by open pastureland and numerous cattle grazing operations. Rain events in the Crooked Creek recharge area mobilize pollutants that have been shown to move through the cave systems into both Dogpatch Springs (Aley and Aley, 2000). The combination of the runoff from Crooked Creek being transferred into upper Mill Creek and contributions of leaking sewage collection infrastructure from Marble Falls cannot be separated by this investigation. The only indication that the Marble Falls SID is actively leaking is through the observation of occasional high *E. coli* concentrations and high nutrients at low base flows, when no rain had occurred. Without specific and detailed dye tracing, there can be no real delineation of the Marble Falls SID contributions of pollution to Mill Creek.

Nutrient concentrations leaving Mill Creek does affect the quality of water within Buffalo River. Nitrate concentration on average within Mill Creek was approximately 0.7 mg/L, a value nearly 50 times more concentrated than the average from Buffalo River at Pruitt. Comparison of single grab samples of nitrates through the summer period from other Buffalo River tributaries found two other tributaries were as high as or higher than Mill Creek. This suggests that although Mill Creek is a definite problem stream, other tributaries are also be polluted as well and may pose additional risk to public safety and to the Buffalo River ecosystem. Continued vigilance in Mill Creek and these other tributaries is warranted.

RECOMMENDATIONS

1) Continue to monitor *E. coli* concentrations within Mill Creek Lower and Buffalo River at Pruitt and Crow Hole, and continue public health advisory and notification.
2) Notify Arkansas Department of Environmental Quality and Arkansas Department of Health of report findings.
3) Discuss the value of monitoring the upper Mill Creek locations, and discuss reducing or eliminating those stations for FY11.
4) Increase sampling frequency around

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Site	Date Collected	Time	Collected By	Air Temp	Daily Precip	Discharge	Flow Regime	Water Temp	Conductivity	pH	DO	%DO	Turbidity	Fecal Coliform	E coli
BUFR03	1/12/2009	12:05	SWH,DDL	12.4	0	119	B	5.0	153	7.5	12.4	99.1	2.4	6	16
BUFR03	3/16/2009	11:50	JKJ,SWH	17	0	81	B	11.3	126	7.1	10.3	95.0	1.1	2	6
BUFR03	6/22/2009	11:55	JKJ	34.8	0	116	B	26.8	192	7.9	6.9	46.6	1.7	24	11
BUFR03	8/3/2009	11:20	JKJ	29.2	0	35	B	26.5	229	8.0	7.5	92.5	1.3	30	20
BUFR03	8/3/2009	11:20	JKJ	29.2	0	36	B	26.5	229	8.0	7.5	92.5	1.3	30	20
BUFR03	8/4/2009	13:01	JKJ	31.8	0	28	B	28.8	200	8.0	7.4	95.8	1.1	8	12
BUFR03	8/4/2009	13:01	JKJ	31.8	0	28	B	28.8	200	8.0	7.4	95.8	1.1	8	12
BUFR03	8/5/2009	13:15	JKJ	29.3	0	20	B	28.8	178	8.1	7.0	91.2	1.9		11
BUFR03	8/5/2009	13:15	JKJ	29.3	0	20	B	28.8	178	8.1	7.0	91.2	1.9		11
BUFR03	10/19/2009	13:00	JKJ,KE	21.2	0		F	12.9	82	7.9	11.2	105.3	3.5	12	26
BUFR03	1/11/2010	10:46	FDU	6.1	0	116	B	0.5	68	8.0	12.5	86.5	1.5	0	0
BUFR03	1/22/2010	11:48	FDU	8.8	0.1	223	R	9.2	112	7.9	11.8	102.4	8.2		21
BUFR03	1/27/2010	12:44	JKJ, SWH	9.5	0	421	B	5.5	83	7.9	12.7	100.4	7.4		9
BUFR03	2/3/2010	12:37	JKJ	10	0	388	R	5.7	107	8.1	13.4	106.6	5.0		9
BUFR03	2/11/2010	13:39	JKJ,SWH	5.7	0	432	F	4.8	88	8.0	13.2	102.7	3.8		1
BUFR03	2/16/2010	9:56	FDU	5.7	0	11	B	3.4	153	8.1	11.0	82.7	0.7		8
BUFR03	2/18/2010	10:22	JKJ,SWH	5	0	278	B	4.3	83	8.0	13.5	103.5	2.5		1
BUFR03	3/1/2010	12:13	JKJ	8.7	0	266	B	6.9	71	8.2	12.1	99.7	2.8	0	0
BUFR03	3/31/2010	9:44	JKJ,SWH	19.9	0	417	F	11.7	101	7.7	11.0	101.0	4.6		9
BUFR03	4/8/2010	11:40	JKJ,FDU	14.1	0	364	B	14.5	118	8.1	10.3	101.0	4.1		2
BUFR03	4/15/2010	9:49	JKJ	22.1	0	170	B	16.9	134	7.9	8.6	89.0	1.8		6
BUFR03	4/22/2010	10:28	JKJ,SWH	21.1	0	113	B	15.7	153	7.9	9.1	91.8	1.4		7
BUFR03	4/29/2010	12:20	JKJ,SWH	26.1	0	90	B	18.6	151	8.1	9.6	102.5	1.3		4
BUFR03	5/4/2010	10:13	JKJ,SWH	21.2	0	136	B	17.6	137	8.0	9.1	95.1	3.7		38
BUFR03	5/13/2010	13:05	JKJ	22.3	0	140	F	19.6	166	8.0	8.5	92.7	2.7		17
BUFR03	5/19/2010	15:27	JKJ,SWH	22.1	0	421	F	17.1	112	8.0	9.6	99.6	9.3		31
BUFR03	5/27/2010	9:30	JKJ	24.5	0	298	B	20.2	133	8.0	10.7	118.0	3.8		35
BUFR03	6/1/2010	10:15	JKJ	27.2	0	119	B	23.3	172	7.8	10.1	118.0	1.0		24
BUFR03	6/7/2010	11:20	JKJ	19.8	0	61	B	24.6	191	7.9	7.9	94.9	1.1	22	19

BUFR03	6/10/2010	10:55	JKJ	28.8	0	53	B	26.2	193	8.0			1.5		10
BUFR03	6/16/2010	11:56	JKJ	28.7	0	55	B	28.1	182	8.0	7.2	92.3	1.1		15
BUFR03	6/23/2010	13:58	JKJ,SAB	31.8	0	38	B	30.1	223	7.9	7.3	97.4	1.2		13
BUFR03	6/28/2010	10:45	JKJ, SAB	30	0.38	33	B	29.1	216	7.7	6.6	86.3	1.7		17
BUFR03	6/30/2010	11:20	SAB	34.1	0	29	B	28.3	206	7.7	7.0	90.9	2.1		11
BUFR03	7/6/2010	10:45	JKJ,SAB	31.2	0	22	B	27.3	215	7.9	13.7	172.4	1.3		35
BUFR03	7/12/2010	11:20	SAB,FDU	28.2	0.9	41	B	26.8	201	7.7	7.2	90.8	2.2		45
BUFR03	7/13/2010	9:55	SAB, FDU	26.4	0.9	51	R	26.3	212	8.0	7.2	89.0	1.5		42
BUFR03	7/14/2010	10:46	SAB	33.4	0	218	R	27.9	213	7.6	6.7	86.1	1.9		96
BUFR03	7/15/2010	12:30	SAB	36.3	0	92	F	31.0	207		7.4	96.4	4.3		21
BUFR03	7/16/2010	11:31	JKJ,SAB	33.2	1.3	588	R	28.4	165	8.0	7.0	89.4	4.5		219
BUFR03	7/19/2010	13:18	JKJ,SAB	31.1	0.75	153	F	27.7	129	8.1	9.4	119.7	7.8		104
BUFR03	7/20/2010	11:09	JKJ,SAB	31	0	109	B	28.7	128	8.2	8.8	113.8	3.4	42	46
BUFR03	7/26/2010	10:25	SAB,JKJ	32	0	36	B	30.4	118	8.1	8.7	115.5	1.1		11
BUFR03	8/3/2010	10:27	SAB,FDU	35.3	0	23	B	31.4	185	8.1	6.7	91.1	1.1		6
BUFR03	8/9/2010	11:51	SAB	34.6	0	15	B	30.5	202	8.0	9.7	128.7	1.9	36	11
BUFR03	8/17/2010	11:10	SAB		0	8	B	29.7	235	8.0	7.9	104.1	1.1		6
BUFR03	8/23/2010	10:54	SAB,JKJ	32.9	0	6	B	30.2	206	7.9	5.4	73.3	1.0		2
BUFR03	8/30/2010	11:18	SAB,JKJ	31.1	0	4	B	26.5	138	7.9	10.4	103.7	0.7		6
BUFR03	9/7/2010	9:29	SAB	22.9	0	7	B	23.5	229	7.9	6.6	78.7	0.8		54
BUFR03	9/13/2010	10:04	SAB,JKJ	25.2	0	85	F	22.6	153	7.9	8.2	94.3	3.5		33
BUFR03	9/20/2010	12:53	SAB,JKJ	28.2	0	41	B	26.8	183	8.2	8.8	109.7	1.1	12	18
BUFR03	9/22/2010	10:47	SAB	26.5	0	33	B	25.4	177	8.1	8.2	100.6	0.7		6
BUFR03	9/29/2010	9:57	SAB	21.1	0	24	B	19.6	175	8.0	10.2	111.6	0.7		10
BUFR03	10/6/2010	10:06	SAB	16.6	0	15	B	15.2	149	8.0	12.4	123.3	0.6		9
BUFR03	10/14/2010	12:53	JKJ	19.4	0	3	B	18.6	207	8.0	12.0	128.1	0.8		11
BUFR03	10/21/2010	12:50	JKJ,SWH	21.2	0	12	B	18.0	152	8.0	10.6	112.4	0.9		13
BUFR03	10/27/2010	9:57	JKJ	12.2	0	9	B	15.7	242	8.1	7.6	76.4	0.6		7.4
BUFR03	11/4/2010	13:27	JKJ	15	0	12	B	14.2	255	8.1	9.2	90.0	0.8		6
BUFR03	11/17/2010	9:51	JKJ	9.3	0.02	13	B	9.7	234	8.0	10.2	89.7	0.7		3
BUFR03	12/2/2010	13:15	JKJ,SWH	13	0	17	B	6.9	252	8.3	11.9	98.2	0.7		6
BUFR03	12/6/2010	11:30	JKJ,KE	3.2	0	16	B	5.5	165	8.2	13.0	101.9	0.8	0	1
BUFR03	12/16/2010	9:56	FDU	5.7	0	11	B	3.4	153	8.1	11.0	82.7	0.7		8

BUFR03	12/29/2010	10:48	FDU	9.7	0.2	11	B	4.0	151	8.0	15.8	119.4	0.7		41
BUFR0304	8/1/2009	12:01	FDU		0.5	26	B	22.7	251	8.0	7.7	89.5	3.7	92	94
BUFR0304	8/1/2009	12:01	FDU		0.5		B	22.7	251	8.0	7.7	89.5	3.7	92	94
BUFR0304	8/2/2009	15:11	FDU	29.6	0	71	B	26.1	297	8.1	9.2	115.0	6.9	350	306
BUFR0304	8/2/2009	15:11	FDU	29.6		71	B	26.1	297	8.1	9.2	115.0	6.9	350	367
BUFR0304	8/3/2009	11:00	JKJ	30	0	43	B	24.2	165	8.0	8.4	99.9	3.1	72	104
BUFR0304	8/3/2009	11:00	JKJ	30	0	43	B	24.2	165	8.0	8.4	99.9	3.1	72	104
BUFR0304	8/4/2009	12:30	JKJ	31.3	0	30	B	27.0	254	8.0	8.8	110.2	2.5	32	42
BUFR0304	8/4/2009	12:30	JKJ	31.3	0	30	B	27.0	254	8.0	8.8	110.2	2.5	32	42
BUFR0304	8/5/2009	13:00	JKJ	28.5	0	29	B	27.4	251	8.2	8.2	102.9	2.7		30
BUFR0304	8/5/2009	13:00	JKJ	28.5	0	29	B	27.4	251	8.2	8.2	102.9	2.7		30
BUFR0304	10/26/2009	10:26	FDU,KE	14.8	0		B	14.0	117	8.0	9.7	94.4	4.3		52
BUFR0304	11/9/2009	9:15	FDU, KE	15.5	0	213	B	14.2	150	7.9	9.8	95.6	2.7		31
BUFR0304	11/10/2009	8:40	FDU, KE	12.6	0	206	B	14.0	2	7.9	9.9	96.4	2.2		36
BUFR0304	11/12/2009	9:59	JKJ, FDU	9.8	0	195	B	13.1	154	8.0	10.1	100.7	1.8		45
BUFR0304	12/28/2009	14:55	JKJ	7.5	0		B	4.9	84	8.0	13.5	105.3			10
BUFR0304	1/11/2010	11:30	FDU	8.6	0	133	B	1.0	104	8.3	13.3	93.0	1.3	2	2
BUFR0304	1/22/2010	11:27	FDU	8.8	0.05	730	R	9.4	132	8.0	12.0	104.4	8.0		17
BUFR0304	1/27/2010	12:15	JKJ,SWH	9.6	0	476	B	5.7	98	8.0	12.6	100.8	7.1		14
BUFR0304	2/3/2010	12:19	JKJ	7.9	0	463	R	5.9	89	7.9	13.4	107.4	3.9		23
BUFR0304	2/11/2010	13:20	JKJ,SWH	6.2	0	510	F	5.1	107	8.1	13.1	103.0	3.7		4
BUFR0304	2/18/2010	9:45	JKJ,SWH	2.1	0	316	B	4.3	103	8.3	13.5	103.8	2.4		51
BUFR0304	3/31/2010	9:27	JKJ,SWH	18	0		F	11.8	121	7.6	10.9	100.4	4.2		15
BUFR0304	4/8/2010	12:00	JKJ,FDU	17.9	0	416	B	14.8	138	8.2	10.8	106.6	3.1		8
BUFR0304	4/15/2010	9:23	JKJ	18	0	198	B	16.3	155	8.1	8.8	90.1	1.6		6
BUFR0304	4/22/2010	10:04	JKJ,SWH	20.3	0	134	B	15.4	178	8.1	9.8	97.8	1.3		13
BUFR0304	4/29/2010	12:00	JKJ,SWH	25.1	0	37	B	17.4	181	8.2	10.6	110.4	1.1		6
BUFR0304	5/4/2010	10:09	JKJ,SWH	18.4	0	162	B	16.8	158	8.1	9.2	94.7	4.5		65
BUFR0304	5/13/2010	12:48	JKJ	23.7	0	175	F	19.4	164	8.2	9.0	98.0	3.8		84
BUFR0304	5/19/2010	15:13	JKJ,SWH	20.1	0		F	16.9	130	8.1	9.6	99.3	8.8		44
BUFR0304	5/27/2010	9:10	JKJ	23.1	0	336	B	19.8	154	8.1	10.6	116.0	3.5		38
BUFR0304	6/1/2010	10:03	JKJ	23.6	0	146	B	21.9	197	7.9	10.1	115.6	1.2		26
BUFR0304	6/10/2010	11:15	JKJ	27.8	0	57	B	25.6	221	8.2			1.3		23

BUFR0304	6/16/2010	11:38	JKJ	31.9	0		B	27.2	214	8.1	8.4	106.1	1.1		21
BUFR0304	6/23/2010	13:39	JKJ, SAB	33.9	0	45	B	30.0	253	8.1	8.9	117.1	3.9		17
BUFR0304	6/28/2010	11:04	JKJ,SAB	29.1	0.38	42	B	27.5	220	7.8	7.2	92.8	1.3		77
BUFR0304	6/30/2010	10:57	SAB	27.4	0	36	B	25.9	229	7.7	7.5	93.6	1.6		30
BUFR0304	7/6/2010	10:22	JKJ,SAB	30.1	0	28	B	25.7	217	7.9	13.6	171.7	3.1		3
BUFR0304	7/12/2010	10:54	SAB,FDU	26.9	0.9	56	B	25.2	235	7.8	7.9	96.8	3.2		143
BUFR0304	7/13/2010	9:30	SAB, FDU	25.8	0.9	130	R	22.8	197	7.9	7.8	90.5	51.2		1986
BUFR0304	7/14/2010	10:05	SAB	30.8	0	238	F	26.8	221	7.6	7.2	90.3	2.7		80
BUFR0304	7/15/2010	11:52	SAB	32.7	0	101	F	27.6	213		7.5	96.7	4.3		42
BUFR0304	7/16/2010	11:49	JKJ,SAB	32.1	1.3	616	R	27.9	141	8.1	7.5	95.9	7.7		326
BUFR0304	7/19/2010	13:05	JKJ,SAB	32.3	0.75	165	F	27.9	144	8.2	9.7	124.2	7.9		201
BUFR0304	7/20/2010	10:47	JKJ,SAB	29.5	0	119	F	27.2	150	8.1	8.8	110.5	3.4	26	56
BUFR0304	7/26/2010	10:00	SAB,JKJ	30.5	0	41	B	28.3	131	8.0	8.5	108.8	1.3		13
BUFR0304	8/3/2010	10:04	SAB,FDU	31.1	0	28	B	28.9	216	7.9	6.1	80.2	1.2		26
BUFR0304	8/9/2010	11:31	SAB	34.4	0	18	B	27.8	228	7.9	9.8	126.3	2.4	12	10
BUFR0304	8/17/2010	11:28	SAB		0	12	B	26.2	265	7.9	8.1	100.3	1.1		9
BUFR0304	8/23/2010	10:29	SAB,JKJ	30.3	0	9	B	27.1	264	7.9	5.8	72.6	1.3		11
BUFR0304	8/30/2010	11:46	SAB,JKJ	30.5	0	8	B	25.2	240	7.9	11.0	133.1	1.0		6
BUFR0304	9/7/2010	8:41	SAB	22.6	0	12	B	22.5	258	7.8	6.0	70.8	0.9		102
BUFR0304	9/13/2010	9:35	SAB,JKJ	19.6	0	97	F	21.7	164	7.9	8.1	92.1	3.2		44
BUFR0304	9/22/2010	9:57	SAB	23.3	0	38	B	24.0	191	8.0	8.0	95.4	0.8		10
BUFR0304	9/29/2010	9:12	SAB	14.4	0	29	B	18.1	191	7.9	8.8	93.1	0.7		3
BUFR0304	10/6/2010	9:10	SAB	10.7	0	20	B	13.6	186	7.9	13.0	125.0	0.6		10
BUFR0304	10/14/2010	12:30	JKJ	22.3	0	10	B	16.3	213	8.0	10.7	109.0	1.0		6
BUFR0304	10/21/2010	12:33	JKJ,SWH	26.2	0	16	B	15.9	173	8.0	10.5	106.2	0.8		62
BUFR0304	10/27/2010	9:37	JKJ	11.6	0	13	B	13.4	293	8.3	9.3	89.0	0.4		11
BUFR0304	11/4/2010	13:06	JKJ	18.1	0	17	B	13.1	258	8.1	9.6	91.6	0.7		5
BUFR0304	11/17/2010	9:52	JKJ	10.4	0.02	18	B	9.1	259	8.0	10.4	90.1	0.5		6
BUFR0304	12/2/2010	13:00	JKJ,SWH	17	0	22	B	6.9	270	8.3	12.6	103.6	0.6		5
BUFR0304	12/16/2010	9:36	FDU	4.5	0	14	B	3.9	169	8.1	12.0	91.4	0.7		8
BUFR0304	12/29/2010	10:27	FDU	8.8	0.2	18	B	4.6	165	7.7	14.9	115.7	0.7		9
BUFT03	3/9/2009	11:00	JKJ	15.3	0	8	B	10.4	212	7.7	10.9	98.8	2.5	22	17
BUFT03	8/4/2009	10:53	JKJ		0		B							140	128

BUFT03	8/5/2009	11:12	JKJ		0		B								79
BUFT03	8/17/2009	12:45	JKJ	31.5	0	0	B	25.4	263	7.7	6.5	78.9	1.2	2	64
BUFT03	8/31/2009	10:35	JKJ	19.1	0	1	B	19.7	260	7.5	7.2	79.3	1.1	296	614
BUFT03	8/31/2009	10:35	JKJ	19.1	0	1	B	19.7	260	7.5	7.2	79.3	1.1	296	614
BUFT03	9/2/2009	9:45	SWH	12.7	0		B						2.3	28	22
BUFT03	9/2/2009	10:00	SWH	12.7	0		B						1.7	34	23
BUFT03	9/2/2009	9:30	SWH	12.7	0		B						1.7	313	649
BUFT03	9/3/2009	10:00	SWH		0.3		B							46	147
BUFT03	9/8/2009	10:30	SWH		0		B							102	79
BUFT03	9/8/2009	10:30	SWH		0		B							94	102
BUFT03	9/8/2009	10:30	SWH		0		B							94	102
BUFT03	9/8/2009	10:30	SWH		0		F							102	179
BUFT03	9/9/2009	12:00	SWH		0.1		B							54	99
BUFT03	9/9/2009	12:00	SWH		0.1		B							90	149
BUFT03	9/9/2009	12:00	SWH		0.1		B							158	236
BUFT03	9/15/2009	10:56	FDU	23	0.25	3	B	19.2	276	7.6	7.3	79.5	1.3	96	111
BUFT03	9/22/2009	10:45	FDU		2		B	18.1	109	7.6	8.6	92.2	34.2	670	925
BUFT03	9/29/2009	10:04	FDU	15.9	0	15	B	14.7	159	7.6	9.2	91.9	3.8	13	32
BUFT03	10/5/2009	10:40	JKJ,SWH	14	0	5	B	14.7	106	7.9	9.9	97.2	1.9	6	32
BUFT03	10/14/2009	12:10	JKJ,SWH	15.1	0.25		F	14.3	104	7.8	10.0	97.9	20.0	97	179
BUFT03	1/11/2010	9:29	FDU	6.6	0	11	B	3.9	131	8.0	11.9	90.2	2.2	4	3
BUFT03	4/12/2010	11:19	JKJ	22.7	0	19	B	13.1	161	7.8	10.7	101.5	5.0	2	2
BUFT03	7/19/2010	12:02	JKJ,SAB	34.1	0.75	1	B	24.9	241	7.9	9.8	118.1	1.5	18	55
BUFT03	9/27/2010	10:43	SAB,JKJ	16.4	0	2	B	16.7	204	7.8	9.9	102.2	1.1	18	22
BUFT04	3/9/2009	9:32	JKJ	10.1	0	13	B	12.0	356	7.8	10.2	94.6	1.5	48	33
BUFT04	6/22/2009	11:40	JKJ	32.5	0	20	B	22.5	339	7.9	8.5	98.6	2.2	92	73
BUFT04	7/31/2009	12:00	FDU		1.5		F	25.0	306	8.0	7.9	86.9	25.0	2555	1034
BUFT04	8/1/2009	12:30	FDU	22.8	0.5	25	B	19.5	403	7.9	7.9	86.8	30.3	375	320
BUFT04	8/2/2009	15:40	FDU	26.2	0	26	B	22.7	356	8.1	8.9	105.0	17.5	760	1473.3
BUFT04	8/3/2009	11:40	JKJ	30.5	0	14	B	21.4	285	8.0	8.3	93.9	7.0	264	344
BUFT04	8/4/2009	13:30	JKJ	34.6	0	8	B	23.9	320	8.0	8.7	103.8	5.1	28	127
BUFT04	8/5/2009	13:30	JKJ	30.2	0	4	B	24.0	313	8.0	7.5	89.2	4.2		91
BUFT04	8/31/2009	9:10	JKJ	17.2	0	6	B	18.0	297	7.4	7.2	76.7	1.6	128	138

BUFT04	9/8/2009	10:30	SWH		0		B							202	276
BUFT04	9/15/2009	9:46	FDU		0.75	20	B	18.5	370	7.8	7.9	84.5	4.4	187	225
BUFT04	9/22/2009	9:49	FDU	20	2		B	17.4	219	8.0	8.9	94.3	25.0	3165	2530
BUFT04	9/29/2009	11:41	FDU	19.1	0	38	B	14.8	287	8.2	9.8	98.4	2.0	114	105
BUFT04	10/5/2009	10:00	JKJ,SWH	14.5	0	25	B	15.2	246	7.9	8.4	84.0	2.3	49	64
BUFT04	10/14/2009	11:15	JKJ, SWH	14.5	0.25	193	F	14.7	225	8.1	9.4	92.6	14.0	316	1203
BUFT04	10/19/2009	12:20	JKJ,KE	22.6	0	50	B	13.7	167	8.1	11.6	112.1	3.4	24	54
BUFT04	10/22/2009	10:45	JKJ,KE	17.7	0.54	43	B	15.2	255	8.1	9.9	99.1	1.7	94	206
BUFT04	10/23/2009	10:30	FDU	11.7	0	77	F	13.9	262	8.3	10.7	104.1	12.0		435
BUFT04	10/26/2009	11:30	FDU, KE	14.7		48	B	14.5	278	8.2	10.9	107.5	4.7		228
BUFT04	11/2/2009	10:20	JKJ,KE	21	0	122	B	13.8	260	7.8	12.1	116.6	3.3		77
BUFT04	11/9/2009	9:39	FDU, KE	15.7	0	37	B	14.2	285	8.2	10.0	97.9	1.5		44
BUFT04	11/10/2009	9:11	FDU, KE	15.7	0	37	B	14.0		8.1	10.4	101.1	1.6		48
BUFT04	11/12/2009	10:28	JKJ, FDU	10.6	0	33	B	12.8	249	8.2	11.3	106.8	2.2		113
BUFT04	12/28/2009	14:17	JKJ	8.3	0	51	B	7.7	219	8.3	13.7	115.1			31
BUFT04	1/11/2010	10:58	FDU		0	17	B	3.6	228	8.2	12.8	97.0	0.6	30	50
BUFT04	1/22/2010	11:55	FDU	10.2	0.05	507	F	10.2	235	8.2	12.2	108.5	14.0		36
BUFT04	1/27/2010	13:01	JKJ,SWH	9.5	0	55	B	8.3	245	8.3	12.3	104.3	4.6		53
BUFT04	2/3/2010	12:50	JKJ	12.6	0	75	R	8.3	245	8.4	13.3	113.4	9.6		107
BUFT04	2/11/2010	13:51	JKJ,SWH	6.2	0	78	F	8.7	242	8.4	12.4	106.1	2.7		12
BUFT04	2/18/2010	10:36	JKJ,SWH	7.2	0	38	B	6.6	231	8.3	13.5	110.5	1.9		10
BUFT04	3/1/2010	11:55	JKJ	9.1	0	52	B	8.9	204	8.3	12.6	109.2	1.4	2	24
BUFT04	3/31/2010	9:56	JKJ,SWH	12.5	0		B	12.5	262	8.1			2.9		159
BUFT04	4/8/2010	11:23	JKJ,FDU	14.4	0	52	B	13.4	294	7.9	9.5	90.8	1.9		140
BUFT04	4/15/2010	10:00	JKJ	24.9	0	28	B	14.9	285	7.9	8.4	83.6	1.4		38
BUFT04	4/22/2010	10:37	JKJ,SWH	20.5	0	21	B	14.1	296	7.9	8.8	85.9	2.3		61
BUFT04	4/29/2010	12:30	JKJ,SWH	24.8	0	18	B	15.9	285	8.1	10.6	107.9	1.8		13
BUFT04	5/4/2010	10:21	JKJ,SWH	20.8	0	26	B	14.9	263	8.1	9.5	94.4	4.6		184
BUFT04	5/13/2010	13:17	JKJ	21.2	0	35	F	16.9	276	7.8	7.9	81.6	5.2		397
BUFT04	5/19/2010	15:35	JKJ,SWH	20.2	0		F	15.1	266	7.9	8.6	85.7	6.5		28
BUFT04	5/27/2010	10:10	JKJ	21.5	0	38	B	18.0	324	7.9	9.8	103.6	2.4		13
BUFT04	6/1/2010	10:25	JKJ	25.8	0	27	B	19.7	334	7.8	9.4	102.2	3.6		17
BUFT04	6/10/2010	10:45	JKJ	24.3	0	4	B	20.0	294	8.0			4.1		121

BUFT04	6/16/2010	12:05	JKJ	31.1	0		B	22.5	334	8.0	9.6	110.9	1.7		228
BUFT04	6/23/2010	14:47	JKJ,SAB	31.6	0	7	B	25.7	271	8.0	10.5	128.4	2.2		71
BUFT04	6/28/2010	10:20	JKJ,SAB	25.9	0.38	9	B	23.6	315	7.8	7.3	87.5	2.3		100
BUFT04	6/30/2010	11:35	SAB	27.3	0	7	B	23.2	322	7.7	8.4	99.8	2.4		107
BUFT04	7/6/2010	11:00	JKJ,SAB	29.3	0	6	B	22.9	299	7.9	15.1	176.3	1.8		84
BUFT04	7/12/2010	11:43	SAB, FDU	25.8	0.9	15	B	2.1	313	7.7	7.8	90.3	8.4		727
BUFT04	7/13/2010	10:20	SAB, FDU	28	0.9	79	R	20.9	208	8.1	8.4	94.6	48.2		1733
BUFT04	7/14/2010	11:01	SAB	31	0	20	F	20.5	239	7.4	7.1	79.7	6.0		326
BUFT04	7/15/2010	13:04	SAB	35.6	0	9	B	20.9	271		6.8	77.4	3.5		71
BUFT04	7/16/2010	10:53	JKJ,SAB	33.7	1.3	28	F	21.2	229	7.7	7.0	79.0	29.1		816
BUFT04	7/19/2010	13:30	JKJ,SAB	33.6	0.75	12	F	24.0	273	7.9	10.8	128.5	6.3		1203
BUFT04	7/20/2010	11:25	JKJ,SAB	31.4	0	10	B	23.0	280	7.8	9.5	110.2	2.3	92	145
BUFT04	7/26/2010	11:00	SAB,JKJ	31.4	0	5	B	24.4	202	7.8	9.0	108.0	2.4		53
BUFT04	8/3/2010	10:47	SAB,FDU	31.4	0	5	B	25.9	320	7.9	6.3	78.0	2.1		50
BUFT04	8/9/2010	12:33	SAB	34.7	0	3	B	26.2	307	7.9	10.7	132.4	2.4	82	62
BUFT04	8/17/2010	10:44	SAB		0	4	B	23.8	320	7.8	8.0	94.5	1.9		33
BUFT04	8/23/2010	11:01	SAB,JKJ	32	0	3	B	25.8	318	8.0	7.0	85.7	2.0		22
BUFT04	8/30/2010	11:05	SAB,JKJ	29.8	0	4	B	23.1	280	7.9	10.2	119.1	1.7		21
BUFT04	9/7/2010	9:45	SAB	23.9	0	5	B	20.9	309	7.8	7.0	78.8	1.6		59
BUFT04	9/13/2010	10:33	SAB,JKJ	27.7	0	12	B	18.8	284	7.9	8.9	96.0	3.3		141
BUFT04	9/22/2010	10:58	SAB	33.6	0	5	B	21.7	290	7.9	8.6	97.3	1.3		33
BUFT04	9/27/2010	9:16	SAB,JKJ	14.4	0	5	B	16.7	289	7.8	9.9	101.5	1.2	28	36
BUFT04	9/29/2010	10:17	SAB	22.5	0	5	B	17.0	283	7.9	10.2	105.3	1.0		33
BUFT04	10/6/2010	10:26	SAB	21.7	0	5	B	13.1	253	7.9	13.1	124.2	1.0		28
BUFT04	10/14/2010	13:04	JKJ	23.5	0	6	B	16.1	292	8.0	13.1	132.7	0.8		25
BUFT04	10/21/2010	13:01	JKJ,SWH	25.6	0	4	B	16.4	298	8.0	11.5	117.1	0.9		21
BUFT04	10/27/2010	10:07	JKJ	15.3	0	4	B	13.9	357	8.0	7.7	74.5	0.9		44
BUFT04	11/4/2010	13:35	JKJ	18.2	0	5	B	13.7	363	8.1	9.8	94.9	0.7		15
BUFT04	11/17/2010	9:59	JKJ	8	0.02	5	B	9.0	322	8.0	10.8	92.9	0.9		12
BUFT04	12/2/2010	13:25	JKJ,SWH	15.1	0	5	B	7.6	376	8.1	12.8	106.6	0.6		42
BUFT04	12/16/2010	10:07	FDU	4.9	0	3	B	4.9	229	8.0	10.6	83.2	0.4		27
BUFT04	12/29/2010	11:00	FDU	8.8	0.2	7	B	5.3	220	8.0	14.6	115.2	0.5		20
BUFT0401	10/22/2009	11:35	JKJ,KE	17.6	0.54	28	B	15.4	170	8.2	10.3	102.9	2.3	180	184

BUFT0401	10/23/2009	12:25	FDU	10.9		72	F	14.0	274	8.4	11.4	110.5	5.7		276
BUFT0401	10/26/2009	12:44	FDU, KE	13.2		32	B	14.7	280	8.3	9.5	93.2	3.8		249
BUFT0401	11/9/2009	10:30	FDU, KE	15.3	0	34	B	14.4	151	8.3	10.5	102.5	2.1		50
BUFT0401	11/10/2009	10:22	FDU, KE	19.2	0	27	B	14.4	265	8.3	11.0	108.2	2.0		54
BUFT0401	11/12/2009	11:12	JKJ, FDU	15.6	0	25	B	13.3	270	8.4	11.9	113.5	6.2		115
BUFT0401	1/22/2010	12:54	FDU	10	0.05	321	F	11.3	268	8.4	12.8	116.4	2.8		51
BUFT0401	1/27/2010	13:20	JKJ,SWH	7.6	0	32	B	9.5	251	8.4	11.9	104.0	5.3		80
BUFT0401	2/3/2010	13:23	JKJ	11.3	0	50	R	9.9	269	8.5	12.8	113.5	6.2		197
BUFT0401	2/11/2010	14:25	JKJ,SWH	4.9	0	44	F	10.1	251	8.5	11.9	105.3	2.5		22
BUFT0401	2/18/2010	11:04	JKJ,SWH	12	0	32	B	8.3	157	8.4	13.4	114.2	1.9		23
BUFT0401	3/31/2010	10:30	JKJ, SWH	17	0		B	13.2	247	8.2			2.8		131
BUFT0401	4/8/2010	10:53	JKJ,FDU	15.7	0	32	B	13.0	281	8.3	11.7	111.1	2.3		192
BUFT0401	4/15/2010	10:23	JKJ	23.6	0	25	B	15.0	284	8.3	10.8	107.5	1.2		118
BUFT0401	4/22/2010	11:02	JKJ,SWH	22.4	0	21	B	15.0	292	8.3	11.2	111.2	2.3		110
BUFT0401	4/29/2010	12:45	JKJ,SWH	24.7	0	14	B	17.7	292	8.4	11.5	121.1	1.7		148
BUFT0401	5/4/2010	10:52	JKJ,SWH	21.8	0	25	B	15.1	263	8.3	11.1	110.2	7.7		579
BUFT0401	5/13/2010	13:42	JKJ	19.8	0	32	F	16.8	269	8.3	9.6	98.5	10.8		345
BUFT0401	5/19/2010	15:51	JKJ,SWH	20.3	0		F	15.8	276	8.3	10.5	105.4	8.0		121
BUFT0401	5/27/2010	10:30	JKJ	26.4	0	32	B	17.3	315	8.3	12.4	129.2	2.2		770
BUFT0401	6/1/2010	10:47	JKJ	23.3	0	26	B	18.5	330	8.2	11.9	127.0	1.9		179
BUFT0401	6/10/2010	10:25	JKJ	27.5	0	4	B	3.9	304	8.2			3.1		275
BUFT0401	6/16/2010	12:15	JKJ	29.1	0		B	22.8	333	8.2	10.5	121.8	1.5		238
BUFT0401	6/23/2010	14:11	JRJ,SAB	28.7	0	7	B	25.0	346	8.2	10.0	120.7	2.4		219
BUFT0401	6/28/2010	10:01	JKJ,SAB	27.3	0.38	5	B	22.7	324	8.0	8.6	101.6	2.2		326
BUFT0401	6/30/2010	12:05	SAB	28.7	0	6	B	23.0	333	8.0	10.2	120.3	2.3		137
BUFT0401	7/6/2010	11:20	JKJ,SAB	27.5	0	5	B	22.7	308	8.1	17.3	201.1	1.9		225
BUFT0401	7/12/2010	13:05	SAB,FDU	27.5	0.9	7	B	21.9	321	8.0	9.0	103.7	8.4		517
BUFT0401	7/14/2010	12:15	SAB	29.1	0	11	F	22.8	340	7.9	9.3	109.2	3.8		179
BUFT0401	7/20/2010	11:39	JKJ,SAB	31.4	0	7	B	24.1	312	8.2	11.3	134.6	2.4	110	172
BUFT0401	7/26/2010	11:20	SAB,JKJ	29.8	0	4	B	25.1	213	8.2	10.9	132.3	2.6		194
BUFT0401	8/3/2010	11:11	SAB,FDU	33.7	0	4	B	26.2	256	8.2	9.0	112.0	2.2		225
BUFT0401	8/9/2010	13:04	SAB	30.8	0	3	B	26.9	313	8.2	11.8	147.9	2.5	392	485
BUFT0401	8/17/2010	10:20	SAB		0	3	B	22.7	314	8.2	9.6	111.3	2.2		205

BUFT0401	8/23/2010	11:34	SAB,JKJ	30.6	0	2	B	25.8	320	8.3	9.5	117.8	2.2		88
BUFT0401	8/30/2010	10:40	SAB,JKJ	27.6	0	2	B	23.1	285	8.2	11.6	135.2	1.5		157
BUFT0401	9/7/2010	11:53	SAB	23	0	3	B	20.9	312	8.2	8.1	91.9	1.7		435
BUFT0401	9/13/2010	10:53	SAB,JKJ	23.3	0	7	B	18.9	282	8.2	10.6	113.6	4.8		225
BUFT0401	9/22/2010	11:38	SAB	26.9	0	4	B	22.1	287	8.3	10.8	124.0	1.5		194
BUFT0401	9/29/2010	10:46	SAB	20.3	0	4	B	17.1	288	8.2	12.5	129.8	0.9		461
BUFT0401	10/6/2010	10:49	SAB	17.3	0	4	B	13.1	253	8.2	14.9	141.5	0.9		122
BUFT0401	10/14/2010	13:20	JKJ	23.4	0	2	B	16.5	299	8.3	14.8	152.1	0.8		99
BUFT0401	10/21/2010	13:20	JKJ,SWH	23.9	0	2	B	17.2	306	8.3	12.6	131.4	0.9		66
BUFT0401	10/27/2010	10:36	JKJ	16.6	0	2	B	13.0	367	8.3	10.6	100.6	0.7		81
BUFT0401	11/4/2010	13:50	JKJ	15.8	0	2	B	14.2	361	8.4	11.5	112.1	1.0		60
BUFT0401	11/17/2010	10:35	JKJ	9.6	0.02	2	B	8.5	326	8.3	12.5	107.2	0.6		43
BUFT0401	12/16/2010	10:23	FDU	5.2	0	2	B	5.0	232	8.3	12.4	97.2	0.4		80
BUFT0401	12/29/2010	11:12	FDU	8.8	0.2	2	B	5.6	222	8.2	15.1	120.6	0.8		93
BUFT0402	10/22/2009	11:47	FDU		0.54	23	B	15.3	294	8.3	9.6	96.8	2.7	36	52
BUFT0402	10/23/2009	13:18	FDU			28	F	14.4	283	8.3	10.3	100.9	4.7		141
BUFT0402	10/26/2009	13:23	FDU,KE	13.4		21	B	14.7	275	8.3	9.5	93.7	4.8		225
BUFT0402	11/9/2009	11:23	FDU, KE	16.8	0	19	B	14.7	210	8.3	10.7	105.6	2.9		49
BUFT0402	11/10/2009	11:21	FDU, KE	20.5	0	19	B	15.1	284	8.3	11.3	112.0	2.8		28
BUFT0402	11/12/2009	11:50	JKJ, FDU	17.2	0	20	B	14.1	272	8.4	11.6	113.0	11.8		57
BUFT0402	1/22/2010	13:36	FDU	11	0.05	235	F	12.5	278	8.3	12.3	115.2	5.8		166
BUFT0402	1/27/2010	14:10	JKJ,SWH	8.8	0	20	B	11.0	252	8.3	11.3	102.9	7.6		64
BUFT0402	2/3/2010	14:00	JKJ	5.5	0	26	R	11.5	288	8.4	13.3	122.4	4.6		30
BUFT0402	2/11/2010	15:00	JKJ,SWH	6.4	0	30	F	11.4	259	8.4	11.8	107.6	3.8		13
BUFT0402	2/18/2010	11:32	JKJ,SWH	9.5	0	17	B	10.6	255	8.3	9.9	89.1	2.4		19
BUFT0402	3/31/2010	10:50	JKJ,SWH	24	0		B	13.6	264	8.2			3.9		23
BUFT0402	4/8/2010	10:22	JKJ,FDU	14.3	0	21	B	13.0	281	8.2	11.3	107.6	3.2		23
BUFT0402	4/15/2010	11:15	JKJ	22.5	0	13	B	15.9	293	8.3	10.7	108.6	1.7		9
BUFT0402	4/22/2010	11:31	JKJ,SWH	23.5	0	13	B	15.2	296	8.3	10.6	106.1	3.5		85
BUFT0402	4/29/2010	13:15	JKJ,SWH	25.2	0	10	B	17.5	298	8.4	10.7	112.4	2.3		158
BUFT0402	5/4/2010	11:20	JKJ,SWH	21.7	0	15	B	15.0	255	8.3	10.4	102.9	11.2		435
BUFT0402	5/13/2010	14:08	JKJ	20.5	0	20	F	16.1	255	8.2	9.4	94.9	15.4		461
BUFT0402	5/19/2010	16:10	JKJ,SWH	21.2	0		F	15.5	267	8.2	10.1	100.9	10.9		93

BUFT0402	5/27/2010	11:05	JKJ	24.1	0	20	B	16.5	308	8.2	12.4	127.2	3.1		22
BUFT0402	6/1/2010	11:25	JKJ	28.8	0	13	B	17.5	327	8.2	11.7	122.7	1.9		13
BUFT0402	6/10/2010	9:54	JKJ	25.4	0	2	B	18.9	304	8.2			3.1		9
BUFT0402	6/16/2010	12:35	JKJ	26.7	0		B	21.7	335	8.1	9.5	108.3	1.6		25
BUFT0402	6/23/2010	11:32	JKJ,SAB	29.6	0	4	B	22.4	345	8.1	9.1	104.6	2.1		122
BUFT0402	6/28/2010	9:27	JKJ,SAB	24.7	0.38	4	B	21.8	330	8.0	8.0	92.5	2.7		54
BUFT0402	6/30/2010	13:00	SAB	31	0	4	B	22.5	344	7.9	9.4	109.1	3.5		18
BUFT0402	7/6/2010	11:56	JKJ,SAB	29.1	0	5	B	21.9	303	8.1	16.6	189.2	1.8		74
BUFT0402	7/12/2010	13:48	SAB,FDU	25.4	0.9	5	B	20.9	338	7.9	8.9	101.0	3.1		66
BUFT0402	7/14/2010	13:16	SAB	31	0	6	B	21.8	343	8.0	9.2	105.2	3.4		43
BUFT0402	7/20/2010	12:08	JKJ,SAB	30	0	3	B	22.7	294	8.3	10.8	124.6	4.0	16	17
BUFT0402	7/26/2010	11:40	SAB,JKJ	29.4	0	3	B	23.8	211	8.1	10.0	118.6	2.3		27
BUFT0402	8/3/2010	11:51	SAB,FDU	33.1	0	2	B	24.7	330	8.2	8.2	99.7	2.1		11
BUFT0402	8/9/2010	13:51	SAB	32	0	2	B	24.8	309	8.2	10.5	126.8	1.6	20	16
BUFT0402	8/17/2010	8:50	SAB		0	2	B	21.6	323	8.1	8.3	93.3	1.4		6
BUFT0402	8/23/2010	12:07	SAB, JKJ	27.3	0	1	B	26.2	331	8.3	7.7	92.2	1.9		8
BUFT0402	8/30/2010	10:08	SAB,JKJ	25.3	0	1	B	21.9	285	8.1	10.6	120.5	1.7		4
BUFT0402	9/7/2010	12:50	SAB	22.6	0.2	4	R	21.2	227	8.1	8.0	91.0	38.4		687
BUFT0402	9/13/2010	11:45	SAB,JKJ	24.2	0	4	B	18.7	238	8.2	10.0	106.7	8.7		60
BUFT0402	9/22/2010	12:25	SAB	25.9	0	3	B	22.2	297	8.2	9.5	108.9	1.1		4
BUFT0402	9/29/2010	11:33	SAB	20.1	0	2	B	17.5	301	8.2	12.5	128.2	0.9		9
BUFT0402	10/6/2010	11:37	SAB	16.4	0	2	B	14.6	270	8.2	14.7	143.4	0.6		12
BUFT0402	10/14/2010	13:40	JKJ	20.2	0	3	B	16.6	315	8.3	13.0	133.6	0.8		8
BUFT0402	10/21/2010	13:40	JKJ,SWH	21	0	2	B	17.1	314	8.2	11.2	116.4	1.0		4
BUFT0402	10/27/2010	10:51	JKJ	16.5	0	1	B	14.4	380	8.3	9.6	93.7	0.6		5
BUFT0402	11/4/2010	14:05	JKJ	14.3	0	1	B	13.6	369	8.3	10.3	99.0	0.7		5
BUFT0402	11/17/2010	10:40	JKJ	10.7	0	2	B	10.1	347	8.4	11.7	103.7	1.1		5
BUFT0402	12/2/2010	13:40	JKJ,SWH	13	0	1	B	9.2	388	8.4	12.4	108.0	0.6		1
BUFT0402	12/16/2010	10:37	FDU	4.2	0	1	B	5.2	239	8.3	11.9	93.9	0.6		15
BUFT0402	12/29/2010	11:30	FDU	9.4	0.2	2	B	6.0	239	8.3	15.0	120.1	1.0		26
BUFT0403	10/22/2009	12:20	FDU		0.54	9	B	15.3	321	7.5	9.4	94.6	1.6	36	33
BUFT0403	10/23/2009	13:38	FDU			12	F	15.0	301	7.5	10.0	98.9	3.0		365
BUFT0403	10/26/2009	13:57	FDU,KE	12.5	0	8	B	15.0	315	7.5	9.0	89.4	2.0		52

BUFT0403	11/9/2009	11:54	FDU, KE	14.9	0	6	B	15.2	313	7.5	10.6	105.8	1.9		21
BUFT0403	11/10/2009	11:44	FDU, KE	20.6	0	7	B	15.9	316	7.5	11.0	110.9	2.1		56
BUFT0403	11/12/2009	12:10	JKJ, FDU	14.4	0	7	B	15.6	321	7.6	10.9	109.5	3.2		18
BUFT0404	10/22/2009	13:07	FDU		0.54	0	R	15.0	30	8.1	8.6	87.1	3.1	372	629
BUFT0404	10/23/2009	13:58	FDU			0	F	13.4	262	8.3	9.7	93.2	3.0		866
BUFT0404	10/26/2009	14:17	FDU,KE	12.5	0	0	B	13.9	280	8.3	8.3	80.7	4.6		866
BUFT0405	10/22/2009	12:12	JKJ,KE	17.4	0.54	6	B	15.3	244	8.2	10.0	100.0	1.9	302	920
BUFT0405	10/23/2009	12:51	FDU	10.8		12	F	13.6	262	8.3	11.0	105.9	14.6		649
BUFT0405	10/26/2009	13:05	FDU,KE	13.4		7	B	14.4	247	8.3	9.2	90.4	3.1		461
BUFT0405	11/9/2009	11:02	FDU, KE	16.5	0	6	B	14.1	296	8.2	10.6	102.8	1.1		154
BUFT0405	11/10/2009	11:02	FDU, KE	19.7	0	5	B	14.3	291	8.2	11.0	107.3	1.0		68
BUFT0405	11/12/2009	11:35	JKJ, FDU	12.3	0	4	B	12.9	282	8.2	11.5	109.1	0.9		74
BUFT0405	1/22/2010	13:16	FDU	11	0.05	73	F	10.1	254	8.3	12.7	112.5	8.2		105
BUFT0405	1/27/2010	13:48	JKJ,SWH	8.1	0	8	B	8.7	271	8.3	12.1	103.6	3.0		78
BUFT0405	2/3/2010	13:41	JKJ	6.9	0	12	R	9.1	253	8.4	13.5	116.7	13.2		613
BUFT0405	2/11/2010	14:45	JKJ,SWH	5.5	0	13	F	9.2	260	8.4	11.8	103.0	2.0		29
BUFT0405	2/18/2010	11:18	JKJ,SWH	7.5	0	8	B	6.8	246	8.3	13.4	109.8	1.4		22
BUFT0405	3/31/2010	10:40	JKJ,SWH	21	0		B	12.8	275	8.2			1.8		135
BUFT0405	4/8/2010	10:35	JKJ,FDU	12.9	0	10	B	12.2	291	8.2	11.4	106.1	2.1		61
BUFT0405	4/15/2010	10:56	JKJ	21.3	0	5	B	14.7	295	8.2	10.6	104.5	1.2		37
BUFT0405	4/22/2010	11:17	JKJ,SWH	19.8	0	3	B	14.6	310	8.1	10.6	104.1	0.8		42
BUFT0405	4/29/2010	13:00	JKJ,SWH	25.3	0	3	B	16.8	296	8.2	10.5	108.2	1.0		1986
BUFT0405	5/4/2010	11:05	JKJ,SWH	18.5	0	5	B	14.7	301	8.3	10.4	102.6	1.6		727
BUFT0405	5/13/2010	13:53	JKJ	20.9	0	5	F	16.8	808	8.2	9.2	94.5	3.8		199
BUFT0405	5/19/2010	16:00	JKJ,SWH	20.3	0		B	15.9	307	8.3	10.0	101.1	4.1		104
BUFT0405	5/27/2010	10:45	JKJ	23.5	0	6	B	17.0	333	8.2	12.0	124.6	1.4		67
BUFT0405	6/1/2010	11:06	JKJ	25.3	0	4	B	18.2	325	8.1	11.3	119.9	1.3		687
BUFT0405	6/10/2010	10:10	JKJ	26.4	0	1	B	19.4	305	8.0			3.5		325
BUFT0405	6/16/2010	12:23	JKJ	25.3	0		B	21.6	332	8.0	9.8	110.6	1.5		115
BUFT0405	6/23/2010	14:35	JKJ, SAB	32	0	1	B	23.8	347	8.0	9.3	110.6	1.6		135
BUFT0405	6/28/2010	9:45	JKJ,SAB	27.4	0.38	0	B	21.6	324	7.8	8.2	93.0	2.2		47
BUFT0405	6/30/2010	12:35	SAB	31.1	0	0	B	22.1	339	7.8	9.2	105.4	1.5		65
BUFT0405	7/6/2010	11:41	JKJ,SAB	29.3	0	0	B	21.6	305	7.9	16.2	184.3	1.3		38

BUFT0405	7/12/2010	13:27	SAB, FDU	25.7	0.9	1	B	21.0	312	7.8	8.5	96.4	4.3		365
BUFT0405	7/14/2010	12:52	SAB	31.8	0	2	B	22.5	355	8.4	8.5	98.9	3.1		238
BUFT0405	7/20/2010	11:54	JKJ,SAB	28.7	0	1	B	22.9	333	8.1	10.2	118.4	1.4	98	162
BUFT0405	7/26/2010	11:30	SAB,JKJ	32.5	0	0	B	22.5	176	7.9	9.2	107.2	1.6		179
BUFT0405	8/3/2010	11:34	SAB,FDU	33.7	0	0	B	25.2	346		6.9	85.0	1.7		30
BUFT0405	8/9/2010	13:26	SAB	29.9	0	0	B	25.3	324	7.9	9.3	112.5	3.1	1000	24
BUFT0405	8/17/2010	10:01	SAB		0	0	B	21.4	355	7.6	6.5	72.8	2.4		86
BUFT0405	8/23/2010	11:49	SAB, JKJ	30.2	0	0	B	24.2	373	7.6	3.6	42.3	1.4		8
BUFT0405	9/7/2010	12:23	SAB	22.8	0.2	0	B	20.2	306	7.8	4.9	55.6	3.4		1553
BUFT0405	9/13/2010	11:11	JKJ,SAB	21.9	0	1	B	18.6	273	8.0	9.3	99.7	1.6		308
BUFT0405	9/22/2010	12:01	SAB	26.4	0	0	B	20.4	316	8.0	9.1	99.7	0.8		22
BUFT0405	9/29/2010	11:10	SAB	19.6	0	0	B	15.7	292	7.9	10.6	106.8	0.8		8
BUFT0405	10/6/2010	11:16	SAB	15	0	0	B	11.4	236	7.9	13.1	120.1	0.8		0
BUFT0406	10/22/2009	9:58	FDU		0.54	2	B	14.9	286	8.3	9.0	90.0	1.3	304	921
BUFT0406	10/23/2009	12:03	FDU			12	F	13.3	210	8.4	11.2	107.0	32.2		649
BUFT0406	10/26/2009	12:20	FDU,KE	13.6		4	B	13.9	268	8.4	10.0	97.2	2.7		248
BUFT0406	11/9/2009	10:11	FDU, KE	14.8	0	2	B	13.2	279	8.4	11.1	105.6	1.5		96
BUFT0406	11/10/2009	10:00	FDU, KE	19.2	0	1	B	13.4	269	8.4	11.7	111.9	0.7		81
BUFT0406	11/12/2009	10:55	JKJ, FDU	11.5	0	1	B	11.3	260	8.4	12.2	111.8	0.9		102
BUFT0406	1/22/2010	12:40	FDU	10	0.05	83	F	9.0	167	8.4	13.0	112.2	37.7		69
BUFT0406	1/27/2010	13:31	JKJ,SWH	8.5	0	6	B	6.2	234	8.5	13.3	107.0	3.6		48
BUFT0406	2/3/2010	13:15	JKJ	10	0	17	R	6.6	192	8.5	13.9	113.3	18.8		40
BUFT0406	2/11/2010	14:13	JKJ,SWH	4.6	0	9	F	6.4	223	8.6	13.8	112.1	2.8		17
BUFT0406	2/18/2010	10:55	JKJ,SWH	9.5	0	3	B	3.4	210	8.4	15.3	115.5	1.7		6
BUFT0406	3/31/2010	10:15	JKJ,SWH	21.1	0		B	12.2	257	8.3			2.2		57
BUFT0406	4/8/2010	11:05	JKJ,FDU	15.4	0	6	B	12.2	283	8.4	12.0	111.7	1.6		39
BUFT0406	4/15/2010	10:40	JKJ	20.6	0	0	B	15.9	278	8.3	10.4	105.2	1.4		75
BUFT0406	5/19/2010	15:45	JKJ,SWH	20.1	0		F	15.8	280	8.4	10.2	103.1	3.6		62
BUFT0406	5/27/2010	10:17	JKJ	24.3	0	0	B	20.0	331	8.2	11.1	122.4	1.1		29
BUFT05	2/17/2009	15:00	JKJ,SWH	10.1	0		B	7.9	212	7.4	10.5	90.3	4.7	82	185
BUFT05	3/9/2009	10:01	JKJ	12.8	0	54	B	13.6	195	7.8	9.3	91.4	2.4	28	27
BUFT05	8/4/2009	11:50	JKJ		0		B							90	68
BUFT05	8/5/2009	12:30	JKJ		0		B								31

BUFT05	8/17/2009	13:40	JKJ	33.1	0	9	B	30.0	256	7.9	7.2	95.0	1.9	2	8
BUFT05	8/31/2009	9:45	JKJ	20	0	10	B	22.1	219	7.4	7.6	87.2	1.2	24	22
BUFT05	1/11/2010	12:12	FDU	8.9	0	72	B	1.8	99	8.2	12.6	90.9	1.1	2	2
BUFT05	4/12/2010	10:40	JKJ	19	0	119	B	14.8	130	8.0	9.7	96.2	2.7	98	93
BUFT05	7/19/2010	12:45	JKJ,SAB	32.9	0.75	106	F	25.3	159	7.9	9.4	114.1	7.8	1000	2420
BUFT05	7/20/2010	10:22	JKJ,SAB												1120
BUFT05	7/21/2010	11:33	FDU,SAB	32.3	0	65	B	27.3	177	8.0	7.8	97.7	3.6		142
BUFT05	9/27/2010	9:40	SAB,JKJ	16.4	0	16	B	19.4	189	8.0	10.0	108.7	0.8	26	24

SITE	DATE	TIME	DISCHARGE	FLOW	TEMP(H2O)	TEMP(Air)	COND(microsiemems/cm)	PH	DO(mg/L)	%SAT	TURBIDITY(NTU)	NO3(mg/L)	PO4(mg/L)	OPO4(mg/L)	TPO4(mg/L)	NH4(mg/L)
BUFR03	6/7/2010	11:20	61.00	B	24.60	19.80	191.00	7.90	7.87	94.90	1.11	0.036		<0.005		<0.030
BUFR03	7/6/2010	10:45	22.00	B	27.30	31.20	215.00	7.93	13.66	172.40	1.26	<0.010		<0.005		<0.030
BUFR03	7/20/2010	11:09	108.50	B	28.70	31.00	128.00	8.17	8.80	113.80	3.44	<0.010		0.006		<0.030
BUFR03	8/9/2010	11:51	15.00	B	30.50	34.60	202.00	8.03	9.65	128.70	1.87	0.018		0.008		<0.030
BUFR0304	7/6/2010	10:22	28.00	B	25.70	30.10	217.00	7.88	13.59	171.70	3.05	0.204		<0.005		<0.030
BUFR0304	7/20/2010	10:47	118.80	F	27.20	29.50	150.00	8.11	8.77	110.50	3.39	0.044		0.006		<0.030
BUFR0304	8/9/2010	11:31	17.50	B	27.80	34.40	228.00	7.94	9.80	126.30	2.37	0.157		0.007		<0.030
BUFR04	6/7/2010	12:30	121.80	B	12.80	19.60	196.00	8.02	9.02	107.00	1.52	0.182		<0.005		<0.030
BUFR04	7/6/2010	9:50	38.10	B	27.00	30.20	230.00	7.81	12.94	162.50	2.02	0.049		<0.005		<0.030
BUFR04	7/20/2010	9:58		F	26.90	28.60	163.00	7.92	8.22	102.90	4.34	0.08		0.008		<0.030
BUFR04	8/9/2010	10:34	35.10	B	29.20	33.60	221.00	7.80	9.46	123.50	2.21	0.07		0.009		<0.030
BUFT04	7/6/2010	11:00	6.00	B	22.90	29.30	299.00	7.87	15.12	176.30	1.77	0.816		0.007		<0.030
BUFT04	7/20/2010	11:25	10.30	B	23.00	31.40	280.00	7.84	9.50	110.20	2.34	0.653		0.014		<0.030
BUFT04	8/9/2010	12:33	2.50	B	26.20	34.70	307.00	7.92	10.65	132.40	2.40	0.612		0.014		<0.030
BUFT0401	7/6/2010	11:20	4.80	B	22.70	27.50	308.00	8.12	17.33	201.10	1.91	1.07		0.012		<0.030
BUFT0401	7/20/2010	11:39	6.80	B	24.10	31.40	312.00	8.22	11.30	134.60	2.39	0.811		0.019		<0.030
BUFT0401	8/9/2010	13:04	2.50	B	26.90	30.80	313.00	8.23	11.79	147.90	2.52	0.821		0.016		<0.030
BUFT0402	7/6/2010	11:56	4.50	B	21.90	29.10	303.00	8.07	16.56	189.20	1.76	1.39		0.012		<0.030
BUFT0402	7/20/2010	12:08	3.30	B	22.70	30.00	294.00	8.28	10.75	124.60	4.02	1.12		0.02		<0.030
BUFT0402	8/9/2010	13:51	2.30	B	24.80	32.00	309.00	8.21	10.48	126.80	1.55	1.11		0.016		<0.030
BUFT0405	7/6/2010	11:41	0.12	B	21.60	29.30	305.00	7.94	16.22	184.30	1.34	0.309		0.014		<0.030
BUFT0405	7/20/2010	11:54	1.00	B	22.90	28.70	333.00	8.06	10.19	118.40	1.35	0.468		0.022		<0.030
BUFT0405	8/9/2010	13:26	-0.20	B	25.30	29.90	324.00	7.92	9.28	112.50	3.12	0.224		0.022		<0.030
BUFT05	7/19/2010	12:45	106.10	F	25.30	32.90	159.00	7.89	9.37	114.10	7.79	0.135		0.012		<0.030

BUFT06	7/19/2010	10:50	76.00	B	23.10	30.40	191.00	7.96	10.50	121.40	5.36	0.266	0.016	<0.030
BUFT07	6/14/2010	13:35	8.50	B	15.20	28.20	307.00	7.30	6.93	69.10	0.60	0.658	0.006	<0.030
BUFT08	7/19/2010	10:15	20.00	B	25.60	34.40	149.00	8.06	10.34	126.50	1.98	0.2	0.014	<0.030
BUFT09	6/7/2010	13:30	47.20	B	19.90	21.70	94.00	7.92	10.76	118.00	3.10	0.043	0.005	<0.030
BUFT10	6/14/2010	13:17	6.70	B	21.00	27.10	333.00	8.15	11.28	126.40	0.54	0.321	0.02	<0.030
BUFT11	6/15/2010	10:35	6.30	B	18.90	30.20	272.00	8.03	9.90	106.60	0.75	0.341	0.009	<0.030
BUFT12	6/15/2010	11:26	29.10	B	27.20	31.60	215.00	8.23	9.74	122.80	1.26	0.331	0.018	<0.030
BUFT13	6/15/2010	12:26	3.30	B	22.70	31.20	295.00	8.22	10.17	118.00	0.40	0.834	0.02	<0.030
BUFT14	6/14/2010	11:30	9.70	B	25.00	29.20	253.00	8.16	11.46	138.80	1.22	0.381	0.006	<0.030
BUFT15	7/6/2010	12:06	7.60	B	27.20		282.00	8.06	92.80	92.90	0.81	0.126	<0.005	<0.030
BUFT16	6/8/2010	12:55	10.21	B	18.40	24.90	293.00	8.10	9.60	102.40	0.62	0.226	<0.005	<0.030
BUFT17	7/6/2010	10:27	2.60	B	26.40		397.00	8.03	8.52	106.80	1.26	0.011	<0.005	<0.030
BUFT18	8/17/2010	6:26	19.10	B	26.90	18.10	219.00	7.70	4.08	51.70	0.95	0.083	0.016	<0.030
BUFT23	8/17/2010	8:21	0.60	B	21.20	18.70	392.00	8.40	6.60	75.60	0.46	0.033	0.006	<0.030
BUFT24	8/17/2010	9:11	1.30	B	25.30	23.00	363.00	8.40	7.20	87.80	0.43	0.052	0.01	<0.030