

# **WATER QUALITY MONITORING IN THE HOOVER CREEK WATERSHED 2009-2010**

**Iowa Geological Survey  
Technical Information Series**

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**Iowa Department of Natural Resources  
Roger Lande, Director**

## INTRODUCTION

The unnamed tributary of the west branch of Wapsinonoc Creek that runs through the Herbert Hoover National Historic Site in eastern Iowa is referred to by project coordinators as “Hoover Creek.” The Hoover Creek watershed has historically been dominated by agricultural landuse. However, in recent years, agricultural landuse has declined as the city of West Branch expands into the western section of the watershed (Figure 1). Approximately 250 acres of agricultural land have been replaced by an urban landscape in the last 65 years. It is likely that such landuse changes have dramatically altered the water quality and stream hydrology throughout the watershed by creating more dynamic surface water flow regimes.

Under Section 303(d) of the Clean Water Act, the State of Iowa is required to submit a list of all waters that do not meet state water quality standards. This list is known as the 303(d) list of impaired waters. Waterbodies on this list are considered “impaired” and steps to improve their water quality must be undertaken. Periodic sampling of Hoover Creek indicates that the creek has elevated bacteria and nitrate+nitrite-nitrogen concentrations with a maximum bacteria level of 39,000 colony forming units (CFU) /100 milliliters (ml) and nitrate+nitrite-nitrogen concentrations that exceed 20 milligrams/liter (mg/L). Based on sampling conducted by the Iowa Department of Natural Resources, the Unnamed Tributary to West Branch Wapsinonoc Creek (aka Hoover Creek; Waterbody ID IA 02-CED-01545\_0) was placed on Iowa’s impaired waters list (category 5p). The impairment is based on the failure of the stream to meet bacteria standards in a Class 1 Waterbody. The inclusion of Hoover Creek on the impaired waters list (category 5) means that the Iowa Department of Natural Resources will be required to write a Total Maximum Daily Load (TMDL) plan to reduce the amount of bacteria in the stream and restore the creek to its designated uses. While a TMDL plan is not currently scheduled for Hoover Creek, this cooperative project will provide a strong foundation for the development of a restoration plan.

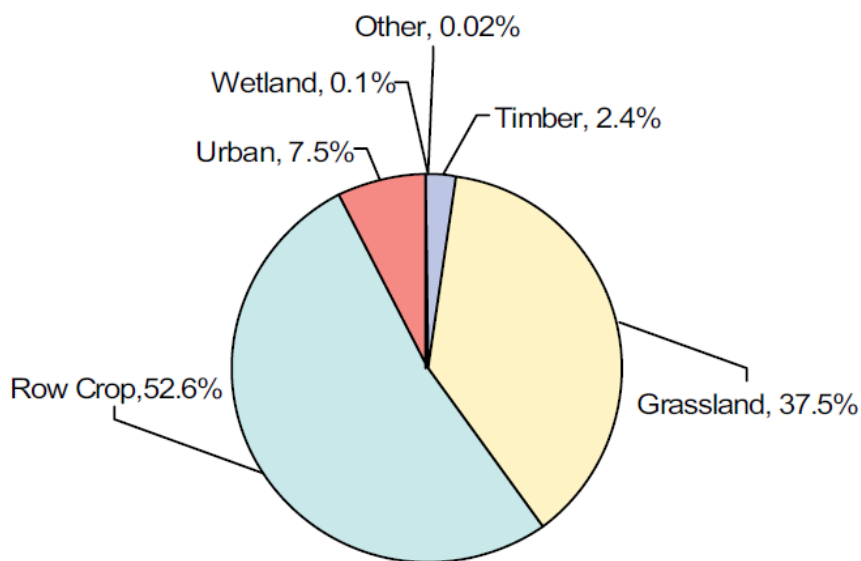


**Figure 1.** Landuse in the Wapsinonoc Creek Watershed, 2002.

This cooperative project is a continuation of previous projects and involves the National Park Service, Iowa Department of Natural Resources (IDNR) – Watershed Monitoring and Assessment Program, the University of Iowa Hygienic Lab (UHL), and the United States Geological Survey (USGS). The goal of the previous monitoring efforts was to characterize the biological, chemical, and physical health of the stream. Previous project objectives included:

- Monitor and characterize patterns in bacteria, nutrient, and total suspended solids concentrations within the creek
- Measure temperature, dissolved oxygen, and turbidity to establish baseline water quality conditions
- Determine nutrient and bacteria pollution Loads
- Determine the sources of bacteria in the watershed
- Characterize the biological and physical integrity of Hoover Creek

To accomplish the project goals, four monthly sampling locations were identified in the Hoover Creek watershed for water quality monitoring. All four sites were located on the western tributary of the west branch of the Wapsinonoc Creek. Sites are denoted as 1, 2, 3, and 4 (Figure 2). Monthly sampling occurred at all four sites from June 8, 2004, to October 25, 2006. The Hoover Creek watershed experienced an extreme drought in the spring and summer of 2005 that eliminated flow in all of the sampling locations. Therefore, sampling did not occur from August 4, 2005, through spring 2006.

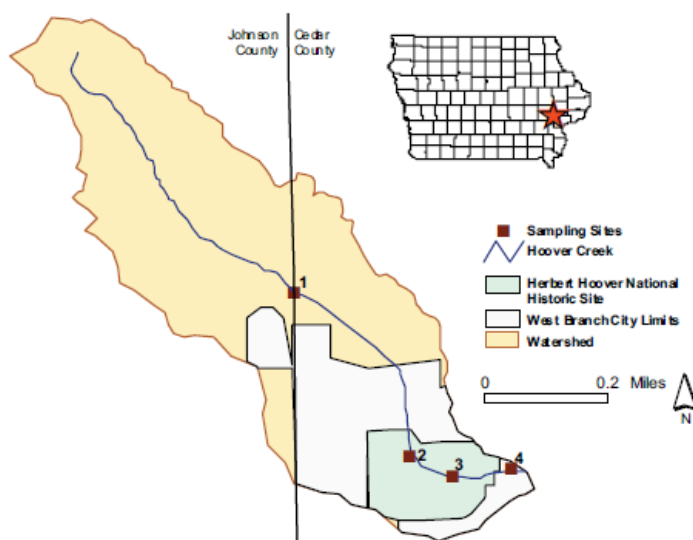


**Figure 2.** Location of monthly monitoring sites in the Hoover Creek watershed 2004 - 2006.

Results from the previous water quality monitoring project demonstrated that Hoover Creek consistently experienced elevated levels of *E. coli* bacteria throughout the watershed. During 2004-2006, *E. coli* values ranged from less than 10 to 29,000 colony forming units (CFU)/100 ml. Median concentrations ranged from 425 CFU/100 ml at site 2 to 650 CFU/100 ml at site 4 (Foreman, 2007). Sixty-nine percent of the samples collected in Hoover Creek violated the State of Iowa one time maximum standard of 235 CFU/100ml, as did 85% of the samples collected at site 4.

Based on the load duration curve for Hoover Creek, bacteria levels were elevated regardless of the flow in the creek (Figure 3). All sampling points above the curve shown are violating the 235 CFU/100 ml bacterial standard. Flows are characterized as high, moist, mid-range, dry, and low. The load duration curve suggests that over 60% of water samples exceeded that bacteria standard. Sixty-two percent of the bacteria standard exceedances occur in midrange and dry conditions, suggesting that these high values are likely associated with both nonpoint and point sources of pollution (Cleland, 2004).

The previous water quality project identified some seasonal patterns in *E. coli* concentrations with some of the highest *E. coli* levels occurring during rain events in the spring and summer months. All sites had *E. coli* concentrations greater than 20,000 CFU/100 ml following a heavy rainfall event on August 9, 2006. However, even though the highest concentrations of bacteria occurred during a high flow event, the largest load of bacteria occurred during dry conditions.

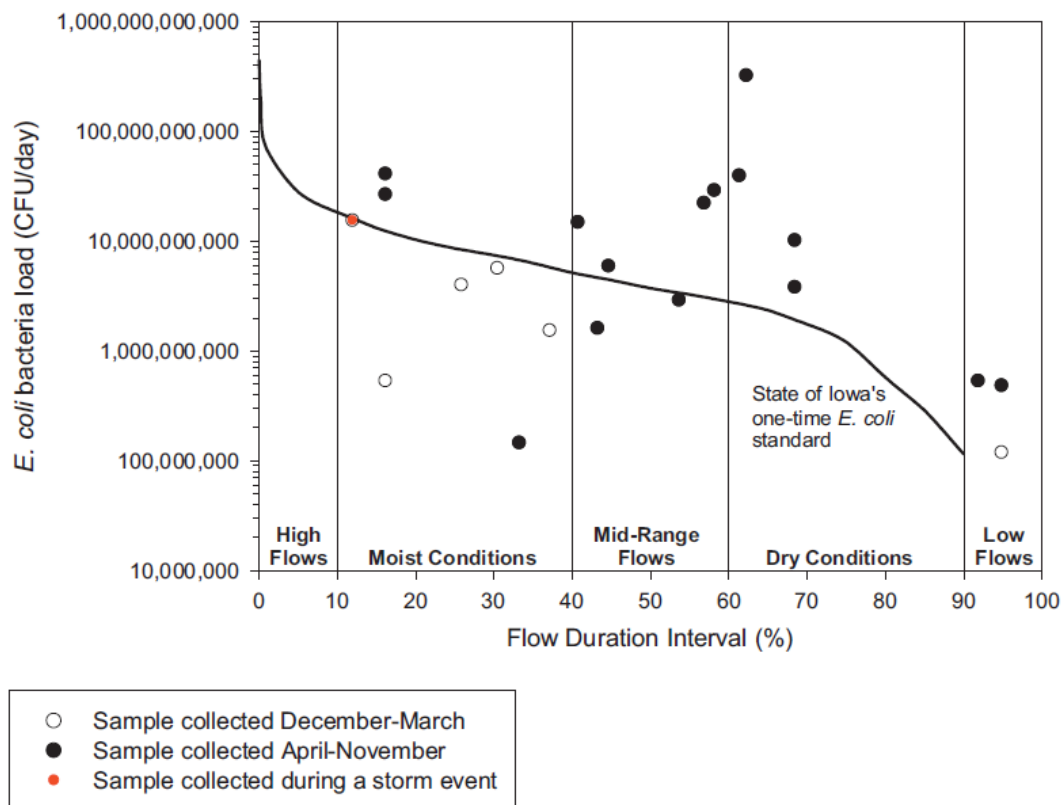


**Figure 3.** Load Duration Curve For Hoover Creek (2004-2006).

## CURRENT PROJECT OBJECTIVES

To further investigate the possible sources and delivery of *E. coli* bacteria to Hoover Creek, the Iowa Department of Natural Resources began a follow-up investigation in 2009. The follow-up project objectives were:

- Investigate the possible input of *E. coli* from urban sources including pipes discharging within the park boundaries.

- Conduct optical brightener monitoring to determine if flows to the creek included human septic sewage.
- Examine the impacts of rainfall events on bacteria concentrations on Hoover Creek.

Iowa Department of Natural Resources staff began sampling Hoover Creek in August of 2009 and continued to sample through September 2010. DNR staff focused on the stretch of Hoover Creek located in the National Park Service property (Sites 1, 1A, 2, 3, 4, 5, 5A, 6, and 7; Figure 4). Seventeen sampling events were recorded between August 2009 and September 2010 (data are included in Appendix A). Sampling sites were a combination of tiles and stream sites.

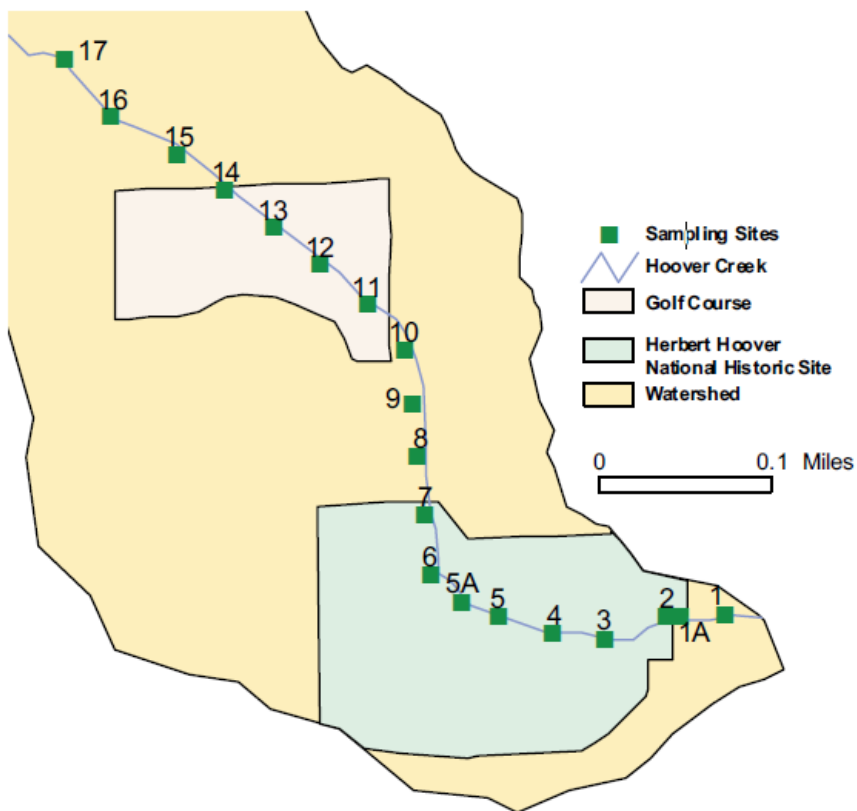


**Figure 4.** Location of targeted bacteria sampling sites.

| Sites | UTM X<br>coordinates<br>(meters) | UTM Y<br>coordinates<br>(meters) |
|-------|----------------------------------|----------------------------------|
| 1     | 637828                           | 4614468                          |
| 1A    | 637693                           | 4614460                          |
| 2     | 637653                           | 4614461                          |
| 3     | 637462                           | 4614392                          |
| 4     | 637308                           | 4614411                          |
| 5     | 637143                           | 4614460                          |
| 5A    | 637034                           | 4614504                          |
| 6     | 636938                           | 4614587                          |
| 7     | 636924                           | 4614767                          |
| 8     | 636899                           | 4614944                          |
| 9     | 636883                           | 4615103                          |
| 10    | 636858                           | 4615264                          |
| 11    | 636748                           | 4615404                          |
| 12    | 636604                           | 4615520                          |
| 13    | 636463                           | 4615634                          |
| 14    | 636319                           | 4615749                          |
| 15    | 636178                           | 4615853                          |
| 16    | 635975                           | 4615967                          |
| 17    | 635828                           | 4616142                          |

**Table 1.** UTM X and Y Coordinates for Targeted Sampling Locations.

## RESULTS

### *Escherichia coli* Bacteria

*Escherichia coli* (*E. coli*) are bacteria that indicate the presence of pathogenic bacteria. *E. coli* bacteria are necessary to promote digestion in humans and other warm-blooded animals. High levels of *E. coli* in stream water typically indicate greater levels of fecal contamination and thus a greater chance that pathogenic microbes may be present in the water. Pathogenic organisms are a health risk to humans; they can cause illness in people and adversely impact aquatic ecosystems. The most frequent sources of bacteria in water are sewage overflows, malfunctioning septic systems and sewer lines, animal waste, and polluted storm water runoff.

The presence of *E. coli* bacteria in a stream suggests a relatively fresh fecal source entering the water. Although monitoring indicated that bacteria concentrations tended to be high in Hoover Creek, the monitoring did not identify the sources of these elevated bacteria levels. Rather than conduct expensive microbial source tracking studies in the watershed, a targeted sampling approach was conducted. This approach entailed taking numerous samples along the stretch of the stream to determine locations with elevated bacteria concentrations. The previous monitoring project conducted during 2004-2006 suggested that focusing on the lower stretch of the stream would likely help focus attention on illegal septic discharges or urban issues that could be remediated more easily than nonpoint source issues.

Data from Sites 1, 1A, 2, 3, 4, 5, 5A, 6, and 7 showed a minimum *E. coli* bacteria concentration of below detection (<10 CFU/100ml) to 24,000 CFU/100ml. Median concentrations ranged from 60 CFU/100ml at site 5A to 790 CFU/100ml at site 2 (Table 2). These median concentrations are generally lower than the medians calculated during the previous monitoring project during 2004-2006. Figures 5-13 show *E. coli* bacteria concentrations at the nine sites during the recent project period. Sites 1A, 2, and 3 had very low levels of bacteria during the early part of the sampling period (2009) with isolated spikes later in 2010. Sites 1, 4, 5, 6, and 7 had elevated bacteria levels when sampling began in 2009, followed by a decline in levels during the winter months of 2009-2010 and large spikes in *E. coli* during 2010. Site 5A began with high levels of *E. coli* in 2009, but experienced significant declines in bacteria in 2010.

Flow conditions during this time period were higher than the flows seen in 2004-2006 (Figure 14). Therefore, it was more difficult to isolate septic sources of bacteria coming from tile lines within the park boundary. Unlike earlier sampling events, the current data do not show a strong upstream to downstream increase in *E. coli* bacteria (see Figure 14), which further suggests dilution of tile inputs of bacteria.

| Site | Median <i>E. coli</i><br>(CFU/100ml) |
|------|--------------------------------------|
| 1    | 105                                  |
| 1A   | 310                                  |
| 2    | 790                                  |
| 3    | 565                                  |
| 4    | 660                                  |
| 5    | 645                                  |
| 5A   | 60                                   |
| 6    | 480                                  |
| 7    | 530                                  |

**Table 2.** Median *E. coli* concentrations, 2009-2010.

### ***Fluorometry***

In order to investigate septic impacts on Hoover Creek, fluorometry was used to determine failed or inadequate sewage treatment systems. Fluorometry can be used to detect optical brighteners from laundry detergents, dishwashing detergents, and toilet paper, which fluoresce when exposed to ultraviolet radiation. Optical brighteners break down when exposed to ultraviolet radiation (UV), whereas most naturally occurring organics which fluoresce at the same wavelength do not. Optical brightener dyes are generally found in domestic waste waters, because the main commercial use of these dyes is in laundry detergents and textile finishing. The brighteners can enter a waterway via leaking sewer pipes, sewer lines improperly cross-connected to storm drains, and malfunctioning on-site waste disposal systems. In the past, fluorometry has not worked well in tracking potential human waste contamination when it was used alone. However, fluorometry combined with bacteria analysis, is an inexpensive method to detect human waste in waterways. Table 3 shows the relationship between levels of bacteria, levels of optical brighteners, and sources of bacteria in waterways (Hartel *et al.* 2005).

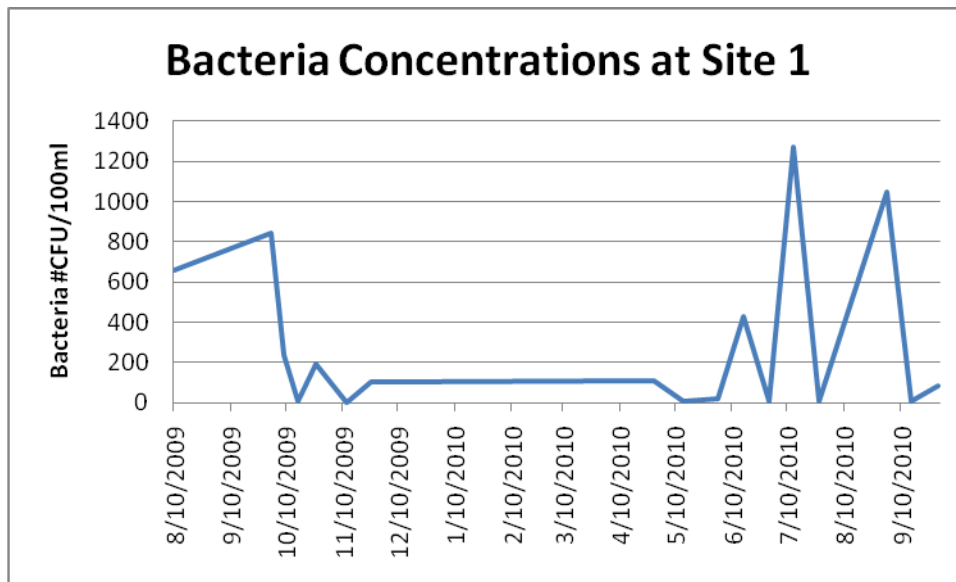


**Figure 5.** *E. coli* bacteria concentrations from targeted sampling at Site 1.

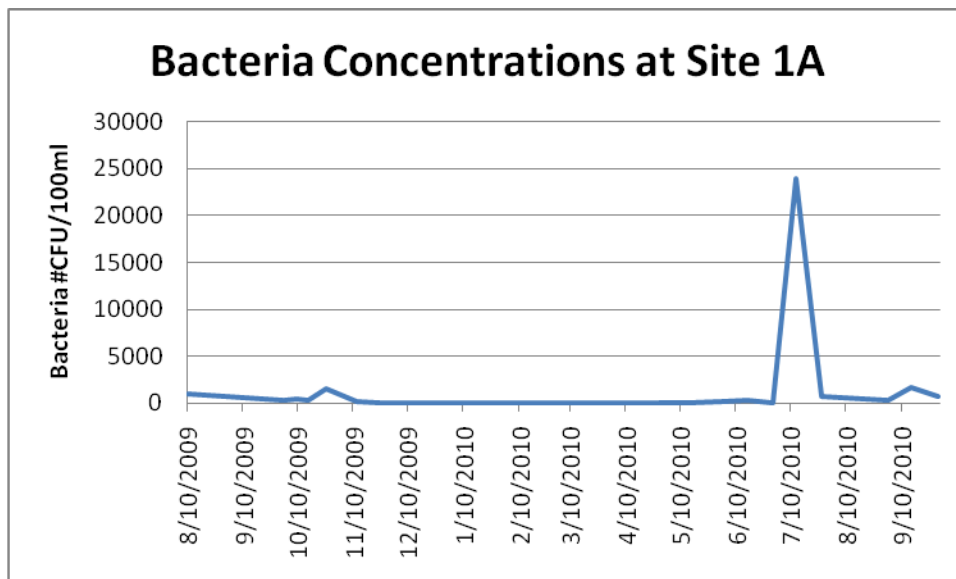


**Figure 6.** *E. coli* bacteria concentrations from targeted sampling at Site 1A.

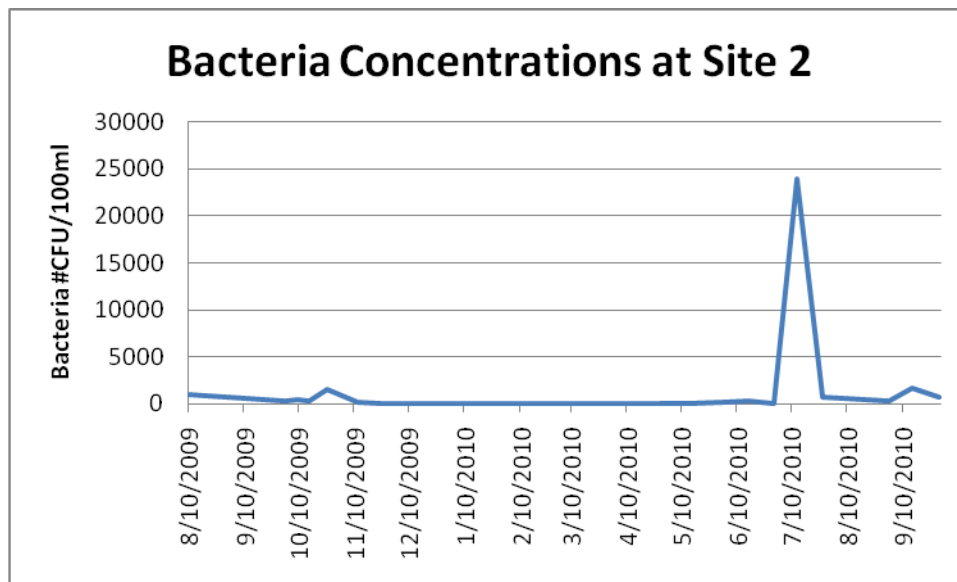


**Figure 7.** *E. coli* bacteria concentrations from targeted sampling at Site 2.

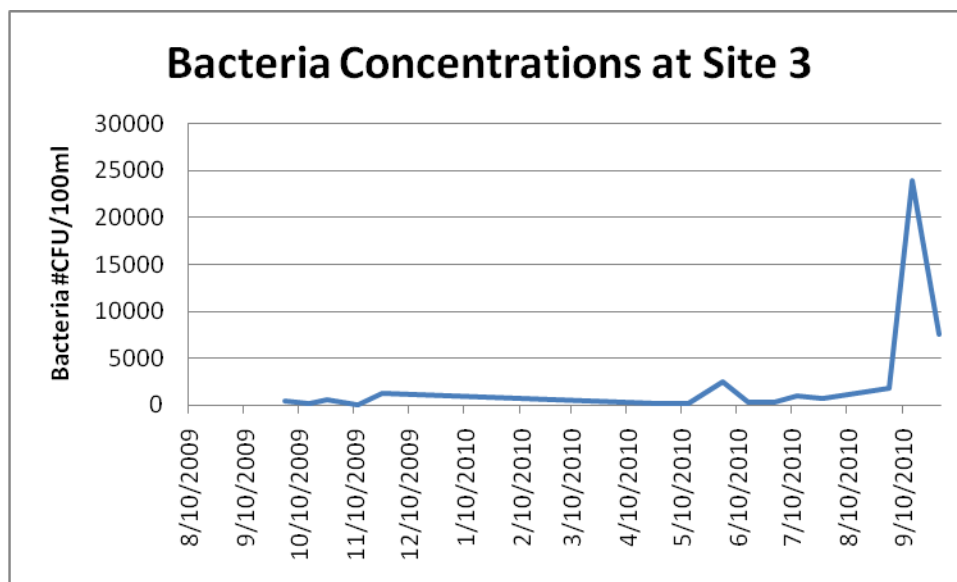


**Figure 8.** *E. coli* bacteria concentrations from targeted sampling at Site 3.

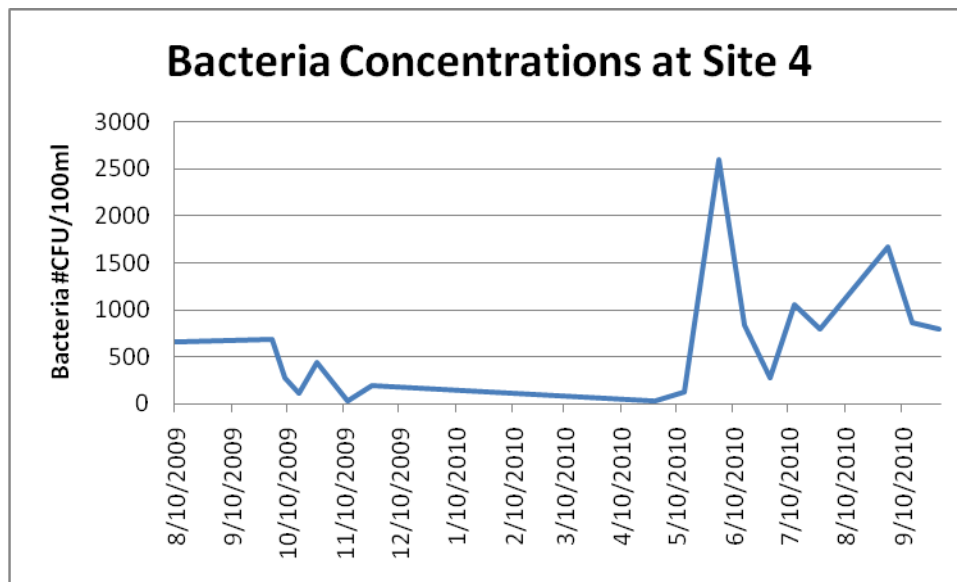


**Figure 9.** *E. coli* bacteria concentrations from targeted sampling at Site 4.

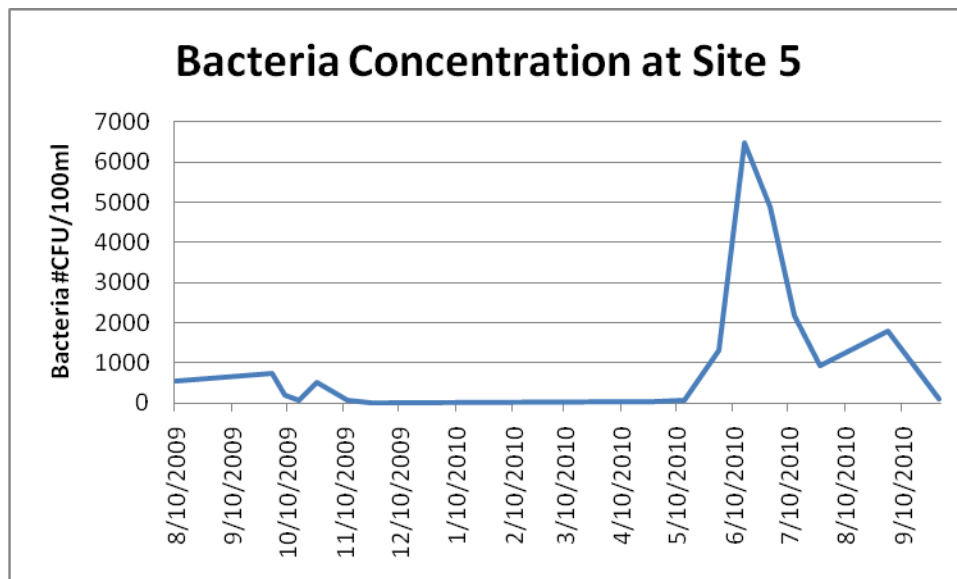


**Figure 10.** *E. coli* bacteria concentrations from targeted sampling at Site 5.

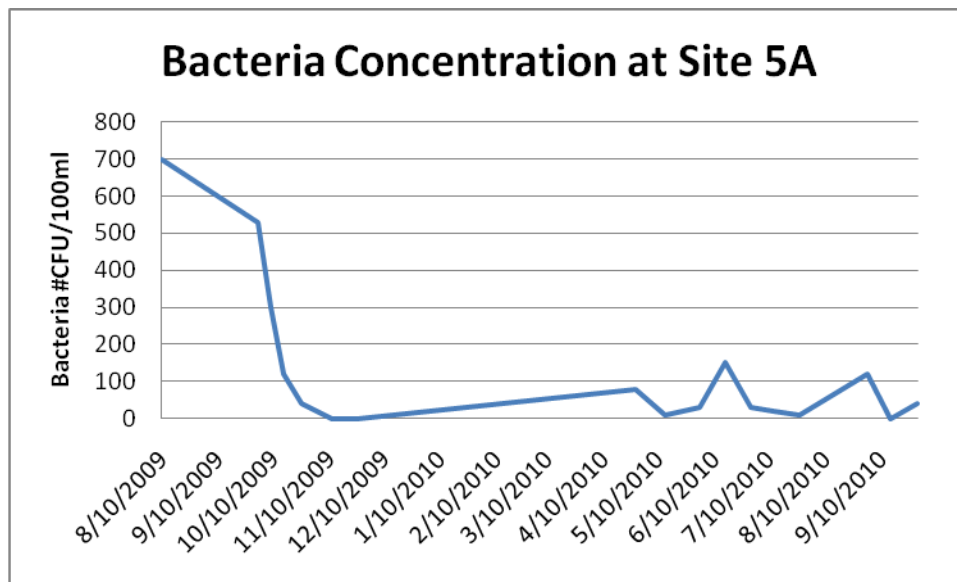


**Figure 11.** *E. coli* bacteria concentrations from targeted sampling at Site 5A.

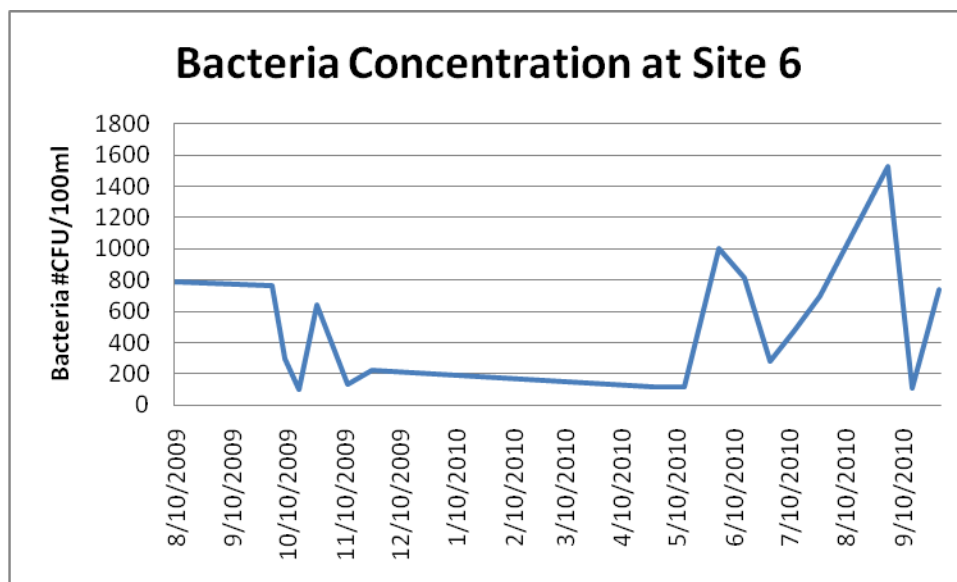


**Figure 12.** *E. coli* bacteria concentrations from targeted sampling at Site 6.

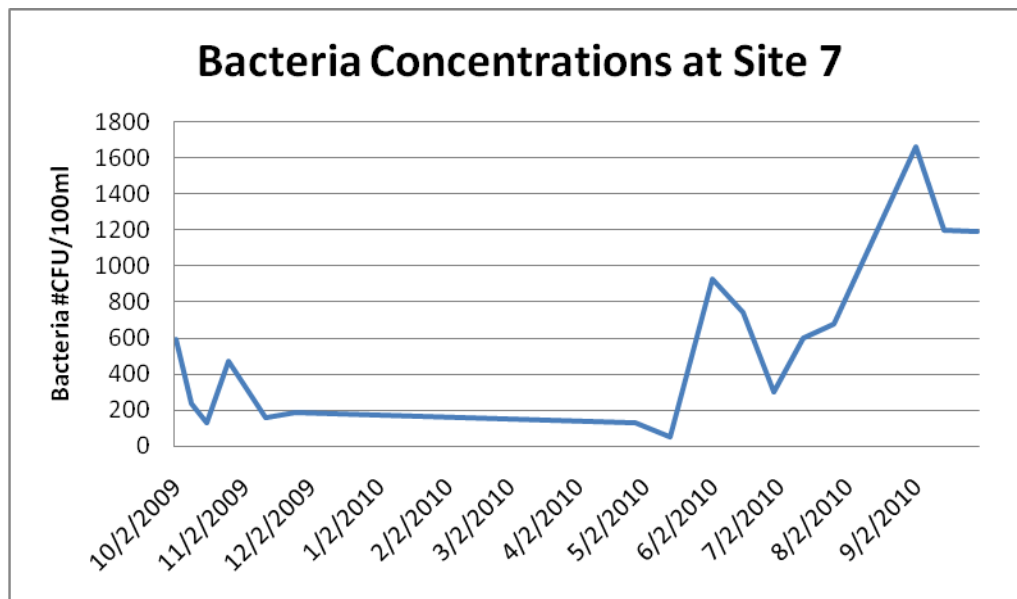


**Figure 13.** *E. coli* bacteria concentrations from targeted sampling at Site 7.

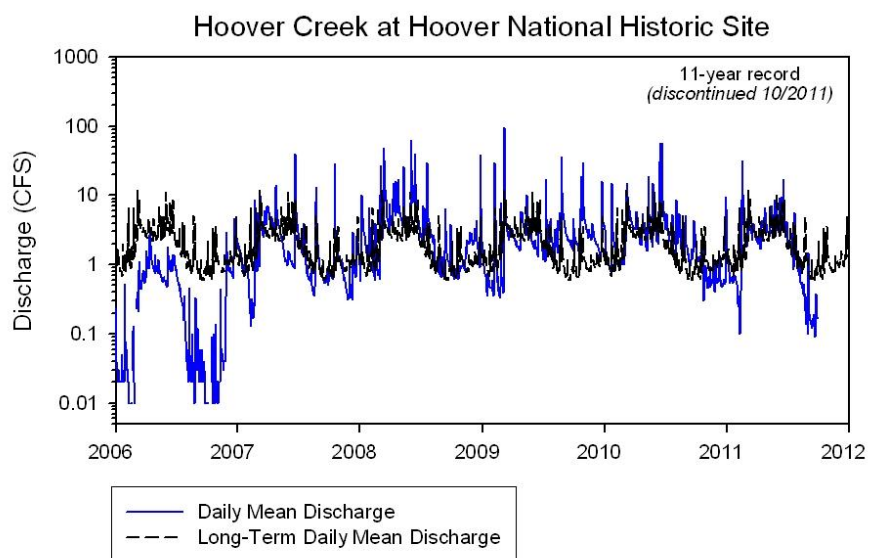


**Figure 14.** Stream Discharge (2006-2011) at Hoover Creek located within Herbert Hoover National Monument.

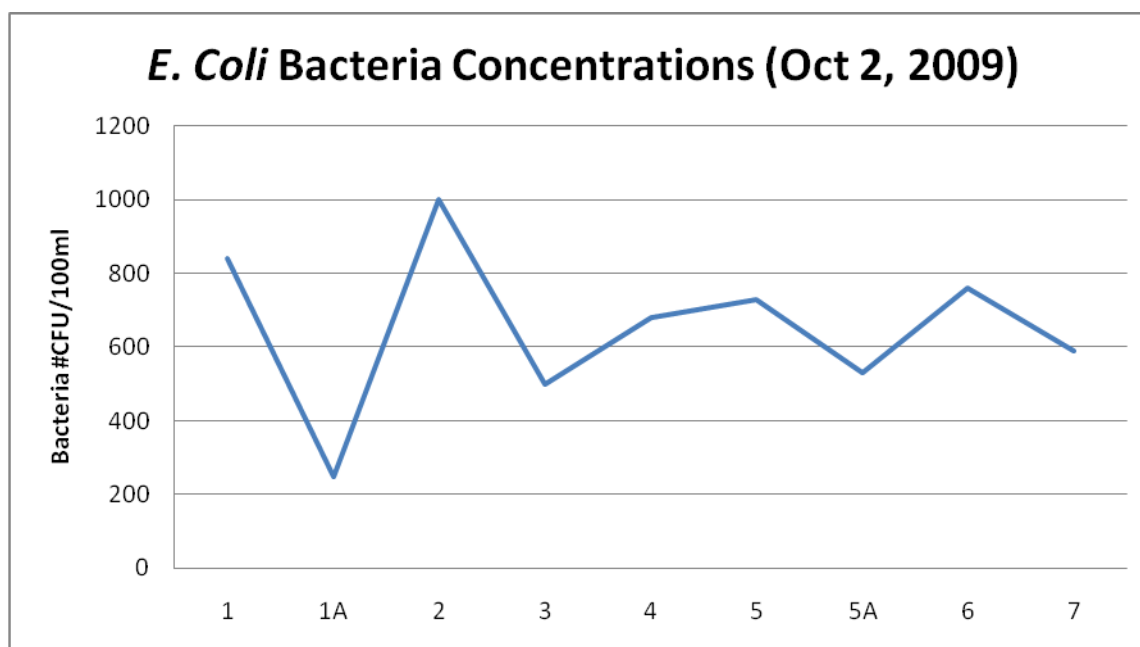


**Figure 15.** *E. coli* bacteria concentrations from targeted sampling sites on Oct 2, 2009. Sites are ordered from Downstream (1) to Upstream (7).

| Fecal Bacterial Numbers | Optical Brightener Values | Potential Bacteria Sources                                  |
|-------------------------|---------------------------|-------------------------------------------------------------|
| High                    | High                      | Failing on-site waste disposal system or leaking sewer pipe |
| High                    | Low                       | Human (e.g., outhouse) or other warm-blooded animals        |
| Low                     | High                      | Gray water in storm water system                            |
| Low                     | Low                       | No evidence of fecal contamination                          |

**Table 3.** Relationship between levels of bacteria, levels of optical brighteners, and sources of bacteria in waterways.

**Sample Collection and Analysis.** Water samples for fluorometric analysis were collected in 125 ml sterilized and acid-washed bottles. Samples were stored in a cool, dark place following collection to prevent further breakdown of the optical brightening agents in the field. Bacteria samples were collected in 100 ml bottles and were analyzed by the Department of Natural Resources water laboratory. Samples for fluorometric analysis were then placed in 30 ml acid-washed borosilicate test tubes. Using a Turner Designs 10-AU Field Fluorometer, the level of fluorescence of each sample at 436 nanometer (nm) was determined and recorded. These samples were then exposed to UV for at least six hours. Samples were analyzed prior to and following UV exposure to assess the influence of background interference from organic compounds present in the water. Differences in the level of fluorescence of each sample were compared to the previous reading. The decline in fluorescence from the first reading to the second indicates the presence of optical brighteners and their concentration in each sample.

## Results

The sampling for optical brighteners in 2009 did not reveal strong spatial patterns in Hoover Creek. In both sampling events, bacteria levels did not change significantly from the upstream to the downstream. Similarly, the concentration of optical brighteners generally was similar in all locations, with the exception of Site 1A, which had increased optical brightener concentrations compared to the other sites. Thresholds for these categories varied between samplings as background conditions were taken into account. Table 3 shows the relationship between levels of bacteria, levels of optical brighteners, and sources of bacteria (Hartel *et al.* 2005). As adapted from Table 3, the combination of bacteria levels and optical brighteners fell into one of three potential sources of bacteria: 1.) failing on-site waste disposal system or leaking sewer pipe/gray water from stormwater, 2.) human or other warmblooded animals, and 3.) no evidence of fecal contamination. Table 5 summarizes the potential sources of bacteria for each site. Based on the results in 2009, only Site 1A demonstrated evidence of human or warm-blooded animal contamination. While other sites did not demonstrate evidence of fecal contamination during the fall 2009 sampling, it should be noted that this may not be the case with future sampling events.

| 16-Oct | Site   | Optical<br>Brightener<br>Change<br>(OBU) | E. Coli<br>(CFU/100ml) | Level<br>Optical<br>Brightener<br>Change | Relative<br>E. Coli |
|--------|--------|------------------------------------------|------------------------|------------------------------------------|---------------------|
| 16-Oct | 1      | 37                                       | 10                     | Low                                      | Low                 |
|        | 1A     | 130                                      | 330                    | High                                     | Low                 |
|        | 2      | 50                                       | 310                    | Low                                      | Low                 |
|        | 3      | 22                                       | 210                    | Low                                      | Low                 |
|        | 4      | 34                                       | 110                    | Low                                      | Low                 |
|        | 5      | 49                                       | 80                     | Low                                      | Low                 |
|        | 5A     | 52                                       | 120                    | Low                                      | Low                 |
|        | 6      | 44                                       | 100                    | Low                                      | Low                 |
|        | 7      | 77                                       | 130                    | Low                                      | Low                 |
|        | 12-Nov |                                          |                        |                                          |                     |
|        | 1      | 96                                       | <10                    | Low                                      | Low                 |
|        | 1A     | 128                                      | 220                    | High                                     | Low                 |
|        | 2      | 46                                       | 180                    | Low                                      | Low                 |
|        | 3      | 48                                       | 40                     | Low                                      | Low                 |
|        | 4      | 42                                       | 30                     | Low                                      | Low                 |
|        | 5      | 37                                       | 60                     | Low                                      | Low                 |
|        | 5A     | 24.8                                     | <10                    | Low                                      | Low                 |
|        | 6      | 43                                       | 130                    | Low                                      | Low                 |
|        | 7      | 45                                       | 160                    | Low                                      | Low                 |

**Table 4.** Hoover Creek optical brightener results, 2009.

| Sites | Potential Sources of Bacteria       |
|-------|-------------------------------------|
| 1     | No evidence of fecal contamination  |
| 1A    | Human or other warm-blooded animals |
| 2     | No evidence of fecal contamination  |
| 3     | No evidence of fecal contamination  |
| 4     | No evidence of fecal contamination  |
| 5     | No evidence of fecal contamination  |
| 5A    | No evidence of fecal contamination  |
| 6     | No evidence of fecal contamination  |
| 7     | No evidence of fecal contamination  |

**Table 5.** Potential sources of bacteria in Hoover Creek based on fluorometry results.

## CONCLUSIONS

Above normal flow conditions characterized the Hoover Creek watershed during 2009 and 2010. Hoover Creek can be characterized as having a very flashy flow regime with generally baseflow conditions that are interrupted by brief, high-flow events. Results from the targeted bacteria sampling showed generally lower *E. coli* levels than were observed in 2004-2006. Fluorometry results suggest that some of the bacteria in Hoover Creek at Site 1A is likely from humans; however the other sites did not exhibit the same level of optical brighteners that were seen in earlier projects.

Under Section 303(d) of the Clean Water Act, the State of Iowa is required to submit a list of all waters that do not meet state water quality standards. Data collected as part of earlier projects placed Hoover Creek on the impaired waters list for excessive bacteria concentrations in a Class 1A stream. Nonpoint source and point source pollution are both contributing to these high values. Further bacteria monitoring in the watershed is recommended, during lower flows in order to better isolate human sources of bacteria coming from failing septic systems or pipes.

## **ACKNOWLEDGEMENTS**

This study was a cooperative project among federal, state, and local agencies. Many organizations and individuals made significant contributions to this project. Jason McCurdy collected and transported water quality samples, conducted the fluorometric investigations, and provided interpretation. The adjacent landowners granted access to Hoover Creek from their property. Heartland Network, Inventory and Monitoring Program, National Park Service provided funding and technical support.

## REFERENCES

- Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency. Office of Water. Washington, D.C.
- Cleland, Bruce 2004. Personal Communication. Watershed Program Circuit Rider. United States Environmental Protection Agency. EPA 2000. Information supporting the development of state and tribal nutrient criteria for rivers and streams in nutrient ecoregion VI. EPA 822-B-00-017. U.S. Environmental Protection Agency. Office of Water. Washington, D.C.
- Foreman, K. L. 2007. Water Quality Monitoring in the Hoover Creek Watershed, 2004-2006, Iowa Geological Survey, Technical Information Series 53, Iowa City, IA.
- Hartel, P., K. Gates, K. Payne, J. McDonald, K. Rodgers, S. Hemmings, J. Fisher, and L. Gentit. 2005. Targeted sampling to determine sources of fecal contamination. *Stormwater* 6:46–53.
- Hilsenhoff, W.L. 1988. Rapid field assessment of organic pollution with a family-level biotic index. *Journal of the North American Benthological Society*: 7(1):65-68. IAC 2002. Iowa Administrative Code [effective date 7/10/02]. Chapter 567-61: water quality standards. <http://www.legis.state.ia.us/Rules/2003/iac/567iac/56761/56761.pdf>.
- IDNR 2001. Biological sampling procedures for wadeable streams and rivers in Iowa. Iowa Department of Natural Resources. Environmental Protection Division. Water Resources Section. Des Moines, IA.
- IDNR 2005. IOWATER benthic macroinvertebrate indexing. IOWATER Manual. Iowa Department of Natural Resources. Des Moines, IA.
- Prior, J.C. 1991. Landforms of Iowa. University of Iowa Press. Iowa City, IA. UHL 2001. Standard operating procedures. Chemical/physical water quality monitoring of Iowa's rivers and streams. Version 1. University of Iowa Hygienic Lab. Iowa City, IA.
- USDA 1998. Stream visual assessment protocol. National Water and Climate Center Technical Note 99-1. U.S. Department of Agriculture. Washington D.C.

# Appendix A

| Site ID | Date       | Time  | PH  | Water Temp | DO (mg/L) | Turbidity (NTU) | Air Temp | CCover (%) | SC (ms) | Bacteria |
|---------|------------|-------|-----|------------|-----------|-----------------|----------|------------|---------|----------|
| 1       | 8/10/2009  | 10:30 | 8   | 15.4       | 9.3       | 10.5            | 76       | 90         | 460     | 660      |
| 1       | 10/2/2009  | 9:50  | 7.7 | 13.1       | 9.18      | 22.9            | 48       | 100        | 421     | 840      |
| 1       | 10/9/2009  | 11:50 | 8.1 | 11.3       | 9.26      | 17.4            | 48       | 100        | 406     | 240      |
| 1       | 10/16/2009 | 2:10  | 7.9 | 12.1       | 5.96      | 5               | 58       | 75         | 752     | 10       |
| 1       | 10/26/2009 | 9:45  | 7.7 | 12         | 5.76      | 8.1             | 46       | 100        | 382     | 190      |
| 1       | 11/12/2009 | 1:25  | 7.8 | 11.2       | 3.57      | 10.2            | 53       | 100        | 869     | <10      |
| 1       | 11/25/2009 | 10:15 | 7.8 | 10.5       | 4.43      | 28              | 42       | 100        | 296     | 100      |
| 1       | 4/28/2010  | 8:10  | 8.5 | 7.4        | 8.93      | 5.06            | 50       | 0          | 338     | 110      |
| 1       | 5/14/2010  | 9:00  | 7.9 | 12.2       | 7.45      | 6.14            | 58       | 50         | 678     | 10       |
| 1       | 6/2/2010   | 8:50  | 7.9 | 18.5       | 6.99      | 5.85            | 66       | 100        | 614     | 20       |
| 1       | 6/16/2010  | 8:25  | 7.4 | 17.6       | 9.58      | 1.63            | 68       | 0          | 558     | 430      |
| 1       | 6/30/2010  | 8:38  | 7.7 | 17.8       | 7.21      | 20.7            | 74       | 0          | 385     | 10       |
| 1       | 7/13/2010  | 9:28  | 8   | 18.7       | 8.63      | 10.7            | 74       | 5          | 329     | 1270     |
| 1       | 7/27/2010  | 9:00  | 7.6 | 19         | 9.74      | 4.51            | 80       | 0          | 437     | 10       |
| 1       | 8/11/2010  |       |     |            |           |                 |          |            |         |          |
| 1       | 9/2/2010   | 9:25  | 8   | 18.6       | 13.89     | 13.4            | 70       | 100        | 710     | 1050     |
| 1       | 9/15/2010  | 8:49  | 7.7 | 17.4       | 5.88      | 6.35            | 67       | 95         | 357     | 10       |
| 1       | 9/30/2010  | 9:00  | 7.4 | 14.2       | 9.46      | 11.1            | 70       | 10         | 423     | 85       |
|         |            |       |     |            |           |                 |          |            |         |          |
| 1A      | 8/10/2009  | 11:00 | 8   | 15.6       | 9.6       | 9.6             | 76       | 90         | 481     | 930      |
| 1A      | 10/2/2009  | 10:03 | 7.9 | 12.9       | 8.5       | 24.5            | 48       | 100        | 423     | 250      |
| 1A      | 10/9/2009  | 12:10 | 8   | 11.1       | 8.16      | 3.38            | 48       | 100        | 450     | 450      |
| 1A      | 10/16/2009 | 2:25  | 8.2 | 11.7       | 9.81      | 9.64            | 58       | 75         | 412     | 330      |
| 1A      | 10/26/2009 | 9:57  | 8   | 11.4       | 6.75      | 9.7             | 46       | 100        | 343     | 1500     |
| 1A      | 11/12/2009 | 1:35  | 7.5 | 10.3       | 7.11      | 4.24            | 53       | 100        | 343     | 220      |
| 1A      | 11/25/2009 | 10:28 | 8   | 9.5        | 5.42      | 9.71            | 42       | 100        | 297     | 60       |
| 1A      | 4/28/2010  | 8:30  | 8.5 | 7.4        | 8.03      | 4.48            | 50       | 0          | 337     | 10       |
| 1A      | 5/14/2010  | 9:15  | 7.8 | 12.5       | 8.09      | 5.78            | 58       | 60         | 430     | 85       |
| 1A      | 6/2/2010   | 9:07  | 7.9 | 15.3       | 6.68      | 5.48            | 66       | 100        | 448     | 220      |
| 1A      | 6/16/2010  | 8:42  | 7.7 | 17.8       | 8.69      | 3.69            | 70       | 0          | 456     | 310      |
| 1A      | 6/30/2010  | 8:56  | 8.2 | 16         | 9.68      | 8.85            | 74       | 0          | 390     | 60       |
| 1A      | 7/13/2010  | 9:45  | 7.9 | 18.4       | 7.71      | 11.7            | 74       | 0          | 424     | 24000    |
| 1A      | 7/27/2010  | 9:12  | 7.9 | 19.2       | 8.85      | 4.06            | 80       | 0          | 365     | 650      |
| 1A      | 8/11/2010  |       |     |            |           |                 |          |            |         |          |
| 1A      | 9/2/2010   | 9:38  | 7.9 | 19.3       | 8.77      | 5.89            | 70       | 100        | 416     | 310      |
| 1A      | 9/15/2010  | 9:05  | 7.9 | 16.3       | 7.4       | 9.16            | 67       | 95         | 398     | 1600     |
| 1A      | 9/30/2010  | 9:16  | 8.1 | 14.2       | 9.53      | 19              | 70       | 0          | 455     | 720      |
|         |            |       |     |            |           |                 |          |            |         |          |
| 2       | 8/10/2009  | 11:10 | 8   | 15.7       | 9.7       | 9.04            | 77       | 90         | 494     | 840      |
| 2       | 10/2/2009  | 10:10 | 7.9 | 12.9       | 8.59      | 25              | 48       | 100        | 423     | 1000     |
| 2       | 10/9/2009  | 12:20 | 8.1 | 11.2       | 8.85      | 16.8            | 48       | 100        | 408     | 170      |
| 2       | 10/16/2009 | 2:35  | 8.2 | 11.5       | 9.86      | 9.89            | 58       | 75         | 412     | 310      |
| 2       | 10/26/2009 | 10:05 | 8.1 | 11.4       | 8.48      | 6.2             | 46       | 100        | 370     | 20       |
| 2       | 11/12/2009 | 1:50  | 8.1 | 10.1       | 8.78      | 11.1            | 53       | 100        | 375     | 180      |

|   |            |       |     |      |       |      |    |     |     |       |
|---|------------|-------|-----|------|-------|------|----|-----|-----|-------|
| 2 | 11/25/2009 | 10:33 | 7.9 | 9.7  | 6.54  | 18.8 | 42 | 100 | 363 | 820   |
| 2 | 4/28/2010  | 8:45  | 8.4 | 7.4  | 8.03  | 6.56 | 52 | 0   | 338 | 170   |
| 2 | 5/14/2010  | 9:24  | 7.9 | 11.6 | 8.32  | 24.8 | 59 | 60  | 365 | 20    |
| 2 | 6/2/2010   | 9:16  | 7.9 | 13.5 | 9.74  | 21.5 | 66 | 100 | 406 | 2280  |
| 2 | 6/16/2010  | 8:50  | 7.1 | 14.9 | 6.78  | 11   | 70 | 0   | 355 | 510   |
| 2 | 6/30/2010  | 9:05  | 7.9 | 15.5 | 10.27 | 27.7 | 74 | 0   | 390 | 450   |
| 2 | 7/13/2010  | 9:55  | 7.9 | 18.5 | 8.88  | 14.9 | 74 | 0   | 348 | 790   |
| 2 | 7/27/2010  | 9:25  | 7.9 | 19.2 | 9.45  | 17.5 | 80 | 0   | 385 | 930   |
| 2 | 8/11/2010  |       |     |      |       |      |    |     |     |       |
| 2 | 9/2/2010   | 9:45  | 7.9 | 18.9 | 8.72  | 15   | 70 | 100 | 423 | 2100  |
| 2 | 9/15/2010  | 9:15  | 8   | 16.1 | 9.45  | 10.1 | 67 | 95  | 495 | 860   |
| 2 | 9/30/2010  | 9:22  | 8   | 14.2 | 9.52  | 19.4 | 70 | 0   | 457 | 794   |
|   |            |       |     |      |       |      |    |     |     |       |
| 3 | 8/10/2009  | NA    | NA  | NA   | NA    | NA   | NA | NA  | NA  | NA    |
| 3 | 10/2/2009  | 10:20 | 7.8 | 12.9 | 8.37  | 23.8 | 48 | 100 | 423 | 500   |
| 3 | 10/9/2009  | 12:35 | 8.1 | 11.4 | 8.89  | 26.9 | 48 | 100 | 409 | 280   |
| 3 | 10/16/2009 | 2:50  | 8.2 | 11.4 | 8.86  | 9.82 | 58 | 50  | 411 | 210   |
| 3 | 10/26/2009 | 10:15 | 7.9 | 11.5 | 8.28  | 14   | 46 | 100 | 372 | 630   |
| 3 | 11/12/2009 | 2:05  | 8.1 | 10.3 | 9.17  | 12.4 | 53 | 100 | 378 | 40    |
| 3 | 11/25/2009 | 10:46 | 7.9 | 9.7  | 6.18  | 18.5 | 42 | 100 | 365 | 1200  |
| 3 | 4/28/2010  | 9:00  | 8.4 | 7.6  | 8.04  | 9.89 | 54 | 0   | 340 | 140   |
| 3 | 5/14/2010  | 9:37  | 8.1 | 11.6 | 8.11  | 27.9 | 62 | 60  | 355 | 120   |
| 3 | 6/2/2010   | 9:30  | 8   | 13.4 | 9.36  | 37.8 | 66 | 100 | 402 | 2480  |
| 3 | 6/16/2010  | 9:00  | 7.7 | 15.4 | 9.58  | 6.2  | 72 | 0   | 330 | 280   |
| 3 | 6/30/2010  | 9:16  | 7.8 | 15.8 | 9.96  | 19.5 | 74 | 0   | 415 | 340   |
| 3 | 7/13/2010  | 10:16 | 7.9 | 18.4 | 8.52  | 15   | 76 | 0   | 374 | 960   |
| 3 | 7/27/2010  | 9:40  | 7.9 | 19.9 | 9.9   | 21.3 | 80 | 0   | 362 | 730   |
| 3 | 8/11/2010  |       |     |      |       |      |    |     |     |       |
| 3 | 9/2/2010   | 10:00 | 7.8 | 18.9 | 8.22  | 14.5 | 70 | 100 | 389 | 1800  |
| 3 | 9/15/2010  | 9:33  | 7.9 | 16.8 | 7.38  | 0.73 | 67 | 95  | 310 | 24000 |
| 3 | 9/30/2010  | 9:35  | 8   | 14.7 | 8.01  | 1.41 | 70 | 0   | 322 | 7600  |
|   |            |       |     |      |       |      |    |     |     |       |
| 4 | 8/10/2009  | 11:30 | 8   | 16.2 | 9.8   | 8.7  | 81 | 90  | 501 | 660   |
| 4 | 10/2/2009  | 10:30 | 7.8 | 13   | 8.25  | 25.6 | 48 | 100 | 434 | 680   |
| 4 | 10/9/2009  | 12:55 | 8.1 | 11.4 | 9.18  | 31.4 | 48 | 100 | 412 | 280   |
| 4 | 10/16/2009 | 3:05  | 7.8 | 11.7 | 9.22  | 14.6 | 58 | 75  | 417 | 110   |
| 4 | 10/26/2009 | 10:30 | 8.2 | 11.5 | 8.34  | 30.8 | 46 | 100 | 371 | 440   |
| 4 | 11/12/2009 | 2:20  | 8.1 | 10.3 | 9.46  | 11.9 | 53 | 100 | 460 | 30    |
| 4 | 11/25/2009 | 10:55 | 7.9 | 9.7  | 6.32  | 38.7 | 42 | 100 | 369 | 200   |
| 4 | 4/28/2010  | 9:15  | 8.2 | 7.8  | 8.02  | 9.42 | 54 | 0   | 345 | 30    |
| 4 | 5/14/2010  | 9:50  | 7.9 | 11.3 | 8.56  | 18.4 | 62 | 60  | 412 | 130   |
| 4 | 6/2/2010   | 9:50  | 7.8 | 13.3 | 9.79  | 22.5 | 66 | 100 | 405 | 2600  |
| 4 | 6/16/2010  | 9:25  | 7.6 | 15.4 | 8.32  | 47.9 | 72 | 0   | 455 | 840   |
| 4 | 6/30/2010  | 9:25  | 7.7 | 15.6 | 9.92  | 26.5 | 74 | 0   | 496 | 280   |
| 4 | 7/13/2010  | 10:35 | 7.8 | 18.4 | 8.76  | 13.2 | 76 | 0   | 414 | 1050  |
| 4 | 7/27/2010  | 9:56  | 7.9 | 19.2 | 9.6   | 19   | 80 | 10  | 380 | 790   |
| 4 | 8/11/2010  |       |     |      |       |      |    |     |     |       |
| 4 | 9/2/2010   | 10:13 | 7.8 | 18.9 | 8.6   | 12.1 | 70 | 100 | 475 | 1670  |

|    |            |       |     |      |       |      |    |     |       |      |
|----|------------|-------|-----|------|-------|------|----|-----|-------|------|
| 4  | 9/15/2010  | 9:40  | 8   | 16.3 | 10    | 11.5 | 67 | 95  | 432   | 860  |
| 4  | 9/30/2010  | 9:45  | 8.1 | 14.5 | 10.28 | 17.6 | 70 | 0   | 463   | 790  |
|    |            |       |     |      |       |      |    |     |       |      |
| 5  | 8/10/2009  | 11:45 | 8   | 16.2 | 9.9   | 9.8  | 81 | 95  | 504   | 560  |
| 5  | 10/2/2009  | 10:45 | 7.8 | 13   | 8.28  | 26.1 | 48 | 100 | 432   | 730  |
| 5  | 10/9/2009  | 1:12  | 7.8 | 11.5 | 9.3   | 17.2 | 48 | 100 | 412   | 190  |
| 5  | 10/16/2009 | 3:15  | 8.1 | 11.6 | 9.19  | 13.8 | 58 | 75  | 413   | 80   |
| 5  | 10/26/2009 | 10:45 | 8.1 | 11.5 | 8.3   | 22.3 | 46 | 100 | 377   | 500  |
| 5  | 11/12/2009 | 2:30  | 8.1 | 10.3 | 8.98  | 15.6 | 53 | 100 | 452   | 60   |
| 5  | 11/25/2009 | 11:10 | 8.1 | 9.8  | 6.24  | 5.44 | 42 | 100 | 373   | <10  |
| 5  | 4/28/2010  | 9:28  | 8.2 | 7.8  | 8.02  | 9.42 | 54 | 0   | 345   | 30   |
| 5  | 5/14/2010  | 10:10 | 7.8 | 11.3 | 8.66  | 19.6 | 62 | 60  | 436   | 75   |
| 5  | 6/2/2010   | 10:05 | 7.9 | 13.3 | 9.79  | 25.2 | 66 | 100 | 408   | 1300 |
| 5  | 6/16/2010  | 9:45  | 7.2 | 14.8 | 8.18  | 12.5 | 72 | 0   | 337   | 6480 |
| 5  | 6/30/2010  | 9:37  | 7.8 | 15.7 | 9.66  | 20.5 | 74 | 0   | 382   | 4880 |
| 5  | 7/13/2010  | 10:50 | 7.8 | 18.3 | 8.93  | 16.4 | 76 | 0   | 354   | 2180 |
| 5  | 7/27/2010  | 10:05 | 7.9 | 19.1 | 9.27  | 29   | 80 | 0   | 415   | 930  |
| 5  | 8/11/2010  |       |     |      |       |      |    |     |       |      |
| 5  | 9/2/2010   | 10:25 | 7.8 | 18.9 | 8.51  | 15.1 | 70 | 80  | 410   | 1780 |
| 5  | 9/15/2010  | 9:50  | 7.4 | 16.3 | 9.75  | 19.8 | 67 | 95  | 389   | 990  |
| 5  | 9/30/2010  | 10:00 | 8   | 14.4 | 10.18 | 17.8 | 70 | 0   | 455   | 95   |
|    |            |       |     |      |       |      |    |     |       |      |
| 5A | 8/10/2009  | 12:15 | 8   | 16.3 | 9.6   | 8.5  | 82 | 100 | 502   | 700  |
| 5A | 10/2/2009  | 11:00 | 7.8 | 13   | 8.23  | 25.8 | 48 | 100 | 431   | 530  |
| 5A | 10/9/2009  | 1:26  | 8   | 11.6 | 8.5   | 14.6 | 48 | 100 | 409   | 300  |
| 5A | 10/16/2009 | 3:30  | 8.1 | 11.6 | 8.6   | 16.1 | 58 | 75  | 418   | 120  |
| 5A | 10/26/2009 | 10:57 | 7.6 | 11.7 | 6.96  | 7.3  | 46 | 100 | 285   | 40   |
| 5A | 11/12/2009 | 2:45  | 7.6 | 10.1 | 7.72  | 3.58 | 53 | 100 | 418   | <10  |
| 5A | 11/25/2009 | 11:20 | 8.1 | 9.9  | 5.74  | 5.98 | 42 | 100 | 285   | <10  |
| 5A | 4/28/2010  | 9:45  | 8.1 | 7.9  | 8.78  | 6.83 | 56 | 0   | 513   | 80   |
| 5A | 5/14/2010  | 10:23 | 7.5 | 11.1 | 8.43  | 13.2 | 62 | 60  | 375   | 10   |
| 5A | 6/2/2010   | 10:15 | 7.4 | 12.9 | 9.41  | 11.1 | 66 | 100 | 303   | 30   |
| 5A | 6/16/2010  | 10:10 | 7.4 | 14.2 | 6.03  | 23.2 | 72 | 0   | 477   | 150  |
| 5A | 6/30/2010  | 9:50  | 7.3 | 15.8 | 10.12 | 7.04 | 74 | 0   | 410   | 30   |
| 5A | 7/13/2010  | 11:10 | 7.1 | 16.6 | 7.42  | 5.2  | 78 | 0   | 405   | 20   |
| 5A | 7/27/2010  | 10:20 | 7.2 | 17.5 | 8.18  | 9.16 | 80 | 0   | 390   | 10   |
| 5A | 8/11/2010  |       |     |      |       |      |    |     |       |      |
| 5A | 9/2/2010   | 10:45 | 7.4 | 17.9 | 6.63  | 3.8  | 70 | 80  | 520   | 120  |
| 5A | 9/15/2010  | 10:00 | 7.5 | 16.8 | 8.47  | 5.55 | 67 | 95  | 468   | <10  |
| 5A | 9/30/2010  | 10:16 | 7.3 | 15.9 | 8.94  | 14.2 | 70 | 0   | 377.5 | 40   |
|    |            |       |     |      |       |      |    |     |       |      |
| 6  | 8/10/2009  | 12:30 | 8   | 16.6 | 9.5   | 9.4  | 80 | 100 | 501   | 790  |
| 6  | 10/2/2009  | 11:20 | 7.7 | 13.2 | 7.9   | 22.8 | 48 | 100 | 428   | 760  |
| 6  | 10/9/2009  | 1:45  | 7.9 | 11.6 | 7.44  | 33.1 | 48 | 100 | 409   | 300  |
| 6  | 10/16/2009 | 3:45  | 7.8 | 11.8 | 8.71  | 14.6 | 58 | 50  | 415   | 100  |
| 6  | 10/26/2009 | 11:10 | 7.8 | 11.6 | 7.81  | 16.2 | 46 | 100 | 379   | 640  |
| 6  | 11/12/2009 | 3:00  | 8.1 | 10.5 | 8.06  | 13.9 | 53 | 100 | 386   | 130  |
| 6  | 11/25/2009 | 11:35 | 7.9 | 9.8  | 6.56  | 30.1 | 42 | 100 | 370   | 220  |

|   |            |       |     |      |       |      |    |     |     |      |
|---|------------|-------|-----|------|-------|------|----|-----|-----|------|
| 6 | 4/28/2010  | 10:10 | 8.1 | 8.2  | 8.91  | 6.6  | 58 | 0   | 340 | 120  |
| 6 | 5/14/2010  | 10:37 | 7.8 | 11.4 | 8.21  | 15.7 | 62 | 60  | 361 | 120  |
| 6 | 6/2/2010   | 10:35 | 7.6 | 13.6 | 9.16  | 18.6 | 66 | 100 | 408 | 1000 |
| 6 | 6/16/2010  | 10:30 | 7.5 | 15.8 | 8.12  | 59.4 | 74 | 0   | 382 | 810  |
| 6 | 6/30/2010  | 10:10 | 7.7 | 16.1 | 12.53 | 33.3 | 74 | 0   | 436 | 280  |
| 6 | 7/13/2010  | 11:28 | 7.7 | 18.6 | 8.51  | 15.6 | 78 | 5   | 376 | 480  |
| 6 | 7/27/2010  | 10:40 | 7.6 | 19.2 | 8.76  | 19.3 | 80 | 5   | 348 | 700  |
| 6 | 8/11/2010  |       |     |      |       |      |    |     |     |      |
| 6 | 9/2/2010   | 11:05 | 7.7 | 19.4 | 7.94  | 17.2 | 70 | 50  | 430 | 1530 |
| 6 | 9/15/2010  | 10:15 | 7.8 | 16.4 | 9.65  | 12.4 | 67 | 95  | 405 | 110  |
| 6 | 9/30/2010  | 10:34 | 7.9 | 14.7 | 8.49  | 22   | 70 | 0   | 454 | 743  |
|   |            |       |     |      |       |      |    |     |     |      |
| 7 | 8/10/2009  | NA    | NA  | NA   | NA    | NA   | NA | NA  | NA  | NA   |
| 7 | 10/2/2009  | 11:30 | 7.8 | 13.4 | 8.09  | 23.4 | 48 | 100 | 429 | 590  |
| 7 | 10/9/2009  | 1:55  | 7.9 | 11.7 | 8.53  | 23.7 | 48 | 100 | 409 | 240  |
| 7 | 10/16/2009 | 3:55  | 7.9 | 11.8 | 8.89  | 12.7 | 58 | 50  | 413 | 130  |
| 7 | 10/26/2009 | 11:16 | 7.8 | 11.6 | 7.81  | 14.7 | 46 | 100 | 370 | 470  |
| 7 | 11/12/2009 | 3:10  | 8.1 | 10.5 | 8.19  | 12.6 | 53 | 100 | 348 | 160  |
| 7 | 11/25/2009 | 11:45 | 7.9 | 9.8  | 6.76  | 24.9 | 42 | 100 | 363 | 190  |
| 7 | 4/28/2010  | 10:25 | 8.1 | 8.2  | 8.8   | 10.4 | 58 | 0   | 385 | 130  |
| 7 | 5/14/2010  | 10:55 | 7.7 | 11.3 | 7.98  | 17.3 | 64 | 60  | 322 | 50   |
| 7 | 6/2/2010   | 10:48 | 7.8 | 13.3 | 8.93  | 21.9 | 66 | 100 | 405 | 930  |
| 7 | 6/16/2010  | 10:40 | 7.6 | 15.8 | 8.21  | 49.9 | 74 | 0   | 358 | 740  |
| 7 | 6/30/2010  | 10:25 | 7.7 | 16.2 | 10.9  | 25.9 | 74 | 0   | 405 | 300  |
| 7 | 7/13/2010  | 11:45 | 7.7 | 18.7 | 8.65  | 25.8 | 78 | 5   | 364 | 600  |
| 7 | 7/27/2010  | 10:55 | 7.7 | 19.2 | 8.94  | 20.1 | 80 | 5   | 394 | 680  |
| 7 | 8/11/2010  |       |     |      |       |      |    |     |     |      |
| 7 | 9/2/2010   | 11:15 | 7.6 | 19.4 | 8.07  | 16.9 | 70 | 50  | 418 | 1660 |
| 7 | 9/15/2010  | 10:30 | 7.9 | 16.4 | 9.74  | 22.8 | 67 | 95  | 378 | 1200 |
| 7 | 9/30/2010  | 10:48 | 7.9 | 14.7 | 11.01 | 25.3 | 70 | 0   | 444 | 1190 |