Beach Monitoring Investigative Sampling at Cannon and Tolovana Beaches

Oregon Beach Monitoring Program – DEQ Laboratory

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Department of Environmental Quality

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Acknowledgements

Several Laboratory and Environmental Assessment Division staff at the Oregon Department of Environmental Quality assisted with this project. Larry Caton contributed to the design of the project. Greg Coffeen and Shannon Hubler assisted with the field work. Aaron Borisenko, Shannon Hubler and Lesley Merrick assisted with GIS, analysis, and review.

Executive Summary

The Oregon Beach Monitoring Program monitors recreational waters along the Oregon coast to assess bacterial contamination at public beaches. The program operating plan allows for investigating outflows on to the beach that may contribute to water contact advisories at Cannon Beach. Investigational sample locations were selected along four creeks in Cannon Beach that discharge to beaches with heavy public use and where marine and fresh water sample results occasionally exceed the U.S. Environmental Protection Agency's recreational water quality criteria. Sampling was successfully scheduled to take place around the first substantial rain storm following the 2012 summer season. Five days of sampling were conducted during October and November of 2012 at the end of a comparatively dry summer season. Cannon Beach received several inches of rain during the sampling events.

The Oregon Health Authority and the Oregon Department of Environmental Quality run the beach monitoring program with funding from the U.S. Environmental Protection Agency. A primary objective of the program is the protection of public health at Oregon beaches. The OBMP has monitored ocean water, creeks, and drainage water in the vicinity of Cannon Beach since 2003. During that time the program has collected more than 1500 samples and issued 18 advisories for beaches in the area. About 2.5 percent of those marine water sample results and 14 percent of the fresh water sample results exceeded the recreational water quality criteria.

The sampling results show bacteria counts increased from upstream to downstream sampling locations. Higher bacteria counts were observed in storm water outfalls and in urban and residential runoff west of Highway 101 than in forested areas east of Highway 101. The highest bacteria results were from the Gower Street and Chisana Creek outfalls, and at Ecola and Logan Creeks.

This study highlighted some sampling locations that likely contribute to higher than normal bacteria counts at Cannon Beach. Sampling sites at Coolidge Avenue and farther downstream at the Gower Street outfall showed bacteria levels up to 40 times higher than the recreational water contact criteria. Creek samples collected downstream of residential areas were 10 to 30 times the criteria.

During the 2013 summer season the Oregon Beach Monitoring Program collected samples from some of the same sample sites included in this study. Sample sites at Ecola Creek, Logan Creek, Gower Street, and Tolovana State Park had high bacteria counts that lead to water contact advisories at Cannon Beach during the summer 2013 beach monitoring season. City employees and volunteer groups have continued to monitor some of these locations. Continued monitoring and communication with stakeholders and the City of Cannon Beach will provide information to support possible improvements or repairs that may lead to better recreational water quality at Cannon Beach.

Introduction

The OBMP has monitored ocean water, creeks, and drainage water in the vicinity of Cannon Beach since 2003. There have been 18 water contact advisories resulting from more than 1500 samples collected at Cannon, Tolovana, and Indian beaches. Since 2003 about 2.5 percent of results from Cannon Beach marine samples and 14 percent of results from fresh water samples have exceeded the recreational water quality criteria. Typically, when sample results are high from creeks and storm water outfalls upstream of marine sampling sites, the marine site results are also higher than normal.

This study was designed to capture the first rain storms occurring after the dry summer season (DEQ, 2012). The timing of the sampling events was close to ideal. Five days of sampling were conducted during October and November of 2012. There had not been any significant rainfall for weeks before the first day of sampling. The Port of Astoria Regional Airport reported more than two inches of rainfall between the first and second day of sampling, and an inch of rainfall during the second day of sampling. Cannon Beach received about a quarter inch of rain on the third and fourth days of sampling and more than half an inch on the final day of sampling. The bacteria counts in the marine and freshwater samples correlated closely with rainfall amounts.

Background

The Oregon Beach Monitoring Program monitors the Oregon coast for bacteria levels at public beaches. Marine waters are tested for enterococci, a fecal indicator bacterium, and water contact advisories are issued when bacteria counts exceed the recreational water quality criteria for *Enterococcus* sp. which is 158 colony forming units per 100 milliliters of sample. The Oregon Health Authority partners with the Oregon Department of Environmental Quality to run the beach monitoring program. The monitoring is funded by annual grants from the U.S. Environmental Protection Agency (USEPA, 2000). The OBMP selects beaches to monitor based the number of people using the beach and the history of monitoring results from that beach. The OBMP periodically reviews bacteria test results and beach use data to determine where to focus monitoring resources to best protect public health. The program takes in to account land use and other relevant information about beach locations where little or no bacteria sampling data is available in order to include new sampling locations for consideration for the routine sampling schedule. Beaches are selected based on a number of parameters, such as magnitude and type of recreational use, proximity to creeks, pipes and outflows, the number of previous water contact advisories, and other factors.

The OBMP operates according to the Oregon Coastal Beach Monitoring Quality Assurance Project Plan (DEQ, 2006). The plan allows for investigating outflows on to the beach that may contribute to water contact advisories at Cannon Beach. Investigational sample locations were selected along four creeks in Cannon Beach that discharge to beaches with heavy public use and where marine and fresh water sample results occasionally exceed the EPA’s recreational water quality criteria.

Recreational Water Quality Criteria

The OBMP is currently using EPA’s 1986 ambient water quality criteria recommendations for recreational waters (Table 1). EPA issues these recommendations under the authority of the Clean Water Act. The criteria rely on studies that show a link between illness and fecal contamination in recreational waters. The fecal indicator bacteria *E. coli* and *Enterococcus* sp. are used to measure fecal contamination and set the criteria (USEPA, Ambient Water Quality Criteria for Bacteria - 1986, 1986). The EPA began recommending revised recreational water quality in 2012 (USEPA, 2012).

Table 1. EPA Recreational Water Quality Criteria

Water Quality Criteria for Bacteria for Marine Recreational Waters				
	Risk Level (% of swimmers)	Geometric Mean* Density (per 100 ml)	Single Sample Maximum	Upper Percentile Value Allowable Density (per 100 ml)
Enterococci sp. *Criteria*	1.9	35	158	82nd
Water Quality Criteria for Bacteria for Fresh Recreational Waters				
E. coli Criteria	0.8	126	406	90th
**The geometric mean uses the product rather than the sum of bacteria results in order to better represent bacteria counts on a logarithmic scale.*				

Beach Use

Beach use by the public is a significant consideration when beaches are chosen for monitoring (ODHS, 2010). Cannon Beach has historically ranked as a high priority public health beach. The OBMP regular summer sampling season is from Memorial Day to Labor Day. There can be hundreds of visitors on the beach and in the water on any summer day at Cannon Beach. Cannon Beach, Tolovana State Park Beach, and nearby Seaside Beach have more people on the beaches and in the water during sampling events than any other beaches monitored by the OBMP. Beach use is noted during sampling and the OBMP uses a ratio of swimmers per sampling event to rank use at beaches. When bacteria monitoring results are adjusted to reflect beach use Cannon Beach ranks higher than other monitored beaches for risk of exposure to swimmers (Table 2).

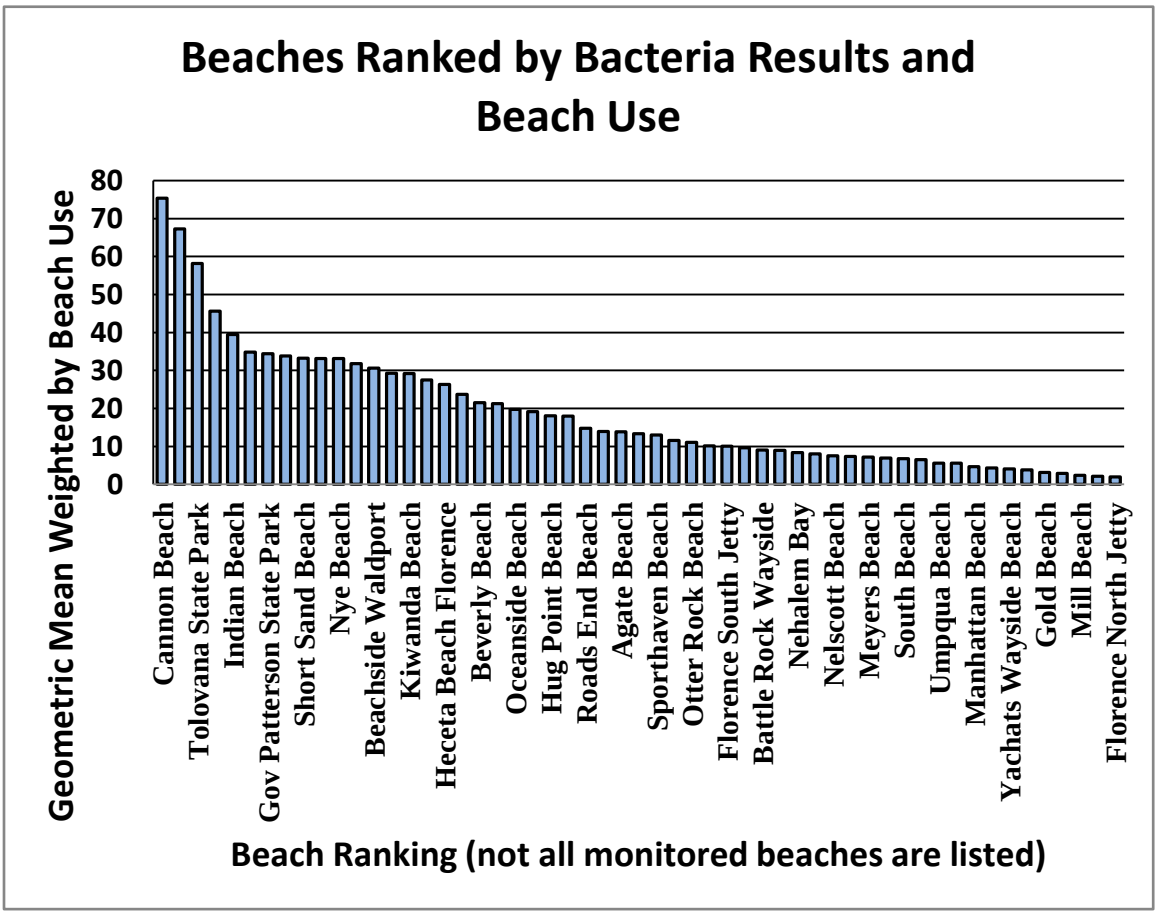


Figure 1. Ranked OBMP beaches.

Table 2. Beach Use.

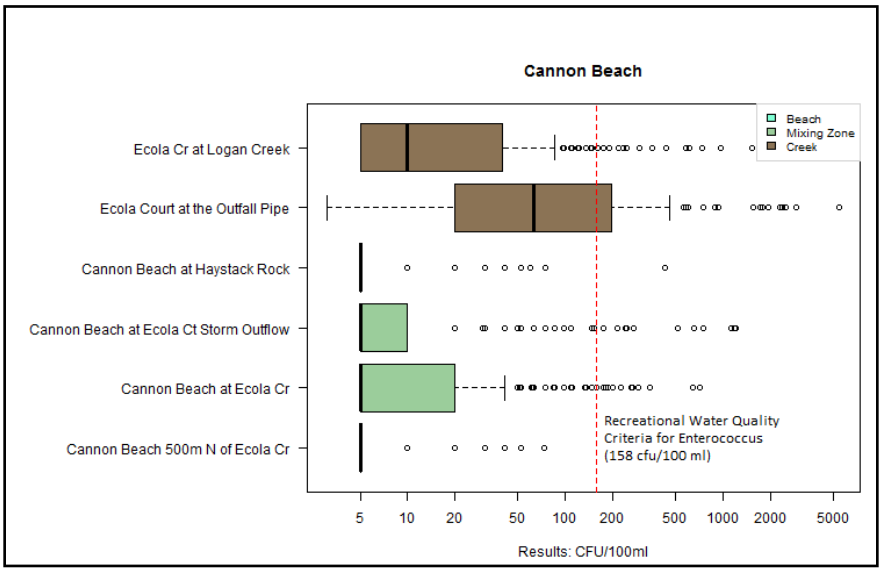
Beach	Swimmers Per Sample
Seaside Beach	6.8
Cannon Beach	6.3
Indian Beach	6.2

Methods

Site Selection

Sample locations were selected to capture potential bacterial pollution sources identified through historic data collected as part of the OBMP. Creek outflows on to the beach, wastewater discharges, storm water outfalls, wildlife, domestic animals, agriculture, and beach visitors are potential pollution sources that were considered when selecting locations (ODHS, 2010). The OBMP monitors selected fresh water locations such as creeks and storm water outfalls associated with marine sample locations. The data showed these conveyances were sources of contamination at marine sample locations (Figure 2).

The sites in this rain-event study were selected to assess whether they were likely sources of pollution. OBMP creek and storm outfalls located on the beach were sampled, and new sites were chosen in upstream developed and forested areas (Figure 3).



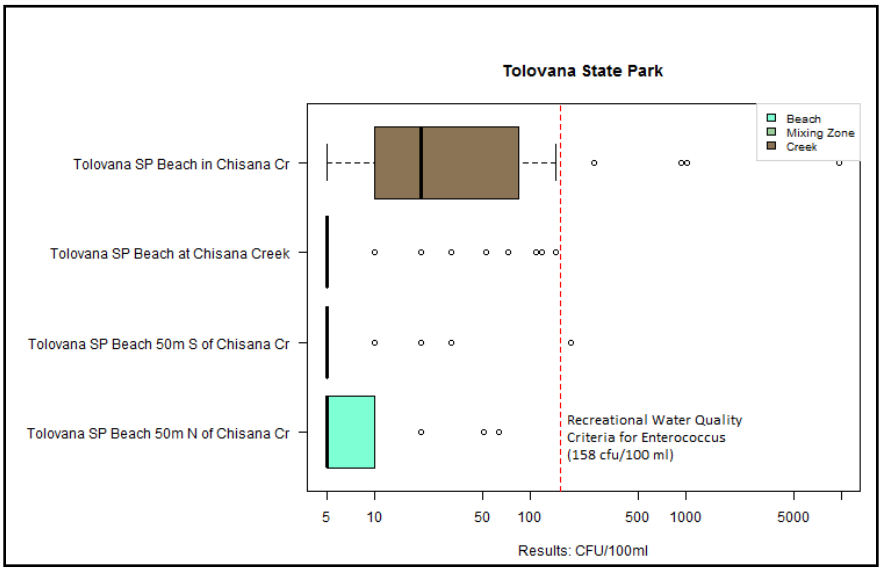
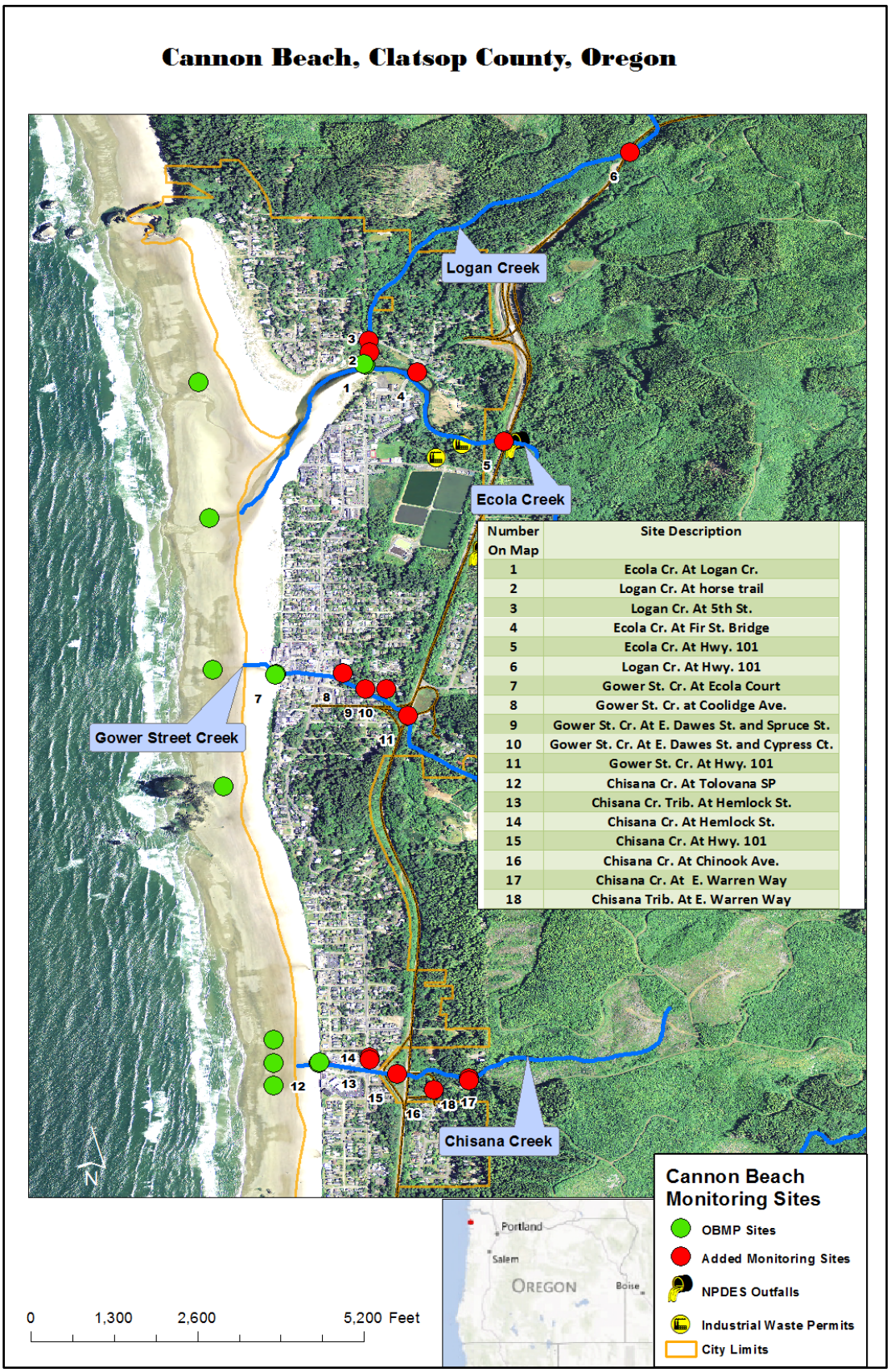


Figure 2. Summary plots of OBMP Cannon Beach fresh and marine water routine monitoring sampling locations.



Number On Map	Site Description
1	Ecola Cr. At Logan Cr.
2	Logan Cr. At horse trail
3	Logan Cr. At 5th St.
4	Ecola Cr. At Fir St. Bridge
5	Ecola Cr. At Hwy. 101
6	Logan Cr. At Hwy. 101
7	Gower St. Cr. At Ecola Court
8	Gower St. Cr. at Coolidge Ave.
9	Gower St. Cr. At E. Dawes St. and Spruce St.
10	Gower St. Cr. At E. Dawes St. and Cypress Ct.
11	Gower St. Cr. At Hwy. 101
12	Chisana Cr. At Tolovana SP
13	Chisana Cr. Trib. At Hemlock St.
14	Chisana Cr. At Hemlock St.
15	Chisana Cr. At Hwy. 101
16	Chisana Cr. At Chinook Ave.
17	Chisana Cr. At E. Warren Way
18	Chisana Trib. At E. Warren Way

Figure 3. Cannon Beach sampling locations.

Study Design

This project investigated *Enterococcus* sp. and *Escherichia coli (E.coli)* concentrations near drainages that may be sources of marine water contamination at high recreational use beaches in Cannon Beach. This survey was conducted during the first big rain event after the dry summer season in October and November of 2012 (NOAA, 2012).

Field Methods

Bacteria

This project used EPA approved methods for quantifying the fecal indicator bacteria *Enterococcus* sp. and *E. coli* (USEPA, Questions and Answers). Enterolert and Colilert methods use nutrient-indicators that fluoresce when metabolized by fecal indicator bacteria (IDEXX, Enterolert, 2013), (IDEXX, Colilert, 2013). Results from these methods are quantified using a probability table and are reported as a most probable number. Water quality criteria for fecal indicator bacteria are often described as colony forming units per 100 ml.

Public health agencies measure *E. coli* and enterococci bacteria to indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoa that live in the digestive systems of humans and other warm blooded animals. *E. coli* is a species of fecal coliform bacteria specific to humans and other warm blooded animals and is recommended for testing in fresh water systems. Enterococci are a subgroup within the fecal streptococcus group and are typically more human-specific than other species in the group. EPA recommends enterococci as the best indicator of health risk in recreational marine water (USEPA, Water: Monitoring & Assessment).

Water Quality Measurements

Water quality measurements were made in the field at the sample sites using standard portable multiparameter meters (Orion A329). On site measurements were taken for temperature, salinity, conductivity, pH, dissolved oxygen, and turbidity. The meter calibrations were checked daily against standards in the lab and in the field (DEQ, Water Monitoring and Assessment Mode of Operations Manual, 2010).

Results

This investigative sampling project was designed to identify potential sources of bacterial contamination at popular beaches in Cannon Beach. Fecal indicator bacteria counts can be higher during and after rainfall. The timing of the sampling for this project focused on collecting samples before and during the first rainstorm in the area after the summer season. There had not been any significant rainfall in Cannon Beach leading up to this first day of sampling on October 11th (NOAA, 2012). The lowest enterococcus bacteria concentrations occurred on the first and driest day with a couple of exceptions. The rainfall started between the first and second day of sampling on October 15th when there was more than an inch of rainfall. That was the rainiest day of the project and the highest sample results were from samples collected that day. Results from the third and fourth sampling days decreased overall with about a quarter inch of rain each of those days. There was more than a half inch of rain on the final day of sampling on November 20th and bacteria concentrations tested higher.

Samples were not collected from all of the locations on all of the sampling days. The first day of sampling, the driest day, involved reconnaissance and additional sites were added for the second day. Ecola Creek at Highway 101, Gower Street Creek at Spruce Drive and Cypress Court, the two Chisana Creek sites next to South Hemlock Street, and the upstream Chisana Creek sites next to East Warren Way were not tested on the first day of sampling. The Chisana Creek sample location at the Ecola Forest gate at East Warren Way was not sampled until the third sampling day on November 1st.

Most of the sample results from the first day of sampling collected during dry weather were low and generally below the recreational use criteria. A couple of sample results from Gower Street Creek collected on the dry day of sampling were higher than the others. The test result from the Gower Street Creek outfall on the beach at Ecola Court was 134 mpn (most probable number used by the Enterolert method). The sample result from the Coolidge Avenue site at the trash rack taken on the dry day was over 1000 mpn. Because there had not been any recent rainfall it is unlikely these results are related to storm water runoff.

There were only two test results from the second day of sampling collected during heavy rain that did not exceed the RWQC. Those two samples were collected from the most upstream sites on Logan and Gower Street Creeks surrounded by forestland. Results from samples collected downstream closer to the beach ranged from 379 mpn to 6488 mpn.

There were no results that exceeded the criteria from the third and fourth sampling days. There was less rain during sampling on those days. The highest results from November 1st were 74 mpn from the Gower Street beach outfall and 63 mpn from the South Hemlock Street roadside ditch tributary to Chisana Creek. The results from November 7th were closer to the test detection limit and the highest result was 20 mpn.

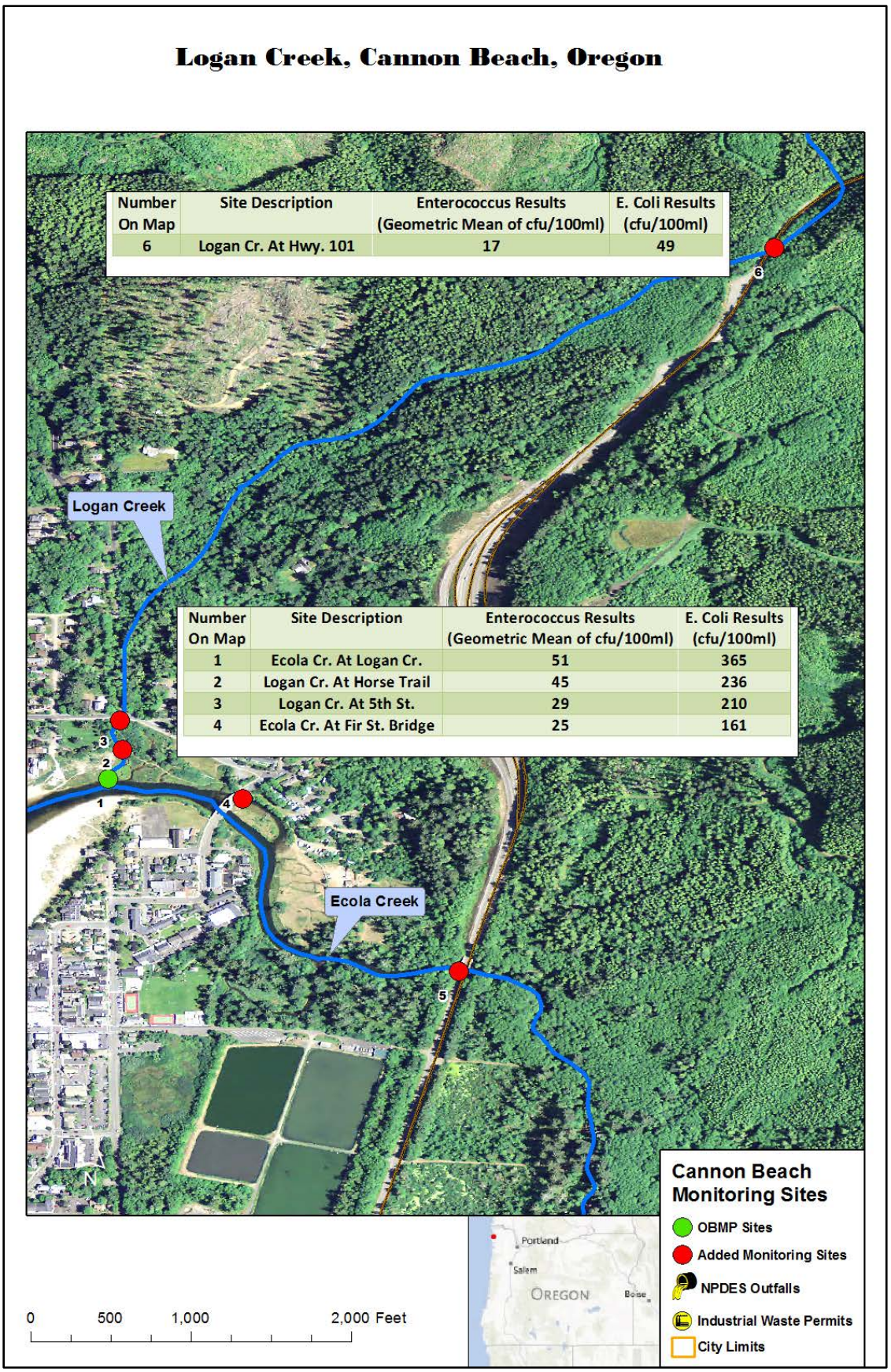
There was a larger rainstorm during the final day of sampling on November 20th and the test results were higher but were generally below the standard. The only sample result that exceeded the recreational water quality criteria was from the Gower Street Creek beach outfall which was 173 mpn. The next highest results were from the Tolovana Beach State Park outfall at 121 mpn and the South Hemlock roadside ditch tributary to Chisana Creek at 73 mpn.

Figure 4. The long term averages of the sampling results exceeded the RWQC at downstream sites in residential areas.

Logan Creek

Logan Creek flows SW between mile posts 27 and 28 on Highway 101 to the confluence with Ecola Creek at Les Shirley Park in Cannon Beach. The watershed is forestland at the Logan Creek headwaters and low density residential near the park. There is public access to the beach from Les Shirley Park. Logan Creek discharges east of the park to the north bank of Ecola Creek about 0.4 miles from the Pacific Ocean (Figure 5). Logan Creek is tidally influenced at least as far upstream as the 5th Street sampling location during storms.

Figure 5. Logan Creek at Les Shirley Park flowing to Ecola Creek.



Number On Map	Site Description	Enterococcus Results (Geometric Mean of cfu/100ml)	E. Coli Results (cfu/100ml)
6	Logan Cr. At Hwy. 101	17	49

Number On Map	Site Description	Enterococcus Results (Geometric Mean of cfu/100ml)	E. Coli Results (cfu/100ml)
1	Ecola Cr. At Logan Cr.	51	365
2	Logan Cr. At Horse Trail	45	236
3	Logan Cr. At 5th St.	29	210
4	Ecola Cr. At Fir St. Bridge	25	161

Figure 6. Logan Creek sampling locations.

Logan Creek at Ecola Creek

Logan Creek water samples were collected at the confluence with Ecola Creek about 0.4 miles upstream from the Pacific Ocean. This location is sampled weekly during the summer OBMP sampling season. The OBMP has collected more than 275 samples from this location since 2004. Eighteen (6.5%) of those results exceeded the RWQC. The salinity at this site can be fresh or marine. Tides and storms push marine water up Ecola Creek and can affect the salinity/conductivity measurements there. For this project the OBMP collected six water samples at this location. Five of the samples were tested for *Enterococcus* sp. and one sample was tested for *E. coli*. One *enterococcus* sp. result exceeded the recreational water quality criteria. None of the *E. coli* results exceeded the single sample maximum criteria for *E. coli* (406 cfu/100 ml).

Figure 7. Logan Creek at the confluence with Ecola Creek.

Table 3. Logan Creek at the Ecola Creek confluence results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Logan Creek at Ecola Creek	10/11/2012	30	No Sample Collected
	10/15/2012	677	
	11/1/2012	20	
	11/7/2012	20	
	11/20/2012	41	365

Logan Creek at the Horse Trail

Logan Creek was sampled where a trail crosses the creek on the east side of Les Shirley Park. The trail is used by horseback riding tours as access to the beach. The horseback riding tours are provided east of the Fir Street Bridge. The site is 0.4 miles upstream from the confluence with Ecola Creek. Five of the samples were tested for *Enterococcus* sp. and one sample was tested for *E. coli*. One *Enterococcus* sp. result exceeded the recreational water quality criteria. None of the *E. coli* results exceeded the criteria for *E. coli*.

Figure 8. Logan Creek at the horse trail.

Table 4. Logan Creek at the horse trail results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Logan Creek at the horse trail	10/11/2012	10	No Sample Collected
	10/15/2012	855	
	11/1/2012	41	
	11/7/2012	10	
	11/20/2012	52	236

Logan Creek at 5th Street

Logan Creek was also sampled on the downstream side of the culverts at 5th Street. The sample location is about 0.8 miles upstream from the confluence with Ecola Creek. There are residences upstream on the north side of this site. Ecola Park Road travels north of the site to Indian Beach in north Ecola State Park. One *Enterococcus* sp. result exceeded the recreational water quality criteria. None of the *E. coli* results at this site exceeded the criteria.

Figure 9. Logan Creek at 5th Street.

Table 5. Logan Creek at 5th Street Culvert results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Logan Creek at 5th Street	10/11/2012	20	No Sample Collected
	10/15/2012	379	
	11/1/2012	10	
	11/7/2012	non-detect	
	11/20/2012	51	210

Logan Creek at Highway 101

The farthest upstream Logan Creek site was sampled on the east side of Highway 101. This location is about 0.9 miles east of the confluence with Ecola Creek. Logan Creek runs from its headwaters nearby through forestland to a culvert at Highway 101 and then on to Ecola Creek. There are no residences along this reach of Logan Creek. None of the sample results from this location exceeded the recreational water quality criteria.

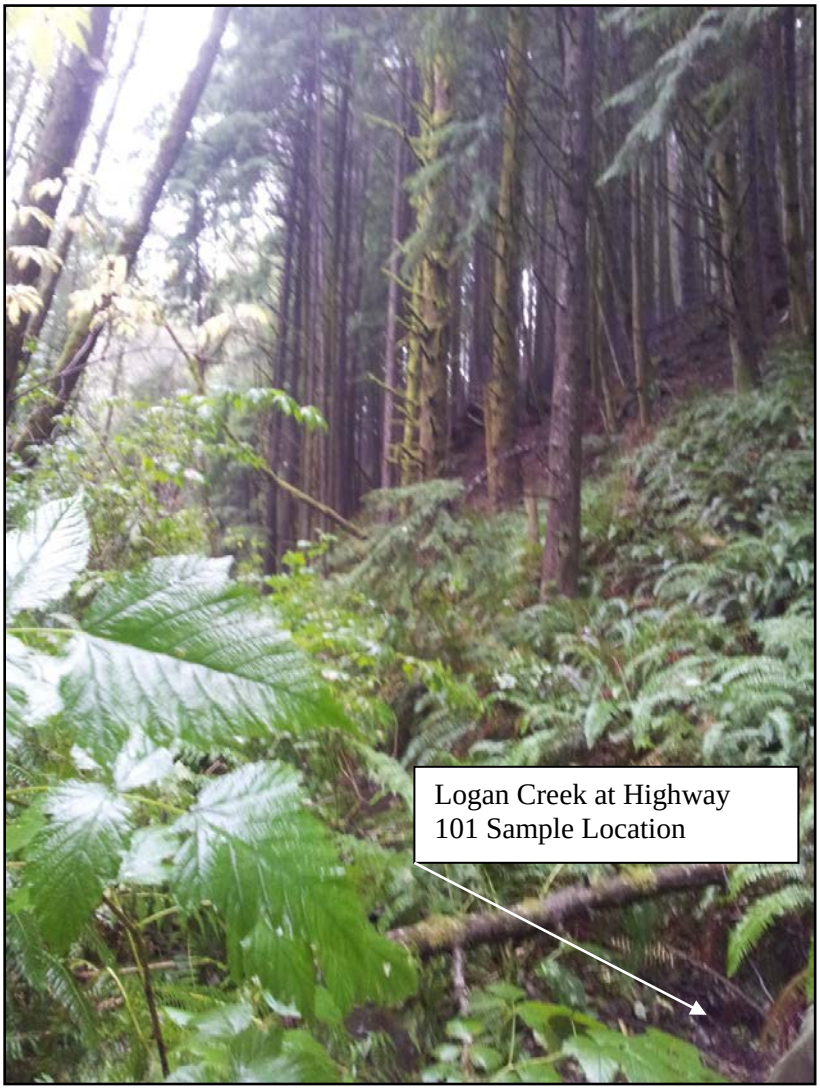


Figure 10. Logan Creek at Highway 101

Table 6. Logan Creek at Highway 101 results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Logan Creek at Highway 101	10/11/2012	non-detect	No Sample Collected
	10/15/2012	135	
	11/1/2012	10	
	11/7/2012	10	
	11/20/2012	20	15

The Logan Creek results were generally higher from downstream sampling sites closer to the confluence with Ecola Creek. Results from upstream Logan Creek sampling sites were lower and results from the most upstream sampling location did not exceed the water quality criteria even on the rainiest sampling day. Average results exceeded the geometric mean criteria from the most downstream sites but not from the upstream locations (Figure 11). The geometric means of all the Logan Creek sample results collected on the two heaviest rainfall days exceeded the water quality criteria. The averages are more closely related to daily rainfall than accumulated rainfall (Figure 12).

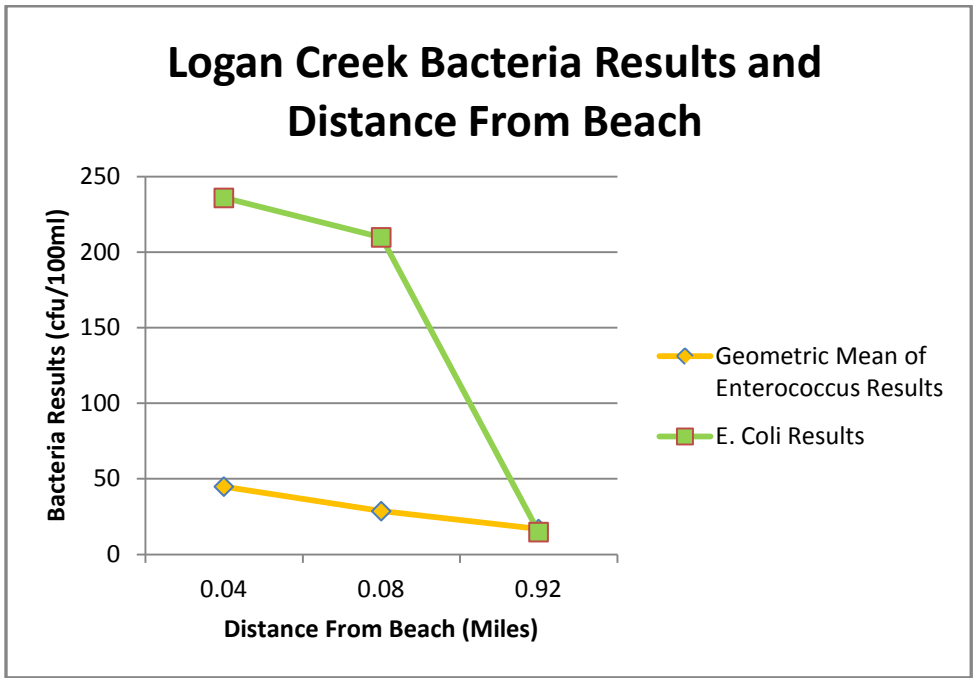


Figure 11. Logan Creek results and distance from the beach.

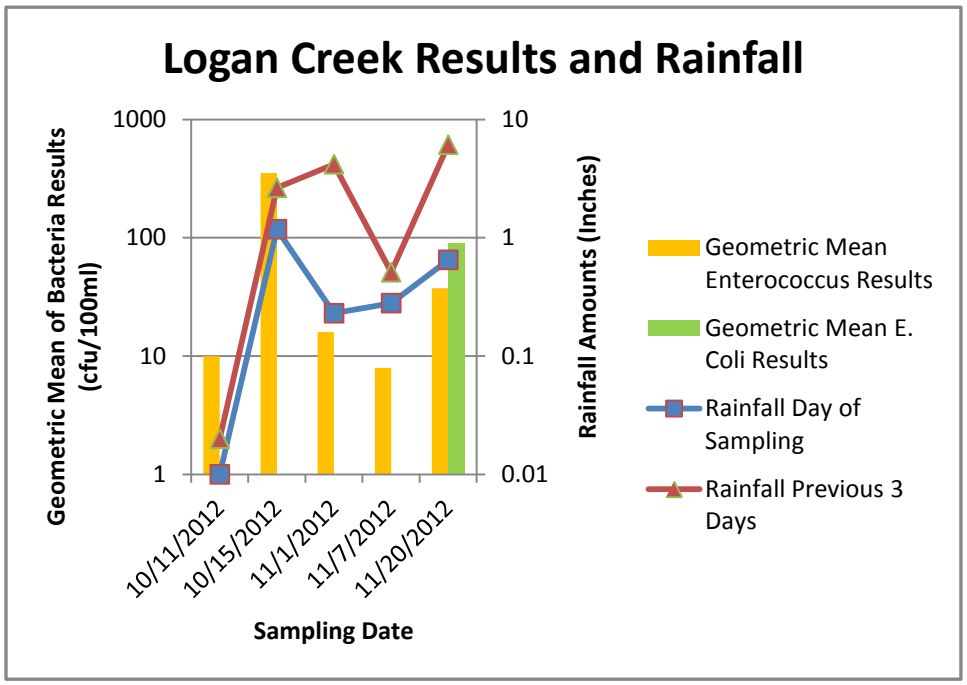


Figure 12. Logan Creek results and rainfall amounts.

The Logan Creek summary plots display a pattern of results than increase from the most upstream sites to the downstream sites. The highest results come from samples taken on the rainiest days (Figure 13).

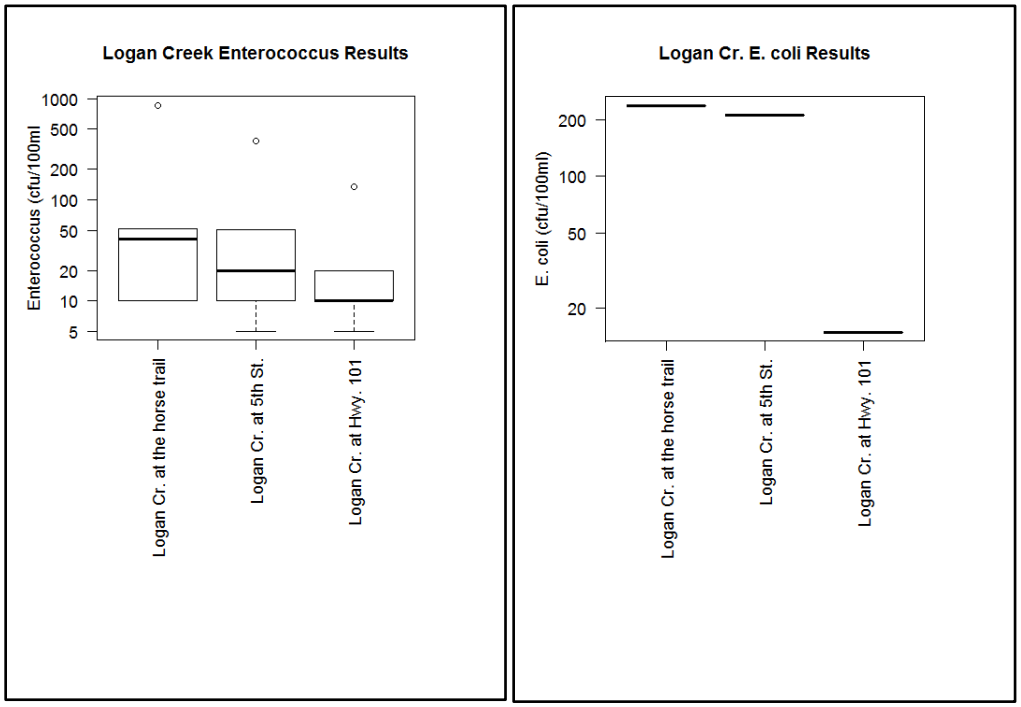
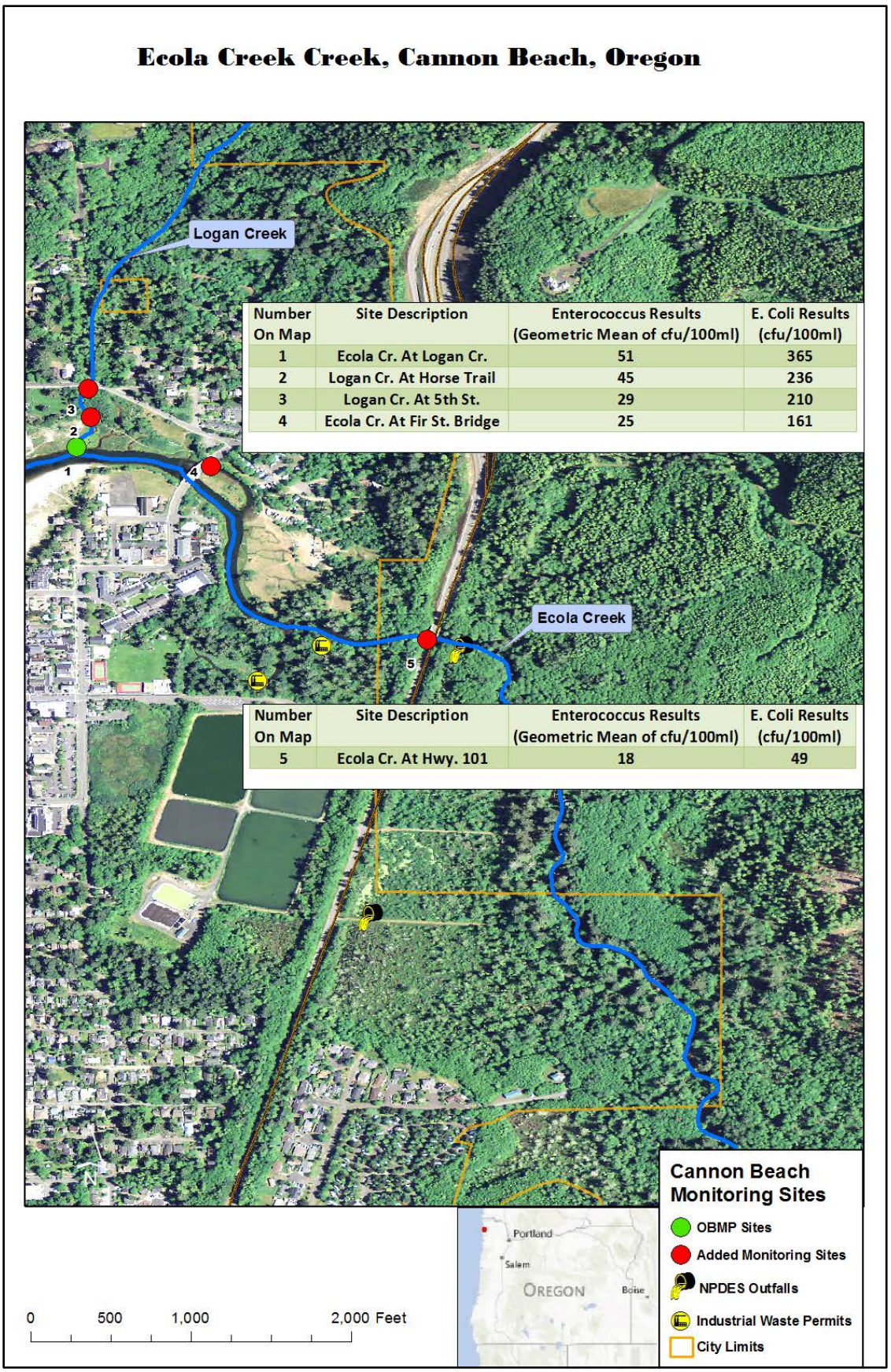


Figure 13. Logan Creek *Enterococcus* sp. and *E. coli* summary results.

Ecola Creek

Ecola Creek is part of a 22 square mile watershed that includes the Ecola Creek Forest Reserve, private timberlands, and the primary water supply for Cannon Beach. The North Fork and West Fork of Ecola Creek converge and flow to the Pacific Ocean at Ecola State Park. The Ecola Creek watershed contains old growth forest and quality salmonid habitat (McComb, 2012).

Figure 14. Ecola Creek at Cannon Beach.



Number On Map	Site Description	Enterococcus Results (Geometric Mean of cfu/100ml)	E. Coli Results (cfu/100ml)
1	Ecola Cr. At Logan Cr.	51	365
2	Logan Cr. At Horse Trail	45	236
3	Logan Cr. At 5th St.	29	210
4	Ecola Cr. At Fir St. Bridge	25	161

Number On Map	Site Description	Enterococcus Results (Geometric Mean of cfu/100ml)	E. Coli Results (cfu/100ml)
5	Ecola Cr. At Hwy. 101	18	49

Figure 15. Ecola Creek sampling locations.

Ecola Creek at the Fir Street Bridge

Ecola Creek water samples were collected at the confluence with Logan Creek about 0.4 miles upstream from the Pacific Ocean. This site description and results are discussed in the Logan Creek section of this document.

The bridge at Fir Street is upstream from the confluence with Logan Creek. This sample location is a popular access to Les Shirley Park and is adjacent to a section of the horseback riding trail that runs from the Sea Ranch RV Park to Ecola State Park. Cannon Beach Elementary School is SW of the site on the south side of Ecola Creek. The surrounding area is estuarine wetland, residential, urban, and parks. Five samples collected from this location were tested for *Enterococcus* sp. and one for *E. coli*. One of the *Enterococcus* sp. results exceeded the recreational water quality criteria. None of the *E. coli* results exceeded the criteria.

Figure 16. Ecola Creek at the Fir Street Bridge.

Table 7. Ecola Creek at the Fir Street Bridge results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Ecola Creek at the Fir Street Bridge	10/11/2012	20	No Sample Collected
	10/15/2012	663	
	11/1/2012	non-detect	
	11/7/2012	non-detect	
	11/20/2012	31	161

Ecola Creek at Highway 101

The most upstream Ecola Creek samples were collected at the Highway 101 bridge. There are forestlands, the Cannon Beach Municipal Watershed, and water treatment facilities upstream. There are also water treatment effluent sample locations upstream of this site. There are wetlands and residential areas downstream. Four samples were tested for *Enterococcus* sp. and one for *E. coli*. One of the *Enterococcus* sp. results exceeded the recreational water quality criteria. The *E. coli* sample result did not exceeded the criteria.

Figure 17. Ecola Creek at the Highway 101 bridge.

Table 8. Ecola Creek at the Highway 101 bridge results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Ecola Creek at Highway 101	10/15/2012	397	No Sample Collected
	11/1/2012	non-detect	
	11/7/2012	10	
	11/20/2012	non-detect	49

The Ecola Creek results were generally higher from sites downstream and closer to the confluence with Logan Creek (Figure 18). There were higher results from samples collected during heavy rainfall. Accumulated rainfall amounts from the previous three days before sampling was more loosely correlated (Figure 19).

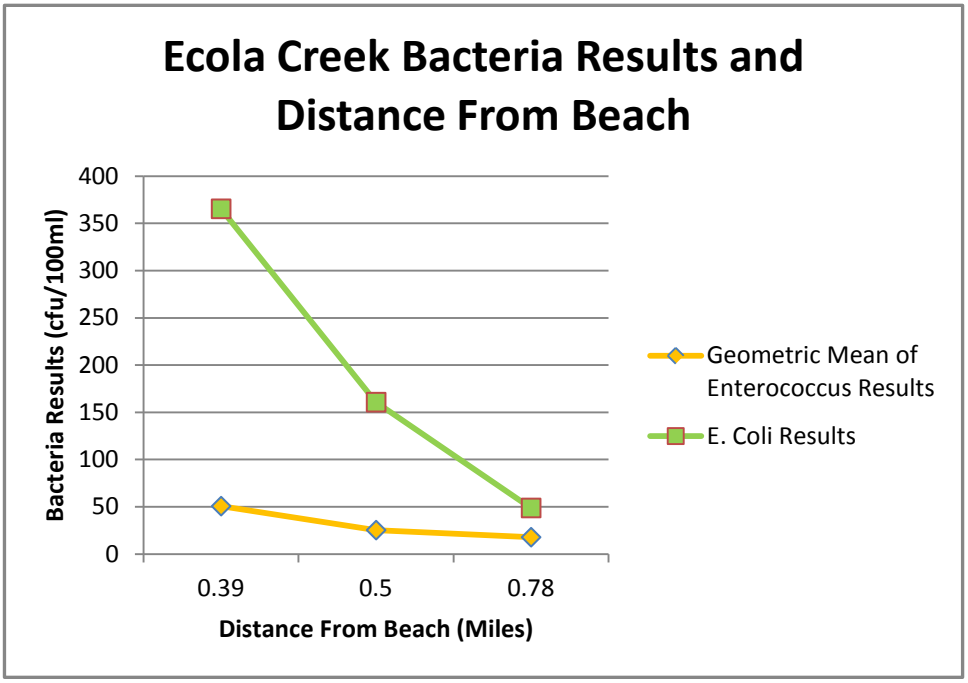


Figure 18. Ecola Creek results and distance from the beach.

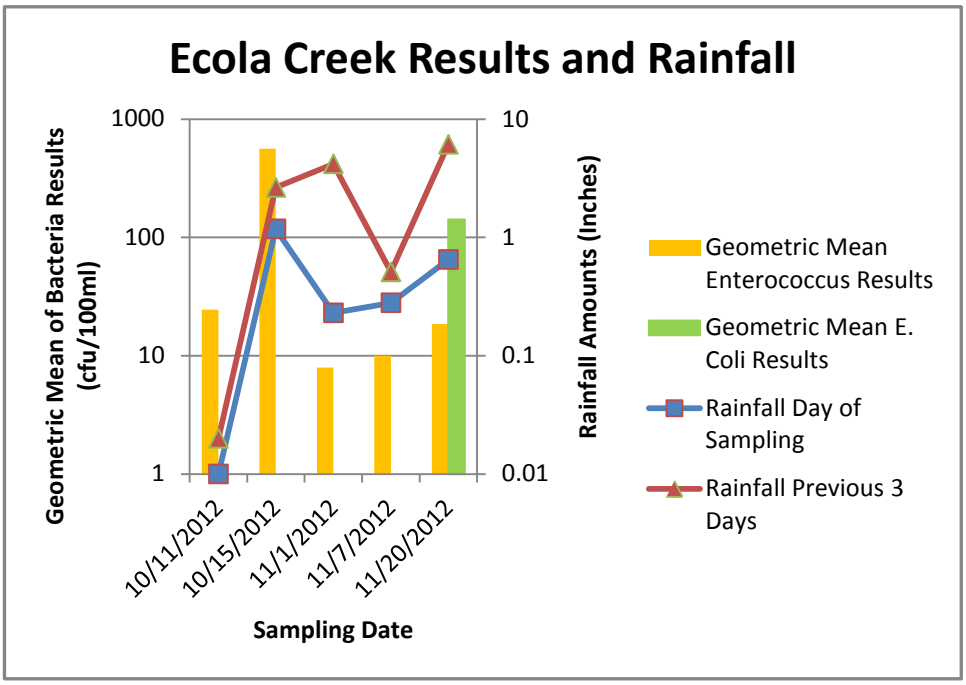


Figure 19. Ecola Creek results and rainfall amounts.

The Ecola Creek summary plots display a pattern of results than increase from the most upstream sites to the downstream sites. The highest results come from samples taken on the rainiest days (Figure 20).

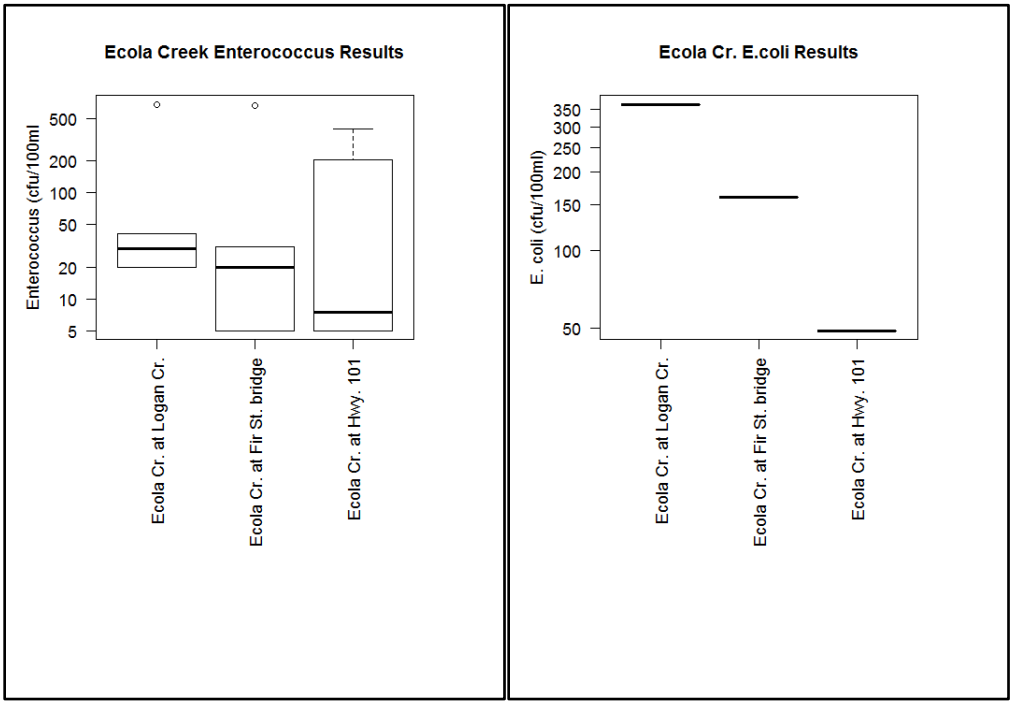
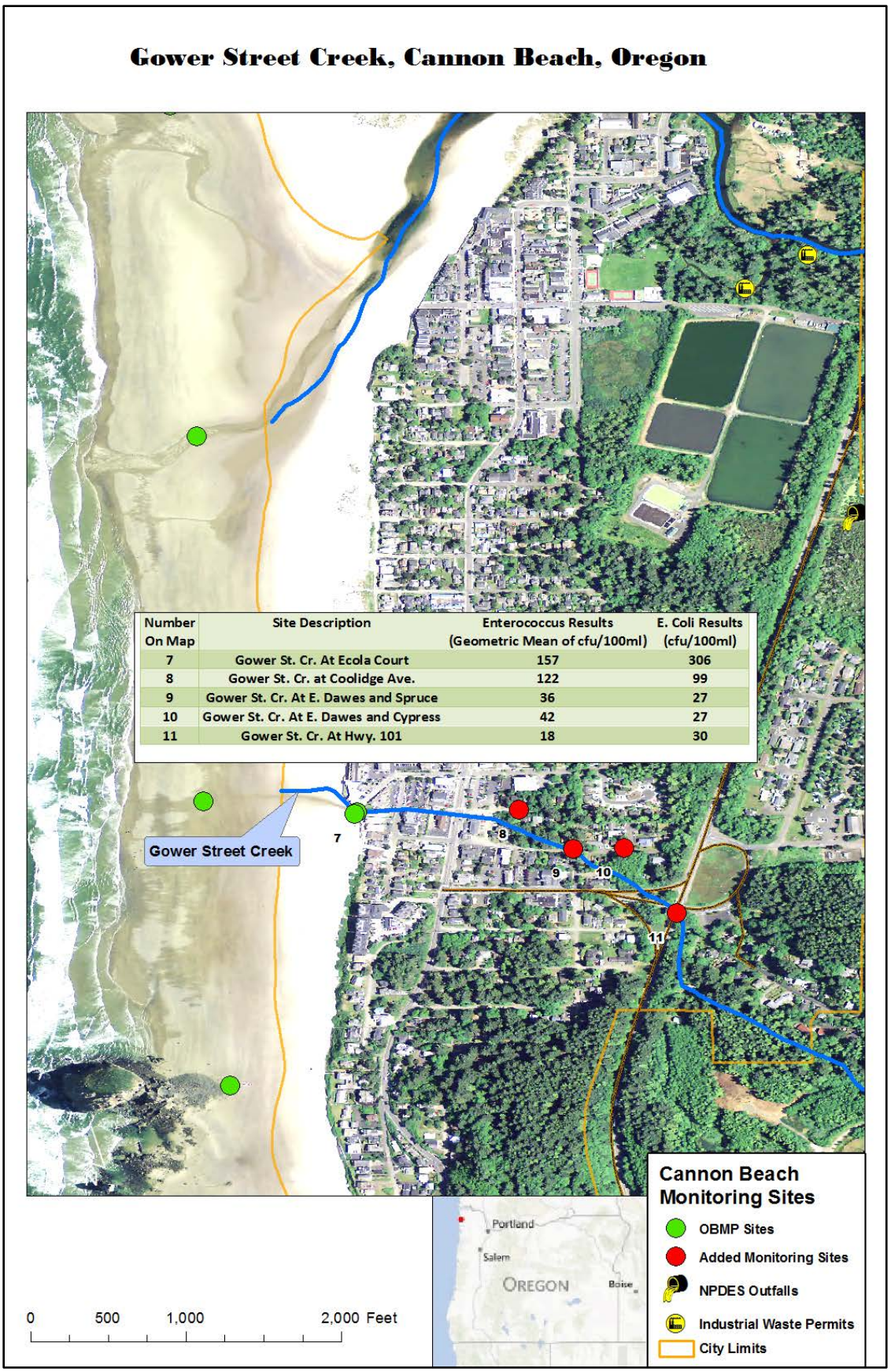


Figure 20. Ecola Creek *Enterococcus* sp. and *E. coli* summary results

Gower Street Creek

Ecola Court is at the west end of Gower Street in Cannon Beach. An outfall discharges out on to Cannon Beach at Ecola Court just north of Haystack Rock. The unnamed runoff has been tested by the OBMP, the City of Cannon Beach, and volunteer groups. The Gower Street Creek passes through urban and residential neighborhoods and some forestland at the headwaters. The creek is considered intermittent and there is a wetland area near the middle of our reach. Ecola Court is a popular destination for beach visitors and provides easy access to Haystack Rock. There are sea birds and marine wildlife on and around the sea stack and tide pools between the sea stack and the beach. On summer days crowds can cover the beach from Ecola Creek at Les Shirley Park south to Tolovana Beach State Park.

Figure 21. The Ecola Court sign board.



Number On Map	Site Description	Enterococcus Results (Geometric Mean of cfu/100ml)	E. Coli Results (cfu/100ml)
7	Gower St. Cr. At Ecola Court	157	306
8	Gower St. Cr. at Coolidge Ave.	122	99
9	Gower St. Cr. At E. Dawes and Spruce	36	27
10	Gower St. Cr. At E. Dawes and Cypress	42	27
11	Gower St. Cr. At Hwy. 101	18	30

Figure 22. Gower Street Creek sample locations.

Gower Street Creek Beach Outfall

Gower Street Creek samples were collected at the west end of Gower Street at the Ecola Court outfall. The OBMP has been sampling this location since 2007 and the downstream marine sample location since 2002. The OBMP collected 132 samples from the tide gate outfall from October 2007 to August 2012. Forty of those samples (30%) exceeded the recreational water quality criteria. Of the 317 samples from the ocean site, 12 (3.7%) exceeded the water quality criteria for enterococci. The outflow streams from the gate across the beach to the ocean. The surface creek may not flow all the way to the ocean during dryer summer months. Beach visitors, pets, and birds wade in the creek.

Surf rider's volunteer monitoring group, the Blue Water Task Force, has monitored this outfall and has communicated with the city of Cannon Beach about their sample results. The task force has been involved with possible solutions to reducing bacterial contamination such as mycofiltration, using mycelium fungus filters to remove bacterial contamination from the runoff (Dias, 2011). The City of Cannon Beach has also sampled this location and has noted high bacteria counts. The city continues to monitor the Ecola Court outfall and recent results can be viewed on the web at City of Cannon Beach Ecola Outfall.

Twelve samples were collected at this location for this project. Five samples and five duplicate samples were tested for *Enterococcus* sp. and one sample and one duplicate was tested for *E. coli*. Four of the *Enterococcus* sp. results (40%) exceeded the recreational water quality criteria. One sample result from this location taken on the driest sampling day for this project (October 11th, 2012) exceeded the recreational water quality criteria. Sample results from this location were also high on the two sampling days with the most rainfall (October 15th and November 20th). The *E. coli* sample results taken November 20th were close to but did not exceed recreational water quality criteria.

Figure 23. Gower Street Creek at the Ecola Court outfall.

Table 9. Gower Street Creek beach outfall results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Gower Street Creek Beach Outfall	10/11/2012	134	No Sample Collected
	10/15/2012	6488	
	11/1/2012	74	
	11/7/2012	10	
	11/20/2012	173	387

Gower Street Creek at Coolidge Avenue

Gower Street Creek samples were also collected upstream at Coolidge Ave. about 0.13 miles east of the beach outfall. The creek drains into culverts through a trash rack at this location. There are residences and a small wetland upstream. Samples were collected a couple of meters upstream from the trash rack. Six samples were taken from this location. Five of those were tested for *Enterococcus* sp. and one for *E. coli*. Two of the *Enterococcus* sp. results from this site exceeded the recreational water quality criteria. Like the downstream sample site on this creek at the beach outfall, the results were high on the driest day of sampling (October 11th). The enterococci sample results were also high on the wettest day of sampling (October 15th). The *E. coli* results from this site were not over the recreational water quality criteria for *E. coli*. There was a noticeable odor similar to sewage at this site on the first day of sampling for this project. This site is at the west downstream edge of the neighborhood between Highway 101 and the beach.

This location has also been monitored by the City of Cannon Beach. The city has reported occasional high results from samples collected at the trash rack. A few of the results reported by the city were significantly higher than the marine recreational water quality criteria.

Figure 24. Coolidge Avenue Gower Street Creek site at the trash rack.

Table 10. Gower Street Creek at Coolidge Avenue results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Gower Street Creek at Coolidge Ave. Trash Rack	10/11/2012	1046	No Sample Collected
	10/15/2012	3255	
	11/1/2012	31	
	11/7/2012	non-detect	
	11/20/2012	52	99

Gower Street Creek at Spruce Street

Samples were taken from the Gower Street creek at the NW corner of East Dawes Avenue and South Spruce Street; about 0.2 miles from the ocean. The site is in the neighborhood just upstream from the Coolidge Avenue site. Here the Gower Street Creek passes through culverts and roadside drainage ditches cutting through the residences. Storm runoff spills in from the west from a roadside drainage and from the south from a drainage pipe. Most of the water spilling into the site surfaces from a midsize concrete culvert pipe where Gower Street Creek runs from the east under Spruce Street. Four samples collected from this site were tested for *Enterococcus* sp. and one was tested for *E. coli*. One *Enterococcus* sp. result exceeded the recreational water quality criteria. This high result was from a sample taken on one of the two sampling days with heavy rainfall. This location was not sampled on the driest day of sampling.

Figure 25. Gower Street Creek at Spruce Street.

Table 11. Gower Street Creek at Spruce Street results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Gower Street Creek at Spruce Street	10/15/2012	2187	No Sample Collected
	11/1/2012	31	
	11/7/2012	non-detect	
	11/20/2012	non-detect	27

Gower Street Creek at Cypress Court

Samples were collected one block SE of the trash rack at the NW corner of East Dawes Avenue and Cypress Court. This site is one block east of the Spruce Street site. The creek runs from a small wetland to the south through a culvert and spills in to a roadside ditch at Cypress Court. The creek then runs east two blocks to the Spruce Street sample site. There are residences in all other directions from the site. Four samples were taken from the site and tested for *Enterococcus* sp. and one sample was tested for *E. coli*. One sample tested for *Enterococcus* sp. exceeded the recreational water quality criteria. That sample was also collected during one of the heavy rainfall sampling days. The other results from this location were relatively low.

Figure 26. Gower Street Creek at Cypress Court.

Table 12. Gower Street Creek at Cypress Court results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Gower Street Creek at Cypress Court	10/15/2012	1918	No Sample Collected
	11/1/2012	31	
	11/7/2012	non-detect	
	11/20/2012	10	27

Gower Street Creek at Highway 101

Gower Street Creek samples were collected south of Sunset Boulevard on the east side of Highway 101. This is the most upstream sample site on this creek and is about 0.35 miles from the beach. There is another small wetland just east of Poplar Lane upstream of this location. The headwaters of the creek are about a half mile SE of this site in urban and residential areas along Sunset Boulevard. Five samples were collected at this site and tested for *Enterococcus* sp. and one sample was tested for *E. coli*. Only one result exceeded the recreational water quality criteria. That sample was collected during the same October 15th rain storm during which other samples had high results. The rest of the results were low or non-detect.

The City of Cannon Beach has also monitored sample locations in this drainage at Sunset Boulevard and noted occasional high results. As with this project, the City of Cannon Beach results are high less often at this location than at the downstream locations on this creek.

Figure 27. Gower Street Creek at Highway 101 and Sunset Boulevard.

Table 13. Gower Street Creek at Highway 101 results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Gower Street Creek at Highway 101	10/11/2012	non-detect	No Sample Collected
	10/15/2012	1376	
	11/1/2012	non-detect	
	11/7/2012	non-detect	
	11/20/2012	10	30

The Logan Creek results from downstream sample locations near the beach outfall and the Coolidge Avenue trash rack were higher (Figure 28). Results generally correlated with rainfall amounts. But the high results from the Gower Street beach outfall and the Coolidge Avenue trash rack on October 11th, the dry sampling day, were an exception (Figure 29).

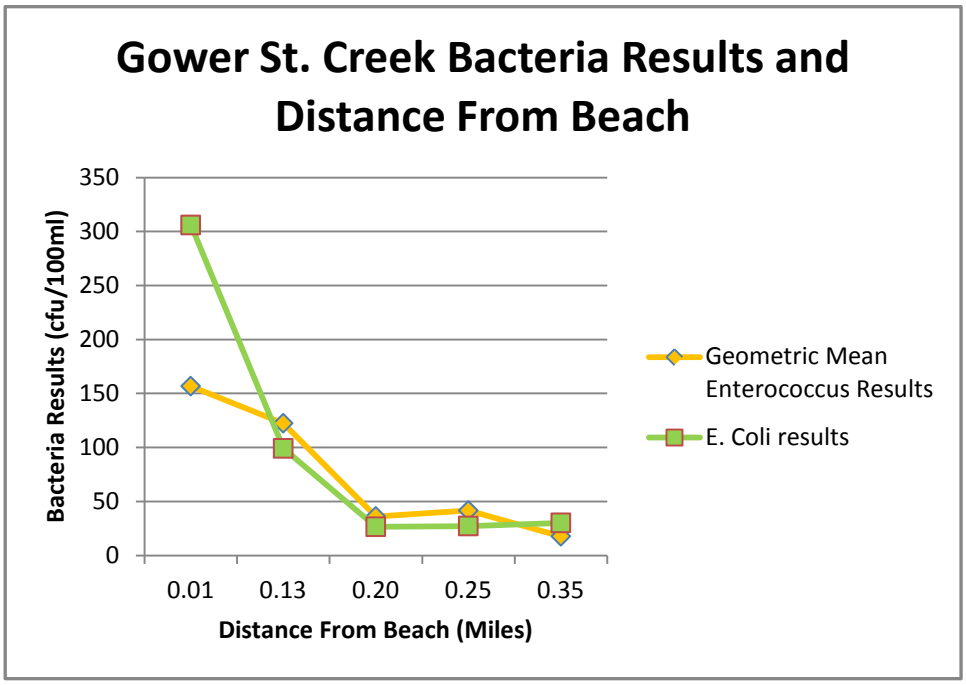


Figure 28. Gower Street Creek and distance from the beach.

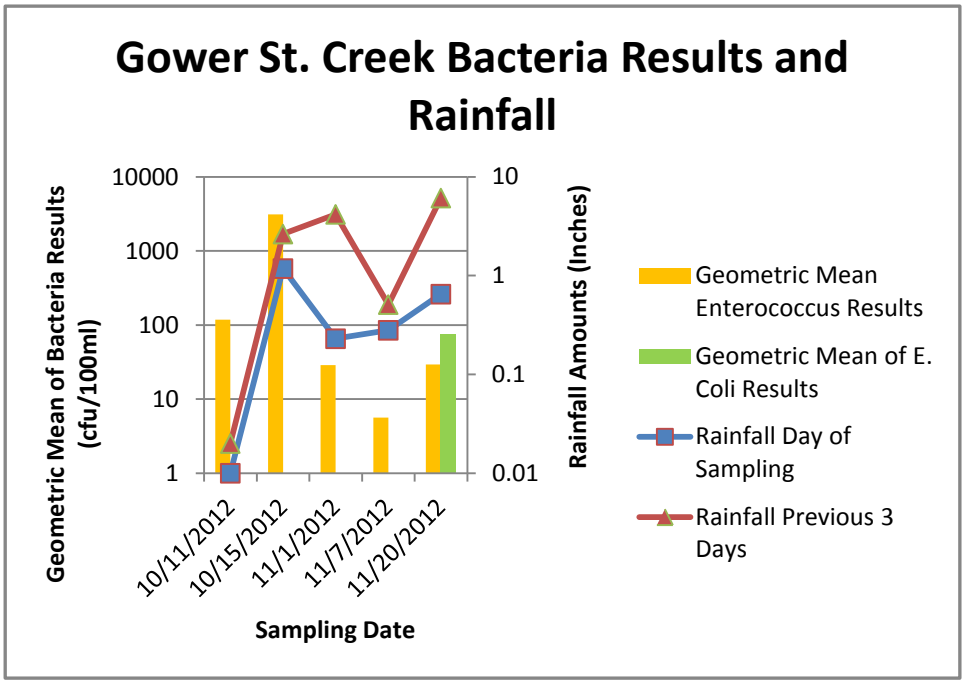


Figure 29. Gower Street results and rainfall amounts.

The summary plots display the same pattern of results decreasing depending on the sample site distance from the beach (Figure 30).

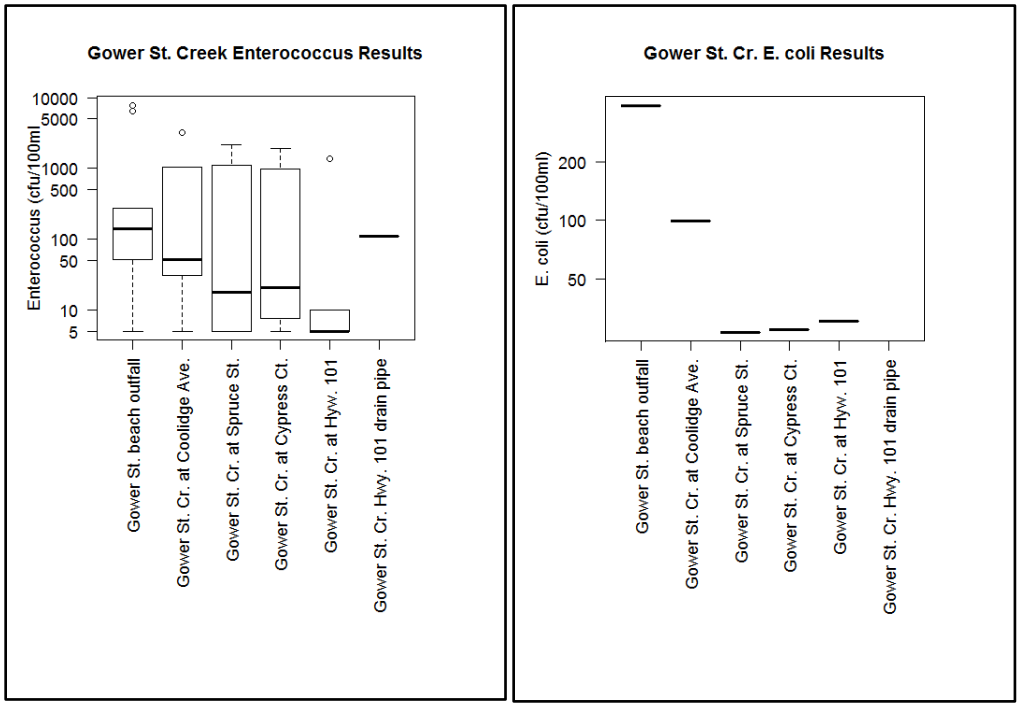


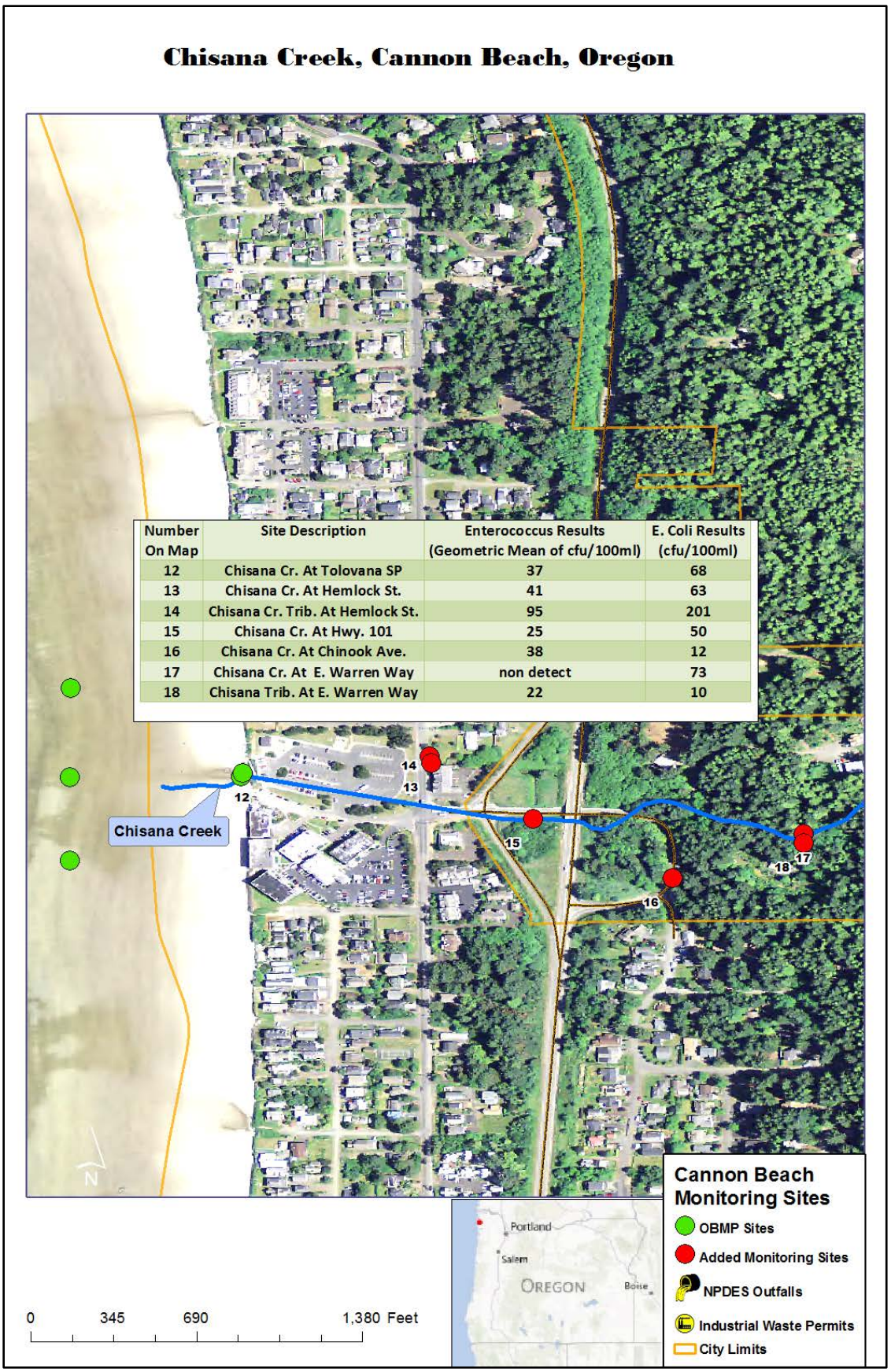
Figure 30. Gower St. Creek *Enterococcus* sp. and *E. coli* summary results.

Chisana Creek

Chisana Creek discharges out on to the beach at Tolovana Beach State Park in south Cannon Beach. The Chisana Creek headwaters originate about one mile east of the Tolovana State Park and flow through privately managed forestland. There are no residences along the creek east of the Ecola Forest gate on East Warren Way. Less than one third mile east of the beach the creek passes through residential and urban areas. Chisana Creek then runs under Highway 101, South Hemlock Street, and to Tolavana State Park and the beach. The OBMP, the City of Cannon Beach and volunteer groups have taken samples from Chisana Creek. Sample results lead to warning signs describing potential high bacteria counts at creek outfalls at Ecola Creek, Ecola Court (Gower Street), and Chisana Creek. Visitors with children, pets, and birds wade in the creek.

Figure 31. Tolovana State Park Beach

Figure 32. Beach visitors wading in Chisana Creek at Tolovana State Park.



Number On Map	Site Description	Enterococcus Results (Geometric Mean of cfu/100ml)	E. Coli Results (cfu/100ml)
12	Chisana Cr. At Tolovana SP	37	68
13	Chisana Cr. At Hemlock St.	41	63
14	Chisana Cr. Trib. At Hemlock St.	95	201
15	Chisana Cr. At Hwy. 101	25	50
16	Chisana Cr. At Chinook Ave.	38	12
17	Chisana Cr. At E. Warren Way	non detect	73
18	Chisana Trib. At E. Warren Way	22	10

Figure 33. Chisana Creek sample locations.

Chisana Creek Outfall at Tolovana Beach State Park

Samples were collected at the Chisana Creek outfall at Tolovana Beach State Park. This location is sampled routinely by the OBMP during the summer sampling season. The creek discharges across the beach and to the ocean from the outfall. The surface outflow to the beach may not reach the ocean during the dryer summer season. Chisana Creek can move several meters north or south depending on the weather and surf conditions. Beach visitors, pets, and birds wade in the creek wherever it ends up crossing the beach. The OBMP collected 42 samples at this location from May 2010 to September 2012. Four of those sample results (9.5%) exceeded the recreational water quality criteria. Six samples were collected at this location for this project. Five of those samples were tested for *Enterococcus* sp. and one for *E. coli*. Only one of the sample results exceeded the recreational water quality criteria. That sample was taken during heavy rainfall on October 15th. *Enterococcu*s sp. test results from the next heavy rainfall event on November 20th were closer to but less than the RWQC. The only *E. coli* test result was relatively low.

This site has also been monitored by the City of Cannon Beach. The city reports several results exceeding the recreational water quality criteria in the fall of 2011.

Figure 34. Chisana Creek outfall at Tolovana Beach State Park.

Table 14. Chisana Creek at Tolovana Beach State Park results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Chisana Creek at Tolovana Beach Outfall	10/11/2012	10	No Sample Collected
	10/15/2012	2359	
	11/1/2012	non-detect	
	11/7/2012	non-detect	
	11/20/2012	121	68

Drainage Ditch at South Hemlock Street

Samples were collected at a tributary to Chisana Creek from a drainage ditch on the east side of South Hemlock Street between East Warren Way and Fernwood Street. The sample location is 0.1 miles from the ocean just west of the Tolovana Beach parking area. The ditch may be dry during the summer season. Four samples were taken from this drainage and tested for *Enterococcus* sp. and one of those results was more than 30 times the recreational water quality criteria. The only sample tested for *E. coli* was about half the standard.

Figure 35. Chisana Creek Tributary at South Hemlock Street.

Table 15. Chisana Creek Tributary at South Hemlock Street results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Chisana Creek Tributary Drainage Ditch at S. Hemlock St.	10/15/2012	4884	No Sample Collected
	11/1/2012	63	
	11/7/2012	non-detect	
	11/20/2012	52	201

Chisana Creek at South Hemlock Street

Samples were collected at confluence of the roadside ditch and the culvert on the north side of the Wayside Inn. This site is on the upstream side of the confluence with the drainage ditch site. The creek drains to this location from Highway 101 and alongside a parking lot and the Wayside Inn to the culvert then to the beach at Tolovana State Park. There is blackberry and thick vegetation near the highway but the creek is more open closer to Hemlock Street. Four samples were taken and tested for *Enterococcus* sp. at this site and one was tested for *E. coli*. One *Enterococcus* sp. sample exceeded the recreational water quality standard. That sample was taken during heavy rainfall on October 15th.

Figure 36. Chisana Creek at South Hemlock Street.

Table 16. Chisana Creek at South Hemlock Street results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Chisana Creek at South Hemlock Street	10/15/2012	1607	No Sample Collected
	11/1/2012	non-detect	
	11/7/2012	non-detect	
	11/20/2012	73	63

Chisana Creek at Highway 101

More Chisana Creek samples were collected about 50 meters west of Highway 101 on public property between the highway and the exit ramp; about 0.17 miles from the beach. There are residences and a business on the east side of highway 101. There is thick vegetation including blackberry on the creek banks. The shrubs extend a few meters out from the banks and the vegetation is maintained to the highway and ramps. Five samples were taken at this site and tested for *Enterococcus* sp. One sample was collected and tested for *E. coli*. One of the *Enterococcus* sp. results was more than five times the recreational water quality criteria. The sample with the high result was taken during heavy rainfall on October 15th.

Figure 37. Chisana Creek at Highway 101.

Table 17. Chisana Creek at Highway 101 results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Chisana Creek at Highway 101	10/11/2012	non-detect	No Sample Collected
	10/15/2012	886	
	11/1/2012	10	
	11/7/2012	non-detect	
	11/20/2012	41	50

Chisana Creek Tributary at Chinook Avenue

Samples were taken at a tributary to Chisana Creek at a culvert under the East Warren Way highway ramp at West Chinook Avenue about 0.28 miles from the beach. The tributary runs through the culvert east of Highway 101 north of the intersection with West Chinook Avenue. The banks are steep and the creek is about a meter wide and shallow. The banks are covered with ferns and shrubs. There is a community of residences south of West Chinook Avenue. The creek runs from forestland SE of West Chinook Avenue and then towards Highway 101. Five samples were taken at the site and tested for *Enterococcus* sp. and one was tested for *E. coli*. One of the *Enterococcus* sp. results was six times the recreational water quality criteria. That sample was taken during heavy rain on October 15th.

Figure 38. Chisana Creek Tributary at E. Warren Way and Chinook Avenue.

Table 18. Chisana Creek at E. Warren Way and Chinook Avenue results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Chisana Creek Tributary E. Warren Way and W. Chinook Ave.	10/11/2012	non-detect	No Sample Collected
	10/15/2012	950	
	11/1/2012	41	
	11/7/2012	20	
	11/20/2012	20	12

Chisana Creek at East Warren Way

The farthest upstream Chisana Creek samples were collected at an Ecola Forest access gate on East Warren Way. Chisana Creek flows in to this location from about a half mile NE through forestland, rural residential land, and past a landscape business. This sample location is about 0.35 miles upstream from the beach and Chisana Creek is less than a meter wide at this location. A similar sized tributary flowing from the east along East Warren Way converges with Chisana Creek here. Upstream from this location the Chisana Creek main stem courses through small pools and riffles. The tributary along East Warren Way runs along the roadside in a drainage ditch.

Figure 39. Chisana Creek at the Ecola Forest gate next to East Warren Way.

Table 19. Chisana Creek and Tributary at E. Warren Way results.

Sample Station	Sample Date	Enterococcus Results (cfu/100 ml)	E. Coli Results (cfu/100 ml)
Chisana Creek Main Stem at East Warren Way	11/1/2012	non-detect	No Sample Collected
	11/7/2012	non-detect	
	11/20/2012	non-detect	73
Chisana Creek Tributary at East Warren Way	10/15/2012	909	No Sample Collected
	11/1/2012	non-detect	
	11/7/2012	non-detect	
	11/20/2012	10	10

The Chisana Creek sample results were higher from sites closer to the beach. Results from sites along South Hemlock Street bump the average up in a graph displaying distance from the beach (Figure 40). Results generally coincided with rainfall amounts as with results from the other creeks sampled in this project (Figure 41).

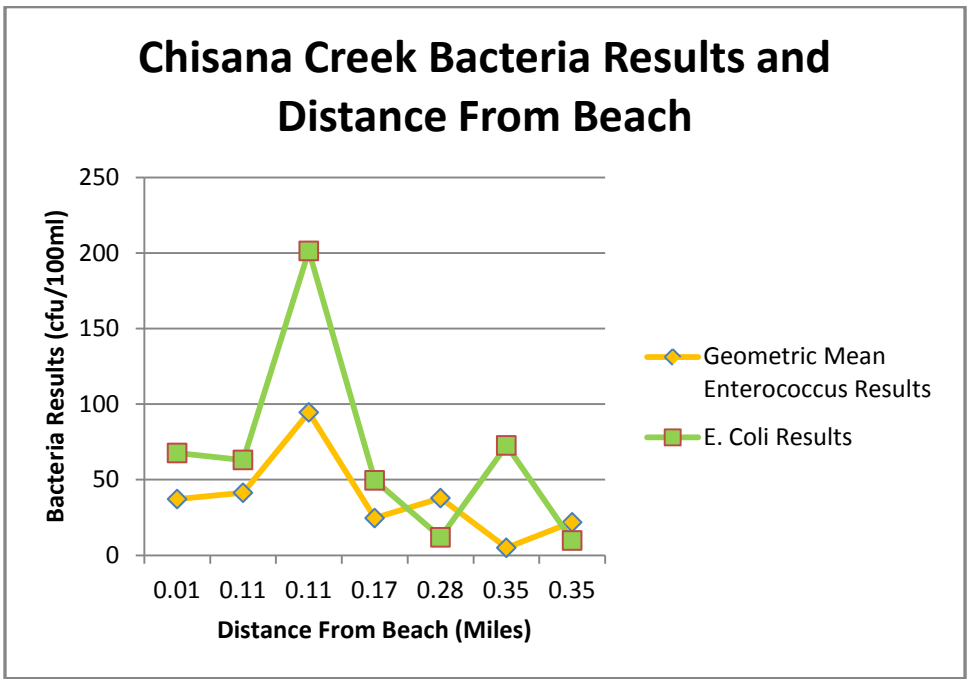


Figure 40. Chisana Creek results and distance from the beach.

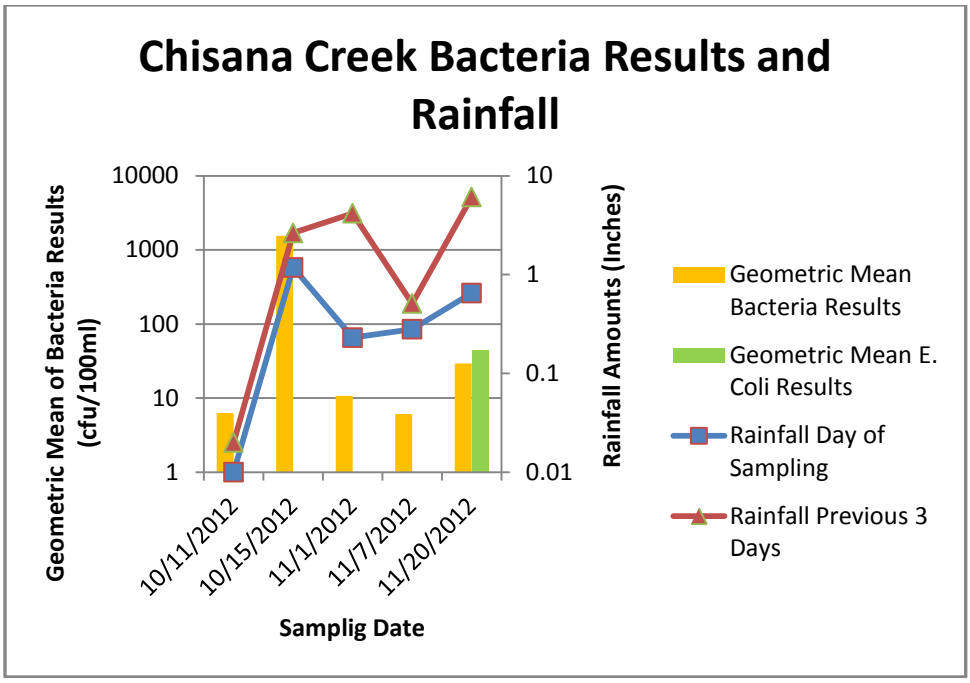


Figure 41. Chisana Creek results and rainfall amounts.

The summary plots for Chisana Creek show higher results closer to the beach. The South Hemlock Street results a block east of the beach are notable. One of the *E. coli* results from the most upstream site on Chisana Creek was 73 mpn, but still well below the 406 cfu/100 ml single sample maximum criteria for *E. coli* (Figure 42).

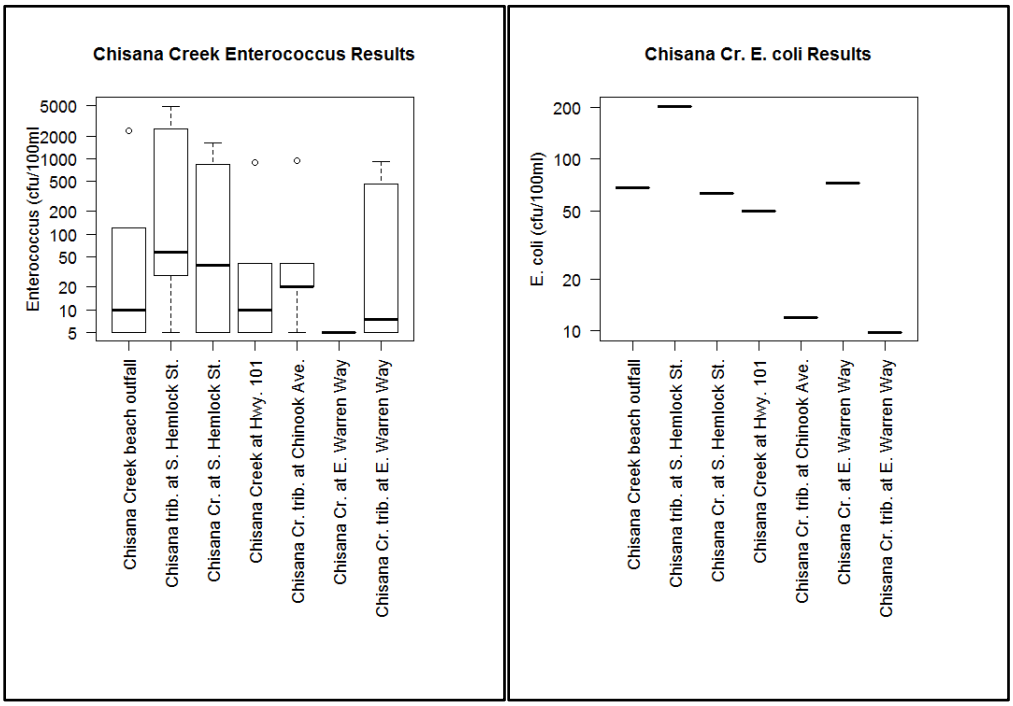


Figure 42. Chisana Creek *Enterococcus* sp. and *E. coli* summary results.

Water Quality

Water quality measurements were taken at the time of sample collection. Temperature, conductivity, salinity, pH, dissolved oxygen, and turbidity, were measured at each sampling location. Most of the parameter measurements were within normal ranges. Conductivity and turbidity measurements were higher than normal on October 15th, the rainiest sampling day, as may be expected. A linear regression model including all of the measured parameters was run in the R statistical program (Wikipedia, 2013). Regression analysis showed rainfall was the most relevant factor affecting the bacteria counts. Water temperature, conductivity, and turbidity added importance in second and third order regression models.

Table 20. Linear Regression Model

Model Order	1st Parameter	2nd Parameter	3rd Parameter	r^2
1st Order Model	Rainfall Day of Sampling			0.71
2nd Order Model	Rainfall Day of Sampling	Distance From Beach		0.75
	Rainfall Day of Sampling	Dissolved Oxygen		0.77
	Rainfall Day of Sampling	Temperature		0.78
3rd Order Model	Rainfall Day of Sampling	Temperature	Turbidity	0.80

Sample results were considered in groupings according to whether the sites were on the beach, in residential neighborhoods, or upstream of residential neighborhoods. Logan and Gower Street Creek watersheds do not reach too far outside of Cannon Beach city limits. The Chisana Creek headwaters are farther in to Ecola Forest than were accessed during this project but samples were collected from the west edge of Ecola Forest. The Ecola Creek watershed is more expansive in to Ecola Forest and only the downstream portion was sampled. Because the creek watersheds are at different scales groupings were considered as the beach, between the beach and Highway 101, and Highway 101 and east of the highway. Bacteria results generally increased moving downstream from Ecola Forest, through residential areas, and to beach outfalls.

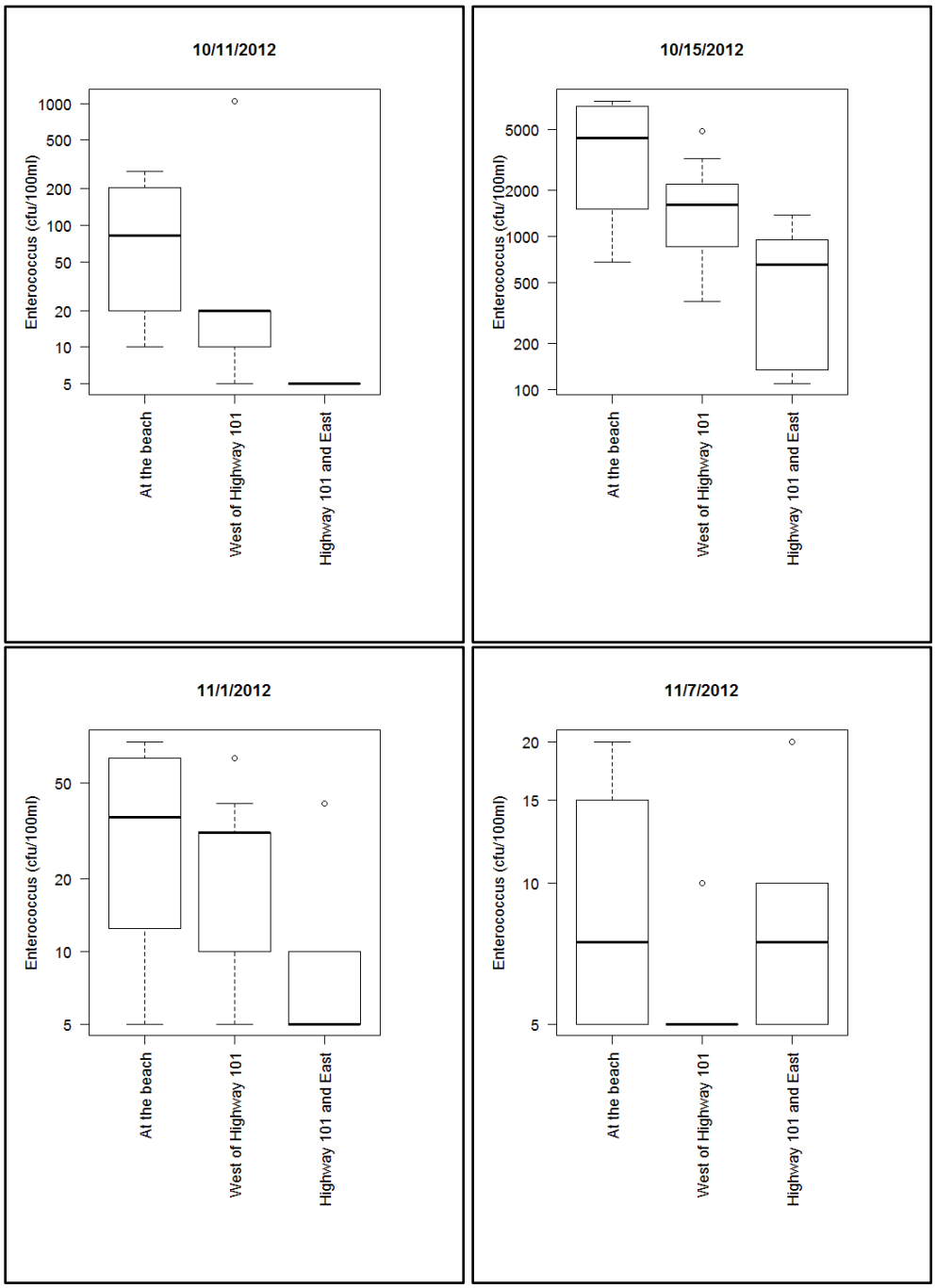


Figure 44. *Enterococcus* sp. summary results grouped by date and distance from the beach.

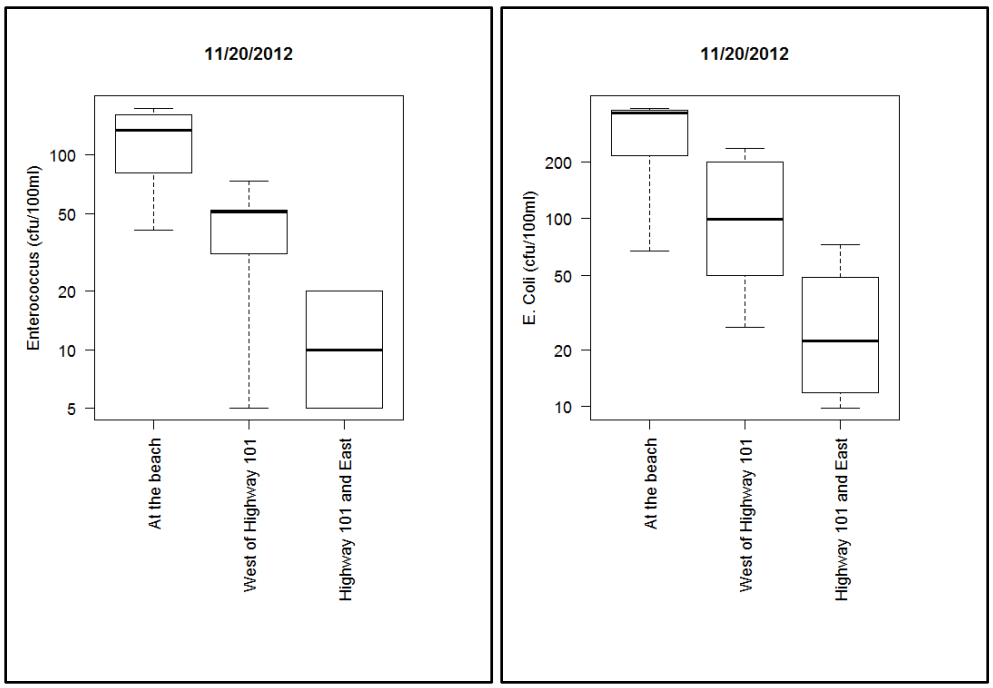


Figure 43. *Enterococcus* sp. and *E. coli* summary results by date grouped by distance from the beach.

Next Steps

The OBMP collected samples from some of the locations studied in this report during the 2013 summer season. Those sites include the mouth of Ecola Creek and the confluence of Ecola Creek and Logan Creek, the marine sites and beach outfalls at the Gower Street Creek, and Chisana Creek at Tolovana State Park. There were water contact advisories at Cannon Beach during the summer 2013 beach monitoring season and results from some of these sites exceeded the recreational water quality criteria at the time of those advisories. The City of Cannon Beach and the Surfrider volunteer groups will likely continue to monitor some of these locations. Representatives from DEQ and OHA are participating in ongoing discussions about the results from these sites. Continued beach monitoring and communication with stakeholders and the City of Cannon Beach will provide insight to better understand the history of these sample locations and discuss possible improvements or repairs that may lead to better recreational water quality at Cannon Beach.

References

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Appendix A.
Cannon Beach Sample Locations Latitude and Longitude

Number On Map	Site Description	Latitude	Longitude
1	Ecola Cr. At Logan Cr.	45.9026	-123.9600
2	Logan Cr. At horse trail	45.9031	-123.9598
3	Logan Cr. At 5th St.	45.9036	-123.9598
4	Ecola Cr. At Fir St. Bridge	45.9023	-123.9567
5	Ecola Cr. At Hwy. 101	45.8993	-123.9540
6	Logan Cr. At Hwy. 101	45.9117	-123.9486
7	Gower St. Cr. At Ecola Court	45.8893	-123.9638
8	Gower St. Cr. at Coolidge Ave.	45.8894	-123.9609
9	Gower St. Cr. At E. Dawes St. and Spruce St.	45.8887	-123.9599
10	Gower St. Cr. At E. Dawes St. and Cypress Ct.	45.8887	-123.9590
11	Gower St. Cr. At Hwy. 101	45.8876	-123.9581
12	Chisana Cr. At Tolovana SP	45.8727	-123.9619
13	Chisana Cr. Trib. At Hemlock St.	45.8729	-123.9598
14	Chisana Cr. At Hemlock St.	45.8728	-123.9597
15	Chisana Cr. At Hwy. 101	45.8727	-123.9586
16	Chisana Cr. At Chinook Ave.	45.8715	-123.9570
17	Chisana Cr. At E. Warren Way	45.8723	-123.9566
18	Chisana Trib. At E. Warren Way	45.8722	-123.9566

Site identification numbers and other data can be viewed on LASARweb.