Water Solutions, Inc.

Technical Memorandum

To: **Water Quality and Quantity Team**
Siuslaw Estuary Partnership

From: **Dennis Nelson and Suzanne Moellendorf, GSI Water Solutions**

Date: **January 30, 2012**

Re: **Water Quality and Quantity: Summary of Observations October 2011 – January 2012**

In this memo we summarize field observational data from Munsel Creek, Ackerley Creek, and the array of 16 monitoring wells (Figure 1) distributed throughout the area of interest in terms of groundwater and surface water quantity and quality. We also report analytical data derived from laboratory analyses.

Groundwater

Water Quantity

Water Table Elevation and Groundwater Movement. In previous reports, we have noted that at a given site, the elevation of the water table, or hydraulic head of groundwater, undergoes significant variations as a function of season, with the two most important controlling parameters being precipitation and, to a lesser extent, the pumping of groundwater from area wells.

In Figure 2, we show how the average rainfall (in) correlates with monthly changes in the elevation of the water table (ft). It would appear that for the 15 month period for which we have data, the earlier observed threshold monthly precipitation value of approximately 7 inches before we observe and increase in the water table continues. As in 2010, the 7 inches of precipitation arriving in November has resulted in an increase in the water table. Of further note, the difference in the amount of rainfall in 2011 vs. 2010 is evident. Further evidence of the marked decrease in precipitation in late 2011 is that Well B-2 in both November and December.

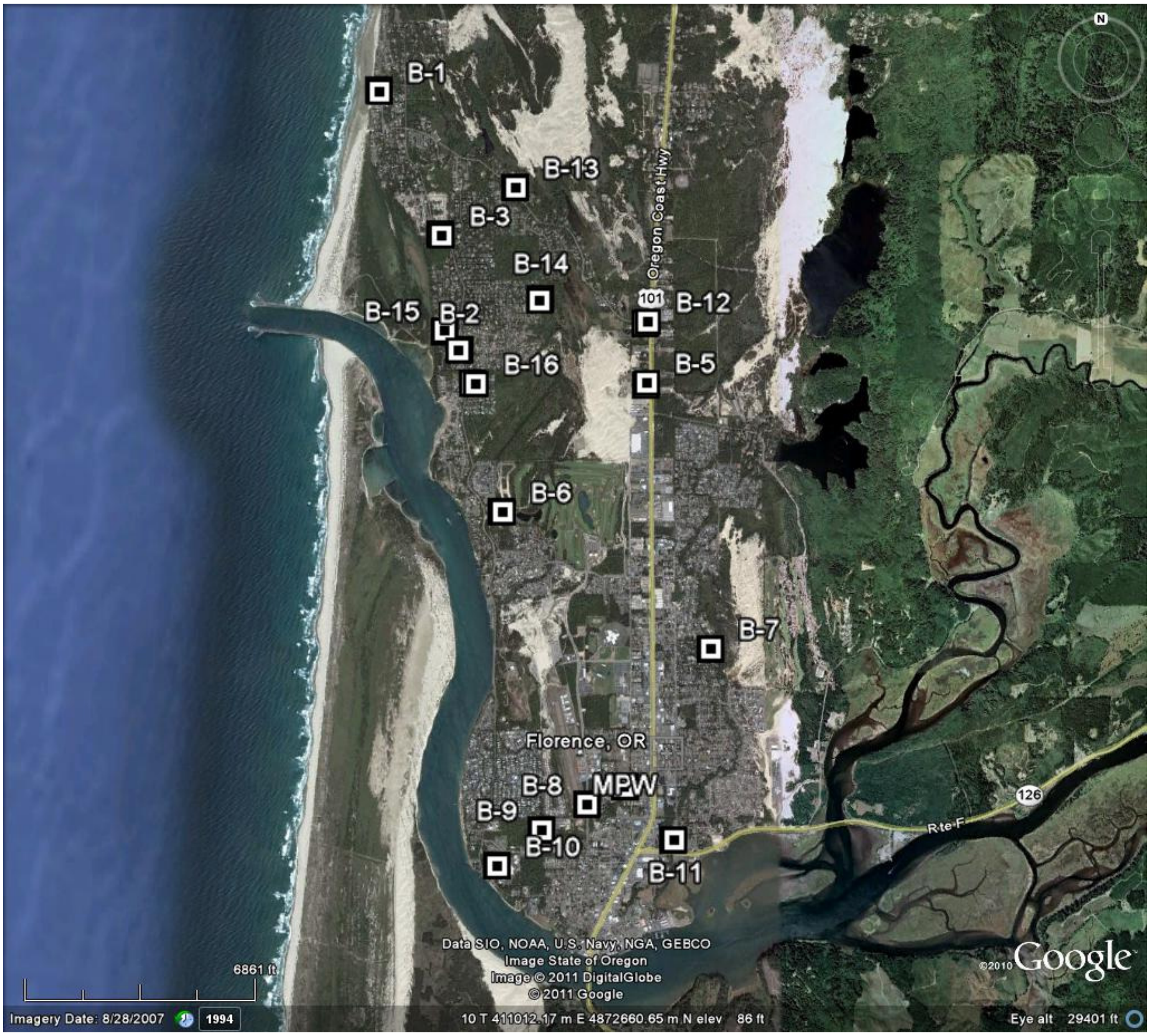


Figure 1. Aerial view of the Florence area showing locations and names of monitoring wells sites.

As noted before, even though the water table elevation at an individual monitoring well might change significantly as a function of precipitation (Figure 3), the relative configuration of the water table as a whole remains similar in character, i.e., no significant changes in groundwater flow direction are indicated (compare head maps in Figure 4). As in previous measurement periods the water table slopes towards the Siuslaw River and the Pacific Ocean, implying that groundwater discharges directly to the Siuslaw River Estuary. Note that in the central part of the area, similar to the past, the water table steepens significantly as the river is approached.

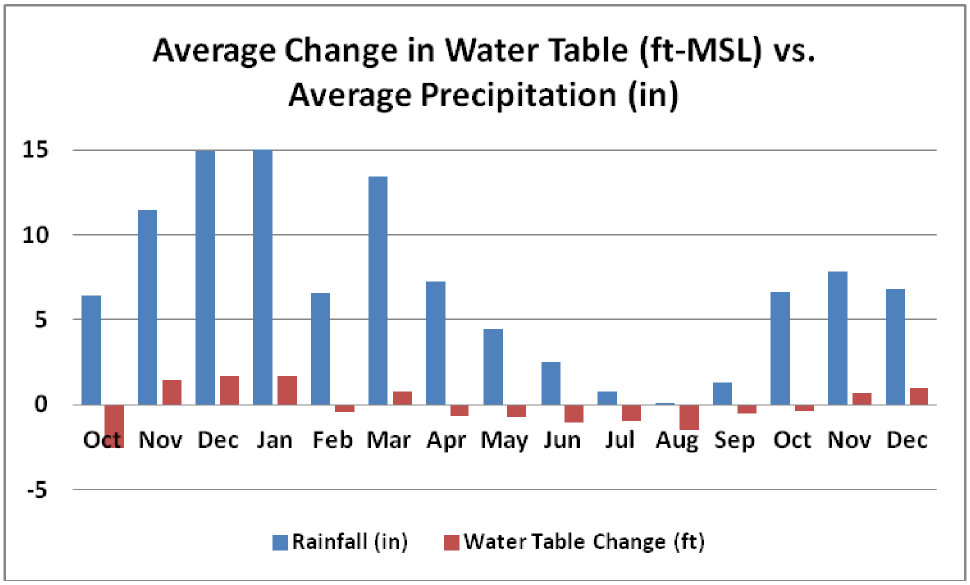


Figure 2. Relationship between the amount (in) of precipitation (blue) and the change in the average elevation (ft) of the water table (red) on a monthly basis. A positive change indicates that the water table is rising; a negative value indicates that it is falling.

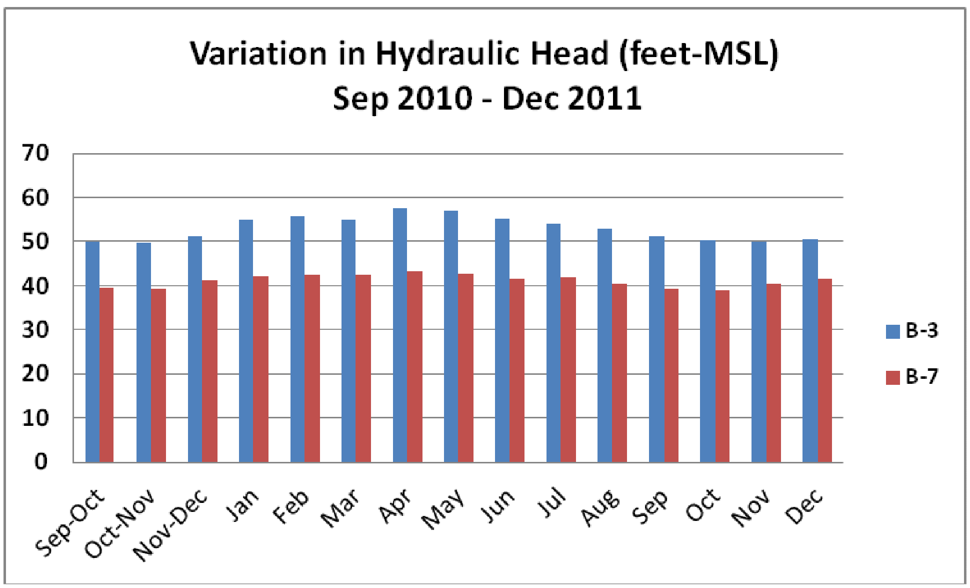


Figure 3. Elevation (ft-msl) of the water table at selected monitoring well site. Note that the variation in hydraulic head observed at the B-3 site is over 7 feet.

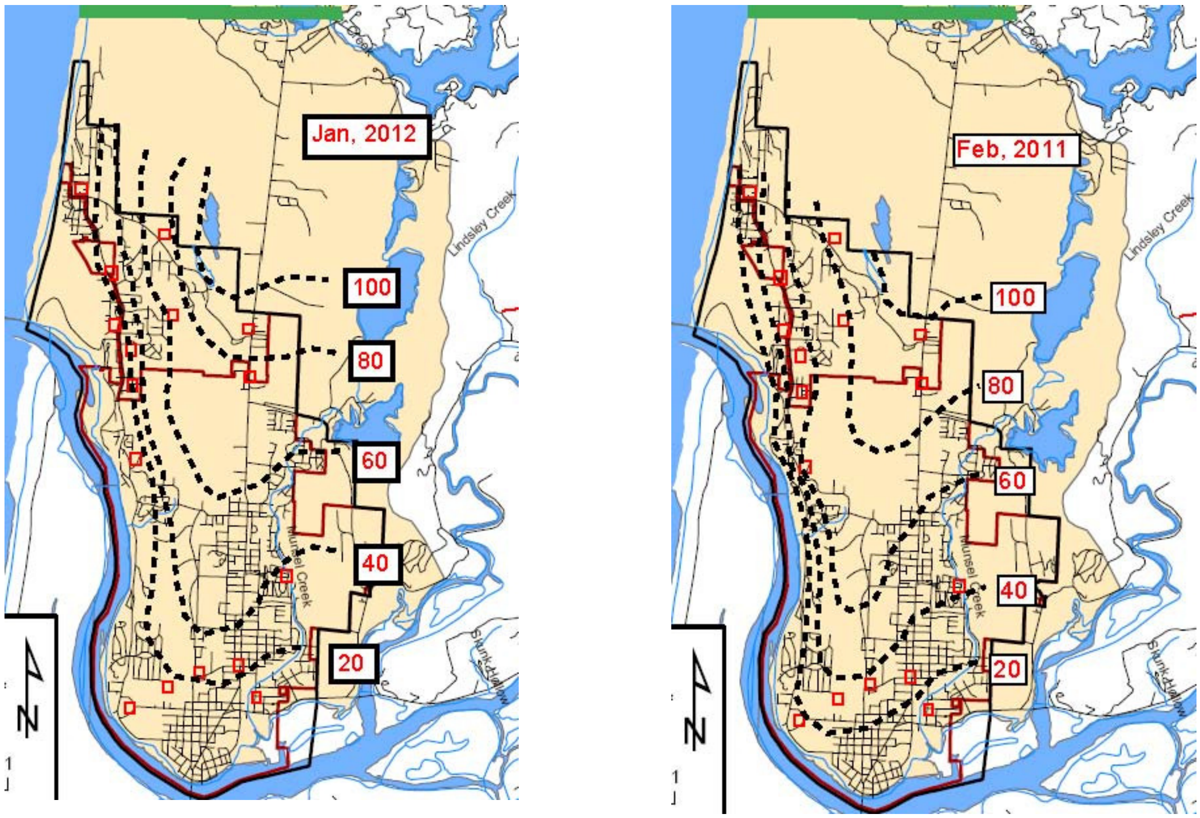


Figure 4. Water table elevation contours for January, 2012 compared with February, 2011. Contour interval is 20 feet and elevation in both ranges from ~10 feet to ~100 feet.

The north-south groundwater ridge separating the eastern side of the area with the western side, evident in both diagrams is more pronounced in the February 2011 map than in January 2012 (note positions of the 80 and 60 foot contours). This may be a reflection of the greater rainfall in early 2011 vs. that of late 2011.

Groundwater Quality

Field Parameters

Groundwater Temperature. Groundwater temperature remains fairly uniform across the Florence area, however, small but significant seasonal changes are observed. Figure 5 shows the average groundwater temperature as a function of the month the data was collected. Based on those averages, groundwater temperature varies by approximately 2.5 ℃. It also appears that the groundwater temperature lags behind the air temperature by two to three months. The lowest average groundwater temperature thus far was in April, 2011, while the lowest air temperatures were likely recorded in January or February of that year. The lag time is the result of the insulating effect of the sands between the water table and the surface.

An earlier observation that the Miller Park Well, added to the monitoring network in May 2011, had a water temperature of at least 1℃ higher than the average has not been borne out. Since October, the temperature of groundwater from the Miller Park well has been in the mid-range of the shallower wells.

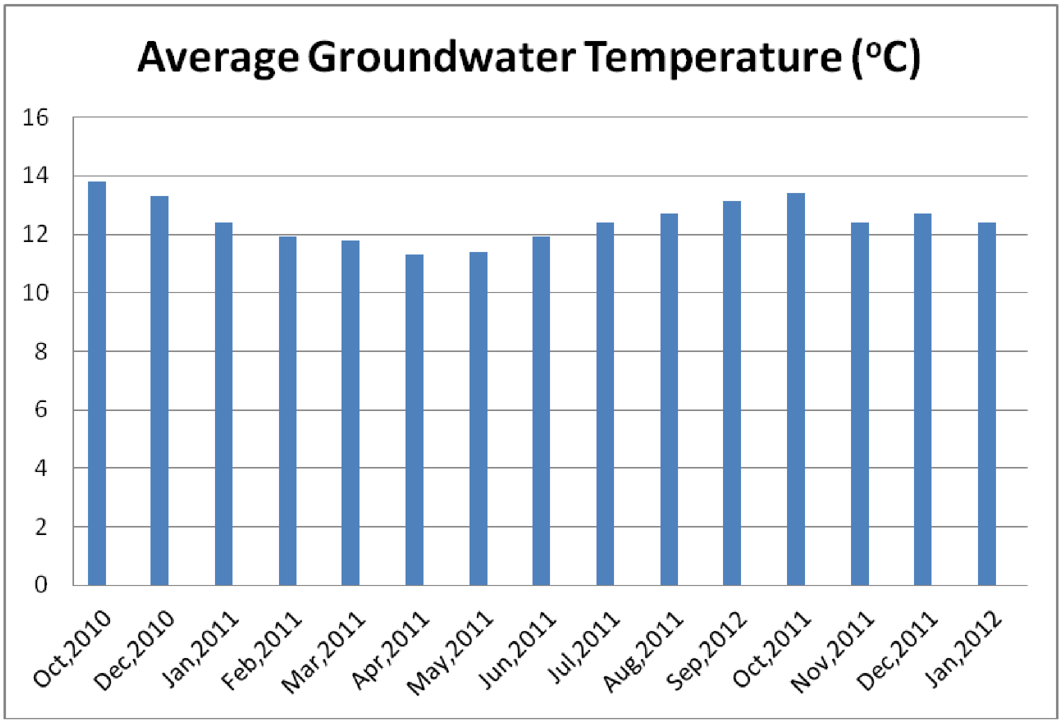


Figure 5. Average temperature (°C)of groundwater from monitoring wells as a function of month of the year.

Groundwater pH. The pH of area groundwater has remained fairly stable. From December 2010 to January 2012, pH of the shallow groundwater varied from 5.08 to 5.99, with no apparent seasonal trend. As already noted, this is typical of shallow groundwater. Rainwater is slightly acidic because of CO_2 in the atmosphere, leading to the formation of carbonic acid. In Oregon, typical precipitation in the coastal areas has a pH of approximately 5.7. Reactions in the soil zone can reduce the pH of infiltrated rainwater even more. Groundwater that has a longer residence time in the subsurface will generally have a higher pH owing to chemical reactions with aquifer mineral matter.

Wells B-2(residential area within the UGB) and B-7 (residential area within the City Limits) did display values outside the typical range, with B-2 as low as 4.7 and B-7 as high as 7.08.

The Miller Park Well remains somewhat anomalous compared to the other monitoring wells. The pH of the Miller Park Well typically is higher than the other wells, e.g., 6.25 to 6.5 as opposed to 5.1 to 6.0. In contrast to the shallow (<25 ft) monitoring wells, the Miller Park Well is deeper, drawing groundwater from a screened interval from 57-82 feet below ground surface. The pH difference in groundwater from the Miller Park Well and that of the shallow monitoring wells is consistent with a longer residence time for the deeper groundwater.

Groundwater Conductivity. Conductivity is related to the dissolved mineral load of the water. A very approximate relationship between the two is TDS (mg/L) = ~50% of the conductivity (uS/cm). Conductivity varies in wells from <70 to >500 uS/cm, with the bulk of the analyses falling in the 100 to 150 uS/cm.

Figure 6 below plots the conductivity of groundwater derived from selected wells within the study area. Wells B-5 and B-7 represent upgradient wells whereas the remaining wells are in downgradient positions. Specifically, B-2 and B-3 are downgradient from an unsewered area within the UGB, B-6 is within the City, downgradient from Sand Pines Golf Course, B-10 is downgradient from the City's downtown area and commercial area, and B-11 is downgradient from a sewered and commercial area (see map in Figure 1 for well locations).

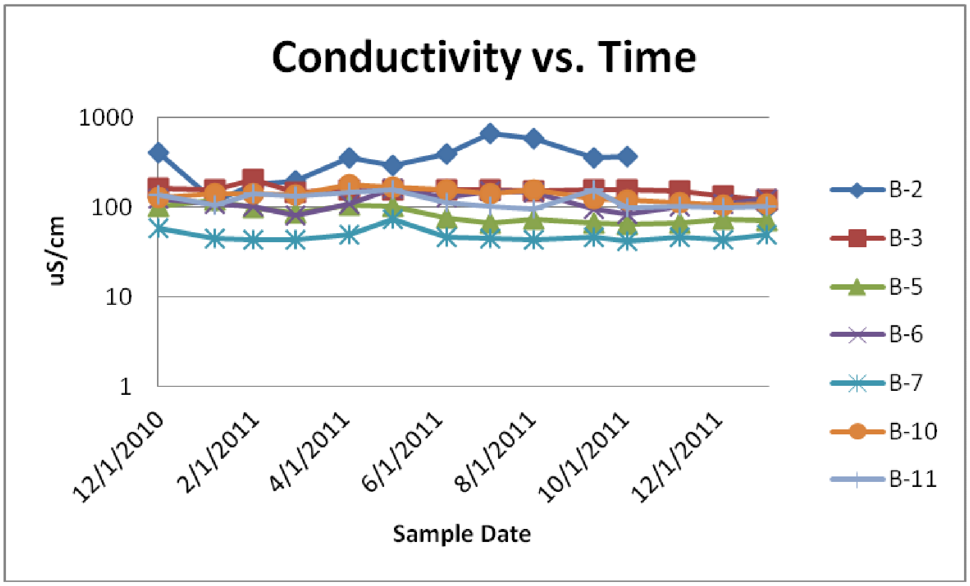


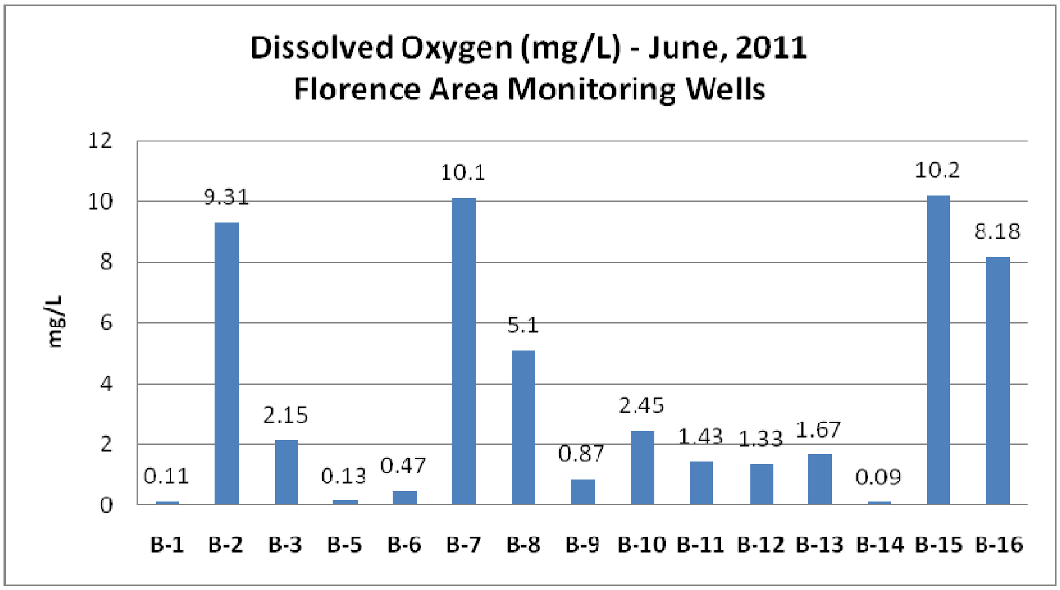
Figure 6. Conductivity in groundwater from select monitoring wells as a function of month. Upgradient wells are B-7 and B-5, while wells B-2, B-3, B-6, B-10, and B-11 represent downgradient wells (see text for explanation).

As would be expected, the upgradient wells tend to have lower conductivity (TDS) values, while those that are downgradient, with longer residence time in the aquifer, tend to have higher conductivity values. Given the shallow nature of the water table, and the significant influence that areas in the immediate area of the well may exert, it is not just water-rock reactions along a flow path that are controlling the conductivity values. This can be readily seen in the anomalous behavior of B-2 where conductivity values have exceeded 600 uS/cm. Such values cannot be the result of natural causes and suggests that the groundwater at this well site has been impacted.

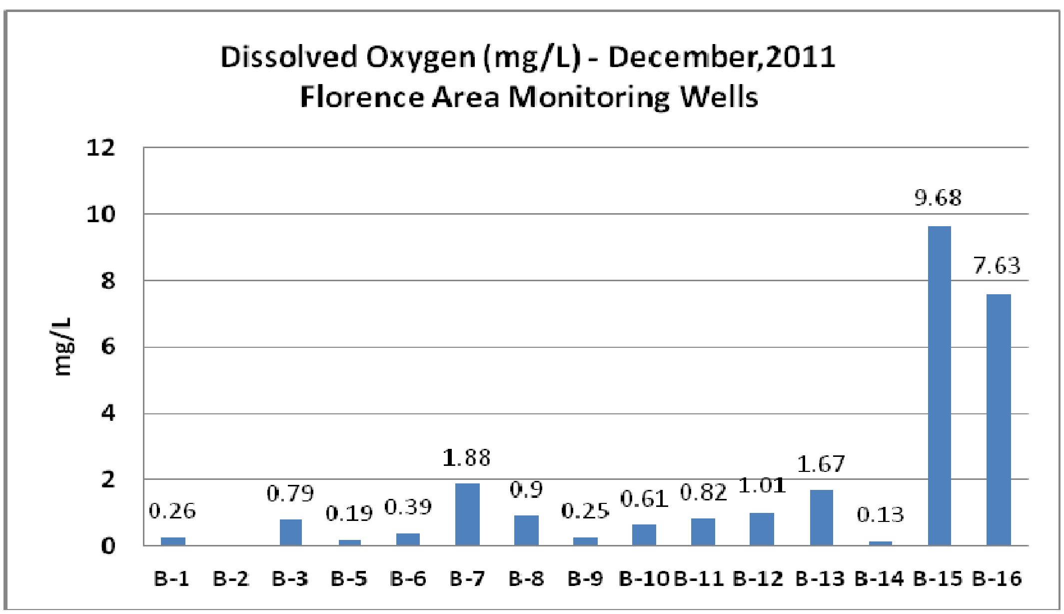
Well B-2 has also yielded nitrate concentrations exceeding the drinking water standard and has experienced positive coliform results. That this is not the case for all the wells in the areas downgradient from home serviced by septic systems is evident from the conductivity of groundwater from B-3 that is similar to other downgradient wells such as B-10 and B-11 in sewered areas.

Groundwater Dissolved Oxygen. Dissolved oxygen (DO) varies from 0.09 mg/L (< 1 % saturated) to over 10 mg/L (> 90 % saturated) in groundwater from the dunal aquifer (see Figure 7). Figure 7 compares data from June and December, 2011. From the figure we see that for both time periods, dissolved oxygen is high in Wells B-15 and B-16, and low in Wells B-1, B-3, B-6, and B-14. Relative values remain consistent for most of the other wells (no value is available for Well 2 for December. Upgradient wells can have quite different values, e.g., B-7 vs. B-5 as can downgradient wells. e.g., June values for B-2 and B-6.

The DO of a given groundwater sample is a function of the ability of groundwater to be able to exchange and equilibrate with the atmosphere, the amount of organic carbon in the aquifer, and the amount of organic matter that is added to the aquifer from the surface or near surface. As a result, the final DO is very likely a function of specific location as opposed to evolution along a flow path.



(a)



(b)

Figure 7. Range of dissolved oxygen levels (mg/L) in groundwater from Florence area monitoring wells in (a) June, 2011 and (b) December, 2011.

Groundwater Quality

Laboratory analyses of samples from all of the monitoring wells from October 2011 through January 2012 were limited to coliform and *E. coli*. Nitrate samples were collected in October for a subset of the wells.

Coliform Bacteria. The groundwater from the monitoring wells is tested monthly for bacteria. If a sample comes back positive for the occurrence to total coliform, the lab routinely tests for *E. coli*. Total coliforms are very common in the environment, but are not indigenous to an aquifer. Their presence in groundwater then generally indicates a connection to the surface, potentially caused by a problem with well construction, e.g., improper or failing well seal, or a nearby coliform source. *E. coli*, however, is a type of fecal coliform that is generally the result of human or other warm blooded animal waste.

All wells were sampled monthly for total coliform and *E. coli*. All wells were nondetect for *E. coli*. Similarly, all wells were nontect for total coliform except for B-6 (2.0 MPN/100ml) in December and B-2 (1.0 MPN/100ml) in January. Well B-2 could not be sampled in November and December because the water table was below the bottom of the well. Although the source of coliform for these wells is at present unknown, the wells were installed by licensed well drillers and well construction is not the likely cause of the detections.

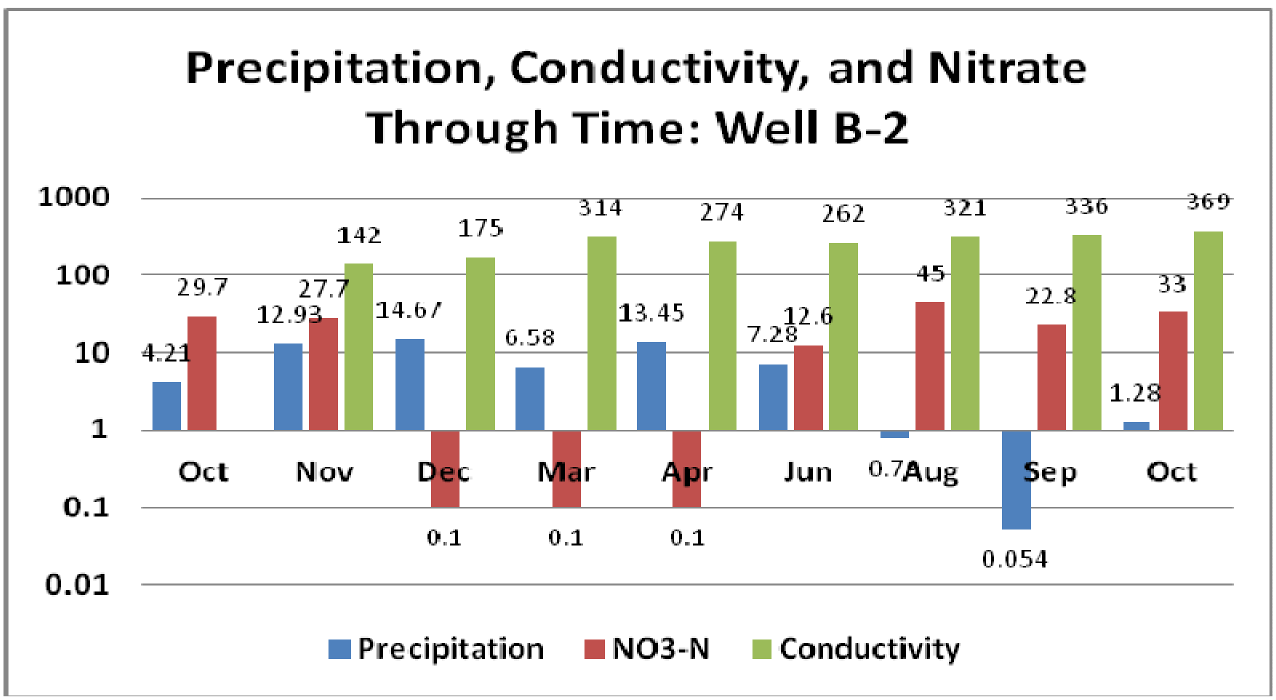


Figure 8. Plot of the conductivity and nitrate concentrations for Well B-2 as a function of area precipitation and time. Nitrate-Nitrogen concentrations are in mg/L, conductivity is in uS/cm, and precipitation is in inches.

Nitrate. Five wells were selected to be monitored for nitrate in October of 2011, based on location and previous monitoring results. Wells B-2, B-3, B-15, and B-16 in downgradient locations in the residential area in the UGB were sampled, as was Well B-10, within the downtown area. B-10 was selected because it had been found to contain nitrate in the past, although at concentrations < 3.0 mg/L. All of the wells were nondetect for nitrate except for B-2, which yielded a value of 33.1 mg/L.

The elevated nitrate concentration in Well B-2 during October continues its relationship with precipitation. During times of decreased precipitation, generally June-November, nitrate is detected in the shallow groundwater near the well. As rainfall increases in the late fall to early winter, nitrate concentrations decrease, suggesting dilution as the cause.

Conductivity data are permissive of this interpretation, although the data are far less clear. As the precipitation rates decreased from March through October of 2011, the conductivity of well water from Well B-2 has increased progressively (Figure 8). One explanation for this observation is that as the amount of dilution decreased, the relative concentration of dissolved species increased. As noted above, nitrate reflects a similar trend (i.e., non-detect during high precipitation periods and higher concentrations as the dilution decreases). Thus, the dilution process is consistent with both nitrate and conductivity (TDS) variations.

Surface Water

Water Quantity

Streamflow. City staff has measured streamflow at the monitoring sites on a monthly basis for all sites, with the exception of January 2011 for all sites and February 2011, March 2011, December 2011, and January 2012 for the Ackerley Creek site, which could not be entered due to the presence of spawning salmon and the presence of redds. Measurements are made using a Pygmy or AA flowmeter. Figure 9 shows that streamflows were greatest in March and April and that July 2011 flows dropped to similar levels as November 2010. It also shows that flows in early December reached summer flow levels, but flows increased markedly after the storms in late December. Figure 10 indicates that Munsel Creek is generally a gaining stream, as demonstrated by the increase in streamflow from upstream to downstream.

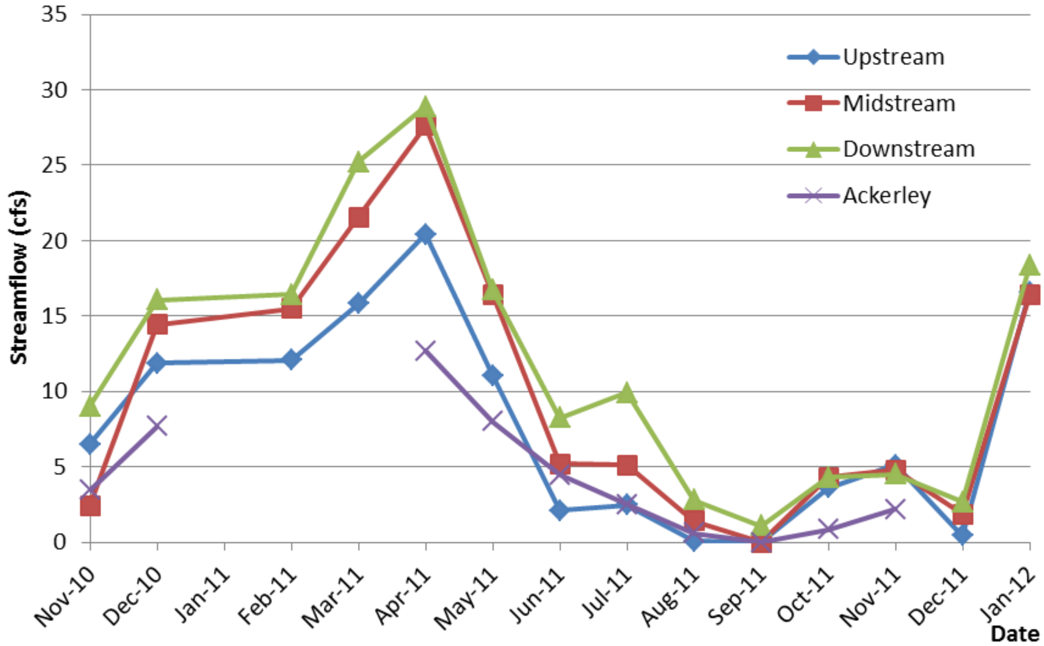


Figure 9. Streamflow over time (November 2010 to January 2012) in Ackerley Creek (ACK) and the Upstream (MLK), Midstream (MGP), and Downstream (PWS) sites on Munsel Creek, using a flowmeter.

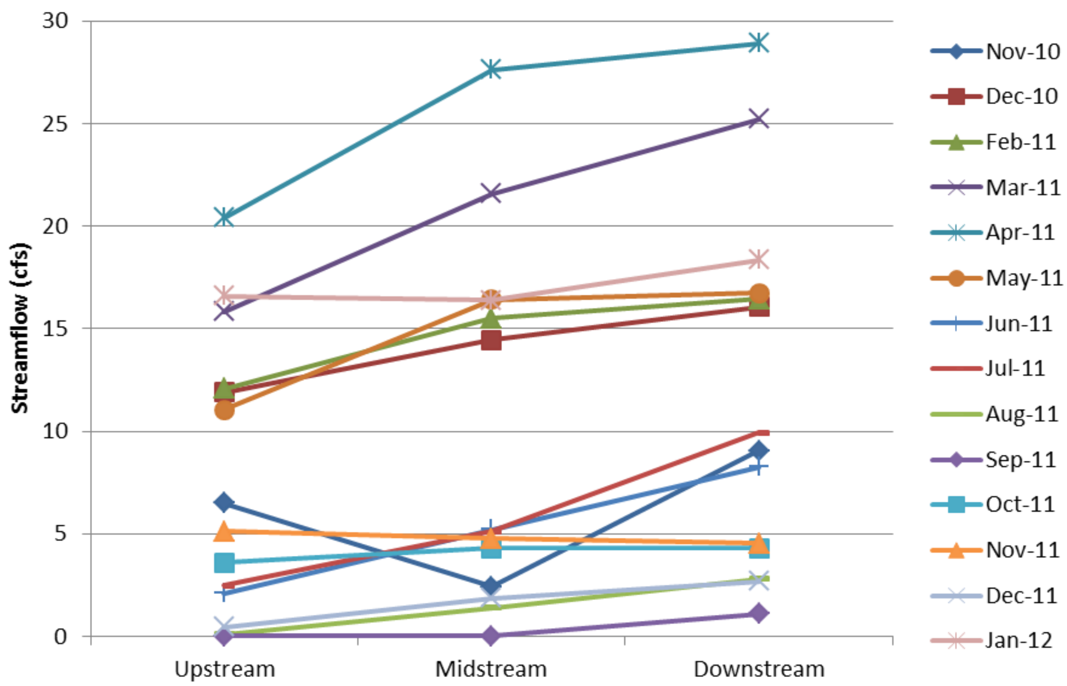


Figure 10. Streamflow by location along Munsel Creek: Upstream (MLK), Midstream (MGP), and Downstream (PWS), using a flowmeter.

Pressure transducers at ACK, MLK, and MGP are also recording water level on a continuous basis, producing information that can be used to determine streamflow.

Surface Water Quality (Grab Samples)

Water Temperature. As shown in Table 5 and Figure 11, stream temperatures at all sites decreased in the winter months, increased in the summer months, and decreased steadily after Augus, except for a slight increase in October. Stream temperatures in Ackerley Creek and Munsel Creek Upstream have been similar except in August and September while Munsel Creek Midstream and Downstream have been similar in stream temperature and lower than the other sites in late spring and summer.

Dissolved Oxygen. Dissolved oxygen concentrations are temperature dependent, being higher at cooler temperatures and lower at warmer temperatures. Dissolved oxygen decreased or fluctuated around the same level from mid-March through June at the sampling sites, then decreased markedly in summer, particularly in Ackerley Creek and Munsel Creek Upstream, and increased thereafter (Figure 12). This decrease in dissolved oxygen corresponds with a prolonged period of lower streamflow and the high stream temperatures.

Table 5. Water quality results using the YSI Multimeter Probe.

SITE	DATE	Temp (°C)	DO (mg/L)	pH (S.U.)	Specific Conductance (us/cm)
Munsel Downstream	10/27/10	11.2	10.56	6.59	71.3
Munsel Midstream	10/28/10	12.0	9.30	6.63	56.9
Munsel Upstream	10/28/10	13.6	9.41	6.97	61.3
Ackerley	10/28/10	13.1	9.31	6.96	59.4
Munsel Downstream	11/29/10	8.4	11.61	6.63	68.6
Munsel Midstream	11/29/10	8.3	11.50	6.61	66.3
Munsel Upstream	11/29/10	8.3	10.97	6.75	61.8
Ackerley	11/29/10	8.4	10.46	6.74	60.7
Munsel Downstream	01/05/11	7.6	11.81	6.71	68.6
Munsel Midstream	01/05/11	7.3	12.05	6.57	66.2
Munsel Upstream	01/05/11	6.7	11.96	6.74	62.1
Ackerley	01/05/11	7.2	11.68	6.70	59.8
Munsel Downstream	01/31/11	8.6	10.43	6.82	72.6
Munsel Midstream	01/31/11	8.7	10.29	6.92	69.2
Munsel Upstream	01/31/11	8.6	10.93	7.16	64.7
Munsel Downstream	03/02/11	8.7	10.60	7.03	72.8
Munsel Midstream	03/02/11	8.4	10.70	6.66	69.8
Munsel Upstream	03/02/11	7.6	11.80	7.15	61.9
Ackerley	03/02/11	7.8	11.30	7.18	60.5
Munsel Downstream	04/06/11	10.1	10.31	6.94	70.3
Munsel Midstream	04/06/11	10.0	10.31	6.77	68.8
Munsel Upstream	04/06/11	10.3	11.55	7.29	63.7

Ackerley	04/06/11	10.3	10.80	7.23	62.1
Munsel Downstream	05/04/11	11.2	9.82	7.84	69.3
Munsel Midstream	05/04/11	11.4	9.54	6.83	65.9
Munsel Upstream	05/04/11	12.9	10.81	7.44	59.6
Ackerley	05/04/11	12.8	10.60	7.14	58.6
Munsel Downstream	06/08/11	13.4	10.44	6.93	76.2
Munsel Midstream	06/08/11	13.8	9.88	6.74	71.6
Munsel Upstream	06/08/11	16.5	9.88	6.91	60.8
Ackerley	06/08/11	17.2	11.30	7.34	59.1
Munsel Downstream	07/07/11	16.6	8.57	7.30	68
Munsel Midstream	07/07/11	16.9	7.93	6.74	66.2
Munsel Upstream	07/07/11	18.7	6.88	6.65	62.9
Ackerley	07/07/11	19.5	7.37	6.89	61.9
Munsel Downstream	08/02/11	14.0	8.59	7.63	89.2
Munsel Midstream	08/02/11	14.1	7.94	6.88	80.9
Munsel Upstream	08/02/11	15.8	5.42	6.42	66.5
Ackerley	08/02/11	19.9	6.65	6.94	64.1
Munsel Downstream	09/06/11	12.4	8.34	6.96	96.9
Munsel Midstream	09/06/11	12.4	7.95	6.71	78.9
Munsel Upstream	09/06/11	12.6	3.59	6.09	67.4
Ackerley	09/06/11	17.1	4.96	6.67	66.2
Munsel Downstream	10/05/11	12.7	8.78	7.35	55.4
Munsel Midstream	10/05/11	13.1	8.86	6.74	58.9
Munsel Upstream	10/05/11	15.6	8.44	7.01	62.8
Ackerley	10/05/11	14.5	7.60	6.84	60.9
Munsel Downstream	11/09/11	10.6	10.44	8.16	78.7
Munsel Midstream	11/09/11	10.6	10.53	7.19	70.8
Munsel Upstream	11/09/11	10.8	10.72	7.02	61.6
Ackerley	11/09/11	11.2	10.98	7.07	60.3
Munsel Downstream	12/07/11	7.4	10.25	8.97	82.1
Munsel Midstream	12/07/11	7.1	10.04	7.58	76.6
Munsel Upstream	12/07/11	6.8	9.23	7.15	63.2
Ackerley	12/07/11	6.3	9.19	6.94	62.7
Munsel Downstream	01/05/12	8.2	11.10	6.82	65.6
Munsel Midstream	01/05/12	7.8	11.22	8.45	63.5
Munsel Upstream	01/05/12	7.1	11.63	7.99	60.6
Ackerley	01/05/12	7.8	11.26	7.33	59

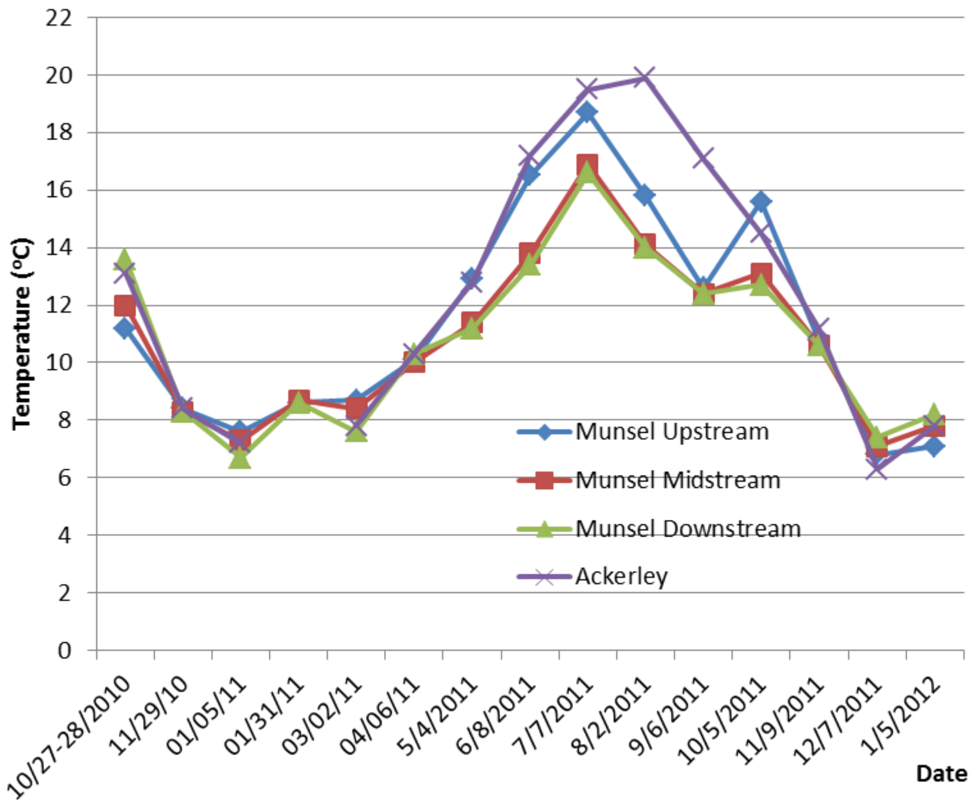


Figure 11. Stream temperature over time, using the YSI Multimeter Probe.

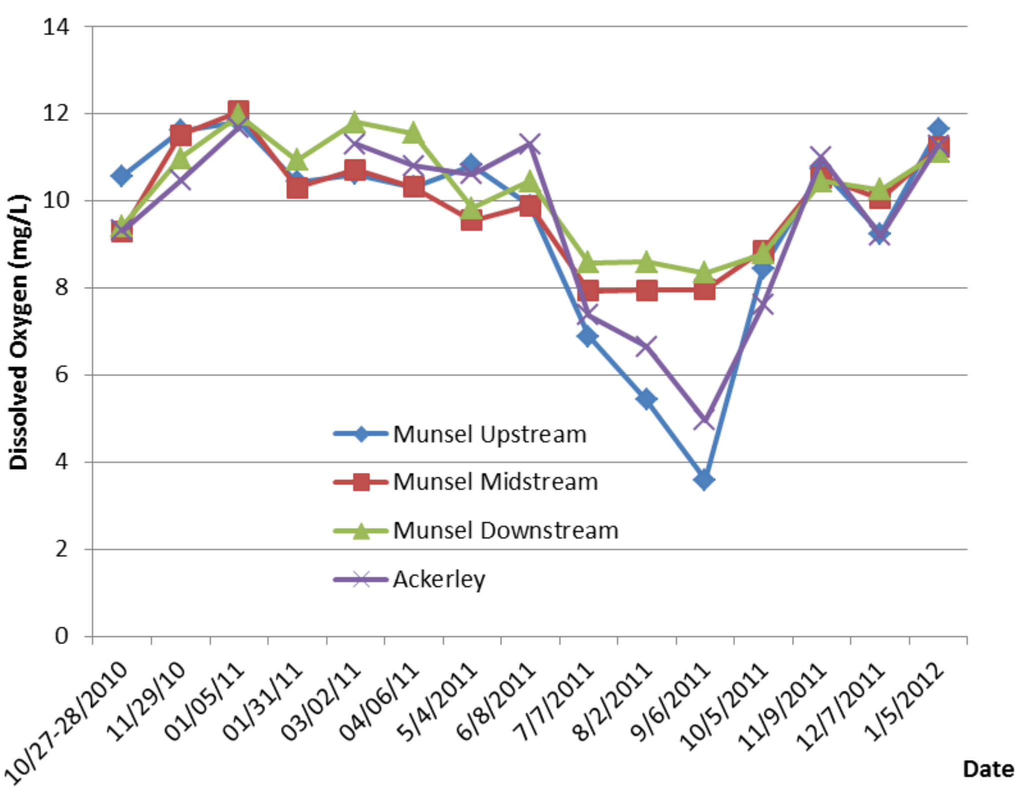


Figure 12. Dissolved oxygen over time, using the YSI Multimeter Probe.

Water Quality (Data Loggers)

Stream Temperature. Hobo data loggers have been recording stream temperature every 30 minutes since October 28, 2010. Temperature data has been uploaded on a monthly basis with the exception of Ackerley Creek, which could not be entered to retrieve the data logger from late January through March and from December through January due to the presence of spawning salmonids and the presence of redds. As shown in Figure 13, stream temperature decreased to as low as approximately 5 ℃ in Winter 2011, increased steadily during the spring, a high near 26℃ in the summer, and in late October 2011 dipped below temperatures seen during that same period in 2010.

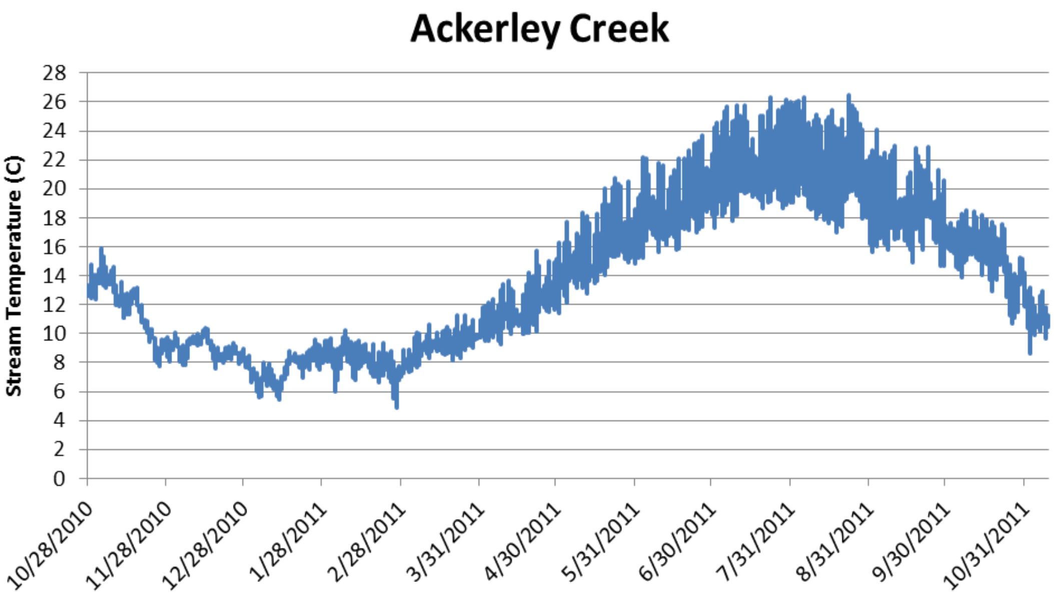
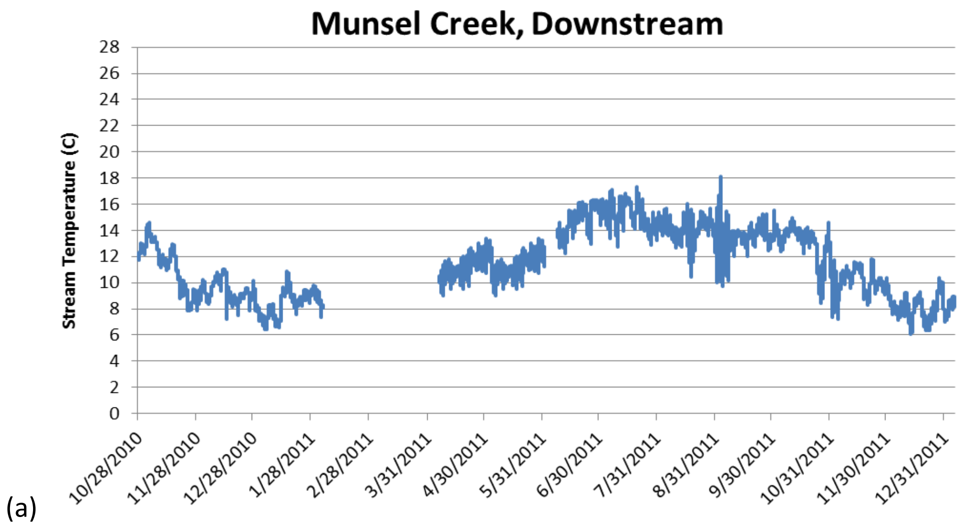
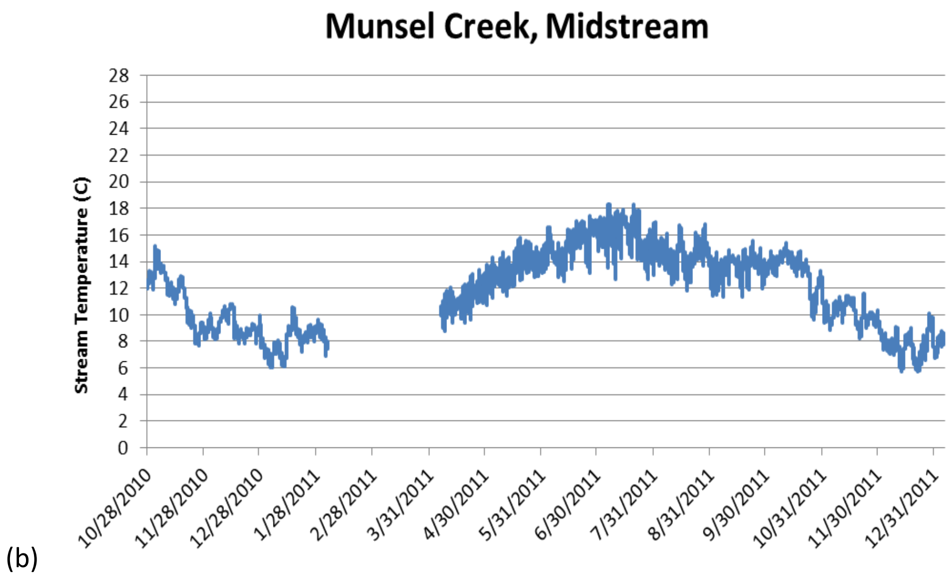


Figure 13. Ackerley Creek Stream Temperatures.

Munsel Creek data loggers also recorded dates one day behind, but only from January 5 to early February. Unlike Ackerley Creek, City staff could retrieve the data loggers in Munsel Creek in February and March. The date was adjusted by one day for that one month period for all Munsel Creek sites. Unfortunately, in the process of retrieving data, the shuttle did not properly synchronize the data loggers again on February 3rd. In this case, the date assigned to the data started on January 29th, five days behind what it should have been (February 3rd). This synchronization error could not be rectified for any of the Munsel Creek sites, because a problem occurred during the process of uploading or saving data in April, which resulted in the loss of March data and made confirming the improper synchronization impossible. Consequently, Figure 14 shows a data gap from February 3rd to April 6th for all three Munsel Creek sites. Synchronization occurred properly on April 6th and has been recording properly since then, except data was either not recorded or lost from June 1st to June 8th for the Munsel Creek Downstream (PWS) data logger (Figure 14a).





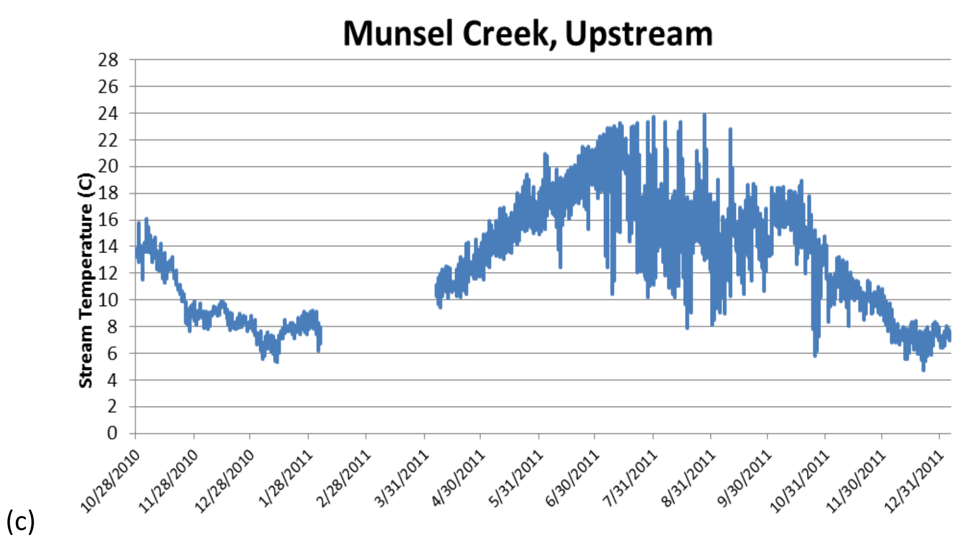


Figure 14. Munsel Creek Stream Temperatures; (a) Munsel Creek downstream near the estuary, (b) Munsel Creek midstream at Munsel Greenway Park, and (c) Munsel Creek upstream near Munsel Lake.

Like Ackerley Creek, Munsel Creek experienced a decrease in stream temperature through the winter months of late December and January, a progressive increase in temperature from April 6 through mid-July, larger diurnal fluctuations from July through early September, and a generally steady decrease starting in November. Figures 13 and 14 show that Ackerley Creek, followed by Munsel Creek Upstream, have reached the highest temperatures of the monitoring sites, both exceeding 20 °C on many days in late spring and in summer while the other sites have remained below 20 °C. Munsel Creek Upstream, in particular, has experienced stream temperature diurnal fluctuations of up to approximately 12 °C in August and appears to have experienced these wide temperature changes consistently during the late spring and summer. Ackerley also experienced large diurnal fluctuations of up to approximately 6°C Munsel Creek Upstream (Figure 14c) shows a similar trend, but to a lesser degree. This may be attributed to their locations almost immediately downstream of lakes.

Surface Water Quality – Lab Results

Total coliform and *E. coli* have been tested monthly since October 2010. Nitrates were tested in October 2010 and in March, June, September, and November 2011. Total Phosphorus was tested in March, June, September, and November 2011. In March and September 2011, a full range of analytes were also tested, as detailed in the original proposal to the USEPA (i.e., volatile organic chemicals (VOCs) (See examples in Table 1), select pesticides, including glyphosate and 2,4-D, (See examples in Table 2), metals (See examples in Table 3), the common ions, e.g., Ca, Na, K, HCO_3, Cl, and SO_4, and caffeine). Table 6 presents results from the lab analyses for the parameters shown. *E.coli* at levels of possible concern has been detected almost every month since April 2011 at one site or more. January 2012 lab results for *E.coli* are not yet available. Lead was detected in a sample from Munsel Creek near a gun club (0.00011 mg/L; reporting limit is 0.000102 mg/L) in September 2011, but not in March 2011. Likewise, Caffeine was detected at MGP, MLK, and ACK (11 ng/L, 49 ng/L, and 15 ng/L, respectively; reporting limit is 4.8 ng/L; ng=nanogam, or one billionth of a gram) in September 2011, but not in March 2011. The caffeine detection suggests human waste may be reaching the stream. The area about Ackerley Creek and Munsel Lake Upstream is on septic while the homes around Munsel Lake Midstream are not.

Table 6. Lab results from surface water quality samples.

Parameter	Date	Result
Nitrates	10/10, 3/11, 6/11, 9/11, 11/11	Not Detected
Total Phosphorus	3/11, 6/11, 9/11, 11/11	Not Detected
VOCs	3/11, 9/11	Not Detected
Glyphosate/2,4-D	3/11, 9/11	Not Detected
Lead	3/11	Not Detected
	9/11	Detected
Caffeine	3/11	Not Detected
	9/11	Detected
E. coli	11/11, 1/5/11, 1/31/11, 3/11, 5/11, 11/11	Detection Below Level of Concern
	4/11, 6/11, 7/11, 8/11, 9/11, 10/11, 12/11	Possible Concern

Table 6 indicates that *E.coli* levels found in April, June, and July 2011 are potentially of concern and Table 7 presents the *E. coli* levels recorded at each site. On these sampling dates, at least one site had *E. coli* levels above 406 mpn/100ml, which is the single sample criterion. These elevated levels occurred in April during the highest flows recorded thus far and at lower flows in June, July, October, and December. A waterbody is considered to be in exceedance of the state standard and thus "impaired" when results show "a 30-day log mean greater than 126 *E. coli* organisms per 100 ml based on a minimum of five (5) samples, or more than 10% of the samples exceed 406 *E. coli* organisms per 100 ml, with a minimum of at least two exceedances" (Oregon's 2010 Integrated Report).

Table 7. *E. coli* lab results from surface water quality samples. Red indicates "High risk," greater than 406 *E. coli* per 100 ml, and yellow indicates "Moderate risk," 127-406 *E. coli* per 100 ml.

Site	Date							
	4/6/2011	6/8/2011	7/7/2011	8/2/2011	9/6/2011	10/5/2011	11/9/2011	12/7/2011
PWS	131.4	1119.9	517.2	112.6	187.2	980.4	31.89	770.1
MGP	816.4	1046.2	579.4	344.8	137.6	387.3	30.5	488.4
MLK	ND	1986.3	36.9	76.7	142.1	42	12.2	142.1
ACK	ND	365.4	5.2	19.9	27.5	34.5	7.5	686.7

Thus far, thirteen samples have been collected from each site, except Ackerley, which only has been sampled twelve times, and more than 10 percent of PWS and MGP samples exceed the standard; MLK does not yet have two exceedances. In addition, a total of 5 samples from the three Munsel Creek sites exceeded 406 mpn/100ml within a 30 day period (June 8-July 7). (Note: the sites are relatively close to one another and may be "autocorrelated," and thus, not independent.) As discussed in previous reports, these levels are sufficient to trigger concern and suggest that Munsel Creek may be "impaired," so the City should continue to monitor these sites to determine whether *E. coli* levels continue to exceed the single sample criterion is recommended. Continued monitoring will help with assessment of seasonal patterns and possible sources or causative factors. Potential sources of *E. coli* in Munsel Creek and Ackerley Creek include: wildlife, domestic animals, the fish hatchery at Munsel Greenway Park, and septic systems north of Munsel Lake Drive.

Summary of Observations

- The water table elevation fluctuates locally, but the overall water table configuration across the area remains similar.
- The lower rainfall that occurred in the late Fall-Winter in 2011-2012 as opposed to that of 2010-2011 can be seen in the individual and collective hydraulic heads for groundwater.
- Groundwater discharges to the Siuslaw River Estuary and to Munsel Creek.
- Groundwater temperature fluctuates seasonally and lags behind ambient air temperature variation by approximately 2 to 3 months.
- The pH of groundwater is low, generally 5.08 to 5.99, similar to typical values associated with precipitation.
- Groundwater conductivity, reflecting total dissolved solids, predictably increases in a downgradient direction, but apparently is also impacted by local land use.
- No *E. coli* were detected in groundwater during the time period covered by this report.
- Five wells were selected to be monitored for nitrate in October of 2011, B-2, B-3, B-15, and B-16, downgradient locations in the residential area in the UGB were sampled, as was Well B-10, located in the downtown area near the hospital.
- Well B-2 had a nitrate concentration of 33.1 mf/L as NO_3-N
- Streamflows were greatest in March and April and lowest in July, August, and December.
- Streamflow data generally indicates that Munsel Creek is a gaining stream.
- Stream temperatures at all sites decreased in the winter months, increased in the summer months, and decreased again in the winter.
- Stream temperatures in Ackerley Creek and Munsel Creek Upstream were similar except for a divergence in August and September while Munsel Creek Midstream and Downstream have been similarly lower in stream temperature in late spring and summer.
- Upstream Munsel Creek, in particular, showed notable diurnal fluctuation in water temperature in the summer (as much as approximately 12 °C).
- Dissolved oxygen decreased markedly in the summer, corresponding with lower flows and the higher stream temperatures.
- No nitrates, phosphates, VOCs, and glyphosate/2,4-D have been detected in surface water samples.
- Caffeine and lead were detected in surface water samples in September 2011.
- *E. coli* was detected at levels of concern in April, June, July, October, and 2011, but further monitoring is necessary to determine whether the creeks may be "impaired."

Reference

Oregon's 2010 Integrated Report. 2010. Oregon Department of Environmental Quality. http://www.deq.state.or.us/wq/assessment/2010Report.htm.