Confluence Environmental Company

Rich Passage Long-Term Beach Monitoring

MAY TO NOVEMBER 2017 BEACH RESPONSE MONITORING REPORT

Prepared for:

Kitsap Transit

March 01, 2018

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Prepared for:

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1.0 INTRODUCTION

Confluence Environmental Company (Confluence) has been contracted by Kitsap Transit to monitor the beaches within Rich Passage during the implementation of commercial service of the fast ferry M/V Rich Passage 1 (RP1) on the Bremerton to Seattle route. In accordance with the recommendation from the Rich Passage Wake Research conducted since 2004, the service is being implemented with a phased approach to allow for continued monitoring and evaluation of beach response along the sensitive shorelines of Rich Passage (Golder 2013).

The 2017 extended summer service was begun with a reduced preliminary level ofservice of 80 one-way trips per week; the operations plan indicates up to 150 one-way trips can be supported by ridership with one vessel in service. A planned additional 12 one-way trips Monday thru Friday during commuting times if a second vessel was in operation. The beaches were monitored for response to the initial service of RP1 using ground-based geo-referenced photographs and laser scanning surveys in August 2017. The August 2017 survey results indicated beaches exhibit typical seasonal patterns of variability (Confluence 2017). Further beach monitoring was conducted using ground-based geo-referenced photographs on October 17, 2017, and laser scanning surveys on November 7, 2017, by Confluence. The location of laser scanning areas and beach photo sites throughout the study area are shown in Figure 1. This report documents the results of the October and November 2017 beach monitoring and comparison of this data to baseline beach monitoring surveys recorded from 2004 to May 2017 during intervals when RP1 was not operating. This report is documenting seasonal monitoring results and the response of beaches to RP1.

2.0 METHODOLOGY

The methods described in this section were used to collect measurements and observations to describe the changes in beach morphology between May and November 2017, including beach response to operation of RP1 (July 10 to November 7, 2017). From July 10 to October 28, 2017, RP1 operated 80 one-way trips per week distributed across 6 days (Monday through Saturday). From October 30 to November 30, RP1 operated 60 one-way trips per week distributed across 5 days (Monday through Friday). Starting December 1, RP1 is operating 80 one-way trips per week distributed across 5 days (Monday through Friday).

Beach observations documented in photographs and laser scanning surveys from 2013 through 2017 are shown along a timeline in Figure 2 and described in the sections below.

2.1 Beach Photo Observations

Observations of beach condition and beach elevations at bulkheads have been made along the shorelines of the Bremerton to Seattle ferry route since June 2004. Beginning in January 2005, geo-referenced and time-stamped photographs were acquired approximately quarterly at

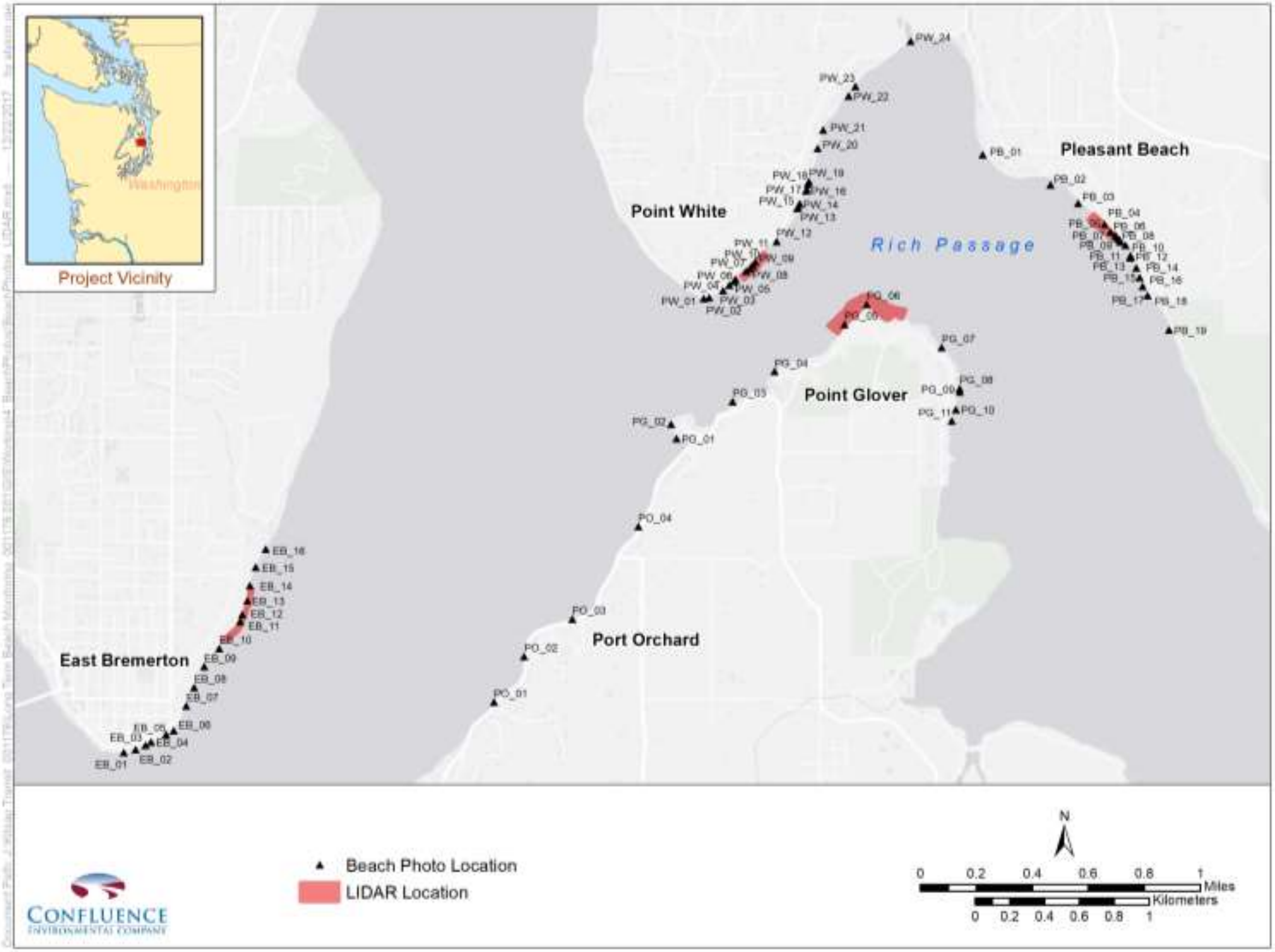
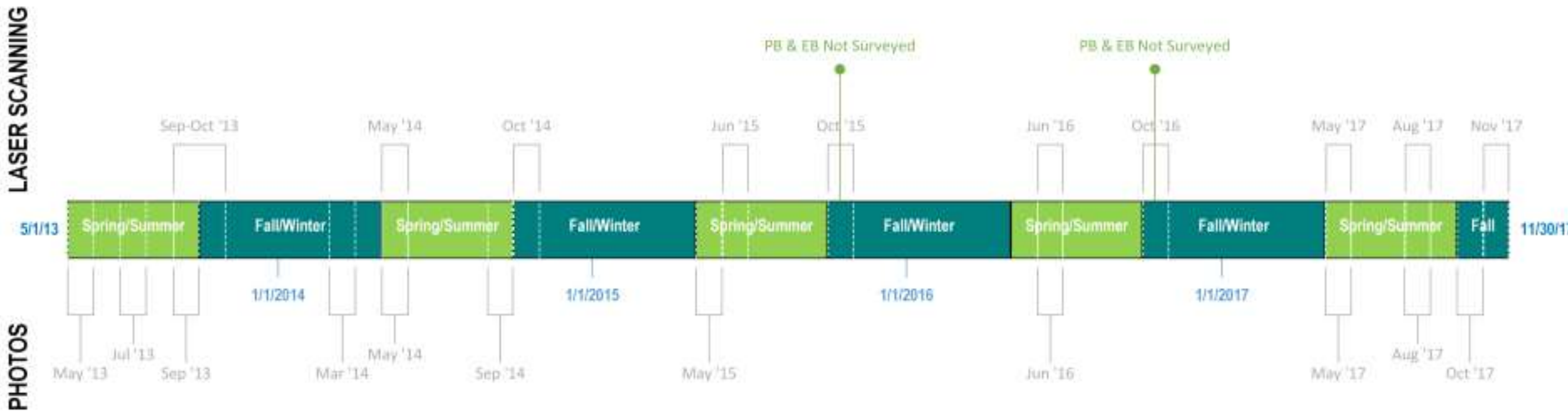


Figure 1. Beach photograph and laser scanning survey (LIDAR) locations along Bremerton to Seattle transportation route



All four areas were surveyed during the specified timeframes unless otherwise indicated.

LEGEND

Fall/Winter = October through April
Spring/Summer = May through September

PB = Pleasant Beach
EB = East Bremerton

Figure 2. Timeline of beach photo observations and laser scanning surveys

several reference locations along the five sections of sensitive shorelines (Pleasant Beach, Point White, East Bremerton, Port Orchard, and Point Glover). The resulting time series of photographs and beach elevations relative to bulkheads for each shoreline for 2005 to 2012 were previously analyzed and documented as part of the Rich Passage Wake Research (Golder 2013). Beach photographs recorded from 2013 through May 2017 were provided to Confluence for analysis as part of the Wake Research data set. Beach photo observations were recorded on August 17, 2017, to identify beach response to RP1 and are documented in an earlier report (Confluence 2017). The beach photographs presented in this report were recorded on October 17, 2017, consistent with seasonal measurements of beach response.

Appendix A presents beach photograph observations and measured elevations at the interface between the beach and bulkhead recorded between 2013 and 2017. Each time series in Appendix A shows a photo from the spring and fall of each year in which they are recorded, with the date of the photo above the image, an inset map showing the location within the monitoring area in which the photo was recorded, and a graph of relative elevation of the beach measured at the toe of the bulkhead as compared to the first elevations recorded in 2005. Beach photo observations prior to 2013 are provided in the Rich Passage Wake Research Report (Golder 2013).

2.2 Laser Scanning Surveys

Laser scanning surveys have been conducted semi-annually in May and October by eTrac Inc. since 2011. These surveys provide three-dimensional measurements of beach elevation over 500-feet-long sections. eTrac performed laser scanning topographic surveys of four shorelines with a Riegl VZ400 scanner mounted on board the MV Especial vessel in November 2017 (Appendix B). Laser scanning survey sites are on Point Glover, Point White, Pleasant Beach, and East Bremerton shorelines. Details of the methods used, locations surveyed, and the quality control and post-processing performed by eTrac are presented in their report, which is attached as Appendix B.

eTrac provided files containing latitude, longitude, and elevation (*.xyz) in a resolution of 0.25 feet (ft) by 0.25 ft. These files provide the coordinates and elevations for points collected during the survey in horizontal datum Washington State Plane North feet and vertical datum North American Vertical Datum 1988. These xyz files were then converted to raster files using ArcGIS. Raster files were completed by Confluence for all analysis presented in this report and for sites and time frames. For data sets where previous analysis was completed by Golder Associates, Inc a visual comparison was conducted to evaluate methodology and results. Confluence's results matched well with Golder Associates' results. Raster files for spring surveys (May or June) were then subtracted from fall surveys (October or November) to determine summer elevation change for three summer intervals prior to vessel service (2013, 2014, and 2016) and during 2017, once vessel service began. The resulting maps were then clipped to include only changes in beach surface elevations. There may be some high value changes (darker red or blues) near the beach/upland interface that are artifacts of overhanging vegetation or complex shoreline armoring structures that are not measured consistently from survey to survey. Beach photo observations were used to determine if large changes in beach elevation shown adjacent to structures were real or artifacts of the survey method.

At Point White and Point Glover, additional analysis was conducted to calculate the total volume of beach change which occurred during the four summer survey intervals. The total volume of change is the summation of all beach change (positive and negative) within a subset of the survey area which was consistently surveyed in all 4 years.

3.0 BEACH RESPONSE RESULTS

The beaches along the five shorelines of East Bremerton, Point White, Pleasant Beach, Port Orchard, and Point Glover exhibit some similar geomorphic patterns, as well as some important differences. Most of the beaches are backed by bulkheads of varying construction and location with respect to tidal water elevations. The beach slopes in front of the bulkhead along Point White, East Bremerton, and Port Orchard are typically steep with gravel overlying mixed sand and gravel that varies in thickness and grain size with increasing distance from the bulkheads. The beach slopes along Pleasant Beach are typically more gently sloping and the sediment grain sizes are smaller, containing more sand and shell hash than the beaches on the adjacent shoreline of Point White. Beaches along Point Glover are pocket beaches bounded by bedrock outcrops and headlands composed of loose sand, silt, and broken shell overlying a hard-bottomed mudstone terrace. The pocket beaches tend to be gently sloping where there is sand, but transition abruptly to deep water where the bedrock outcrops dip seaward.

The condition of each of these beaches can be observed in the beach photo observations in Appendix A. The changes in elevation of each of these shorelines can be observed in Figures 3 through 6, in which red represents erosion and blue represents accretion, and the darker color indicates a larger volume of erosion or accretion.

The results presented in the sections below describe the changes in beach morphology of each shoreline from May to November 2017 when RP1 was operating as compared to summer beach change patterns which have been observed from 2005 to 2017 through beach photo observations and 2011 to 2017 through laser scanning surveys. A series of technical reports submitted to Kitsap Transit documents the seasonal and annual variability during the interval of 2012 to May 2017 when RP1 was not operating (Golder 2013, 2015, 2016, 2017a,b).

3.1 East Bremerton

The beaches along East Bremerton tend to be coarse and depleted of sediment on the southern end of the shoreline as observed at sites EB_01 through EB_04 (Appendix A, Figures A-1 through

A-4). The beach elevations at these sites have gradually decreased since 2005 and experience small seasonal fluctuations of 0.25 to 0.5 ft (Golder 2013). At site EB_01, a decrease of almost 1 ft was observed between May and October 2017. Beach photo observations at sites EB_02 through EB_04 recorded in October 2017 are consistent with the seasonal and annual variability, and show no elevation change at the beach bulkhead interface between May and August 2017.

East Bremerton sites EB_05 through EB_16 (Appendix A, Figures A-5 through A-16) are mixed sand and gravel beaches that exhibit seasonal fluctuations from 0 to 0.5 ft. Beach photo observations at sites EB_05 through EB_16 recorded in October 2017 generally show small changes in beach elevation (less than 0.25 ft) between May 2017 and October 2017. These observations are consistent with historical beach variability (Golder 2013). Two sites, EB_06 (Figure A-06) and EB_16 (Figure A-16), exhibited decreases of about 0.5 ft during the same time frame. At site EB_15 (Figure A-15), beach elevation increased by just over 0.5 ft, which is consistent with historical observations at this site.

The laser scanning survey difference map for East Bremerton (Figure 3) also shows little to no changes in beach elevation, typically +/-0.3 ft. At the north end of the scanning area there are slightly larger elevation changes on the upper beach, indicating sediment has been pushed up the beach and accumulated at the bulkhead interface. This is supported by beach photos at EB_13 (Figure A-13), which show an influx of larger grained sediment on the middle to lower beach observed visually to have changed from sand in May 2017 to gravel and cobble in October 2017. However, an elevation change at the beach bulkhead interface was not measured at site EB_13 during beach photo observations between May and October 2017. In May 2017, a gravel berm with some vegetation is shown seaward of the beach photo elevation measurement location. The gravel berm developed between May 2015 and June 2016 (pre-RP1 operations) seaward of the concrete bulkhead; the berm provides a buffer to potential erosion from wind-waves and wake wash at this location. Therefore, there have not been any changes in elevation observed at the beach photo elevation point measurement since the berm formed in June 2016, but seasonal changes such as fining of the sediment in winter and coarsening of the sediment in the summer on the middle to lower beach are observed in the beach photos and laser scanning survey data.

The beach elevation change measurements along East Bremerton from May to October 2017 are similar in magnitude and spatial patterns to beach change measurements from May to October 2014 (Figure 3). In May to October 2013, during an interval when RP1 was not operating, the beach elevation changes were larger in magnitude and spatial extent than observed in May to October 2017. On East Bremerton, there is no measurable beach response between May and November 2017 which can be directly attributed to RP1 operations.

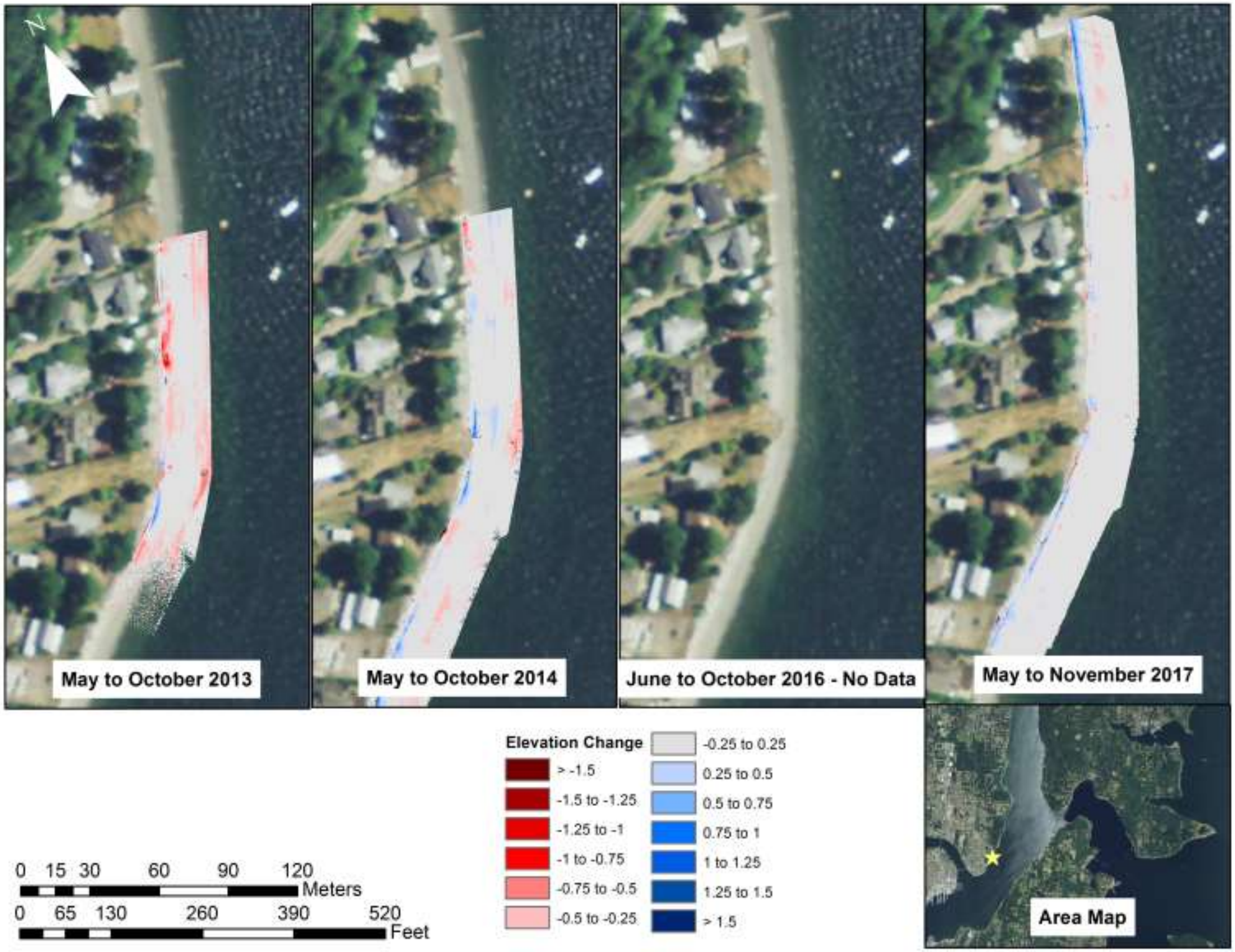


Figure 3. East Bremerton summer elevation change in 2013, 2014, and 2017

3.2 Pleasant Beach

The beaches along Pleasant Beach are composed of mixed sand and gravel and exhibit seasonal variability on the order of +/- 0.5 ft (Golder 2013). The beach elevations along Pleasant Beach are typically lower in the spring and higher in the fall. Beach photo observations along Pleasant Beach (Appendix A, Figures A-17 through A-35) generally show a decrease in beach elevation at the bulkheads at most sites from August to October 2017 that results in a similar, or slightly lower, elevation measurement from May to October. A few sites did appear to increase over this same time frame by about 0.25 ft.

The laser scanning survey difference map for Pleasant Beach (Figure 4) also shows little to no changes in beach elevation, with some moderate accretion high on the beach. This compares well with photos and elevation measurements at PB_05 (Figure A-21), which show an increase in elevation at the beach bulkhead interface of 0.25 ft and coarsening of sediment. Site PB_06 (Figure A-22) also indicates a slight accretion of sediment at the beach bulkhead interface and site PB_07 (Figure A-23) shows slight erosion. The beach photo observations compare well with laser scanning results, which show small volumes of erosion and accretion over the summer of 2017, with slightly more accretion in the northern end of the laser scanning area.

Beach elevation changes were larger in magnitude and spatial extent in May to October 2013 and May to October 2014, during intervals when RP1 was not operating (Figure 4). The beach elevation changes observed in May to October 2017, during RP1 operations, were smaller in magnitude and spatial extent than the other two intervals. On Pleasant Beach, there is no measurable beach response between May and November 2017, which can be directly attributed to RP1 operations.

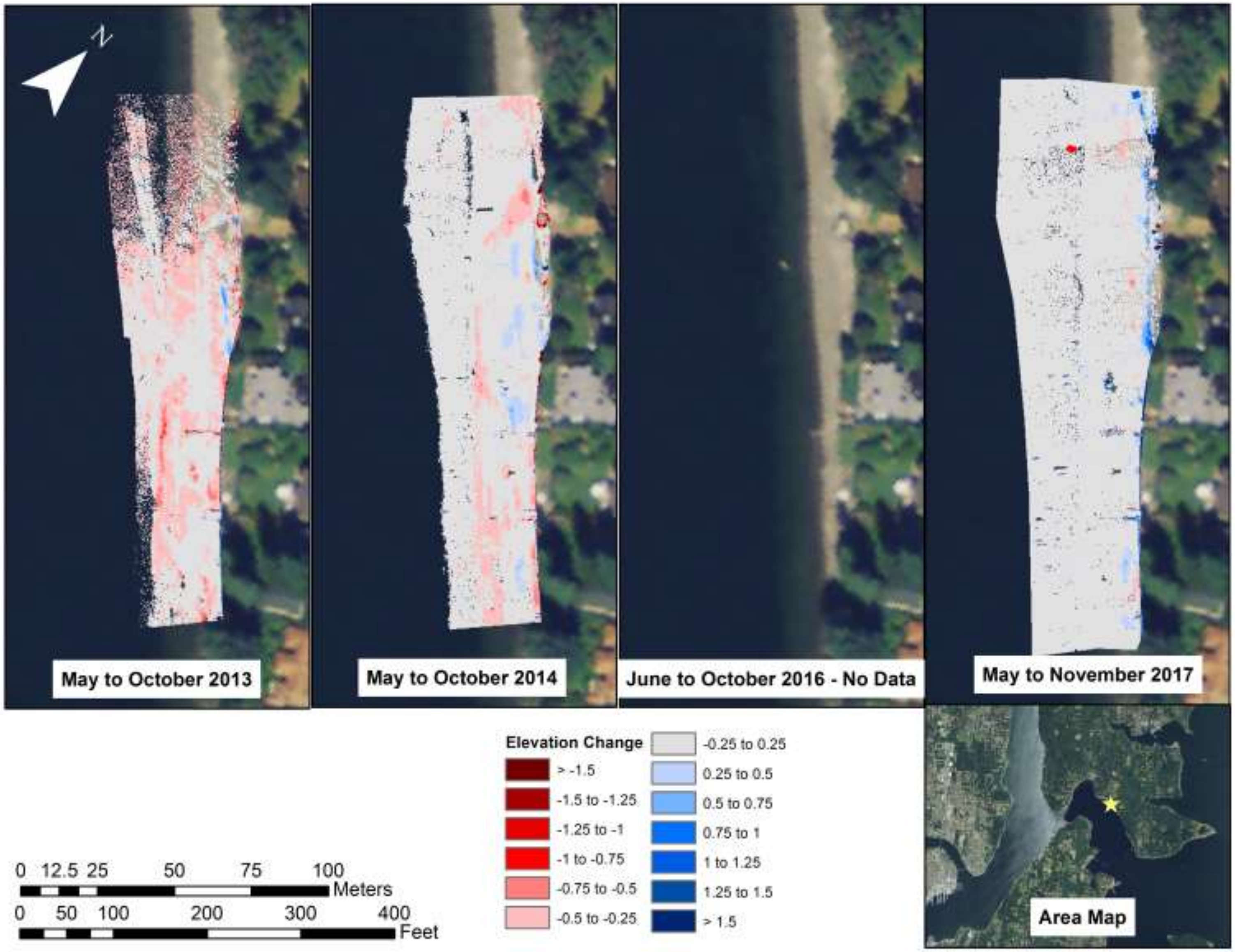


Figure 4. Pleasant Beach summer elevation change in 2013, 2014, and 2017

3.3 Point Glover

The beaches along Point Glover are composed of loose sand, silt, and broken shell overlying a mudstone hard-bottom. These beaches form in pockets between outcrops of bedrock and the harder mudstone which protrude into the intertidal zone and limit along-shore sediment transport. The beaches at the interface with bulkheads exhibit a seasonal variability ranging from +/- 0. 25 ft to +/- 0.5 ft as observed in the beach photo observations (Appendix A, Figures A-36 to A-46). Lower portions of the beach in the intertidal zone vary in elevation on a seasonal basis by as much as +/- 1.5 ft, as observed in the laser scanning difference plots (Figures 5 and 6).

The changes in beach elevations within the pocket beaches of Point Glover vary from beach to beach dependent on local effects. The sediment within the pocket beaches on the west side of Point Glover tends to shift back and forth seasonally due to wind-waves in the winter and vessel wakes (from all size and class of vessels) in the summer. Sediment movement along the west side of Point Glover is limited by the bedrock outcrops and to some extent by groins (stacked rock placed in a line perpendicular to the shoreline). These groins have been present in this area since at least 1992, based on imagery available from the Department of Ecology. The bulkhead was constructed in 1952, based on Kitsap County parcel information, and it is likely the structures were built at that time (Figure 5).

Seasonal shifts in sediment can result in localized increases in elevation of the beach at the bulkhead in the summer and fall, as observed at site PG_04 (Figure A-39). In the laser scanning survey difference map, the shifts in sediment are shown as a large red patch on the northeast end of survey area, indicating erosion of sediment which was deposited to the southwest as indicated by the blue colors (Figure 6). The alternating pattern of erosion and accretion (deposition) is similar for the years of observation when the fast ferry operation was not running (2013, 2014, and 2016) as compared to 2017, when the fast ferry service was operating. The geographic extent and intensity of erosion and accretion patterns varies from year to year.

The pocket beaches on the east side of Point Glover at sites PG_07, PG_09, and PG_10 show increases in the elevation at the bulkhead between May and October 2017 (Figures A-42, A-44, and A-45). The laser scanning survey difference map also shows an area of accretion of sediment on the upper beach (blue) and an increase in elevation of 0.5 to 2 ft in the pocket beach to east of Point Glover (Figure 7). The localized accretion on the upper beach (dark blue) has been associated with a creek outlet, where sediment accumulates at the mouth of the creek during the summer and is then dispersed throughout the pocket beach during high creek flows and storms in the fall and winter (Golder 2015, 2016, 2017a,b). In the same area, there is erosion low on the beach during the summer (red), which is replenished with sediment over the winter from the process described above.

The magnitude and spatial extent of the erosion and accretion patterns along the east side of Point Glover vary extensively from year to year (Figure 7). As a result, further analysis was conducted to calculate the total volumetric change within a subset of the survey area (Figure 8). The results of this analysis are shown in Table 1; a positive number indicates net increase in volume within the calculation area and a negative number indicates net decrease in volume.

Figure 5. Location of groin structures on Point Glover.

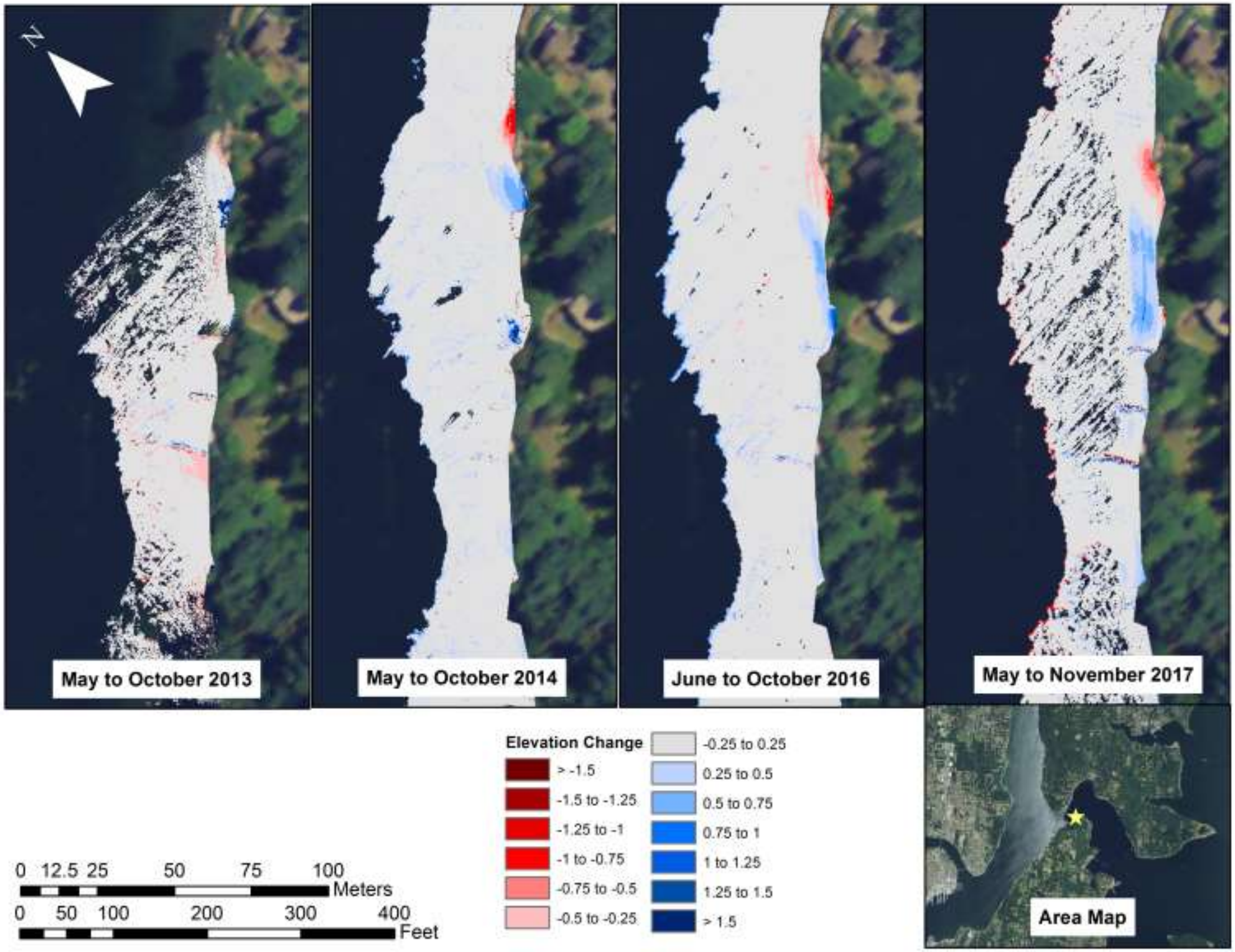


Figure 6. Point Glover West summer elevation change in 2013, 2014, 2016 and 2017

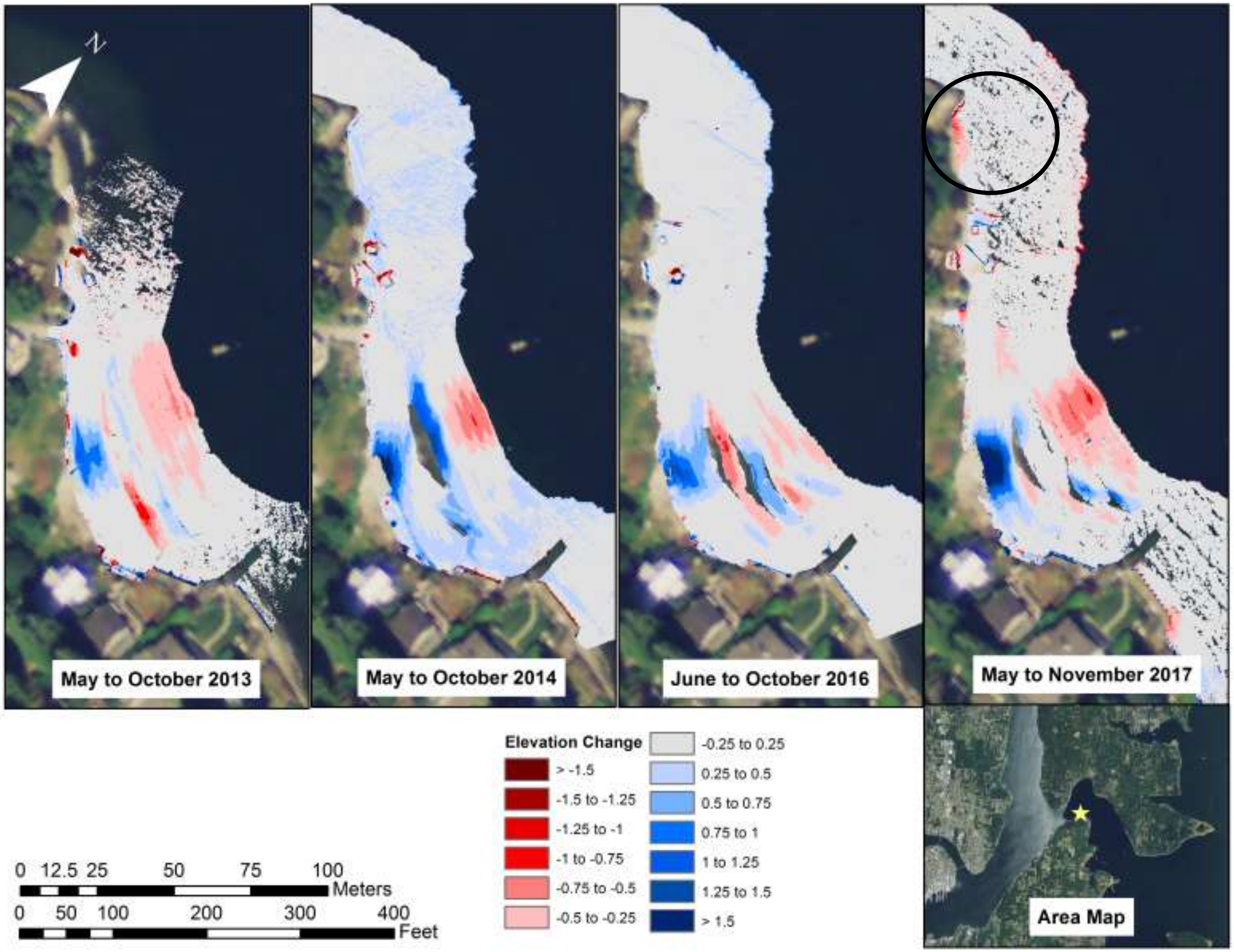


Figure 7. Point Glover East summer elevation change in 2013, 2014, 2016 and 2017

Figure 8. Point Glover East volume change calculation area

The total beach volume change between May and November 2017 was nearly equal to the total beach volume change between June and October 2016; a net increase in beach volume of 58 cubic yards (CY) in 2017 as compared to 66 CY in 2016. The largest volume of beach change of 258 CY (net increase) was measured from May to October 2014. During May to October 2013, a total volume of -56 CY was measured, indicating a net loss of material from the area.

Table 1. Volume change in calculation area on Point Glover East

Site	Date Range	Volume Change (cubic yards)
Point Glover East	May - October 2013	-56
Point Glover East	May - October 2014	258
Point Glover East	June - October 2016	66
Point Glover East	May - November 2017	58

Much of beach elevation changes on the east side of Point Glover from year to year and season to season can be attributed to patterns in precipitation, which generates the flows in the creek in this pocket beach. The amount of precipitation for months and years in which beach volume change has been calculated are shown in Table 2. The total amount of precipitation between May and October 2017 was the lowest of the 4 years analyzed (Table 2) which allowed for a larger accretion of sediment at the creek mouth than any other years. There was a net loss of material from the Point Glover East area in 2013, and there was an unusually high amount of precipitation in September 2013: 6.17 inches as compared to between 2.23 and 0.59 inches the other years. The elevation change maps show there was less accretion on the upper beach between May and October 2013, which is likely due to the September rain event generating creek flow which might have washed out some of the sediment that had accreted at the creek mouth. In 2014, the total beach volume change was 258 CY resulting in net accretion of four to five times the amount of other years. Although the total amount of precipitation in 2014 is similar to other years, the individual precipitation events were smaller and therefore would generate lower creek flows and move less material per event. In September 2013, there was an intense weather event which generated 1.7 inches of rain as compared to the largest event in October 2014, which generated 1.26 inches of rain. The precipitation patterns from May to October 2016 as compared to May to November 4, 2017, are similar, and therefore the total beach volume changes is also similar.

The volumetric change analysis on Point Glover East indicate there is no measurable beach response between May and November 2017 that can be directly attributed to RP1 operations.

Table 2. Precipitation measured at Seattle-Tacoma Airport from May through October for 4 years (National Climatic Data Center 2018)

Month	Precipitation (inches)			
	2013	2014	2016	2017
June	1.30	0.73	1.77	1.52
July	0	0.70	0.72	0
August	1.35	1.81	0.17	0.02
Sept	6.17	2.23	1.05	0.59
October	1.54	5.16	6.19	5.72
TOTAL	10.36	10.63	9.9	7.85

There is an erosion hotspot at the north end of the Point Glover East survey area from May to November 2017 (circled area in Figure 7) which is not evident in the laser scanning difference analysis during previous summer intervals. In the circled area there was a decrease in beach elevation of approximately 0.25 to 0.5 ft across a section of beach that is 50 ft long by 15 ft wide between May and November 2017 Beach photo site PG_06 is slightly west of this area of erosion and shows that the beaches on Point Glover have been experiencing long-term erosion since 2013. There is a beach scarp (vertical drop in elevation at the shoreline) visible in the beach photos at site PG_06 indicative of shoreline erosion since 2013 (Appendix A, Figure A-41). The historic beach photos suggest the changes observed from May to November 2017 are an ongoing process of erosion at this location which predates the operation of RP1. However, this location will continue to be monitored closely with photos and laser scanning during subsequent observations intervals.

3.4 Port Orchard

The beaches along Port Orchard tend to be coarse and depleted of sediment as observed at sites PO_01 through PO_04 (Appendix A, Figures A-47 through A-50). The beach elevations at these sites experience small seasonal fluctuations of 0.25 to 0.5 ft (Golder 2013). Beach photo observations at sites PO_01 through PO_04 recorded in October 2017 are consistent with the seasonal and annual variability, with slight elevation increases (0.25 ft) from May to October. Laser scanning surveys are not conducted along Port Orchard, since it exhibits minimal change seasonally and annually. There is no measurable beach response along Port Orchard between May and October 2017 that can be directly attributed to RP1 operations.

3.5 Point White

The beaches along Point White tend to be coarse and depleted of sediment on the southern end of the shoreline, as observed at sites PW_01 through PW_06 (Appendix A, Figures A-51 through A-56). The beach elevations at these sites have gradually decreased since 2005 and experience small seasonal fluctuations of 0.25 to 0.5 ft (Golder 2013). Beach photo observations at sites PW_01 through PW_05 recorded in August 2017 are consistent with the seasonal and annual variability. At site PW_06, beach elevation has decreased about 1 ft since August 2017, resulting in a similar elevation to that measured in May 2017.

Point White sites PW_07 through PW_18 (Figures A-57 through A-68) are mixed sand and gravel beaches that exhibit seasonal and annual fluctuations on the order of 1 ft. Waves of gravel move from the south to the north along Point White over a 4-year cycle (Golder 2013) and result in localized highs and lows in beach elevation between sites PW_07 and PW_18 during different years. Beach photo observations at sites PW_19 through PW_24 recorded in October 2017 show little to no changes in beach elevation between May 2017 and October 2017 (Figures A-69 through A-74).

The laser scanning survey difference map for Point White (Figure 8) shows approximately 0.25 ft of erosion across localized areas of the beach, with smaller areas of accretion high on the beach during the 2013, 2014, and 2016 summer seasons. These patterns are the result of cross-shore transport of sediment from the lower beach to the upper beach, and along-shore transport of sediment along the upper beach which has been directly measured using gravel tracers (Golder 2017b). In 2017 the pattern is similar, but there is less accretion on the upper beach than has been recorded in previous years (2013, 2014, and 2016). Similar patterns are shown in the beach photos observation.

At site PW_07, near the southern extent of the laser scanning area, beach photos indicate a decrease in beach elevation of approximately 0.4 ft from May to October 2017 (Figure A-57). A similar decrease of 0.2 ft was observed from May to September 2013 (Figure A-57). At beach photo site PW_08 there is no net change in beach elevation from May to October 2017, but there is an increase of 0.7 ft from May to August 2017 followed by a decrease from August to October 2017 (Figure A-58). The observations of accretion from May to August and erosion from August to October at site PW_08 are likely the result of a wave of gravel which moved along shore at this location between May and October 2017. At site PW_11 a small decrease in elevation (0.2 ft) at the bulkhead was measured over the course of summer 2017 (Figure A-61).

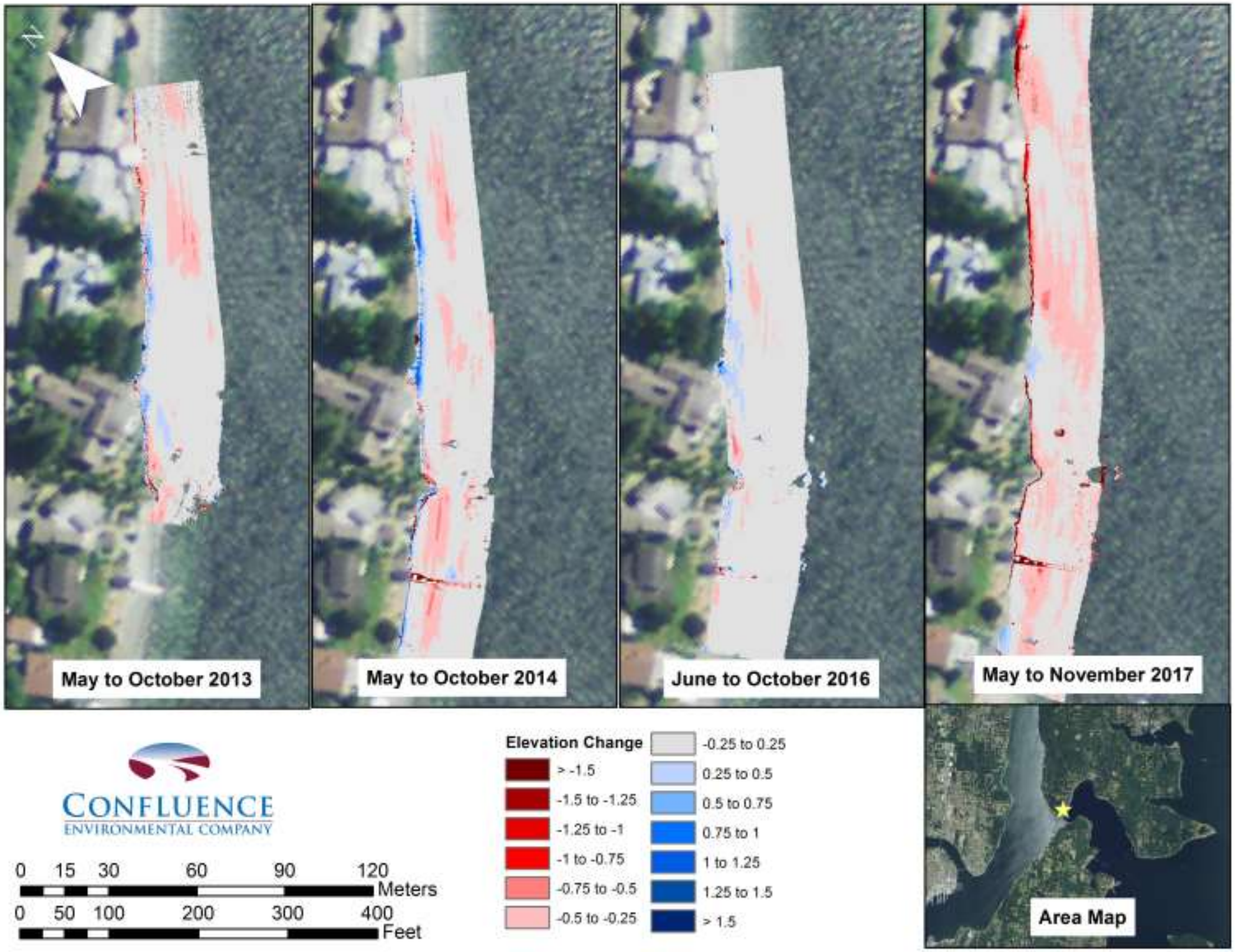


Figure 9. Point White summer elevation change in 2013, 2014, 2016 and 2017

The magnitude and spatial extent of the erosion and accretion patterns along Point White vary from year to year, so further analysis was conducted to calculate the total volumetric change within two subsets of the survey area (Point White North and Point White South [Figure 10]). The results of this analysis are shown in Tables 3 and 4, where a positive number indicates net increase in volume within the calculation area and a negative number indicates net decrease in volume. The total beach volume change between May and November 2017 was nearly equal to the total beach volume change between May and October 2014: a net decrease in beach volume of 63 CY in 2017 as compared to 70 CY in 2014 at Point White South and a net decrease of 81 CY in both 2017 and 2014 at Point White North. The smallest volume of beach change of -17 CY at Point White South and -35 CY at Point White North was measured from May to October 2014.

The volume change analysis indicates there is a net decrease in the volume of sediment within the calculation areas during each of the four summers. A similar analysis will be conducted after the May 2018 laser scanning surveys are completed to determine if the sediment is being deposited outside the calculation area and is transported back into the calculation area during the winter. Although there is a net loss of sediment between May and November 2017, this pattern is similar to previous years and, therefore, there is no measurable beach response along Point White in summer 2017 that can be directly attributed to RP1 operations.

Table 3. Volume change in calculation area on Point White South

Site	Date Range	Volume Change (cubic yards)
Point White South	May - October 2013	Not available
Point White South	May - October 2014	-70
Point White South	June - October 2016	-17
Point White South	May - November 2017	-63

Table 4. Volume change in calculation area on Point White North

Site	Date Range	Volume Change (cubic yards)
Point White North	May - October 2013	-95
Point White North	May - October 2014	-81
Point White North	June - October 2016	-35
Point White North	May - November 2017	-81

Figure 10. Point White volume change calculation area

4.0 CONCLUSIONS

Beach photo observations were recorded in October 2017, approximately 14 weeks after M/V Rich Passage 1 began operations of 80 one-way trips per week. Laser scanning surveys were completed at the beginning of November, approximately 16 weeks after service began.

These observations indicate that in most areas, summer seasonal patterns are consistent between 2017 and years prior to vessel operations. Although there appears to have been less accretion of sediment high on the beach in the summer of 2017 at Point White, the net volume change across the beach was the same as previous summers. In addition, photo observation and laser scanning surveys from August 2017 as compared to November 2017 indicate there may have been accretional areas that had started eroding from winter storm events by the time of the November laser scanning survey.

Point White and Point Glover are both sediment supply limited systems (depleted of sediment over time) and closer to the ferry sailing line than other sites. As a result, these two shorelines are more sensitive to sediment transport from local effects such as wind-wave events and precipitation events that change creek flows. These areas will continue to be closely monitoring during subsequent beach observations. A calculation of annual beach volume change will be conducted after the May 2018 surveys to differentiate between seasonal shifts in sediment volumes and potential sediment volume changes because of transport by vessel wake wash.

The second phase of operation is proposed to increase the peak operation schedule to 100 one-way trips. Since beach response patterns are consistent with seasonal changes, the second phase of operation can be implemented. The beaches will be monitored again in May 2018 to record both the complete seasonal cycle as well as any beach response to the increased level of operation.

5.0 REFERENCES

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