Module Goals

Students will be able to:

1. **Design** and **conduct** a complex TLS and/or SfM survey to **address** a geologic research question.
2. **Articulate** the societal impetus for answering a given research question.
3. **Justify** why TLS and/or SfM is the appropriate method in some circumstances (if both methods are used).

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Introduction and Motivation

Our main objective for this project is to compare old scans of Magnolia Bluff taken in 2015 to a modern scan our class preformed on April 22, 2017 to see any differences between the scans. The main questions of our study are to see if any erosion has occurred, such as much of the Bluff has eroded since the last scan in 2015, how fast is the erosion, and the rate of the erosion. Based on our finding, we could determine whether the slopes are stable or not. We used two methods, SfM and TLS, to conduct our survey.

Our area of study, Magnolia Bluff, is part of Discovery Park, located in the northwestern area of Seattle in the Magnolia region bordering Puget Sound. Seattle is situated in the Puget Lowland. The city geological materials distributions consists of "postglacial 16%, late glacial deposits 12%, Vashon glacial deposits 60%, pre-Vashon deposits 9%, and bedrock 3%. Of these 49% are considered fine-grained deposits, 19% are considered intermediate or imbedded deposits, and 32% are considered coarse-grained deposits" (Booth and Trust, 2008).

Seattle is surrounded by bodies of water, Puget Sound to the west and Lake Washington to the east, with three major geologic features: Seattle uplift, Seattle fault zone, and Seattle basin, that underlines the area. The modern landscapes was "molded by glacial and glaciofluvial scouring and deposition, tectonic folding and faulting, inundations by volcanic mudflow deposits, modern processes such as landslides and stream erosions, and extensive human modification" (Booth and Trust, 2008). Addition modern hazards includes earthquakes,

tsunamis, seiches, volcanic events, and compressible/expandable soils (Booth and Trust, 2008). Magnolia Bluff itself is mainly composed of mostly fine grained materials, such as sands and clay, and is situated on a beach. Above the bluff is a dense vegetated area. During high tides, the water surfaces would cover majority of the Bluff lower region, thus wave/water motion is the main erosion process occurring there. Majority of the Bluff is only accessible during low tides.

Since Magnolia Bluff is situated in the beach portion of Discovery Park, the area is frequently visited by numerous visitors. Our survey in the area would give us an insight of whether the area is safe for visitors to be around or should be closed off due to instability. This would act as a sign of warning in preventing major disasters (i.e. landslide or caving of the Bluff) and give us vital information on possible prediction for when Magnolia would collapse on itself.

Workflow and Methods

Equipment used in this field survey includes: camera (model: Pentax K200D) plus back-up batteries and memory card, scanner (model: Riegl VZ4000), heavy duty laptop (used to store scanned data), power generator plus back-up battery (for the scanner), 2 long electrical cords, 6 reflectors, 7-8 paper makers with metal spikes (to help wedged them in place), 1 large tripod (for the scanner), 6 smaller tripods (one for each reflectors), large collapsible wheeled cart (used for easy travel), cloth and paper towels, large rainproof cover (to shield equipment placed in cart from rain), few large umbrella (to shield scanner from rain), and measurements tape.

Before collecting the data, we had to first consider how many scans we wanted to take and where the scanner should be placed so we could fully capture the area of interest, Magnolia Bluff. When thinking of the location(s), we had to consider the movement of the tides behind us to ensure that during the scanning process, which takes around 30 minutes. By then, our equipment and we would not be knee-deep in water if the tides were to come in. With limited

time, we split up into two teams; one team to set up the scanner, while the other spread out the reflectors and markers across the entire bluff. The markers and reflectors were spaced apart from each other, some at different heights to see some variations within the scan. At the time (around 9:30 A.M.), the weather was still very cloudy with moderately gusty cold winds and no sign of rain, yet. The ground was completely saturated, especially the completely saturated fine silt on the beach that acted almost like quicksand and sank anything on top down an inch or so. We had to work against the wet mud, making sure the tripods, especially the scanner's tripod, was evenly leveled and completely stable before connecting all the cables into it.

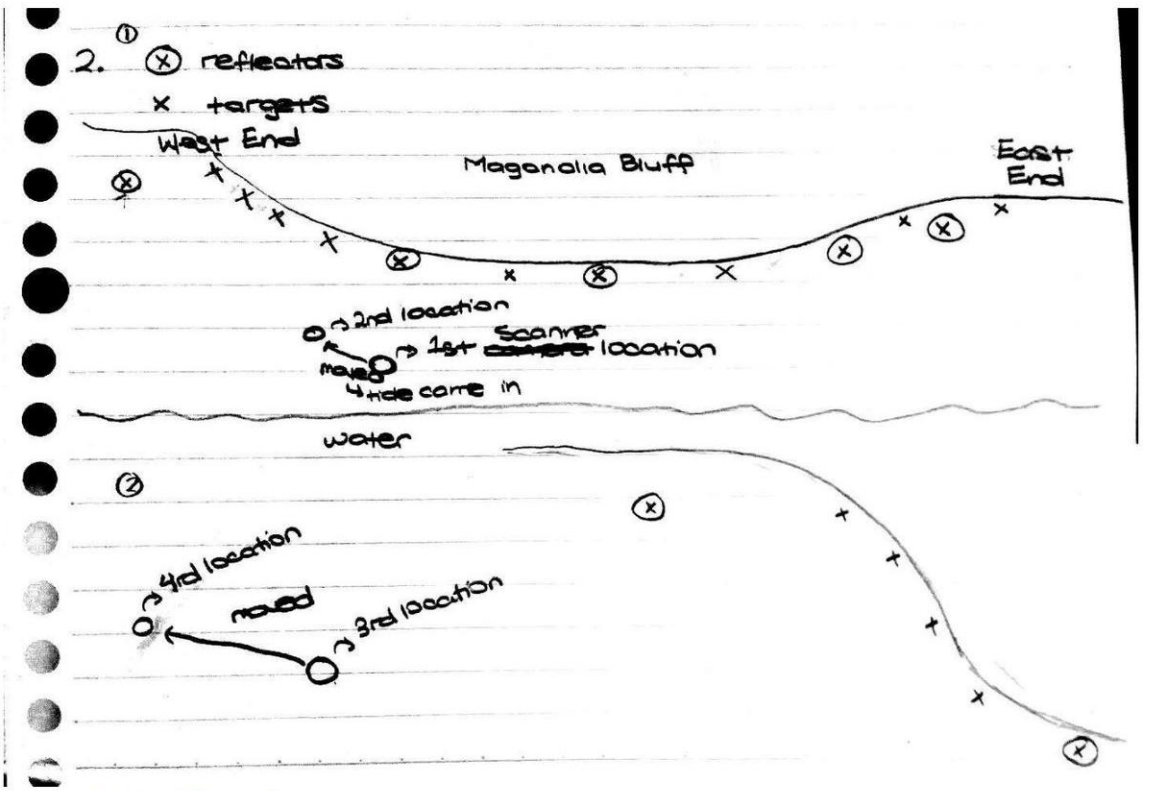

Figure 1: Map of Location

Initially, we wanted to obtain the entire premises of Magnolia Bluff, so we picked out two locations, one on the lower west end and another on the east end, of where our scans would be. Our initial (flat area on the outer part of the beach) and secondary (hilly area a few meters in

front of the initial) locations were picked when the tides were still far behind us around 10 A.M., but after setting up the equipment the tides had moved in towards our area. We were forced to relocate. At that point, we abandoned the idea of taking the scan on the east sides of the Bluff out of fear that we would be inundated by the tides. Location 3 and 4 only gave us the western nose of the bluff, but that was the best we could have done considering condition. We did start to scan at the third location around 10:30 A.M., but decided to move to the fourth location to get the full extent of the western nose of the bluff. Those two locations mainly consist of beach cobbles and sand that were moderately wet, but not entire saturated like the first and second locations. Since we decided on taking scans of the western nose only, we moved some of the paper markers from the east end to that location. When we were setting up the scanner at the fourth location around 11 A.M., heavy rain and gust began. One person had to cover the scanner from the large umbrella and worked around the scanner to prevent raindrops from interfering with the equipment. Occasionally, the high wind blew away the paper markers or knocked down the reflector so those had to be fixed.

While the scanning was in progress, two people went and took a series of photos of the entire Magnolia Bluff going from the West end to the East end. Those in charge of the photos, tried to make sure to include at least three reflectors, targets, or any distinguishable reoccurring features are in each photo. The goal was to take close-up and far view shots of the bluff. The wet and bumpy ground made it hard to travel over to the bluff locations, while the upcoming tides made it difficult to move out further onto the beach to take distant photos of the cliff. Gusty cold winds would distort the position of the markers and make the bluff wall moderately damp. When the first person took the photos, the clouds covered the sky but no rain was present. When the second person took the photos, heavy rain came in mid-way through the shoot along with slightly

stronger winds. Droplets of water did drop on the camera lens at some points. Some of the photos had small sections of smeared or white blobs caused by the rain drops. Furthermore, at some point, the paper targets moved in the wind, subsequently additional photos of those areas had to be retaken just in case.

The scanned data from the VZ4000 was stored as points cloud data in the RiSCAN software. This software was later used to analyze the collected TSL data from this survey and the previous 2015 survey. Photos taken by the Pentax K200D was processed using Agisoft PhotoScan Professional software to create a dense point cloud. Measurements were taken for between certain objects, reflectors, or targets to be used as distances references in the PhotoScan program. Additionally, we used ENVI Classic (64-bit) as a tool to compare the 2017 models to the 2015 model to see if any differences have occurred between the two-year gaps. After the completion of the model, we had to translate RiSCAN model into a LiDAR file, while the PhotoScan model into a TIFF file. From there we could convert them into readable vectors (LiDAR file) or use their original file setting (TIFF file).

Data Summary

In total, 197 photos were taken. All the photos were taken by the same camera, the Pentax K200D, on the night mode setting. The photos were all taken by hand without the use of any additional stabilizers or leveler (i.e., tripod). The qualities of the photos are moderately good, from around 0.6 to 0.8. This type of data collection is decent enough for this kind of feature. Magnolia Bluff was a stationary feature and, fortunately, with no sign of motions present during the the survey, therefore the Pentax K200D was sufficient to complete this field survey. However, limited amount of sunlight, windy conditions, and, later into the day, heavy rain did prove challenging during data acquisition. Blurry images caused by raindrops on the camera lens

were not included in the images. There are multiple shots of the locations like the blurry images, so removing them won't affect the overall final product. About 100 photos were used to create the model. These photos covered the entire area of the bluff.

Based on the map of the area, there is extensive coverage of the western portion of the bluff. Since the markers in this area was changing at some point during the shoot, additional photos had to been taken, but that did make the overall process of creating the model more confusing as PhotoScan did not recognized majority of the markers/reflectors. There were enough photos covering the Eastern portion of the Bluff. Even so, in the final model, the photos did successfully recreate the entire area of Magnolia Bluff. Although, the model covered the entire vertical portions of the area, there wasn't enough data to cover the entire height of the bluff. Technically, there was enough data to cover the vertical aspects, but not the horizontal aspects.

However, majority of them had to be cut down to make the model manageable, so only the western section is included in the final model.

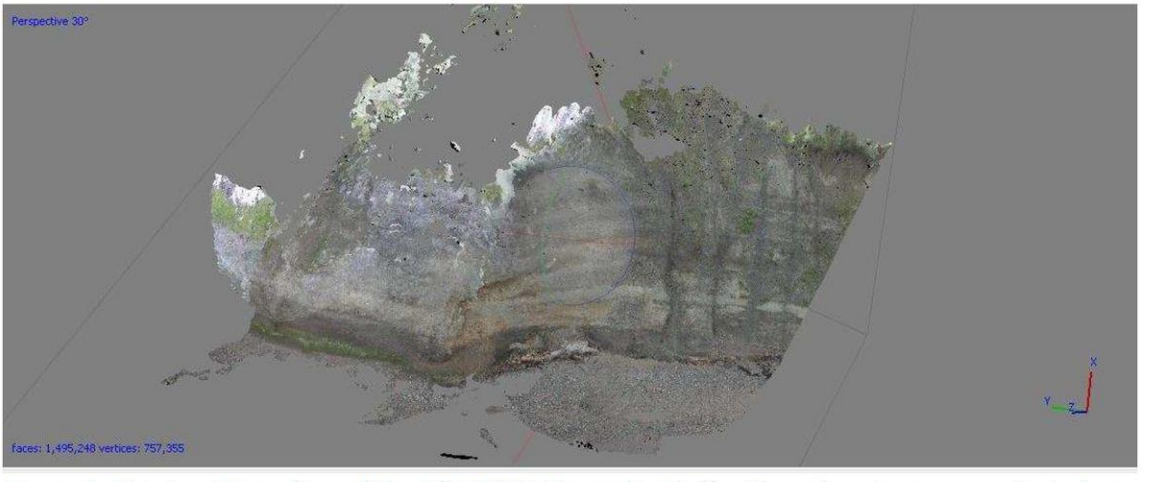

Figure 2: This is a 3D surface of the SfM 2017 Magnolia Bluff with surface imagery projected on to the surface in PhotoScan.

Data Exploration, Analysis, and Results

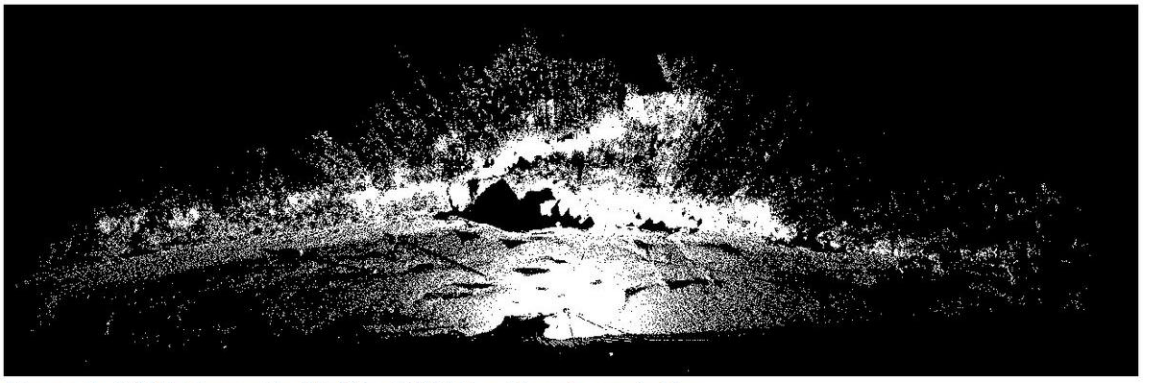

Figure 3: 2015 Magnolia Bluff in RiSCAN without vegetation.

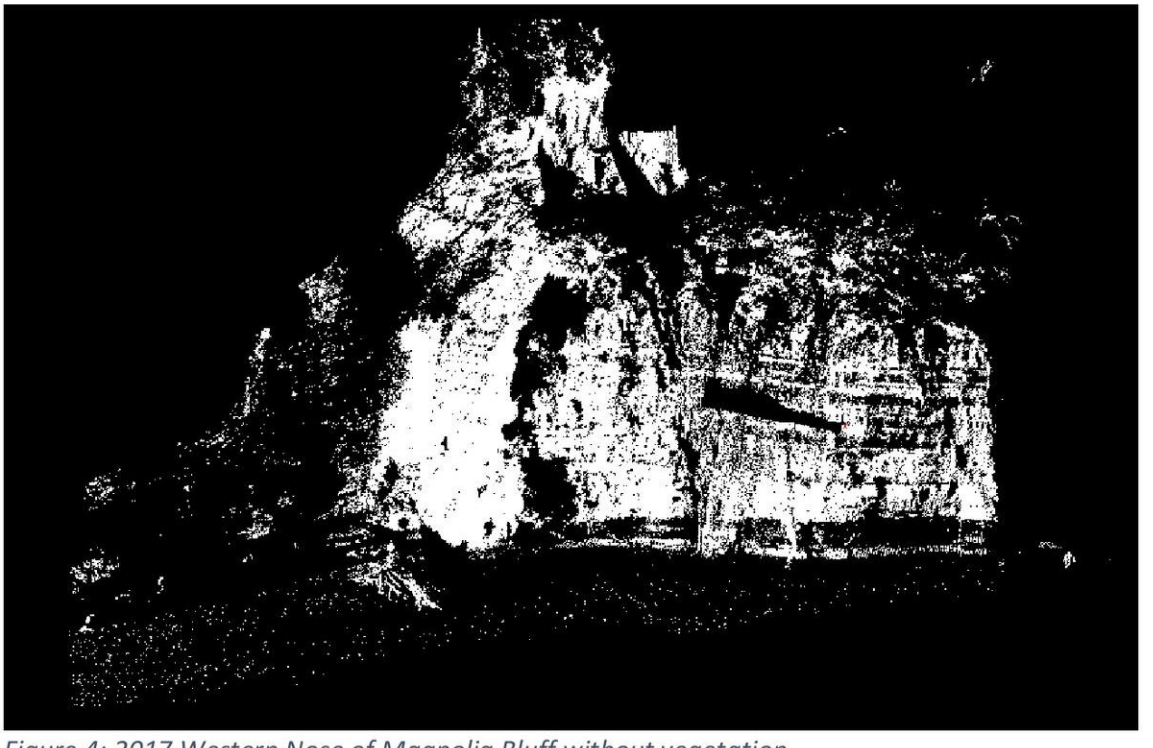

Figure 4: 2017 Western Nose of Magnolia Bluff without vegetation.

When the SfM and TLS models were generated, there were some gaps within them. The LiDAR surface model is about 0.2 meters in resolution with accuracy of about 0.034 meters. For the SfM model, the image has a resolution of 0.1 meters with an accuracy of 0.5 meters. The TLS model would have a lower quality resolution in this case, but its accuracy is better than the SfM model. In RiSCAN, for the 2015 data, after removing the vegetation, it was a bit difficult to

see the bluff clearly. Besides the Bluff area, the beachside seems to have been included in the overall final results, but it did not interfere much with the overall analysis. In ENVI, those areas would be read as ground elevation (0 or in the negatives), but some of the gaps were filled when the DEM was generated (trees that were removed), so it was confusing to tell which was beachside and which were trees pockets.

For the 2017 RiSCAN model, the removal of vegetation didn't create much differences between the tree pockets and the beachside since the beachside was not included in the generated model. However, since the 2017 data was only limited to the Western nose of Magnolia Bluff, it makes sense there's lower amounts of noises (i.e. people present in the background of the scan) by the surrounding. Moreover, the smaller area of the Western portion visually gives us a better view of the bluff than the entire scanned view. It's hard to tell which areas of the bluff and areas of everything else, namely trees and people. In the first generalizations of the PhotoScan SfM model, there were white blobs that covered a small portion of the lower region on the Eastern side of the bluff and part of the top with random scattering of points all over the model. After cleaning up the data more, the random scattering of points lessens, but the white blob was still there. The origin of the white blobs is unresolved.

Working with the final product of the TLS data, it was possible to pin-point the differences in elevations between them with ENVI. However, since the 2017 scanned image only covers the western nose of the bluff, it was difficult to accurately measure or calculate the total amount of erosion, as we don't have data for the rest of the bluff. It could be possible with the SfM 2017 image, but the accuracy of that data is lower than the TLS data as the other has a much lower quality than LiDAR data. Also, in the LiDAR data, it's possible that the output model incorporated tree elevations with the bluff elevations, so there's a possible bias between the

actual height of the cliff and the model's reading of the height of the cliff. This would be true for the PhotoScan model as there were branches laying on the ground near the makers and reflectors. Furthermore, there are anomalies, the mysterious white blob, that affect the overall final products. Besides those anomalies, even with a large set of photos, most of them were not useable.

A comparison of the models showed that the bluff seemed to have expanded outward to the side since 2015. Using the 2017 LiDAR image, we got an estimated reading of around 16-18 meters for the bluff total heights, while in the 2015 LiDAR image, it was about 5-6 meters. This does show that the bluff has gained heights since 2017 with the materials eroded from above has builder up on the left sides of the bluff or was washed away by the tides. Or perhaps there was an error when we translated the data from RiSCAN to ENVI that caused this major change in elevations. Another note is that we had included portions of the beach area into the 2015 model, so that could had offset the values somewhat. Furthermore, the two survey were done in two very different locations on the beach. The differences of scan locations could have caused the variation in the reading of elevations we observed in ENVI.

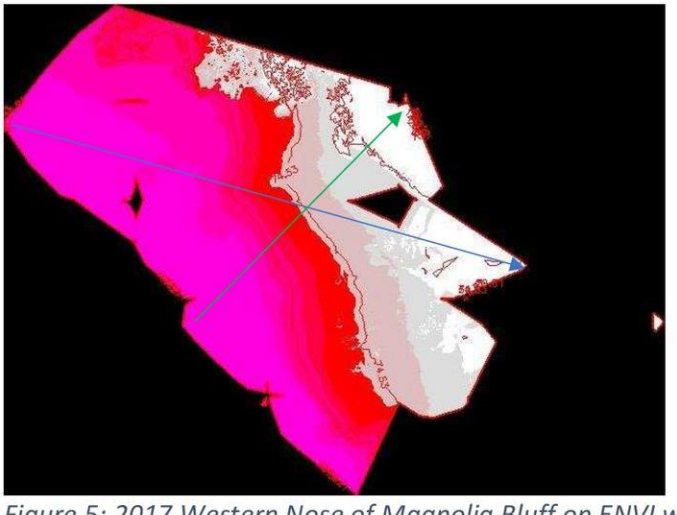

Figure 5: 2017 Western Nose of Magnolia Bluff on ENVI with Contour lines. Pink is the lower end while white is the higher end of the value spectrum.

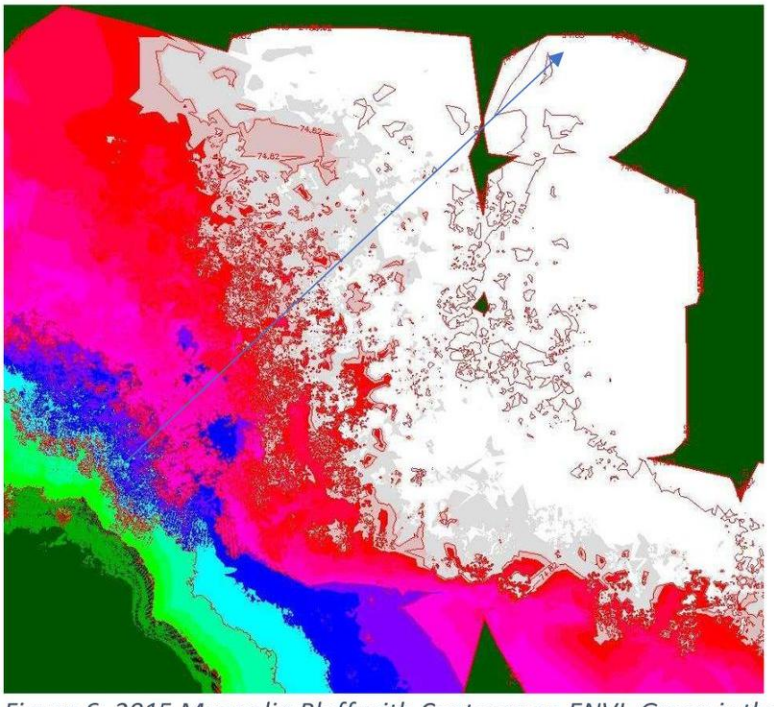

Figure 6: 2015 Magnolia Bluff with Contours on ENVI. Green is the lower end and white is the higher end of the value spectrum.

Figure 5 and 6 are set to '16 LEVEL' color scale with dark green representing the lowest data value and white representing the highest data value. In figure 6, the elevation, shown by the blue arrow, goes from 1.5 to 20 meters. Majority of the upper portion of the cliff ranges from 18-19 meters, with 20 meters being the highest elevation. In figure 5, the elevation, shown by the blue arrow, goes from 9.84 to 18 meters, while the green arrow goes from 9.8 to 20.7 meters. The measurements does shows that the 2015 model has a larger range in height than the 2017 model. The lower elevation is possibly the beach area. Also, the bluff seems to have gained 0.7 meters at its peak height, while losing about 1 meter in height everywhere else. When we added in contour lines, there were more variable variation in the elevation in the 2017 image than the 2015 image, so the slope slides seems to have increased going upward. Additionally, from the PhotoScan model, we could see that chunks of lose materials on the eastern portion of the bluff,

felled off and piled on top of one another. This does indicate that the bluff is still actively being eroded.

Project Summary

From 2015 to 2017, Magnolia Bluff have slowly been eroding away with a max of 1 meter lost in height. Vegetation that was present during 2015 seems to have disappeared in the from the 2017 survey or were moved further away from the bluff. Given all our observations from SfM and TLS data, along with the fact that the entire premises are exposed to windy, rainy conditions, and constantly changing tides every day, the slope stability is slowly declining. Magnolia Bluff is slowly being reclining inward due the changing tides and windy conditions in the area. The bluff mainly consists of sand and clay materials, which are highly valuable to water processes. Parts of the bluff already been falling off it in the eastern part, so even if the bluff seems stable now, water processes is slowly weakening the slope. Vegetation above the bluff does seems to help maintain its current stability, but this is possibly true for the upper portion of the Bluff only and not for the lower portion. The lower portion seems to be more sustainable to erosion induced by water processes, though this would only occur during high tides.

Comparing between the SfM and the TLS, the TLS would be best method in getting the necessary coverage for large-scale with high accuracy and accomplishing the object for this study. While there are many difficulties, such as checking to make sure we have all the equipment we need, the long period of time to set up the camera and for the scanner to run for one complete scan, etc., the amount of scanned needed to obtain the entire area of interest is lesser when compare to SfM data collecting needs. Also, the process of creating a workable for the Bluff is faster with the TLS data compare to the SfM. The resolution is higher when compared to the SfM data; we could obtain more information from the TLS in comparison.

With the SfM, we must make sure we took many (100 or so) of the entire area of interests. In the PhotoScan program, it takes a very long time in adding (if the program didn't register the target/maker), changing (since it putted them in the place), deleting/unpinning (target/reflector not in photo boundaries at all), or fixing (in random space and nowhere near the target/reflector) the markers for all the targets/reflectors in the before creating the dense point cloud, which also takes an extremely long time to do. At times, PhotoScan would increase the total number of hours needed for the point clouds to be create or stay at the same time even when several hours had already passes. However, once the dense point clouds are done, if the model is distorted in some ways, we must manually fix everything, which becomes intensely tedious to do. Even when those areas where fixed multiple times, the image didn't change much. These two part is simply frustrating and the only major problems associated with this program. PhotoScan seems to be only recommended to be used if the datasets are small, such as 50 images or less.

This would be different if the photos were taken from different platforms. Aerial platforms, such as drones, kites, planes, etc., would have less difficulties capturing a bird-eye view of the area; possibly making it easier to spot all the makers/targets on the ground. In this case, few of the difficulties mentioned before would be gone, making the SfM technique the better method when time is limited. However, aerial platforms do have their own limitations. For example, kites are restricted to windy areas as they required wind to maneuver and its flight pattern is dependent on the wind direction. Planes only limitation is that they are quite expensive to use. Drones depend on human visually coordinated and battery life; this would not make them a good tool to be used during long periods of time.

Despite all the difficulties associated with PhotoScan, the model turned out well. We could visually see the color details of the Bluff, which was not present in the RiSCAN program.

In previous usage of the RiSCAN program, we could see a moderate natural color model of Rainer Vista, but for Magnolia Bluff, it was only visible when we set the color tone to single color. Another surprise was that, as mentioned above as a negative feedback, PhotoScan had only recognized one maker out of the total 14 reflectors and targets. In our previous use, the program could recognize majority of the markers while in this project, it didn't at all. It should have recognized at least majority of the reflectors as those never changed location, unless they got blown down by the winds (only one had fallen). Therefore, it should have automatically created more than one maker, but it didn't, which is the most surprising part.

References

Troost, K. G., and D. B. Booth. "Geology of Seattle and the Seattle Area, Washington. *"Reviews in Engineering Geology* 20.0 (2008): 1-36. Web.

Magnolia Bluff Technical Report

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1. INTRODUCTION

1.1 Motivation

This report is intended to detail the methods and execution of assessing the erosion of Magnolia Bluff in Discovery Park, Seattle. It highlights the methods and procedures used to collect data and the programs utilized for data analysis in order to quantify the erosion of the bluff and investigate the uniformity of erosion.

1.2 Background

Magnolia Bluff is located in Seattle, WA along the Puget Sound. The bluff is made up of unconsolidated glacial sediment from the most recent glacial event maximum in the area.[1] These bluffs are subject to long-term erosion and landslides due to the loose structure of the sediments. Waves continue to beat down and erode the bluff, which is a desirable residential area, as well as a recreational area, providing a reason to investigate the rate that this erosion is occurring and if it is constant over the entire shoreline.

1.3 Scope

This report will spend time detailing how the field component of the data collection was designed and executed, as well as summarizing the raw data that was collected. It will further discuss the point cloud model that was formed from the data and the quality of the resulting surface model. Finally, it will summarize all findings and takeaways from conducting this erosion analysis.

2. METHODS

2.1 Overview

To get an idea of the state of erosion that Magnolia Bluff was experiencing, we decided to gather data through two different methods of remote sensing: Structure from Motion (SfM) and Terrestrial Laser Scanning (TLS). Both methods of data collection required unobscured views of the eroding bluff face, and identifying markers or features that could be used to tie data together to form data sets for erosion analysis.

2.2 Equipment

Equipment was brought to the site on a large wheeled cart. Large umbrellas and a large rain cover were utilized to avoid electrical equipment being exposed to rain. Reflectors were placed on individual tripods and placed along the shore in six locations. Paper targets were tacked to the bluff itself with metal spikes in eight places along the bluff at varying heights. A Nikon camera was originally used for photo collection for the SfM aspect of the data gathering, but ran out of power shortly after arrival in Discovery Park. The Nikon was then replaced with a Pentax K200D, which was not GPS-capable like the Nikon but did have its own set of backup batteries. A heavy duty laptop, power generator, back-up battery, and two electrical cords were used to support a Riegl-VZ4000 Terrestrial Laser Scanner (TLS).

2.3 Collection Locations

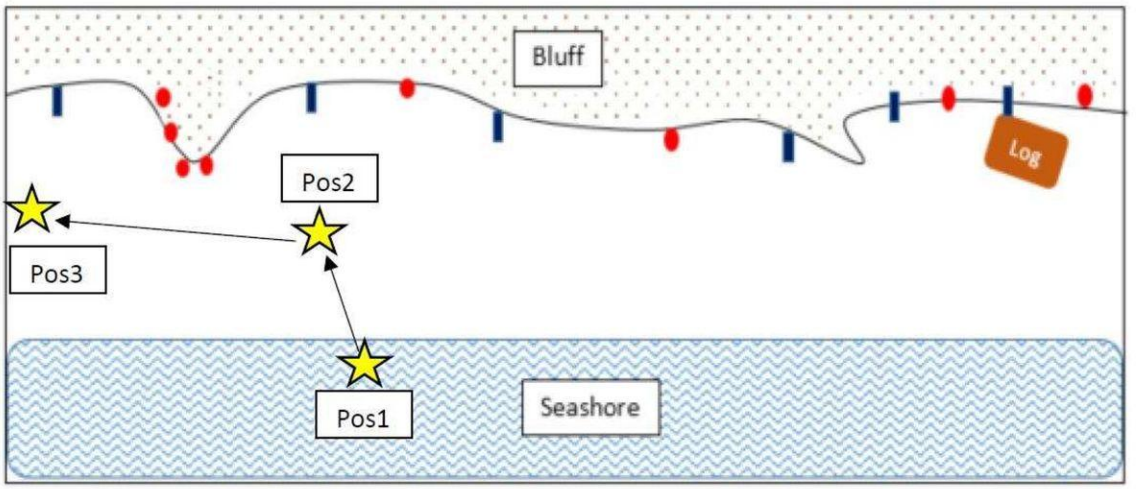

Figure 1. Locations of targets (red ovals) and reflectors (blue rectangles) for photo collection, and scan positions (yellow stars) for TLS scans[2]

2.4 Required Data

Data for the formation of a dense point cloud was gathered through photos taken with the Pentax camera. Photos were stored on a memory card within the cameras and uploaded to a computer after the excursion was complete. This data was stored on a google drive account until the photos were compiled into a point cloud using AgiSoft PhotoScan Professional. The resulting point cloud was then converted into a digital elevation model (DEM). Data gathered by the TLS scanner was collected in a point cloud format; in RiSCAN Pro 2.0 this data was converted into another DEM. Both of these data sets were compared to a TLS data set from 2015 through tie points in ENVI to determine the rate of erosion occurring along the bluff.

2.5 Procedures

Both methods of data collection used for this study work best under cloudy/overcast weather situations to avoid shadows and reflections. Windy weather is not ideal due to the extra movement in brush and targets. On the day data was collected, the weather was mostly cloudy and windy, with intermittent rain. While it was not the ideal data collection weather, the equipment brought along (namely the umbrellas and rain cover) was helpful in offsetting difficulties that may have arisen from exposure to water.

2.5.1 Photo Collection

When collecting photos for Structure from Motion (SfM) to create a point cloud, several targets/reflectors were placed in the same view as the target object. Photos were taken without any zoom or filters applied, and without unnecessary objects or features blocking the target object. Photo-taking was taken with consideration towards both vertical and horizontal angles so the entire target was captured, ideally with at least three targets/reflectors in view along the entire bluff (see Figure 3). Data collection was completed during midday, in overcast windy weather. Umbrellas were used during photo-taking to prevent rain from affecting the cameras; raindrops that affected the data collection and umbrellas that entered view were masked or not used in the point cloud formation.

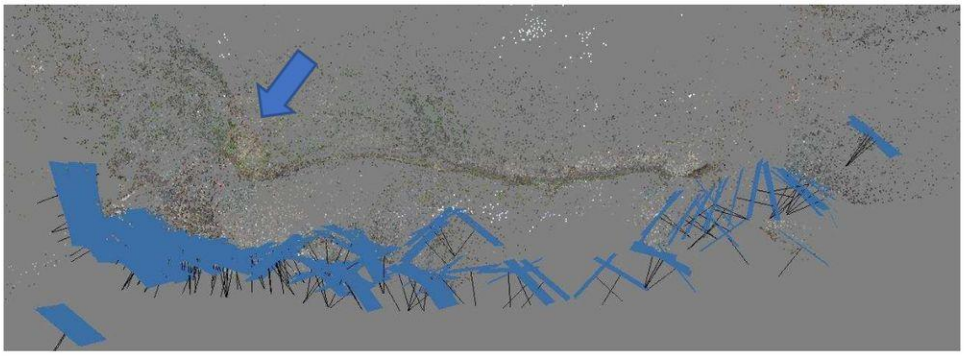

Figure 3. Positions of cameras for each data collection photo with arrow highlighting the most documented portion of the bluff.

2.5.2 Scan Collection

Scan data collection is also ideal on overcast days. Multiple positions were scanned to create an overlap between images and prevent shadows; however, scan position #1 had to be aborted due to the rising tide along the beach, and scan position #2 was located too close to the bluff to capture all the necessary data (refer to Figure 1). GPS locations were utilized for each scan position so that they could be compared to scans from previous years. Positions were centered around a portion of the bluff that jutted out further than the rest. A rain cover was used to protect the equipment from water exposure.

2.6 Model Generation

To create a point cloud, photos were imported into a folder that was opened through AgiSoft PhotoScan. Images that had at least 20% of the target obscured (e.g. by an umbrella) were deleted from the data set. The photos were then aligned and markers were detected by the program. One marker was detected; all other markers and reflectors were manually added in and adjusted in each photo to provide accurate data for the program to form a point cloud.

Measurements collected in the field allowed three “rulers” to be added. The first measurement was between a target placed near the center of the bluff’s length and a large gray rock located on the ground just below it measuring 2.9 meters apart. The second measurement of 16.8 meters was for the distance between a reflector located on a tripod and another reflector sitting on a log. The third and final measurement was between a target located by the backpack and equipment storage, and a slightly more elevated target several feet to the left; the distance between these two targets measured 3.52 meters.

A dense point cloud was formed at high quality and with moderate depth filtering, taking five days (with intermittent breaks) to generate. After the model was complete, extraneous points were removed. A mesh was then formed from the point cloud and converted into a DEM that could be analyzed in ENVI. The scanned data collected by the TLS was imported into RiSCAN and the desired portions of the bluff were turned into polydata objects. Vegetation captured in the scanned data was hidden, and the data left behind was converted into an LAS LiDAR file. In ENVI, this file was converted into a raster file so that it’s information could be compared to a TLS scan from 2015 and the DEM created from the point cloud.

3. DATA

3.1 Data Collected

In total, 197 photos were collected of Magnolia Bluff as digital negatives (.dng). Three scans in total were collected with the Riegl-VZ4000 that were compiled into projects by the machine’s software and could be opened and manipulated by RiSCAN Pro 2.0.

3.2 Platform Analysis

Due to the size of the bluff, these were acceptable platforms for analyzing erosion. A larger scale operation involving LiDAR that was not ground-based would be unnecessary since the depth of the scans and the point cloud could be determined, and features along the bluff were distinct. The shore along the bluff was accessible by foot so both SfM and TLS were good methods of collecting data.

3.3 Analysis Criteria

Photos used for SfM data analysis had a clear focus of the bluff in question. Some photos containing views of the umbrellas being carried around were eliminated from the data set used to create the point cloud. Other photos containing large portions of the sky were masked, along with brush that extended about the bluff's boundaries, to prevent unnecessary additions to the point cloud. In total, 190/197 photos were used to build the final dense point cloud. Scan collection data from the TLS were refined to exclude irrelevant terrain like brush and trees so that only the bluff itself was utilized in the final elevation models.

3.4 Data Coverage

The range of data collection for the SfM photo series was larger in terms of the area covered while using the cameras. The horizontal area covered during photo collection can be seen between the bluff and seashore in Figure 1. There were more photos taken around a portion of the bluff that jutted out from the rest, located in a similar area to the scan positions for the TLS (see Figure 2). Below, the individual camera positions (blue rectangles) can be seen.

From this figure it is clear that the data collection was not spread evenly across the bluff's face. However, since we are only analyzing one portion of the bluff to compare erosion, it is okay for the focus to be on the section that is jutting out, as it will be easier to distinguish from the rest of the bluff in data from previous years.

4. ANALYSIS AND RESULTS

4.1 Surface Model

In terms of spatial sampling, the SfM program was able to create a model that was to scale and could be properly converted to a DEM. In general the point cloud was accurate when it was fully formed, with some distortion around the edges where the sky was not completely masked and around logs.

4.1.1 Feature Readability

Once the model was formed via a dense point cloud, it was easy to see features of the bluff that matched the raw photos collected. Around halfway up the bluff, the points are less dense and the features are harder to read, likely due to all data collected being from the base of the bluffs.

4.1.2 Model Resolution

The resolution of the model is realistic since the measurements of geologic features within the point cloud were placed into the model based on values measured between physical targets and reflectors in the field.

4.1.3 Model Deficiencies

The main portion of the bluff that was studied was near some logs and where some equipment and backpacks were stored. These logs caused some distortion near the base of the bluff, but ultimately did not detract from the portion that would be used to

study erosion. It is more clear that the portion of the model near the logs is distorted when it is compared to some of the photos taken for the point cloud; the red bags located under the logs appear to be a few feet away in the model. Overall, acquisition of the data could have been improved by being more thorough/collecting more photos at the other end of the bluff so that multiple sections could be compared to past models, instead of just one particular section being well built.

4.2 Point Cloud

Figure 4. The final dense point cloud model

4.3 Erosion Analysis

The DEMs formed from SfM and the TLS scans were difficult to align and match with the previous scan from 2015. From the point cloud model we can see that erosion is occurring at the base of the bluff, likely from higher tides. It was also seen that the northwestern portion of the bluff has experienced landslides, leading to its smoother sloped surface.

4.4 Stability Implications

The erosion seen at the bottom of the bluff implies that as time passes, the landform will become more unstable. Parts of the bluff that remain above eroded rock may transform into landslides as the bluff can no longer support itself from the base.

5. CONCLUSIONS

5.1 Findings

The intention for this work was to analyze data collected from Magnolia Bluff on April 22nd, 2017 and compare it to previously gathered data. Primarily it was seen that erosion occurred along Magnolia Bluff between 2015 and 2017. Both SfM and TLS provided 3D DEMs that accurately depicted the bluff's features. Erosion was not necessarily uniform, occurring along the bluff's base and along steeply-sloped faces.

5.2 Method Comparison

SfM was the easier option for visualizing how the bluff looked because it offered photos and formed a 3D model that was distinctly colored. The downside to using this program is that the formation of the point cloud and the mesh was time consuming, which may be a deterrent if a larger portion of the bluff was to be analyzed. SfM also would be helpful if used multiple years in a row because it allows the visual component as well as being able to create an elevation model, which provides two ways to analyze the data. Additionally, seeing the dense point cloud and being able to compare it to previous models would make it easier to see what sections of a DEM should be focused on to determine rates of erosion. Both methods of data collection could have been improved by collecting data as the tide was going out and/or when it was not raining to prevent image distortion (SfM) or being limited in distance from the bluff by incoming waves (SfM and TLS).

5.3 Opinions and Observations

What surprised me the most about using a TLS scan is that the program can identify vegetation within a rock face and select it. Granted, it wasn't 100% accurate, but

its ability to distinguish brush from the bluff was much quicker than selecting all of the points manually. SfM surprised me when it only detected one marker. The assignment guide did mention this would happen, but after the first assignment using the program I expected a bit more. I do understand that the fact that the targets and markers kept disappearing and moving around made it much more difficult for the program to recognize them.

6. REFERENCES

1.Kiehl, David; “Quantitative Analysis of Shoreline Erosion” Department of Earth and Space Sciences. Online: https://www.ess.washington.edu/content/people/student_publications_files/kiehl--david/kiehld_MG_posterTWSrev.pdf
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