FINAL SUBMITTAL
REVISION 0

EXPLORATION PLAN

GEOTECHNICAL INVESTIGATION AND ANALYSIS
HAINES BEACH ROAD LANDSLIDE
HAINES, ALASKA

FEDERAL NO. TBD/STATE NO. SDRER00317
PSA NO. 25213018/NTP NO. 02

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2 JULY 2021

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ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
ADAS	automatic data acquisition system
AOC	Area of Concern
BGC	BGC Engineering, Inc.
DGGS	Alaska Division of Geological and Geophysical Surveys
DOT&PF	Department of Transportation and Public Facilities
EP	Exploration Plan
GPS	Global positioning system
LT	Landslide Technology
MASW	multichannel analysis or surface waves
MEMs	Micro Electro-Mechanical Systems
PSA	Professional services agreement
R&M	R&M Consultants, Inc.
S&A	Siemens & Associates
SR	Southcoast Region
VWP	vibrating wire piezometer

1.0 INTRODUCTION

The Department of Transportation and Public Facilities (DOT&PF) retained R&M Consultants, Inc. (R&M) under Professional Services Agreement Number 25213018, Notice to Proceed Number 02, to perform a summer geotechnical field investigation for the Haines Beach Road Landslide geotechnical investigation and analysis project. R&M has subcontracted Landslide Technology (LT) and Siemens & Associates (S&A) to provide geotechnical and geophysical investigation and analysis services. R&M will provide geophysical technicians, terrestrial survey services, and project management and contracting services. BGC Engineering, Inc. (BGC) was also subcontracted to provide peer-review of reporting products and public messaging services.

Geotechnical Investigation and analysis will be conducted in accordance with this Exploration Plan (EP). Drawings **A-01 through A-02** of Appendix A provide a location and vicinity, and a geotechnical/geophysical investigation location map.

1.1 INVESTIGATION OBJECTIVES

DOT&PF, Southcoast Region is requesting the services of a Geotechnical Engineering Consultant to assist by providing data on geotechnical hazards to allow the Haines Borough to make informed decisions on resuming recovery activities, reconnecting impacted utilities, and re-establishing a temporary roadway connection to residential properties. Investigation activities are also intended to gather data which will aid in the development of recommendations for future work activities in the Area of Concern (AOC) and potentially provide opinions with regard to re-occupancy of impacted residences.

1.2 PROJECT PURPOSE AND NEED

On Dec 2, 2020, damaging storms impacted several Southeast Alaska communities. The greater Haines Borough was impacted by flooding, landslides, and debris flows, causing widespread and severe infrastructure damage, mandatory and voluntary evacuations, and loss of life. Several local, state and federal agencies responded along with local contractors to assist the Haines Borough with the initial response. The Alaska Division of Geological and Geophysical Survey (DGGS) and DOT&PF deployed a team of geoscientists with different specialties to assist by collecting data to support decision making by the Local and State EOC teams.

The most severe impact was a large landslide along Beach Road which completely destroyed two homes, significantly damaged one home, blocked road access and disrupted utilities to approximately 20 homes. Two residents of these homes are unaccounted for and presumed to have perished. After ten days of on-site analysis, DGGS recommended that recovery operations and re-occupancy of several homes be halted until further assessment of the Beach Road Slide could be conducted by a qualified geotechnical engineering consultant.

In late February and early March, the project team of LT and R&M performed an initial site reconnaissance of the AOC, but findings and observations were significantly hampered by the presence of winter snowpack. Initial findings were summarized and presented within two reports (LT, 2021 & R&M, 2021) presented to the Haines Borough which detailed our understanding of the geological hazards technical limitations present within the AOC. Since presentation of the initial findings report, Haines Borough determined that a temporary pioneer road could and has been

established allowing vehicles to travel across the affected area. The Borough has also determined that temporary power to the affected areas should be reestablished.

1.3 SCOPE OF WORK

The intent of this geotechnical investigation and analysis is to gather data on the geologic and geotechnical conditions and geo-hazards that are hampering recovery activities, road reopening, and utility reconnection. Investigation activities are also designed to gather data which will aid in the development of recommendations for future work activities and potentially provide opinions with regard to re-occupancy of impacted residences.

These tasks and their general descriptions and associated limitations are as follows:

1.3.1 GEOTECHNICAL CONSULTATION

The project team is providing virtual and on-call geotechnical consultation to the Haines Borough and DOT&PF to assist with planning recovery efforts in the AOC. The project team's efforts include providing geotechnical input to the Borough and DOT&PF regarding stability concerns, landslide issues, and access/site safety related to existing and potential geo-hazards. Consultation services also include providing input to the Borough and DOT&PF for their development guidelines, recommended precautions, and restrictions for Borough personnel, consultants, contractors, recovery teams, and residents regarding accessing the AOC and the temporary interim road across the slide area.

A conditions list will be developed regarding climatic events and other factors (i.e. ground cracks, slide movement, etc.) that could be indicators of potential or ongoing slope movements and provide recommendations for action items/protocols to address these risks (i.e. limiting access to the AOC, closing the interim road, suspending recovery/maintenance operations, etc.). The project team will work with the Borough and DOT&PF to develop infographics, warning signs, and other communication tools as needed to advise residents, Borough and DOT&PF personnel, and consultants/contractors regarding potential slide hazards and recommended precautions.

Observational guidelines are being developed to educate safety spotters that can be utilized by Borough maintenance personnel, contractors, or any other group working in the AOC or along the interim road. The project team is also participating in various meetings with the Borough to help facilitate recovery efforts and address community concerns.

1.3.2 GEOTECHNICAL ONSITE SUPPORT FOR ACCESS AND RECOVERY

The project team is providing onsite geotechnical support services to the Haines Borough team during resumption of recovery activities in the AOC, assessment of the interim road, including measures needed to allow access by consultants, Borough personnel, and contractors to evaluate maintenance and potential debris removal efforts, and restricted access by residents. The overall scope of these efforts is continuing to evolve and this task contains flexibility to manage the evolving nature of the recovery efforts and assessment of the interim road.

Onsite geotechnical personnel can perform daily observations and evaluations to provide real-time feedback and recommendations to the Haines Borough regarding landslide conditions and geo-hazards as the work progresses. Monitoring during onsite access and recovery activities can include:

reconnaissance of landslide and slopes to provide updates on the latest conditions prior to working in the lower slide area; coordination with Borough and/or contractor provided spotters (located in various upslope areas to visually identify potential movements); installation of tell-tale stakes, immediately upslope of Beach Road, to help make ballpark visual observations or the slide debris in the immediate area of the road corridor.

1.3.3 SUMMER GEOTECHNICAL INVESTIGATION AND ANALYSIS

This task is necessary for evaluating stability concerns of the existing landslide mass and other geologic features adjacent to the upper landslide headscarp area where an extensive ground (tension) crack was identified extending east from the headscarp indicating stability concerns in the AOC, as recommended in the Winter Reconnaissance – Preliminary Findings Report (LT, 2021).

Task 5 is divided into five separate subtasks including and is identified as Task 5 in order to remain consistent with proposal, notice-to-proceed, and contracting documents:

- 5.1 – Summer Surface Reconnaissance of hillside slopes in the AOC to assess changes in landslide features and evaluate existing features that were not previously observable.

- 5.2 – Surface Instrumentation to measure and monitor potential ground movements across the ground tension crack east of the headscarp.

- 5.3 – Subsurface Investigation consisting of geotechnical borings and test pits to investigate soil conditions and stability concerns. PLEASE NOTE: THE COMPLETION OF GEOTECHNICAL BORINGS AND SUBSURFACE INSTRUMENT INSTALLATION PORTION OF THIS TASK HAVE BEEN POSTPONED UNTIL FUTHER NOTICE. TEST PITTING OPERATIONS ARE STILL PLANNED TO OCCUR. THE FOLLOWING TASK DESCRIPTIONS ARE ONLY PROVIDED TO MAINTAIN CONTINUITY WITH REGARD TO THE OVERALL PROJECT OBJECTIVES PRESENTED IN THE PRELIMINARY FINDINGS REPORT (LT, 2021).

- 5.4 – Geophysical Subsurface Investigations of slope area to estimate bedrock stratigraphy and overburden thickness for slope stability assessments.

- 5.5 – Updated Findings Report (based on the foregoing tasks).

Subtask 5.1 – Summer Surface Reconnaissance

This task includes a post-snowmelt surface reconnaissance to observe, assess, and map landslide features on the hillside slopes in the AOC, the landslide, and the area containing the east tension crack(s). Most geologic and landslide features that influence slope stability were not able to be observed during the winter reconnaissance due to snow cover. These features include: new and existing tension cracks, spring locations and wet/saturated areas, bedrock structure, fault evidence/features, rock mass conditions in the headscarp and sidescarps, and conditions of the existing slide debris. Other efforts include the collection of rock samples for mineralogy evaluations (to determine if weak zones exist that could affect stability), future stability concerns, and faulting. This task also includes a program to perform test pits upslope the interim road to assess slide debris conditions. Additional test pits would be performed within the slide area to assess slide debris conditions to inform potential contractors of near surface conditions during recovery and maintenance activity. Geotechnical laboratory testing would be performed on obtained samples to

characterize the engineering properties of the slide debris and subsurface materials for subsequent recovery design efforts.

It is the understanding of R&M that the DGGS has recently obtained expanded LiDAR data collected in 2014 which provides data on local topography and geomorphological conditions. We will assess this data to help determine causation of the 2020 landslide event. This information will help determine existing factors that could have contributed to the initial landslide event (existing evidence of hillside mass movements) other than climatic conditions to help estimate potential geologic hazards.

During the reconnaissance, locations for surface instruments, potential geotechnical borings and test pits, survey prisms, and geophysical lines will be identified. Those identified areas will be cleared of trees and debris in advance to facilitate the planned investigations.

As the summer reconnaissance proceeds, acquired data and observations will be incorporated by office staff to update geologic interpretations and re-evaluate remaining data and monitoring needs. Upon completion of subtask 5.1, the project team will produce a memorandum to summarize the findings from the Winter and Summer Surface Reconnaissance.

Subtask 5.2 – Surface Instrumentation Installation

This subtask is planned to be accomplished concurrently with subtask 5.1. Understanding weather conditions, soil moisture, and surface temperatures in and around the slide area is a critical aspect to forecasting potential movements or changes in stability. The project team will coordinate with DGGS for an onsite weather station to continuously monitor precipitation amounts and intensity and other atmospheric conditions that could adversely impact slope stability. This information will be used as an indicator for potentially unsafe conditions and provide advance warning of impeding conditions that could increase the risk of slope and landslide movements in the AOC. When the weather station instrumentation is functional and trends can be evaluated, the data could be used by the Borough to limit access, close the interim road, and suspend recovery/maintenance operations if necessary.

The tension cracks east of the headscarp are features of concern. The stability of the slope materials directly adjacent to the eastern sidescarp is not known and estimated to be marginally stable due to the presence of the tension crack(s). This task includes efforts to design, layout and install six extensometers, (long-distance measurements, on the order of several feet, across the tension crack(s) and extending downslope onto the apparently slumping slope). This subtask also includes installation of a robotic total station that will measure changes on and around the perimeter of the landslide at design locations identified in Task 5.1. These surface instrumentation and monitoring efforts will be critical for the safe resumption of recovery activities in the AOC, assessment of the interim road, including measures needed to allow access by consultants, Borough personnel, and contractors to evaluate maintenance and potential debris removal efforts, and restricted access by residents. Upon completion of subtask 5.2, the project team will produce a memorandum to summarize the findings form the Surface Instrumentation Installation, with periodic monitoring updates.

Subtask 5.3 – Subsurface Investigation and Instrumentation

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The Winter Reconnaissance – Preliminary Findings Report (LT, 2021) identified recommended geotechnical instrumented borings to evaluate critical geologic hazards and risks. This subtask consists of performing a program of 12 instrumented borings, several test pits, and a series of analyses to evaluate critical slope geometry and stability factors in the landslide and adjacent slopes in the AOC, including the critical terrain in the vicinity of the east tension crack(s). Subsurface explorations are necessary for evaluating and managing geologic hazards while supporting initial community recovery efforts, assessment of the interim road, including measures needed to allow access to evaluate maintenance and potential debris removal efforts, and restricted access by residents. Rock coring and downhole optical televiewing can be utilized to determine rock quality and structure. Geotechnical instrumentation can also be installed, including vibrating wire piezometers and MEMS array inclinometers to measure groundwater pressures and subsurface deformations, respectively. Supplemental test pits in slide runout deposits will be performed during this effort. Data obtained from this task would allow for the development of 2-D and 3-D models critical to slope stability modeling for various geologic hazards and landslide scenarios.

Subtask 5.4 – Geophysical Subsurface Investigation of Critical Areas

The subsurface investigation includes the use of passive MASW and electrical resistivity methods. These geophysical methods will allow for more widespread interpretations of geologic stratigraphy and groundwater conditions in the steep upper hillside sections within the slide and the AOC. The nature of these steep upper areas is not fully understood and the geophysical subsurface investigation will help fill the gaps between the recommended geotechnical borings potentially being drilled in these areas. Upon completion of subtask 5.4, the project team will produce a geophysical subsurface investigation report to summarize the findings from the geophysical investigation.

Subtask 5.5 – Updated Geotechnical Findings Report

Upon completion of the foregoing investigation activities, geologic interpretations and analyses will be performed to evaluate potential geologic hazards and stability of the landslide and slopes in the AOC. The existing preliminary findings report will be updated to incorporate data, conclusions, and recommendations resulting from the winter reconnaissance and summer surface and limited summer subsurface investigation activities.

Geotechnical tasks include: developing limited subsurface data summaries (from test pitting); developing instrumentation plots and trends; updating geology interpretations, maps, and geologic cross-sections; summarizing bedrock conditions, including rock structures and mineralogy and petrology tests; preparing profiles of slide debris scouring and deposition along Beach Road; updating evaluations of landslide conditions and causation; evaluations of slope conditions in the area containing the eastern tension crack(s); updating recommendations for possible supplemental geotechnical investigation and instrumentation; performing preliminary slope stability and debris flow slide runout modeling analyses; etc.

An online portal will be used to display instrumentation data and trends. The project team will develop data plotting formats and will provide troubleshooting and management for 12 months.

A combined Winter Reconnaissance and Summer Investigation Findings Report will be prepared that summarizes the investigation and monitoring results, which would update the evaluations and opinions presented in the prior Winter Reconnaissance Preliminary Findings Report (LT, 2021).

1.4 TENTATIVE SCHEDULE

To support the rapidly evolving nature of the proposed reopening activities scheduled for Beach Road, R&M and LT are committing key experts in substantial roles. A project schedule has been developed and is included in **Appendix B**. Mobilization is planned to begin on June 23rd with an initial site reconnaissance by LT with further disciplines working at the site through early August. The schedule is contingent on instrumentation delivery, transportation schedules, weather and slope conditions. The field teams will apprise the DOT&PF if delays to the work are anticipated.

1.5 KEY PROJECT FIELD PERSONNEL AND QUALIFICATIONS

Field reconnaissance and rope access of the project site will be conducted by a team of experienced geologists, geotechnical engineers, and geophysicists. Terrestrial survey services will be conducted by an experienced professional land surveyor. Proposed field personnel are listed in **Table 1-1**. Both primary and alternate personnel are listed.

TABLE 1-1: KEY PROJECT FIELD PERSONNEL

Name / Company & Role	Qualifications
Primary	
Ben George / LT Investigation Team Leader	17 years of geotechnical engineering, geologic, and rope access experience
Charlie Hammond / LT Engineering Geologist	30 years of engineering geology experience
Darren Beckstrand / LT Senior Geologist	21 years of engineering geology experience
Noah Kimmes / LT Project Engineer	5 years of geotechnical engineering, geologic, and rope access experience
AJ Griffin / R&M Senior Professional Land Surveyor	21 years of surveying experience
Andy Siemens / S&A Senior Geophysicist	More than 25 years of geophysical exper
Alternates	
Brent Black / LT Lead Engineering Geologist	30 years of engineering geology experience
Adam Koslofsky / LT Associate Geologist	17 years of engineering geology and rope access experience
Logan Alexander / LT Associate Engineer	10 years of geotechnical engineering, and rope access experience
Sebastian Dirringer / LT Project Geologist	6 years of engineering geology and rope access experience
Chris Fell / R&M Senior Geologist	15 years of engineering geology experience
Aaron Banks / R&M Senior Geologist	21 years of engineering geology experience

1.6 FIELD CONTACTS

General work status and progress will be coordinated with Travis Eckhoff (DOT&PF, SRD-Materials) by phone at (907) 328-8693 or by email at travis.eckhoff@alaska.gov and Aaron Banks (R&M, Project Manager) by phone at (907) 646-9684 or by email at abanks@rmconsult.com .

2.0 REGIONAL DESCRIPTION

The Haines landslide is located on the Chilkat Peninsula along Beach Road approximately 1.5 miles southeast of downtown Haines. Drawings **A-01 through A-02** of Appendix A provide location and vicinity, and reconnaissance location maps.

2.1 TOPOGRAPHY

Topography at the project site generally consists of rounded even-topped ridges rising to about 1,600 in elevation above the adjacent Chilkoot Inlet. This slide itself rises to an elevation of 800 feet and slopes down at an angle of about 20 degrees to the northeast where it terminates into Chilkoot Inlet.

2.2 SURFACE DRAINAGE

Drainage at project area generally occurs via sheet flow down vegetated slopes into the underlying soils. Much of this water infiltrates soils with some flowing to nearby thaw lakes or limited streams and creeks within the area. Within the existing slide path, there is a general lack of established drainage which contributes to numerous areas of ponded water and saturated soils, particularly after major storm events.

2.3 VEGETATION

Vegetation in the Haines area consists of Coastal Western Hemlock – Sitka Spruce Forest biotic community. Within this biotic community, the dominant tree species are western hemlock and Sitka spruce with smaller amounts of Alaska cedar and red cedar. Black cottonwood usually invades newly deposited alluvium and glacial material. Understory vegetation includes shrubs and young conifers. Moss covers the ground, and lichens drape from many trees (AEIDC, 1976).

2.4 GENERAL GEOLOGY

The project site is located within the Chatham Trough physiographic province. The Chatham Trough is a deep, straight trench 4-15 miles, which is entirely below the sea except for its north end located in the Haines region. The Chatham trough probably marks a major fault line. Rocks on opposite sides of the trough do not match across the trough, either in their structure or in their age. It probably owes its greater depth to glacial erosion of relatively soft rocks (Wahrhaftig, 1965).

Haines is located on a low relief peninsula occupied by slough and floodplain deposits associated with a former channel of the Chilkat River. These sediments are Quaternary in age and overlie Cretaceous undifferentiated ultramafic bedrock, gabbro and diorite (Gehrels and Berg, 1992) (March, 1987).

During the late Pleistocene, glaciers covered the Southeast Alaska region. The entirety of the Haines area is inferred to have been glaciated with up to 5,000 feet of ice (Coulter, 1965). The region is considered to be generally free of permafrost, although a few small isolated masses of occur at high altitudes, and in lowland areas where ground insulation is high and ground insolation is low (Ferrians, 1965).

2.5 GROUNDWATER CONDITIONS

Due to the steep topography and relatively shallow bedrock at the project site, groundwater is only expected to be perched in nature and situated near the bedrock interface. Outside of the project site and in more level areas, groundwater is expected to be found in poorly drained areas of muskeg.

2.6 CLIMATE

The project area experiences a maritime climate. Based on climate data recorded at the Haines National Weather Service weather station: the mean annual air temperature is approximately 41.8 degrees Fahrenheit (°F), with minimum and maximum monthly averages of approximately -19.3 °F (January) and 65.7 °F (July), respectively. The area receives an average of approximately 47.77 inches of precipitation per year, with maximum monthly mean of approximately 20.37 inches in October (WRCC, 2021).

3.0 SITE ACTIVITIES EXPLORATION PLAN

This site activities exploration plan provides details on investigation methods and site activities, to occur once the planning phase has been completed.

3.1 SUMMER GEOTECHNICAL INVESTIGATION AND ANALYSIS

The summer geotechnical reconnaissance and geotechnical/geophysical investigations require planning and implementation of activities and support needs, including safety measures in this high-risk environment, and coordination with agencies, emergency personnel, and vendors/contractors. Flexibility is necessary to achieve the workscope in this environment. The reconnaissance includes technical expertise efforts in the office in addition to field staff onsite for planning and processing geotechnical observations to fast-track and test findings expediently. The team of key experts provided by R&M and LT during the winter reconnaissance will be maintained during additional reconnaissance and investigation efforts. The durations of staff involvement are approximate and may be adjusted as the work progresses.

There are significant risks associated with reconnoitering an unstable debris flow landslide and marginally-stable slopes adjacent to the landslide due to the potential for creep movements, sudden accelerations of slide movement, reactivations of slide lobes, and traversing across ground where large tension cracks, cavities and liquefied zones exist but may be hidden. R&M and LT will revise the Site Safety, Health and Environment Plan (SSHE) and Activity Hazard Analyses (AHA) as appropriate for the new activities and as site conditions evolve.

During the reconnaissance, locations for surface instruments, geotechnical borings, survey prisms, geophysical lines, and test pits will be identified. Those identified areas will be cleared of trees and debris in advance to facilitate the planned investigations.

3.1.1 SUMMER FIELD RECONNAISSANCE (TASK 5.1)

Prior to deployment, a review of additional 2014 LiDAR will be conducted at LT offices to update geomorphic interpretations and identify target areas of interest for surface observation. LT will then compile mapping materials, field supplies, and rope access gear.

Three LT geotechnical staff will travel one-way from Portland to Haines via air. The field reconnaissance anticipates three LT staff will be onsite for an 8-day period based on weather and flight schedules, assuming an average of 10 hours per day per person. An additional 2 days will be required for travel to and from Haines.

Upon arrival into Haines, we will coordinate with the Haines Borough to acquire radios and develop daily communication protocols. Reconnaissance will include several targeted mapping efforts to characterize landslide features, the headscarp/sidescarps, the eastern tension crack area, drainages/springs/wet areas, bedrock areas, the basin/hollow south of the slide, and other areas of interest. Locations will be accessed by foot and with use of rope access equipment as necessary. Landslide features such as lobes of colluvium, potential flow paths, source area and flow path for the secondary slide event, etc. will be evaluated and sampled as accessible. Springs and residential spring-water collection systems will be identified and characterized. These evaluations and characterizations will be used to refine our landslide hazard analyses and causation interpretations.

During the reconnaissance surface instrumentation locations, supplemental test pit locations, proposed borehole locations (to be drilled under next phase) will be confirmed and marked. Likewise, potential locations for prisms will be identified for use in a robotic total station monitoring approach. Should monitoring locations be accessible and materials available, prisms may be installed.

Additional test pits will be conducted along the interim road to further characterize subsurface materials, measure the thickness of slide debris materials over the road, collect material samples, and possibly identify potential scour areas. A local contractor is being retained to perform the test pit excavations.

Samples of slide debris, colluvium/alluvium, and bedrock materials collected during reconnaissance and test pit work will be shipped to a testing laboratory for further characterization, to be performed (or outsourced) by R&M. Anticipated testing would include (but not limited to): gradations, moisture contents, Atterberg limits, and rock petrology. Laboratory testing will be used to refine landslide interpretations and to develop slope stability models.

LT will verbally update DOT&PF and R&M at the end of each field day on progress and planned work for the next day. As the spring reconnaissance proceeds, acquired data and observations will be incorporated by office staff to update geologic interpretations and re-evaluate remaining data and monitoring needs.

3.1.2 SURFACE INSTRUMENTATION INSTALLATION (TASK 5.2)

Understanding weather conditions, soil moisture, and temperatures in and around the slide is a critical aspect to forecasting potential movements or changes in stability. LT will continue to provide input to DGGS for implementation of a weather station that can eventually be incorporated into an early warning system. Instruments such as tipping-bucket rain-gauge, temperature thermistors, humidity sensors, snow depth sensors, soil moisture sensors, and wind meters are being considered by DGGS. Data logging and telemetry of the data to an offsite computer server will be part of the weather station design. It is anticipated DGGS will incorporate an automated data acquisition system (ADAS). In the interim, the surface instrumentation (i.e. extensometers) will be independent of the DGGS weather station ADAS. Should the test borings be completed at a later phase, an ADAS could be set up to collect and distribute the extensometer, MEMs, and VWP data in conjunction with the DGGS ADAS.

The tension cracks east of the headscarp are features of concern. The stability of the slope materials directly adjacent to the eastern sidescarp is not known and estimated to marginally stable due to the presence of the tension cracks. Our plan includes efforts to design, layout and install six extensometers, which are long distance extensometer rods/cables would extend on the order of 50 feet across the tension cracks and downslope onto the interpreted slump mass. Design and layout work will include: i) determining hardware requirements, ii) procuring instruments, data loggers, enclosures, and associated hardware, iii) building data logger equipment and developing logger programming, iv) determining data output needs, v) bench testing instrumentation equipment and programming, and vi) shipment/installation of the meters, data loggers, and enclosures, and similar. We have estimated one LT personnel will require two weeks of work in the office to design, build, test and ship the instrumentation. Installations will require a minimum of three LT personnel over a 9-day period onsite with helicopter support.

The surface instrumentation/monitoring program will also include installation of a robotic total station that will measure changes on and around the landslide perimeter at locations identified during Task 5.1 (Spring Reconnaissance). LT will assist R&M with locating prisms (as described in Task 5.1) and total station equipment.

Understanding weather conditions, soil moisture, and temperatures in and around the slide is a critical aspect to forecasting potential movements or changes in stability. LT will continue to provide input to DGGS for implementation of a weather station that can eventually be incorporated into an early warning system. Instruments such as tipping-bucket rain-gauge, temperature thermistors, humidity sensors, snow depth sensors, soil moisture sensors, and wind meters are being considered by DGGS. Data logging and telemetry of the data to an offsite computer server will be part of the weather station design. It is anticipated DGGS will incorporate an automated data acquisition system (ADAS). In the interim, the surface instrumentation (i.e. extensometers) will be independent of the DGGS weather station ADAS. Should the test borings be completed at a later phase, an ADAS could be set up to collect and distribute the extensometer, MEMs, and VWP data in conjunction with the DGGS ADAS.

Periodic review and analysis of the surface instrumentation data will be conducted by LT remotely as data becomes available. A baseline of site conditions will be evaluated and, subsequently, will be discussed with DGGS and DOT&PF. It should be noted collection of seasonal data is critical for understanding site conditions and changes. Trends will be evaluated over a full season (i.e., summer 2021 through 2022) as data is collected and baseline conditions are better understood.

3.1.3 SUBSURFACE INVESTIGATION (TASK 5.3)

Additional test pits will be conducted at a midslope location within the landslide body at the discretion of the Lead Engineering Geologist. These test pits will be conducted to characterize the slide mass, sample materials, and attempt to identify bedrock areas. It is anticipated the midslope pits will be accessed via the interim road and/or Mt. Riley Road. A local contractor would be retained to perform the test pit excavations. We have included four days for an LT person to observe road pioneering and test pit excavations plus travel.

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An understanding of subsurface conditions is required in order to refine landslide interpretations so that slope stability models can be developed. Geologic hazard mechanisms, slide geometry, geologic stratigraphy, structural orientations, groundwater conditions, and material strength properties are key elements of a slope stability model. All these elements would be evaluated with completion of a subsurface investigation and laboratory testing of collected samples. As detailed in the Winter Reconnaissance, Preliminary Findings Report (LT, 2021), we recommend completion of 12 borings.

Completion of subsurface investigations will require several coordination aspects. We can work with specialized drilling contractors to perform helicopter accessed explorations to mobilize equipment and support daily operations. There may be an option to utilize multiple contractors,

therefore we have included two driller mobilization costs. Nine of the boring locations will require clearing trees from an approximate 30- by 30-foot area. Due to the location of the borings, water is not readily available; therefore, we anticipate helicopter support for delivery of water to all boring locations, except those adjacent to Beach Road.

To understand groundwater conditions, measure pore pressures, and determine if slope movement is occurring, each boring will have vibrating wire piezometer (VWP) and Measurand ShapeArrays © (consisting of continuous strings of MEMS displacement monitoring sensors). The VWPs can measure groundwater pressures at identified depths within the borehole and the MEMS strings can measure subsurface deformations. The VWPs and MEMS strings can be connected to data loggers and a telemetry system that can likely tie into the weather station ADAS. The data could be made available to the investigation team and various stakeholders.

Measurement of geologic structural orientations in boreholes will be accomplished with down-hole optical televiewing. An optical televiewer (camera) with magnetometers and accelerometers could be lowered into each boring to record oriented images of the exposed sidewalls. Geologic discontinuities could later be measured with use a proprietary computer software. This equipment can be rented and shipped to Haines during the subsurface investigation program.

We have planned that any rock core samples (collected during a later phase) could be shipped to DOT&PF facilities in Juneau for storage. As an alternative, samples could be stored at the DOT&PF construction offices in Haines.

3.1.4 GEOPHYSICAL SUBSURFACE INVESTIGATION PLANNING AND INTERPRETATION OF RESULTS (TASK 5.4)

The limited test pitting subsurface investigation will be supplemented with use of passive MASW and electrical resistivity methods. These geophysical methods will allow for more widespread interpretations of geologic stratigraphy and groundwater conditions. All geophysics conducted will be calibrated with use of the subsurface investigation results. Goals of the subsurface investigations include: i) estimation of colluvium thickness within the landslide, ii) estimation of overburden (colluvial) presence and thickness in areas outside of the landslide, iii) identification of bedrock areas outside of the landslide to assist with refinement of mapping (completed during Task 5.1), and iv) estimations of the depth to groundwater or presence of saturated conditions, if feasible.

A table presenting the proposed geophysical survey line locations is provided below and a figure depicting their location in relation to the project site is provided in Appendix A.

TABLE 3-1: PROPOSED GEOPHYSICAL SURVEY LOCATIONS

ID	Description	Latitude	Longitude	Elevation (ft.)
A1	Begin	-135.408814	59.219822	447.5
	End	-135.414252	59.22113	284.6
A2	Begin	-135.407632	59.217778	850.6
	Inflection 1	-135.408646	59.217897	880.3
	Inflection 2	-135.409146	59.218497	798.8
	End	-135.41435	59.219407	680.7
A3	Begin	-135.412183	59.217784	921.3
	End	-135.41165	59.221246	280.6
A4	Begin	-135.411363	59.21788	931.8
	End	-135.410053	59.220141	405.6
A5	Begin	-135.40791	59.217429	909.4
	End	-135.413801	59.218475	880.7
A6	Begin	-135.410543	59.217569	975.0
	End	-135.40901	59.22027	382.9
A7	Begin	-135.413851	59.218999	769.3
	End	-135.412926	59.22113	281.9
B1	Begin	-135.409327	59.2175	957.2
	End	-135.408318	59.219202	530.6
B2	Begin	-135.408701	59.217416	938.2
	End	-135.40745	59.219099	503.2
B3	Begin	-135.410053	59.220141	405.6
	End	-135.409115	59.221799	230.1
B4	Begin	-135.4078	59.220304	304.7
	End	-135.410132	59.220882	303.1

Notes: Geophysical lines identified with an A are considered a higher priority than those lines identified with a B.

The geophysical consultant will provide two to three personnel to perform field activities and R&M will provide two additional field personnel to assist with the geophysical investigations. LT will assist with evaluation and geologic interpretation of the geophysical subsurface investigation results with the data collected during the field reconnaissance and limited (test pitting) subsurface investigation.

3.1.5 UPDATED GEOTECHNICAL FINDINGS REPORT (TASK 5.5)

A Summer Investigation Findings report will be prepared that summarizes the investigation and monitoring results (which would update the evaluations and opinions in the prior Winter Reconnaissance Preliminary Findings Report (LT, 2021)). The preliminary findings report will be updated as appropriate with the results of Tasks 5.1 through 5.4. The updated figures, maps, cross sections will be incorporated, and a report will be compiled.

4.0 REPORTS

4.1 UPDATED GEOTECHNICAL FINDINGS REPORT

Upon completion of the Summer Reconnaissance and Geotechnical Investigation activities, geologic interpretations and analyses would be performed to evaluate potential geologic hazards and stability of slopes and the landslide. Geotechnical tasks include developing limited (based on test pit data) subsurface data summaries; developing instrumentation plots and trends; updating geology interpretations maps and geologic cross sections; summarizing bedrock conditions, including rock structures and mineralogy and petrology tests; preparing profiles of slide debris scouring and deposition along Beach Road; updating evaluations of landslide conditions and causation; evaluating of slope conditions of the upper east slope in vicinity of east tension crack; updating recommendations for possible supplemental geotechnical investigation (test borings) and instrumentation; performing preliminary slope stability and debris flow slide runout modeling analyses; etc.

The data gathered during Tasks 5.1 through 5.4 will be used to update interpretations and opinions offered in the preliminary findings report. The geology interpretative maps and cross sections will be refined, based on mapping and subsurface information. Landslide debris will be characterized, including estimates of slide debris deposition thicknesses and/or scoured conditions. Conditions of the tension cracks that are present on the eastern side of the headscarp will be evaluated and interpretations of geologic hazards will be developed. Bedrock conditions and geologic structure evaluations will be updated and refined so that interpretations of geologic hazards outside of the landslide area can be developed. Should additional work be necessary, recommendations will be presented.

An online portal would be used to display instrumentation data and trends. The consultant team will develop data plotting formats and will provide troubleshooting and management for 12 months.

Slope and slide stability analyses are planned to evaluate geologic risks during interim recovery efforts and for developing recommendations for debris removal where excavation cuts and/or fills made at the toe of the landslide runout are anticipated, but potentially could inadvertently exacerbate instability, hazards and risks. Slope stability models will be developed to estimate local and global stability along with models to analyze potential debris flow runout extents. Local and global stability models will be based on landslide geometry and hillside stratigraphy determined during the subsurface and geophysical investigations.

It is anticipated GeoStudo's computer program Slope/W will be utilized for slope stability modeling. Runout due to mobilization of materials within the landslide body as well as areas outside of the slide, as identified during Tasks 5.1 through 5.4, will likely be conducted with use of the computer program Flow-R. Models will be calibrated to known pre-slide and post-slide conditions and our understanding of slide geometries, adjacent site conditions, and material properties.

BGC will also provide peer reviews for this task so that landslide interpretations can be professionally vetted, and complex technical issues can be more understood. Their expertise in the areas of landslide/debris flow site characterization, monitoring, remote sensing, hazard and risk

assessment, etc. was quite useful for refinement of landslide interpretations. We will identify the key issues and facilitate the peer reviews, as needed.

A Summer Investigation Findings report will be prepared that summarizes the investigation and monitoring results (which would update the evaluations and opinions in the prior Winter Reconnaissance Preliminary Findings Report (LT, 2021)). The preliminary findings report will be updated as appropriate with the results of Tasks 5.1 through 5.4. The updated figures, maps, cross sections will be incorporated, and a report will be compiled.

4.2 FINDINGS REVIEW MEETING

A review meeting will be scheduled and attended with R&M, DOT&PF and appropriate stakeholders. Upon receipt of comments and completion of the review meeting the report will be finalized and resubmitted.

5.0 REFERENCES

Arctic Environmental Information and Data Center (AEIDC), "Alaska Regional Profiles-Yukon Region", Vol. IV, University of Alaska, 1976.

Coulter, H.W., et al.., "Map Showing Extent of Glaciations in Alaska", U.S. Geological Survey Miscellaneous Geologic Investigations Map I-415, 1965.

Ferrians, O.J., Jr., 1965, Permafrost Map of Alaska: U.S. Geological Survey Miscellaneous Geological Investigations Map I-445, 1 sheet, scale 1:2,500,000.

Gehrels, G.E., and Berg, H.C., "Geologic map of Southeastern Alaska", U.S.G.S. Miscellaneous Investigation Series I-1867, 1:600,000 scale, 1992.

Landslide Technology (LT), "Winter Reconnaissance – Preliminary Findings Report, Beach Road Landslide, Haines, Alaska", Prepared for Alaska DOT&PF Southcoast Region, April 8, 2021.

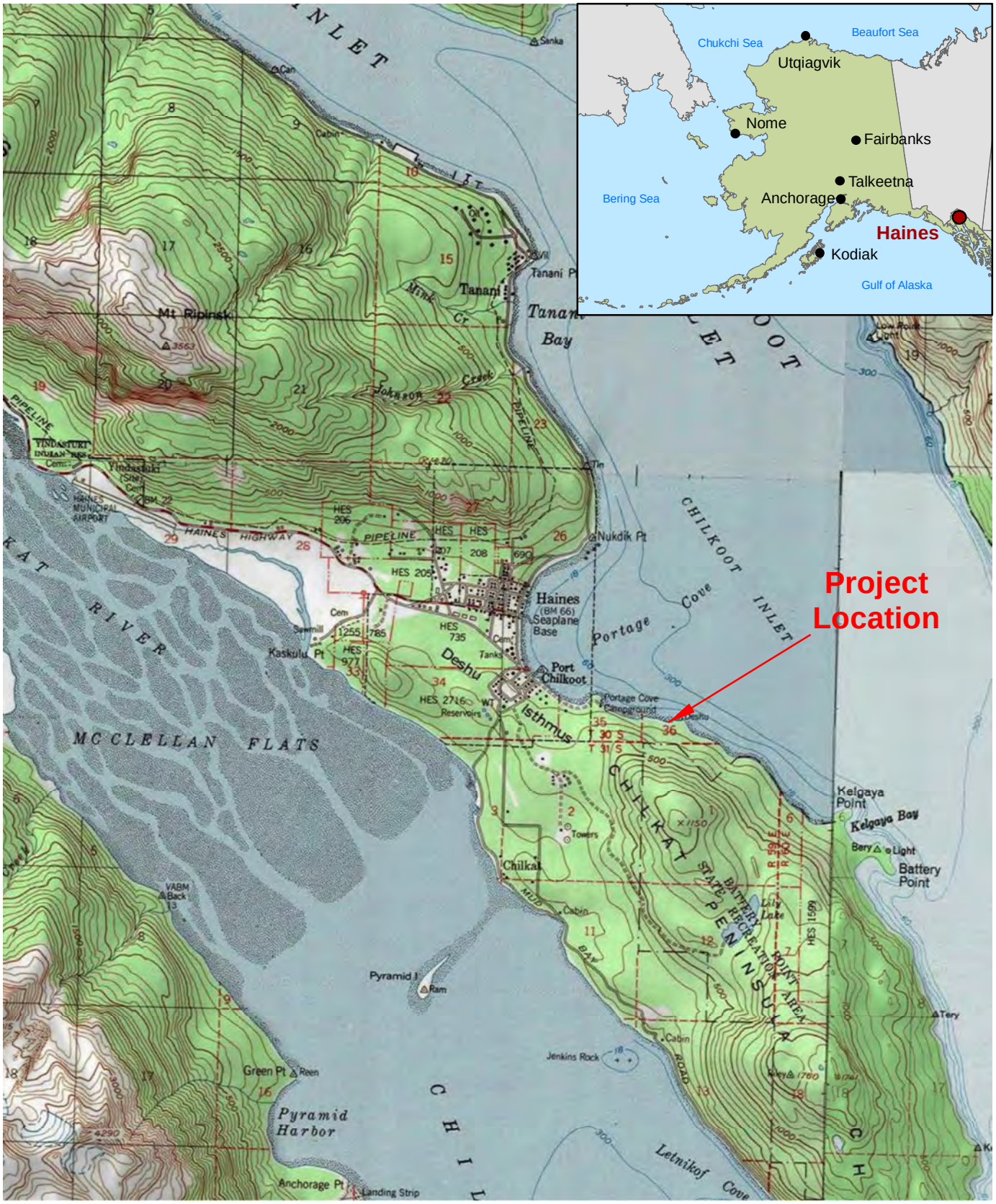
March, G.D., "Surficial geology and materials-resources maps of the Skagway A-2 Quadrangle, Alaska", Alaska Division of Geological & Geophysical Surveys, Report of Investigation 87-6, 1:63,360, 1987.

R&M Consultants, Inc. (R&M), "Winter Survey Reconnaissance, Haines Beach Road Landslide" Prepared for Alaska DOT&PF Southcoast Region, March 18, 2021.

Wahrhaftig, Clyde, "Physiographic Divisions of Alaska", U.S. Geological Survey Professional Paper 482, 1965.

WRCC (Western Regional Climate Center), http://www.wrcc.dri.edu/index.html, accessed February 2019.

APPENDIX A
DRAWINGS



ALL LOCATIONS ARE APPROXIMATE

0 0.5 1 2

APPROXIMATE SCALE IN MILES

NOTES:
Skagway A-2, USGS 15-minute quadrangle, 1:63,360

N

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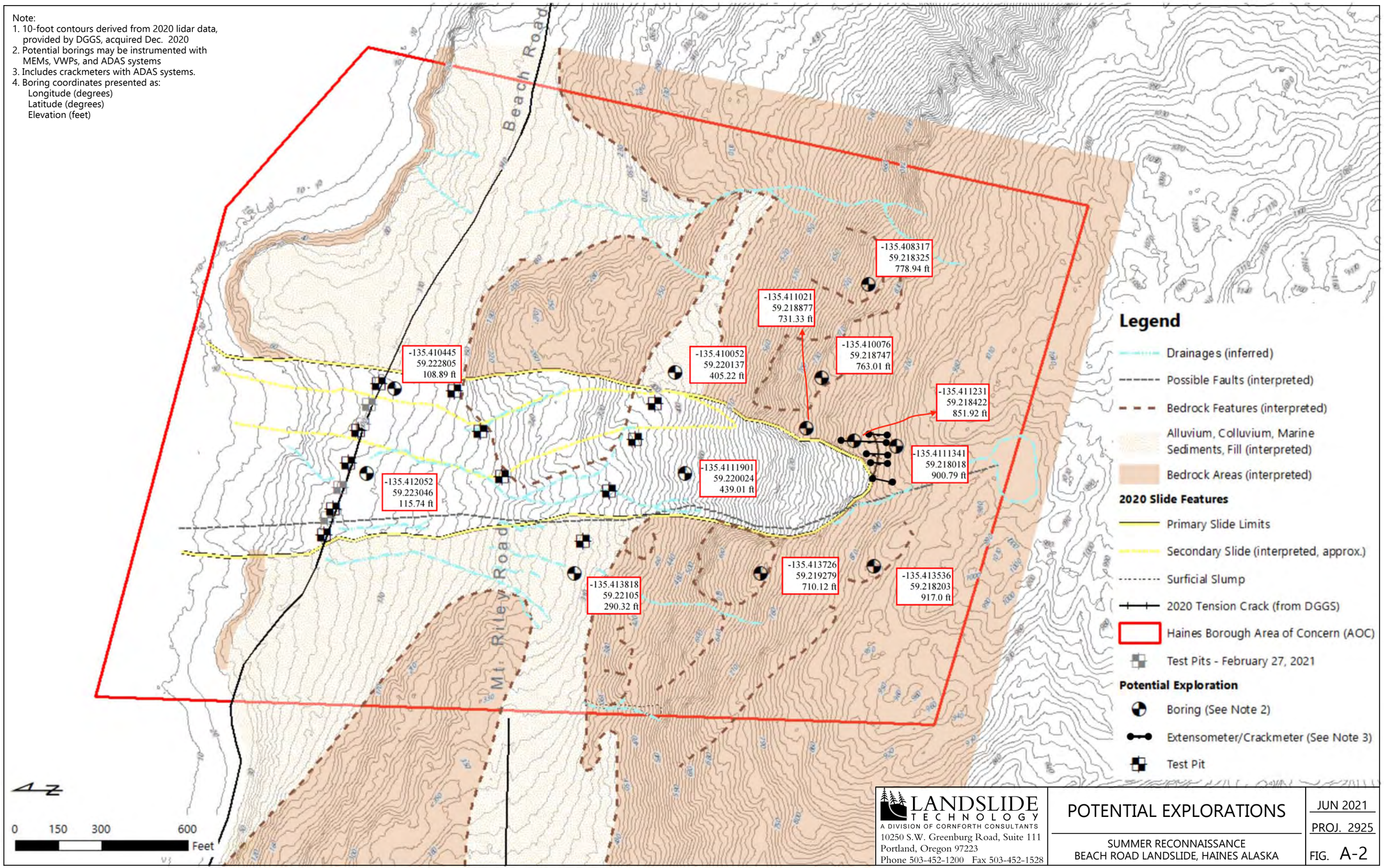
PREPARED BY:
R&M CONSULTANTS, INC.

WINTER RECONNAISSANCE
HAINES LANDSLIDE

LOCATION AND VICINITY

PROJ.NO:	2888.01
DATE:	FEB 2021
REF:	WNTR RECON
DRAWING NO.:	A-01

Note:
1. 10-foot contours derived from 2020 lidar data, provided by DGGS, acquired Dec. 2020
2. Potential borings may be instrumented with MEMs, VWPs, and ADAS systems
3. Includes crackmeters with ADAS systems.
4. Boring coordinates presented as:
   Longitude (degrees)
   Latitude (degrees)
   Elevation (feet)



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POTENTIAL EXPLORATIONS

SUMMER RECONNAISSANCE
BEACH ROAD LANDSLIDE, HAINES ALASKA

JUN 2021
PROJ. 2925
FIG. A-2

Note:
1. 10-foot contours derived from 2020 lidar data, provided by DGGS, acquired Dec. 2020

Beach Road

Mt. Riley Road

B1
B2
B3
B4
A1
A2
A3
A4
A5
A6
A7

Legend

- Drainages (inferred)
- Possible Faults (interpreted)
- Bedrock Features (interpreted)
- Alluvium, Colluvium, Marine Sediments, Fill (interpreted)
- Bedrock Areas (interpreted)

2020 Slide Features

- Primary Slide Limits
- Secondary Slide (interpreted, approx.)
- Surficial Slump
- 2020 Tension Crack (from DGGS)
- Haines Borough Area of Concern (AOC)

Geophysical Survey Lines

- First Priority
- Second Priority
- Potential Robotic Total Station

N

0 150 300 600 Feet

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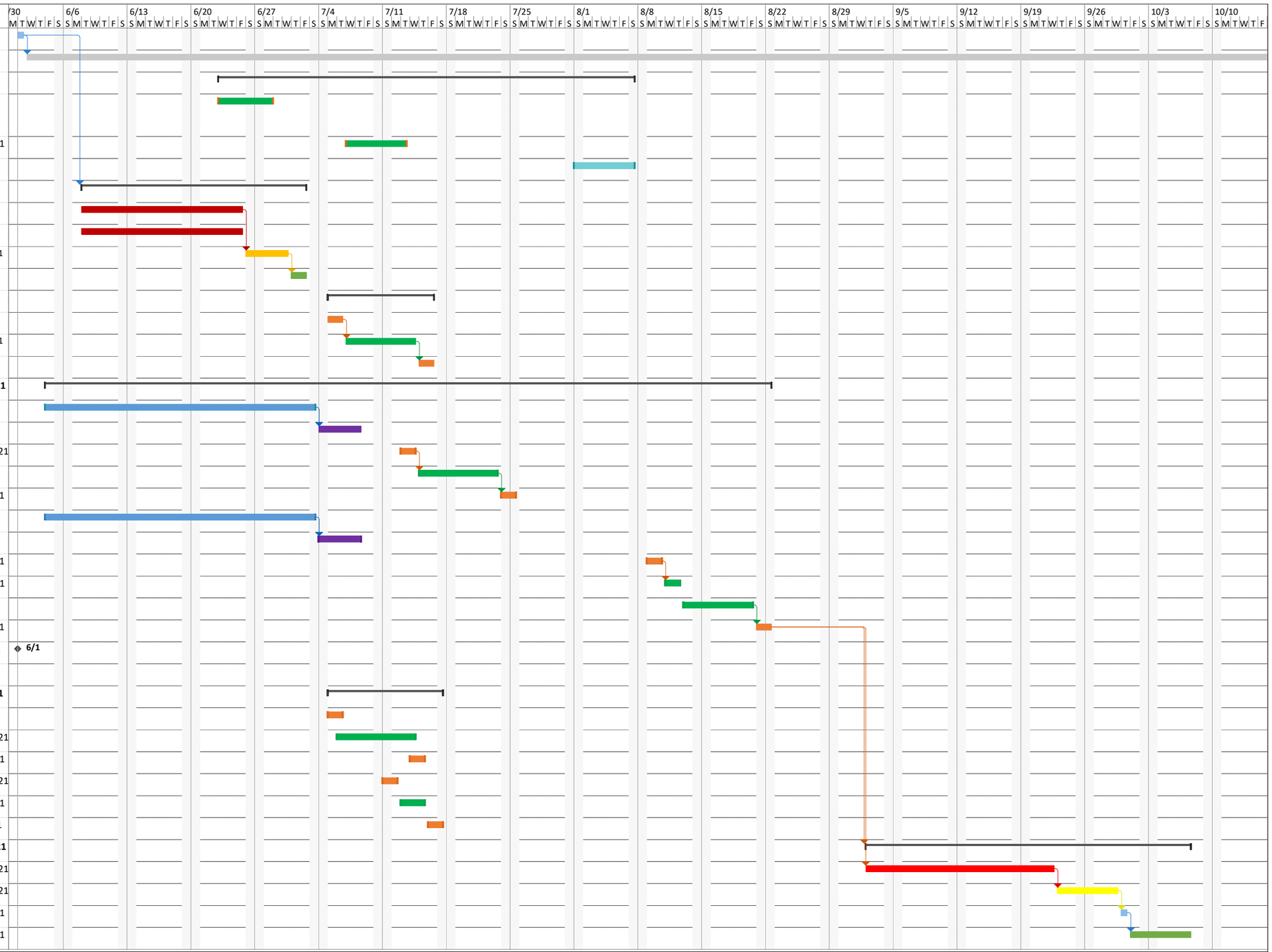
POTENTIAL GEOPHYSICS AND SURVEYING

SUMMER RECONNAISSANCE
BEACH ROAD LANDSLIDE, HAINES ALASKA

JUN 2021
PROJ. 2925
FIG. A-3

APPENDIX B
PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Notice To Proceed**	**1 day**	Tue 6/1/21	Tue 6/1/21
2	**Task 3: Geotechnical Consultation**	213 days	Wed 6/2/21	Fri 12/31/21
3	**Task 4: Geotechnical Onsite Support (As needed**	**46 days**	**Wed 6/23/21**	**Sat 8/7/21**
4	Phase 1 - Access RoadTest Pits, Geophys Staking, and Safety Survey	6.13 days	Wed 6/23/21	Mon 6/28/21
5	Phase 2 - Brent Black Onsite	7 days	Wed 7/7/21	Tue 7/13/21
6	Phase 3 - TBD	7 days	Sun 8/1/21	Sat 8/7/21
7	**Investigation Planning**	**25 days**	**Tue 6/8/21**	**Fri 7/2/21**
8	Draft Recon Plan	18 days	Tue 6/8/21	Fri 6/25/21
9	Draft SSHE Plan	18 days	Tue 6/8/21	Fri 6/25/21
10	DOT/EOC Review	5 days	Sat 6/26/21	Wed 6/30/21
11	Final Work Plan RTC, Preparation, and Submitt	2 days	Thu 7/1/21	Fri 7/2/21
12	**Task 5.1: Summer Surface Reconnaissance**	**12 days**	**Mon 7/5/21**	**Fri 7/16/21**
13	Geotech Mobilize	2 days	Mon 7/5/21	Tue 7/6/21
14	Geotech Recon	8 days	Wed 7/7/21	Wed 7/14/21
15	Geotech Demobilize	2 days	Thu 7/15/21	Fri 7/16/21
16	**Task 5.2: Surface Instrumentation Installation**	**80 days**	**Fri 6/4/21**	**Sun 8/22/21**
17	Order Geotech Insturments and Equipment	30 days	Fri 6/4/21	Sat 7/3/21
18	Bench Test Instruments and Equipment	5 days	Sun 7/4/21	Thu 7/8/21
19	Geotech Mobilize	2 days	Tue 7/13/21	Wed 7/14/21
20	Instrument Installation	9 days	Thu 7/15/21	Fri 7/23/21
21	Geotech Demobilize	2 days	Sat 7/24/21	Sun 7/25/21
22	Order Survey Instruments and Equipment	30 days	Fri 6/4/21	Sat 7/3/21
23	Bench Test Survey Instruments and Equipment	5 days	Sun 7/4/21	Thu 7/8/21
24	Survey Mobilize	2 days	Mon 8/9/21	Tue 8/10/21
25	Instrumentation Survey	2 days	Wed 8/11/21	Thu 8/12/21
26	Install Robotic Total Station	8 days	Fri 8/13/21	Fri 8/20/21
27	Survey Deomobilize	2 days	Sat 8/21/21	Sun 8/22/21
28	**Task 5.3: Phase I Subsurface Investigation**	**0 days?**	**Tue 6/1/21**	**Tue 6/1/21**
29	Delayed Until Additional Funding is Secured			
30	**Task 5.4: Geophysical Subsurface Investigation**	**13 days**	**Mon 7/5/21**	**Sat 7/17/21**
31	Geophys Mobilize	2 days	Mon 7/5/21	Tue 7/6/21
32	Geophysical Subsurface Investigation	9 days	Tue 7/6/21	Wed 7/14/21
33	Geophysical Demobize	2 days	Wed 7/14/21	Thu 7/15/21
34	Survey Mobilize	2 days	Sun 7/11/21	Mon 7/12/21
35	Survey Geophysical Lines	3 days	Tue 7/13/21	Thu 7/15/21
36	Survey Deomobilize	2 days	Fri 7/16/21	Sat 7/17/21
37	**Task 5.5: Updated Findings Report**	**36 days**	**Thu 9/2/21**	**Thu 10/7/21**
38	Draft Updated Findings Report	21 days	Thu 9/2/21	Wed 9/22/21
39	DOT/HNS Borough Review	7 days	Thu 9/23/21	Wed 9/29/21
40	Findings Review Meeting (Virtual)	1 day	Thu 9/30/21	Thu 9/30/21
41	Finalize Updated Findings Report	7 days	Fri 10/1/21	Thu 10/7/21



State Number: SDER00317
PSA Number: 25213018

Geotechnical Investigation and Analysis - Haines Beach Road Landslide
Haines, Alaska