APPENDIX S ANALYTICAL RESULTS OF GROUNDWATER SAMPLING AND WATER QUALITY MONITORING AT PROPOSED LIQUEFACTION FACILITY, NIKISKI

SUMMARY OF LNG FACILITIES ONSHORE 2016 HYDROGEOLOGY PROGRAM

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Alaska Gasline Development Corporation (Applicant) plans to construct one integrated liquefied natural gas (LNG) Project (Project) with interdependent facilities for the purpose of liquefying supplies of natural gas from Alaska, in particular from the Point Thomson Unit (PTU) and Prudhoe Bay Unit (PBU) production fields on the Alaska North Slope (North Slope), for export in foreign commerce and for in-state deliveries of natural gas.

The Natural Gas Act (NGA), 15 U.S.C. § 717a(11) (2006), and Federal Energy Regulatory Commission (FERC) regulations, 18 Code of Federal Regulations (C.F.R.) § 153.2(d) (2014), define "LNG terminal" to include "all natural gas facilities located onshore or in State waters that are used to receive, unload, load, store, transport, gasify, liquefy, or process natural gas that is ... exported to a foreign country from the United States." With respect to this Project, the "LNG Terminal" includes the following: a liquefaction facility (Liquefaction Facility) in Southcentral Alaska; an approximately 807-mile gas pipeline (Mainline); a gas treatment plant (GTP) within the PBU on the North Slope; an approximately 63-mile gas transmission line connecting the GTP to the PTU gas production facility (PTU Gas Transmission Line or PTTL); and an approximately 1-mile gas transmission line connecting the GTP to the PBU gas production facility (PBU Gas Transmission Line or PBTL). All of these facilities are essential to export natural gas in foreign commerce and will have a nominal design life of 30 years.

These components are shown in Resource Report No. 1, Figure 1.1-1, as well as the maps found in Appendices A and B of Resource Report No. 1. Their proposed basis for design is described as follows.

The new Liquefaction Facility would be constructed on the eastern shore of Cook Inlet just south of the existing Agrium fertilizer plant on the Kenai Peninsula, approximately 3 miles southwest of Nikiski and 8.5 miles north of Kenai. The Liquefaction Facility would include the structures, equipment, underlying access rights, and all other associated systems for final processing and liquefaction of natural gas, as well as storage and loading of LNG, including terminal facilities and auxiliary marine vessels used to support Marine Terminal operations (excluding LNG carriers [LNGCs]). The Liquefaction Facility would include three liquefaction trains combining to process up to approximately 20 million metric tons per annum (MMTPA) of LNG. Two 240,000-cubic-meter tanks would be constructed to store the LNG. The Liquefaction Facility would be capable of accommodating two LNGCs. The size of LNGCs that the Liquefaction Facility would accommodate would range between 125,000–216,000-cubic-meter vessels.

1.2 PURPOSE AND SCOPE

The hydrogeological study components of the Project's site investigation included the installation, development, and sampling of selected groundwater monitoring wells (**Figure 1**). The wells were installed to collect baseline groundwater quality data, delineate aquifers and aquitards across the proposed Liquuefaction Facility site, and provide means to develop an understanding of aquifer characteristics including variations in permeability, depth, fluctuation, tidal impacts, gradient, and flow direction.

The groundwater monitoring wells were installed using subsurface lithological information from nearby co-located borings. Groundwater quality data and elevations were used to delineate aquifers and aquitards across the proposed Liquefaction Facility site; and to provide means to develop an understanding of aquifer characteristics including artesian conditions, hydraulic conductivity, occurrence, elevation fluctuation, tidal impacts, gradient, and flow direction.

Observation and aquifer pump test wells were installed in the eastern portion of the proposed facility footprint. The wells were installed to enable water withdrawal and aquifer monitoring to assess the nature of groundwater flow, yield, quality, and interconnectedness of three observed water bearing units.

The following sections summarizes the *LNG Facilities Onshore Hydrogeological Report* (**Resource Report No. 13, Appendix J**) with *Selected Illustrations and Lithologic Cross Secti*ons (**Attachment A**); the *Liquefaction Facilities Aquifer Pump Test Well and Groundwater Observation Well Installation Report* (**Attachment B**); *Liquefaction Facility Groundwater Quality Report – Event 1* (**Attachment C**); and the *Liquefaction Facility Groundwater Quality Report – Event 2* (**Attachment D**).

1.3 REGIONAL DATA REVIEW

Stratigraphy descriptions by others of the Liquefaction Facility site area are dominated by discussions of the occurrence, movement, and deposition of glacial and glaciofluvial sediments during the late Pleistocene Naptowne glaciation period. The two main lithologic formations at the Liquefaction Facility site include the stratigraphically higher Killey Unit and the stratigraphically lower Moosehorn Unit. The transition zone between the Killey Unit outwash deposits and the late Moosehorn Unit subestuarine deposits are generally marked by rust discoloration of the underlying late Moosehorn deposits. The finer-grained and more compact (i.e., lower permeability) upper Moosehorn deposits act as a leaky aquitard for iron-rich groundwater descending through the Killey sands, which leaves behind a characteristic iron staining.

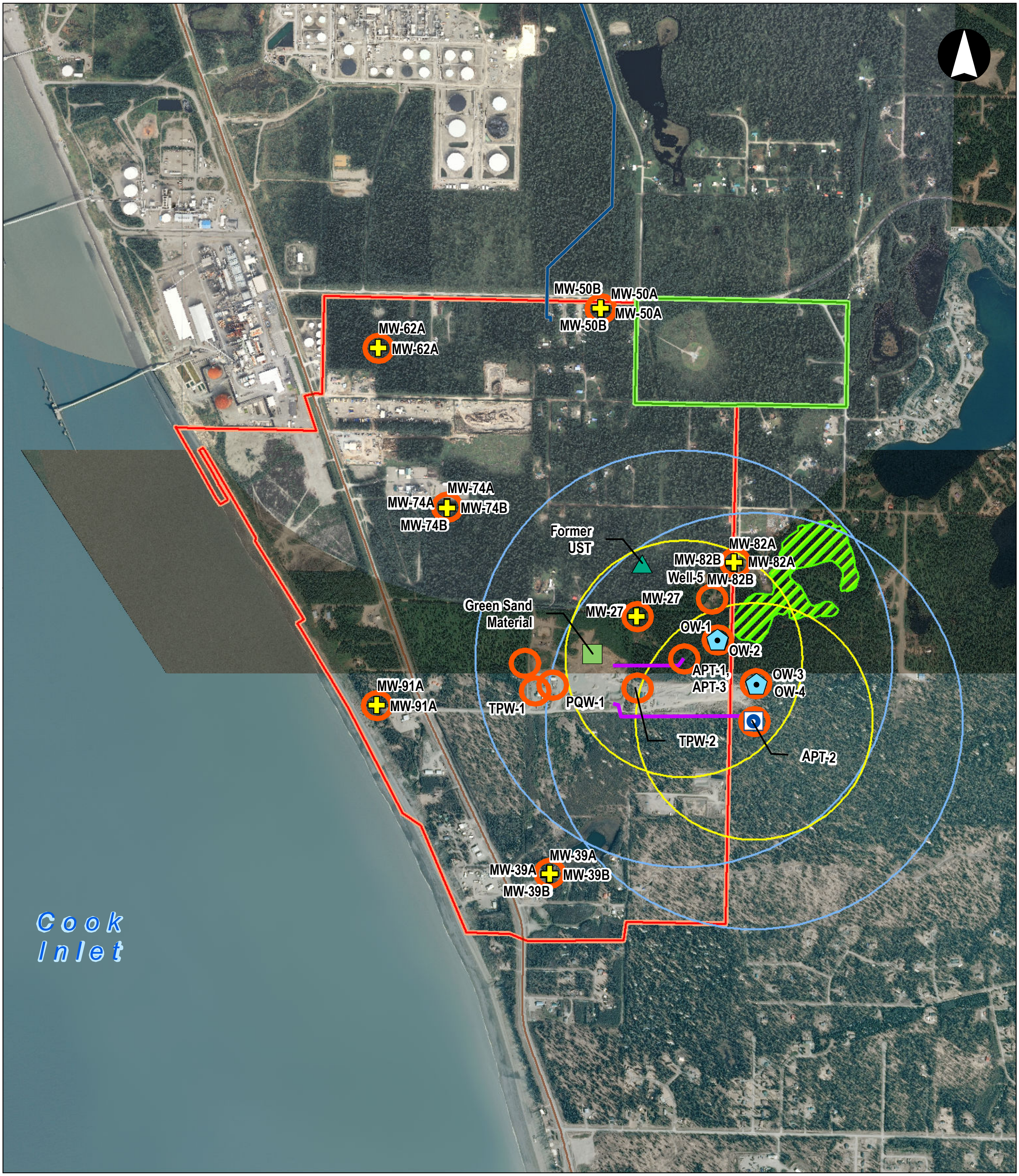
Locally, the unconsolidated sediments that make up the regional aquifer system consist of discontinuous clay, silt, sand, gravel and boulders deposited primarily by glaciers, but also by alluvial and colluvial processes. The sediments are complexly interbedded, with lenses and thin beds of sand and gravel interfingering with beds of clay, silt, and till. This complexity and the high variability in grain size distribution of the sediments causes discontinuity and variability in their hydraulic characteristics (USGS Ground Water Atlas of the United States, Publication HA 730-N).

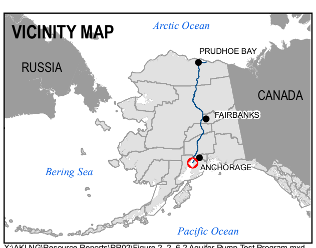
There are three regional aquifers noted by researchers in the Nikiski area. The uppermost aquifer, referred to herein as Water Bearing Unit 1 is unconfined. The next encountered aquifer (Water Bearing Unit 2) is confined or semi-confined, and the last encountered aquifer (Water Bearing Unit 3) is confined. Reportedly, the unconfined aquifer (Water Bearing Unit 1) is hydraulically connected to Beaver and Bishop Creeks and other lakes in the area (USGS, 1972).

The base of the unconfined aquifer (Water Bearing Unit 1) is comprised of discontinuous layers of silt and clay within the Killey-Moosehorn transition zone. Water Bearing Units 2 and 3 receive recharge from upland sources to the east and to a lesser extent from water percolating through the Killey-Moosehorn transition zone from the overlying Water Bearing Unit 1. A lower confined aquifer (not encountered during the investigation described in this report) is separated from the Water Bearing Units 2 and 3 by a silt and clay unit, and reportedly consists of many interconnected lenses and layers of sand, gravel, silt and clay at depths greater than 400 feet below ground surface (bgs) (USGS, 1981).

1.4 OFFSITE PRODUCTION WELLS

A review of the sparse publicly available documentation offsite production wells has identified several such wells at and near the Liquefaction Facility site (**Attachment A, Plate 5**). Most of these wells are in the industrialized northwest portion of the peninsula, and are associated with various local plant operations. Pertinent data regarding these wells is presented in the following **Table 1**.





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LEGEND

- Water Quality Well Testing
- Installed Monitoring Well
- 3rd Party Well with Access to Aquifer Pump Testing (APT) Well
- APT Well
- Observation Well
- Former UST
- Former Quarry Area, Green Sand Material, Inert Solid Waste
- APT Discharge Pipe
- Alaska LNG Rev C2 Route
- Major Highways
- APT Study Area (1500 Feet Radius)
- APT Vicinity (0.5 Mile Radius)
- Approximate Wetland Boundary

Liquefaction Facility

- Operations Area
- Construction Camp

No ADEC contaminated sites present within 0.5 mile radius of APT Vicinity.

0 0.1 0.2 0.4 Miles

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2016 AQUIFER PUMP TEST PROGRAM

FIGURE 1

ALASKA LNG

Table 1. Indrustrial Well Summary

Well ID	Owner	Casing Diameter (inches)	Pump Rate (GPM)	Well Depth (feet, approximate)	Static Water Level (feet, approximate)
TW-9	Tesoro	10"/14"	550	351	113
T2-A	Tesoro	8"	1300	200	Unavailable
PW 5-8	UNOCAL	Unavailable	1000	319	Unavailable
Kasilof River Plant	Trans-Aqua Int.	10"	1700 (Artesian)	335	Unavailable
Kasilof River Plant	Trans-Aqua Int.	8" Dis. Pipe	1400	335	Unavailable
Production Well 10	Collier Carbon & Chem.	16"	1250	75	15
Production Well 12	Collier Carbon & Chem.	16"	725	68	27
Production Well 9	Collier Carbon & Chem.	12"	1000	90	15
PW 5A	Collier Carbon & Chem.	16"	Unavailable	296	Unavailable
Production Well 1	Litwin Corporation	12"	525	140	50
Production Well 1	Collier Carbon & Chem.	16"	4000	340	110
Well Number 2	USGS	12"	700	215	58
Phillips Number 1	Phillips Petroleum	6"	900	245	72
Well 16	Unocal Chemicals	10"	520	198	65
2167	Seward Fish	8"	250 (Salt Water)	108	20-30 Var. w/ Tide
2166	Seward Fish	6"	150 (Salt Water)	107	25-30 Var. w/ Tide
Well 2	City of Soldotna	6"	Unavailable	197	Unavailable
Well 1	City of Soldotna	6"	Unavailable	210	Unavailable
PW 6	Union Chemicals	16"	1200	160	62

Source: USAKL-PT-PROPT-00-0001, MVE, Alaska SCLNG Project, Technical Evaluation of Water Cooled LNG Plan, September 13, 2013; and MW Drilling (Tesoro TW-9)

Production wells in the nearby vicinity (within approximately 2 miles) of the Liquefaction Facility site vary in diameter from 6 to 16-inches, in depth from 160 to 350.5 feet, and in production rates from 520 to 4,000 gallons per minute (gpm). Based on the depths of the wells and reported static water levels, it may be assumed that most of these wells targeted the first and/or second encountered aquifers (Water Bearing Units 1 and/or 2, respectively). Based upon their relatively deeper well depths and static water levels, it may also be assumed that Tesoro Well TW-9, Trans-Aqua Int. Kasilof River Plant Well, and Collier Carbon & Chemical Production Well 1 are most likely screened within the third encountered aquifer (Water Bearing Unit 3). Additional information on the Tesoro Well can be found in *Resource Report No. 13 Engineering and Design Material, Appendix 13J – Soil Characteristics.*

1.5 LITHOLOGIC RELATIONSHIP TO GROUNDWATER

The proposed Liquefaction Facility site is underlain by glacially derived deposits of Late Pleistocene age. Lithology in the study area is very complex and spatially varies due to the episodic glacial nature of sediment deposition. Groundwater occurrence and flow is controlled by these lithologic strata.

Sandy and gravelly bedded outwash deposits of the Killey Unit (Water Bearing Unit 1) extend to depths of approximately 60 (+/- 25) feet beneath the Liquefaction Facility site. Local rain water and snow melt percolate through these poorly consolidated sediments, until reaching the Killey-Moosehorn transition zone. The transition zone ranges between 25 to 50 feet thick and undulates with variable depth and thickness across the Liquefaction Facility site. The transition zone is characterized by the less dense lithologies of the Killey Unit (Water Bearing Unit 1) transitioning to the denser subestuarine deposits of the Moosehorn Unit (Water Bearing Units 2 and 3). The transition zone acts as leaky barrier between Water Bearing Units 1 and 2. Within the transition zone, one to several dense silt beds interfinger with sandier materials. Individual silt beds, observed in the sea cliff exposures, are observed to be laterally continuous over hundreds of feet, and locally form barriers to impede percolating water from reaching Water Bearing Unit 2. Water Bearing Units 2 and 3 are recharged predominately by upland, distal sources to the east. Based on field observations, the transitional contact zone between the two deposits represents a prominent surface present throughout the Kenai-Nikiski area.

Cross section lines were selected to show lithologic and hydrologic trends both parallel to general coastal topography (northwest-southeast) and perpendicular to topography (northeast-southwest, and generally parallel to groundwater flow regimes). The cross sections reflect the highly heterogeneous nature of sediments at the Liquefaction Facility site. The thickness and elevation variabilities of the strata can be observed on all cross sections, and in many cases, there is no horizontal connectivity between strata as shown on the borehole logs. The Liquefaction Facility Investigation Plan (**Attachment A, Plate 4)** showing locations of cross sections, and cross sections depicting variations in observed conditions across the proposed site, groundwater monitoring well schematics, groundwater measurements, and the locations of the water bearing units are presented in **Attachment B**.

1.6 GROUNDWATER BEARING UNITS

Three (3) distinct water bearing units have been identified and observed during subsurface field activities. These units are discussed in the following subsections. Micro Diver devices have been installed in all wells at the Liquefaction Facility site to provide data collection of changes in depth to groundwater. The static water surface (Water Bearing Unit 1) and potentiometric surface elevations (Water Bearing Units 2 and 3) in proposed site wells, as recorded on September 22, 2016, are presented in **Table 2**. The wells cover a large spatial area, and top of well casing elevations vary from 97.99 feet (North America Verticle Datum [NAVD88]) at well MW-39A in the southern portion of the Liquefaction Facility site to 136.24 feet (NAVD88) at well MW-14B, about 5,000 feet to the north.

Table 2. Observed Static Water Elevations

Water Bearing Unit	Well ID	Year Installed	Water Elevation [1,2]
1	MW-14B	2015	91.64
1	MW-27B	2014	92.54
1	MW-39B	2014	72.62
1	MW-50B	2014	89.47
1	MW-62B	2015	Dry
1	MW-74B	2015	72.92
1	MW-77B	2015	Dry
1	MW-80B	2015	84.69
1	MW-82B	2015	99.21
1	MW-86BA	2016	71.23
1	MW-87B	2015	79.56
1	MW-91B	2015	Dry
1	MW-98B	2015	91.30
1	MW-112B	2015	Dry
1	MW-138B	2015	82.84
1	OW-1	2016	96.94
1	OW-3	2016	97.00
2	MW-39A	2014	33.48
2	MW-50A	2014	69.00
2	MW-62A	2015	50.01
2	MW-74A	2015	63.36
2	MW-77A	2015	28.69
2	MW-82A	2015	94.84
2	MW-86A	2015	56.83
2	MW-91A	2015	15.71
2	MW-98A	2015	26.81
2	MW-112AA	2015	19.50
2	MW-138A	2015	61.28
2	OW-2	2016	74.62
2	OW-4	2016	75.09
2	APT-1	2016	72.22
2	APT-2	2016	74.35
3	APT-3	2016	45.86

Notes:
[1] Measured September 22, 2016 at 18:00 hours
[2] Datum: NAVD88

1.6.1.1 Water Bearing Unit 1

Water Bearing Unit 1 is found within the Killey geologic unit, is unconfined, and was observed across the Liquefaction Facility site at elevations ranging between 100.12 feet (NAVD88) (at the location of well MW-82B) and 72.62 feet (NAVD88) (at the location of well MW-39B). This groundwater unit was observed present at shallower depths in proximity to surface water bodies.

Five of the groundwater monitoring wells targeting Water Bearing Unit 1 remain dry, consistent with observations made following well installation. This confirms that perched water conditions were observed during well installation, and suggests variable groundwater conditions exist within Water Bearing Unit 1. All of the dry wells are also located in the western, near-shore portion of the Liquefaction Facility site. Groundwater levels in Water Bearing Unit 1 also appear to drop as the water surface coincides with the point of discharge along the Kiley-Moosehorn transition zone along the western face of the shoreline bluff.

1.6.1.2 Water Bearing Unit 2

Water Bearing Unit 2 is present within the Moosehorn geologic unit, is semi-confined, and lies immediately beneath the Killey-Moosehorn transition zone. The potentiometric surface (the surface to which water in a confined aquifer will rise within a well) elevation in Water Bearing Unit 2 was observed ranging between 95.18 feet (NAVD88) (at the location of well MW-82A) and 16.73 feet (NAVD88) (at the location of well MW-91A). This elevation range is reflective of conditions at the most upgradient and most downgradient locations, respectively.

1.6.1.3 Water Bearing Unit 3

Water Bearing Unit 3 is found beneath a second encountered confining lithologic stratum in the Moosehorn Unit. This water bearing unit extends at least as deep as the maximum drilled depth (437 feet below ground surface [bgs] within boring well APT-3) and water within the unit was observed to be confined or under pressure. During the drilling of well APT-3, no sequences of lithologies conducive to produce a sustainable well yield were encountered within the depth explored through Water Bearing Unit 3. In contrast, at Tesoro Well TW-9 (located approximately 9,000 feet to the northeast of well APT-3) a medium to coarse gravel was encountered from 328 to 352 feet bgs within Water Bearing Unit 3 (see Plate 6). The TW-9 well log documents a field well yield of 550 gallons per minute. The difference in lithologies and well yields between well APT-3 and TW-9, support the theory that there is a geologic formational feature between these two well locations which is a limiting factor to well recharge and yield at well APT-3.

Well APT-3 was screened within Water Bearing Unit 3. The potentiometric water surface elevation measured on September 22, 2016 at the location of well APT-3 was 45.86 feet (NAVD88). There is insufficient data upon which to provide comment regarding water flow and direction in Water Bearing Unit 3.

The water level within well APT-3 is shown to be influenced by Cook Inlet tidal fluctuations. This influence is graphically presented on **Plate 40** in **Attachment A**. The magnitude of the cyclic response wave pattern observed at well APT-3 is greater than those observed at co-located well APT-1.

2.0 HYDROLOGICAL SETTING

Water falling to the land surface as rain or snow percolates into underlying soils down to the water table, where it recharges Water Bearing Unit 1. Groundwater in this unconfined aquifer flows toward springs on the coastal bluffs where it was observed to be discharging during the 2014 and 2015 field investigations. Groundwater in Water Bearing Unit 1 is also reported to leak through the clay units to recharge deeper aquifers. Groundwater in Water Bearing Unit 2 flows towards the west (USGS, 1981).

Lakes in the area are recharged by precipitation, snowmelt, and by groundwater inflow. Groundwater levels adjacent to lakes correlate to lake water levels and fluctuations based on hydrologic processes. Similarly, as distance away from lakes increases, groundwater levels are expected to rise or fall to meet stabilized groundwater levels in an area.

Several factors contribute to seasonal and annual fluctuations in groundwater aquifer levels. Recharge is influenced by the amount of precipitation received both locally and regionally, evapotranspiration rates, and the rate of surface water runoff.

2.1 PRECIPITATION

The mean annual precipitation for Nikiski between 1980 and 2010 was 19.01 inches per year according to Nikiski data compiled by the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service. The average annual precipitation, as measured at the Nikiski Airport monitoring station from 2010 to 2015, was 19.96 inches per year.

Much of the water available for aquifer recharge falls during the winter season and is stored as snow and ice. Recharge to lakes, streams, and aquifer units occurs as the snow and ice melt.

2.2 ARTESIAN CONDITIONS

Artesian groundwater conditions in select wells are observed at the Liquefaction Facility site in Water Bearing Units 2 and 3 with potentiometric water surfaces measured above the aquitard formed by the Killey-Moosehorn transition zone. Most potentiometric water surface elevations recorded in wells installed within Water Bearing Unit 2 are all noted to rise above the corresponding top of the Killey-Moosehorn transition zone (see **Attachment A, Plates A-6, A-7, A-8, A-9, A-11, and A-12**). Well APT-3 is screened between 253 and 283 feet bgs and beneath a substantial clay and silt strata within Water Bearing Unit 3. The potentiometric water surface elevation within this well was observed at approximately 72 feet bgs, also rising above the Killey-Moosehorn transition zone.

Artesian groundwater conditions were also observed in two of the completed Alaska LNG beach borings during the 2015 campaign. At these locations (B-117 and B-136), artesian conditions were encountered at elevations of approximately -84 feet (NAVD88) and -78 feet, respectively. These two borings are in the southern area of the onshore geotechnical investigation program. A review of the two referenced beach boring logs, as well as other nearby boring logs, show a wide variation in lithology. It appears that the widely varied, lenticular, and heterogeneous properties of the sediments are acting as confining layers, controlling the presence and nature of these artesian conditions. The artesian condition has been observed to be flowing (where enough hydraulic pressure exists to push the groundwater up to the ground surface) at boring B-136. Artesian conditions were also observed in one offshore boring, MB-24. At this location, a flowing artesian condition was encountered at an elevation of approximately -100 feet (NAVD88).

2.3 PROPOSED WELLS FIELD CONDITIONS

Wells APT-1, APT-3, OW-1, and OW-2 are clustered within a regional northeast-southwest trending geological feature characterized by clustered surface water bodies and relatively shallow depth to groundwater in Water Bearing Unit 1. Wells APT-2, OW-3, and OW-4 are situated approximately 1,000 feet to the southeast, and are either on the margin or just beyond the regional subsurface geologic feature which has been observed to limit water recharge and yield locally in the proposed well field. A summary regarding hydrologic conditions within each water bearing unit follows below.

2.3.1 APT Well Development Effects on Water Bearing Unit 1

Depth to water within this unit varies depending on proximity to the subsurface geologic feature. Static water depth within well OW-1 is approximately 15.29 feet below top of casing (BTOC) (corresponding elevation of 96.94 feet NAVD88); the static water depth within well OW-3 is approximately 34.26 feet BTOC (corresponding elevation of 97.00 feet NAVD88).

Well APT-1, completed in Water Bearing Unit 2, was developed on September 12, 2016 by pumping approximately 7,540 gallons of water in two intervals. The development of well APT-1 consisted of originally pumping at approximately 100 gpm, and subsequently increasing the pumping rate in increments to approximately 300 gpm. Well APT-1 was dewatered to the pump intake level (approximately 23 feet elevation NAVD88) during development. None of the nearby wells (within 1,000 feet of well APT-1) screened within Water Bearing Unit 1 (e.g., wells MW-27B, OW-1, and OW-3) showed any discernable water level response to the water extraction during well APT-1 development activities (**Attachment A, Plate 44**).

Well APT-2, also completed in Water Bearing Unit 2, was developed on September 19, 2016 by pumping approximately 7,059 gallons of water in two intervals. During development, water was originally pumped at a rate of approximately 200 gpm, and stepped up in one increment to approximately 250 gpm during the first pumping interval. Well APT-2 was dewatered to the pump intake level (approximately 33 feet elevation NAVD88) during the first interval. Pumping was maintained at approximately 200 gpm during the second development interval for 11 minutes. Well APT-2 was not dewatered to the pump intake level during the short second pumping interval.

The closest well to well APT-2 (well OW-3, located approximately 500 feet north) is screened within Water Bearing Unit 1, and did not show a discernable water level response to the water extraction during the development activities (**Attachment A, Plate 45**).

Although there is likely communication between water within Water Bearing Unit 1 and Water Bearing Unit 2 at the Liquefaction Facility site, there was no measurable decrease in water elevation in nearby Water Bearing Unit 1 wells during the pumping of water from wells screened within Water Bearing Unit 2. This may be attributable to several factors including the limited nature of the well development activities, and the presence of a relatively competent aquitard separating Water Bearing Unit 1 and Water Bearing Unit 2 in this area, or a combination of these and other possible factors.

2.3.2 APT Well Development Effects on Water Bearing Unit 2

During well APT-1 development activities, water elevations recorded within wells OW-2 (located approximately 550 feet east/northeast of well APT-1) and OW-4 (located approximately 1,000 feet east/southeast of well APT-1) were observed to quickly respond to the pumping, with two discrete decreases recorded in water elevations (**Attachment A, Plate 44**). Water elevations within the wells quickly recovered after cessation of pumping activities. Given the quick responses to pumping and cessation of pumping, it is evident that good hydraulic communication within Water Bearing Unit 2 exists between the locations of wells APT-1, OW-2, and OW-4.

There was no discernable response to well APT-1 development pumping recorded at well MW-82A (located approximately 1,450 feet northeast of well APT-1); indicating that either this well is located outside of the limited radius of influence of the well development activities, or there is an impediment to hydraulic communication somewhere between wells APT-1 and MW-82A.

During well APT-2 development activities, the water elevation recorded within well OW-4 (located approximately 500 feet north of well APT-2) was observed to quickly respond to the pumping, with two discrete decreases recorded in groundwater elevations (**Attachment A, Plate 45**). The water elevation within this well quickly recovered after cessation of pumping activities.

Water elevations within well OW-2 (located approximately 1,225 feet north-northwest of well APT-2) did not show a discernable response to well APT-2 water development pumping activities; indicating that either this well is located outside the limited radius of influence of the well development activities, or there is an impediment to hydraulic communication somewhere between wells APT-2 and OW-2.

Water was pumped at a continuous rate of approximately 200 gpm during the second interval of development of well APT-2. During that interval, the rate of water drawdown was observed to slow over time, and did not reach the pump intake elevation. The slowing of the rate of drawdown at 200 gpm may signify that this pumping rate may be close to the well's sustainable yield

2.3.3 APT Well Development Effects on Water Bearing Unit 3

During development water removal from co-located well APT-1, no discernable response was noted in the potentiometric water surface elevation at well APT-3. This may be attributable to the limited nature of the well development activities, a relatively competent aquitard separating Water Bearing Unit 2 and Water Bearing Unit 3 in this area, or a combination of these or other possible factors.

Well APT-3, completed in Water Bearing Unit 3, was developed on September 3, 2016 by pumping groundwater at a continuous rate of approximately 25 gpm. The well was completely dewatered to the pump intake depth of 231 feet bgs; indicating that a sustained groundwater yield would be less than 25 gpm.

2.3.4 Hydraulic Conductivity

Data collected during well development activities were analyzed, and hydraulic conductivity estimated utilizing the Hvorslev Method of analysis. Charts depicting changes in water elevations (drawdown and recovery) and temperature data (collected to graphically illustrate conductivity) during the development of wells APT-1, APT-2, and APT-3 are presented in **Attachment A (Plates 46, 47 and 48)**, respectively. Hydraulic conductivity at wells APT-1, APT-2, and APT-3 is calculated at 30.4, 49.9, and 0.12 feet per day, respectively.

2.4 GENERALIZED HYDROGEOLOGICAL CONCEPTUALIZED MODEL

Hydrogeology within the study area is complex in nature. This complexity is due to the heterogeneous and sporadic spatial occurrence of sediments comprising the three water bearing units observed at the Liquefaction Facility site. General site lithologies with water bearing units and fence diagrams are graphically depicted in **Figures 2** and **3**.

The interactions between precipitation, surface water bodies, and water percolation through the diverse identified glacial and glaciofluvial formations have created unconfined, semi-confined and confined aquifers at the Liquefaction Facility site. The three aquifers are separated by discontinuous aquitards (typically between Water Bearing Units 1 and 2), and a generally more continuous aquitard (between Water Bearing Units 2 and 3). There appears to be significant hydraulic communication between surface water bodies and Water Bearing Unit 1, and a lesser degree of hydraulic communication between Water Bearing Units 1 and 2. This is likely attributable to the discontinuous nature of the aquitard separating these units.

Groundwater within Water Bearing Unit 1 is recharged by percolation of local precipitation through overlying sediments, and from local surface water bodies. The predominant recharge source of water within Water Bearing Units 2 and 3 is distal, and to the east.

Groundwater in both Water Bearing Units 1 and 2 flows to the west, at relatively flat gradients. Groundwater with Water Bearing Units 2 and 3 are influenced by Cook Inlet tides. This influence may be due to hydraulic connectivity with Cook Inlet waters, by increased hydrostatic pressure due to increased load during high tides, or a combination of both.

The quick response in water levels observed within nearby wells screened within Water Bearing Unit 2 during development water removal from wells APT-1 and APT-2 indicate good hydraulic communication within Water Bearing Unit 2 in the well field area.

A review of the recovery graph generated from well APT-3 development data (**Attachment A**, **Plate 48, Chart D**) shows an upward curve at the end of recovery. This indicates influence of an impermeable geologic barrier near this well. As there are no known geologic structures (e.g., folds, faults, joints) in this area, it may be inferred that very stiff sedimentary strata in this area could be acting as a barrier to groundwater flow.

Figure 2. General Site Lithology and Water Bearing Units Fence Diagram, View Toward N / NW From Bluff, South of Project Area

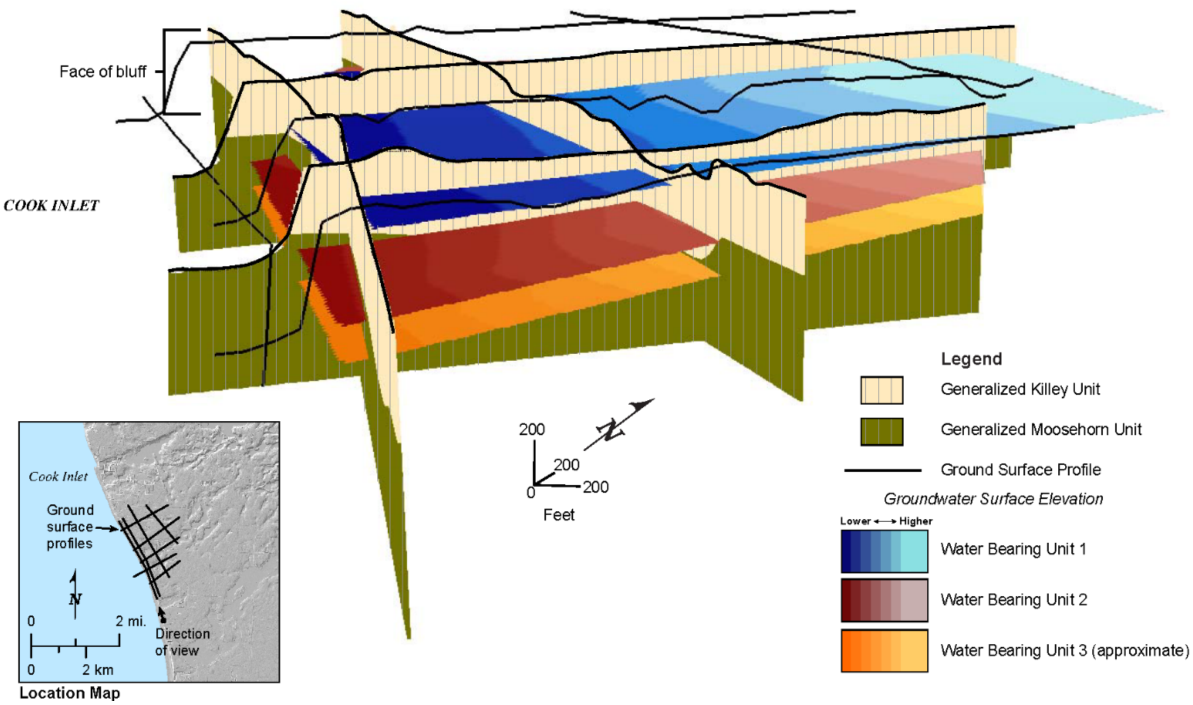
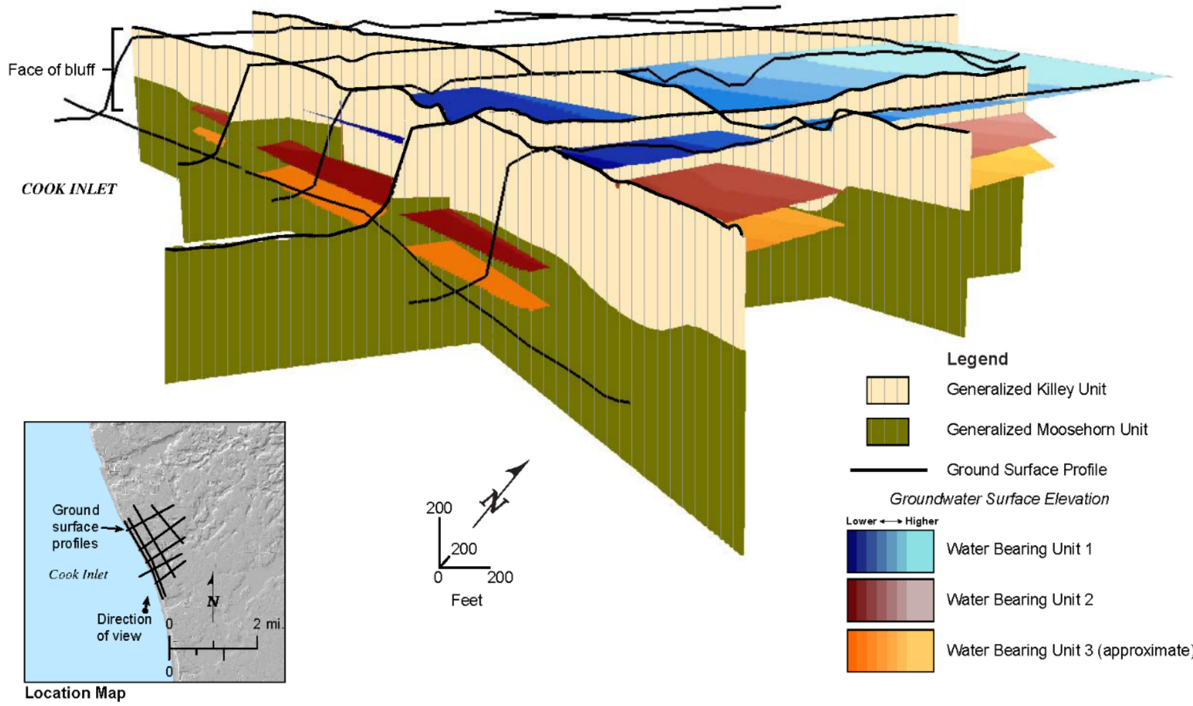


Figure 3. General Site Lithology and Water Bearing Units Fence Diagram, View Toward N / NE From Cook Inlet, South of Project Area



3.0 GROUNDWATER QUALITY

Two groundwater quality sampling events have been conducted in 2016 to evaluate groundwater quality in proposed production wells. The groundwater sampling program activities and results are documented in LNG Facilities Groundwater Sampling and Testing Report – Event 1 Report (**Attachment C**); and LNG Facilities Groundwater Sampling and Testing Report – Event 2 Report (**Attachment D**). Major findings of the sampling program are summarized below by water bearing unit.

3.1 WATER BEARING UNIT 1

Detected total and dissolved metal concentrations were below respective Alaska Department of Environmental Conservation (ADEC) Table C groundwater cleanup levels, where established. For wells OW-1 and OW-3, detected concentrations of select total and/or dissolved metals including aluminum, chromium, copper, iron, manganese, and/or nickel exceeded respective ADEC Water Quality Standards for Designated Uses. Arsenic was not detected at concentrations above regulatory thresholds, as compared with Water Bearing Unit 2 and Water Bearing Unit 3 (see below).

Petroleum hydrocarbons, including diesel range organics, gasoline range organics, and residual range organics have been detected in several Water Bearing Unit 1 wells, at concentrations below regulatory thresholds.

Values of pH in groundwater collected during Event 1 ranged between 6.40 and 7.93 (average of 7.14) Standard Units (SU), and between 4.82 and 7.30 (average of 6.86) SU in groundwater collected during Event 2.

No VOCs, PCBs, pesticides, fecal coliform, or Chlorophyll-A were detected in samples submitted for analyses.

3.2 WATER BEARING UNIT 2

Analyses detected arsenic at concentrations ranging from 0.0077 milligrams per Liter (mg/L) to 0.131 mg/L, exceeding the ADEC Table C groundwater cleanup level of 0.01 mg/L in wells MW-39A, MW-50A, MW-62A, MW-74A, OW-2, OW-4, APT-1, and APT-2. Arsenic was not detected above this regulatory threshold in samples collected from wells MW-82A and MW-91A.

For wellsOW-2, OW-4, APT-1, and APT-3, detected concentrations of select total and/or dissolved metals including aluminum, antimony, arsenic, chromium, copper, iron, lead, manganese, nickel, vanadium, and/or zinc exceeded respective ADEC Water Quality Standards for designated uses.

No VOCs were detected in any of the six (6) wells sampled during Event 1. Apart from trichloroethene, toluene, and chloromethane, no VOCs were detected in any of the ten (10) wells sampled during Event 2. Analyses detected trichloroethene in three (3) of ten (10) wells (wells OW-2, OW-4, and APT-1) at concentrations ranging between 0.00047 mg/L and 0.057 mg/L, exceeding ADEC Table C groundwater cleanup level of 0.005 mg/L in wells OW-4 and APT-1. Analyses detected toluene at 0.0027 mg/L (well APT-2) and chloromethane at a concentration of 0.00039 mg/L (OW-2 and OW-4), all below ADEC Table C groundwater cleanup criteria.

Detected petroleum hydrocarbon concentrations were well below respective ADEC Table C groundwater cleanup levels. Analyses detected gasoline range organics in one (1) of the six (6) wells sampled during the Event 1 (see **Attachment C** for further information) monitoring event (well MW-39A) at a concentration of 0.0539 mg/L. Analyses detected gasoline range organics in one (1) of the ten (10) wells sampled during the Event 2 monitoring event (well APT-1) at a concentration of 0.0497 mg/L. Diesel range organics were detected in eight (8) out of ten (10) samples collected during the Event 2 monitoring event at concentrations ranging between 0.24 mg/L and 0.486 mg/L (wells MW-39A, MW-50A, MW-62A, MW-74A, MW-82A, OW-4, APT-1, and APT-2). Diesel range organics were not detected in any wells sampled during Event 1. Residual range organics were detected in one (1) of six (6) wells collected during the Event 1 monitoring event (MW-74A) at a concentration of 0.352 mg/L; and at two (2) of the ten (10) wells sampled during the Event 2 monitoring event at concentrations of 0.192 mg/L (well OW-2) and 0.476 mg/L (well OW-4). These concentrations are below ADEC Table C groundwater cleanup criteria.

Values of pH in groundwater collected during Event 1 ranged between 8.37 and 9.99 (average of 9.04) SU, and between 7.08 and 8.67 (average of 8.13) SU in groundwater collected during Event 2.

3.3 WATER BEARING UNIT 3

The second groundwater quality sampling event (Event 2) represented the first opportunity to collect groundwater quality data from Water Bearing Unit 3, and at only one (1) location, well APT-3 (see **Attachment D** for further information).

Detected concentrations of select total and/or dissolved metals including, aluminum, arsenic, boron, chromium, copper, iron, lead, manganese, molybdenum, nickel, and/or zinc exceeded respective ADEC Water Quality Standards for designated uses.

Except for trichloroethene, no VOCs were detected during this event. Analyses detected 0.015 mg/L of trichloroethene, exceeding the ADEC Table C groundwater cleanup level of 0.006 mg/L.

Petroleum hydrocarbons were detected at concentrations well below respective ADEC Table C groundwater cleanup levels. Analyses detected diesel range and residual range organics at concentrations of 0.518 mg/L and 0.165 mg/L, respectively.

The pH value was measured at 9.03 SU in a groundwater sample collected from well APT-3.

3.4 COMPARISON OF WATER QUALITY DATA BETWEEN WATER BEARING UNITS

Groundwater within Water Bearing Units 2 and 3, including groundwater near the quarry and the APT wells, has been shown to contain total and dissolved metals and select VOCs at higher concentrations than values detected in Water Bearing Unit 1. The presence of total arsenic and trichloroethene concentrations that were detected at an order of magnitude higher in Water Bearing Units 2 and 3 wells than in Water Bearing Unit 1 wells. Detected concentrations of these analytes in select wells screened within Water Bearing Units 2 and 3 exceed ADEC groundwater cleanup levels, whereas these analytes, if detected, are below ADEC levels in Water Bearing Unit 1. Additionally, Water Bearing Units 2 and 3 also have higher pH levels than Water Bearing Unit 1.

With the exception of bis(2-ethylhexyl)phthalate in well MW-74B, detected analytes in groundwater samples within Water Bearing Unit 1 have all been below ADEC groundwater cleanup levels. During the September monitoring event, bis(2-ethylhexyl)phthalate was detected in well MW-74B at 0.0077 mg/L, exceeding the ADEC groundwater cleanup level of 0.006 mg/L.

In general, no PCBs or pesticides were identified in any of the groundwater samples analyzed from the three water bearing units underlying the Liquefaction Facility site. Between the two monitoring events, gasoline range, diesel range, and residual range organics have been detected within all three water bearing units, at similar concentrations, and below ADEC groundwater cleanup levels.

Table 3. Comparison of Major Analytes by Water Bearing Unit

Analyte	Water Bearing Unit 1	Water Bearing Unit 2	Water Bearing Unit 3
Total Arsenic	0.000713 mg/L to 0.00336 mg/L	0.00883 mg/L to 0.0474 mg/L	0.0798 mg/L
Trichloroethene	Not Detected (ND)	ND to 0.057 mg/L	0.015 mg/L
pH	4.82 to 7.30 SU.	7.08 to 8.67 SU	9.03 SU
Alkalinity	12 mg/L to 70.9 mg/L	70.3 mg/L to 106 mg/L	509 mg/L

Note:

Results from Third-Party wells are not included in the data comparison presented above as it is not known what water bearing unit the wells are screened within.

Cations (positively-charge ions) and anions (negatively-charged ions) from wells sampled during the two monitoring events were plotted on Piper Diagrams by Water Bearing Unit (**see Attachment D**). Based on the data, apart from well MW-39B, water within Water Bearing Unit 1 is calcium bicarbonate rich, indicative of a shallow fresh water environment. Water near well MW-39B is slightly more calcium sulfate rich than other wells screened within the shallow water bearing unit. Apart from groundwater near MW-50A, MW-82A, and OW-2, groundwater within Water Bearing Unit 2 is also calcium bicarbonate rich, indicative of a shallow fresh water environment. Water near wells MW-50A, MW-82A, and OW-2 tends to be more sodium bicarbonate rich, which may be indicative of a deep groundwater environment influenced by ion exchanges. Similar to wells MW-50A, MW-82A, and OW-2, cations and anions for well APT-3, screened within Water Bearing Unit 3, are also indicative of a deep groundwater environment influenced by ion exchanges.

3.5 CONDITIONS IN THE PROPOSED WELL FIELD AREA

Groundwater sample analyses has detected antimony at concentrations ranging from 0.000362 mg/L to 0.00775 mg/L, exceeding the ADEC Table C groundwater cleanup level of 0.006 mg/L in OW-4. Detected total arsenic concentrations varied between 0.00131 mg/L and 0.131 mg/L, exceeding ADEC Table C ground water cleanup level of 0.01 mg/L, and the ADEC Alaska General Permit AKG003000 for Discharge of Aquifer Pump Test (Table 3) in samples obtained from wells OW-2, OW-4, and APT-1 through APT-3. It should be noted that most total metals also exceeded ADEC Water Quality Standards for Designated Uses in most wells.

Analyses detected trichloroethene at concentrations ranging from 0.00047 mg/L (well OW-2) to 0.057 mg/L (well OW-4), exceeding the ADEC Water Quality Standard for Designated Use criteria of 0.005 mg/L in samples collected from OW-4, APT-1, APT-2, and APT-3.

For wells OW-2, OW-4, APT-1, APT-2, and APT-3, detected concentrations of select dissolved metals including arsenic, copper, lead, and zinc also exceeded respective ADEC Water Quality Standards for Designated Uses.

Gasoline range organics were detected in well APT-1 at 0.0497 mg/L. Analyses detected diesel range organics in all three APT wells and in well OW-4 at concentrations ranging from 0.24 mg/L (well APT-2) to 0.518 mg/L (well APT-3). Residual range organics were detected in all four OW wells and in well APT-3 at concentrations ranging from 0.155 mg/L to 0.476 mg/L. All detected hydrocarbons were well below respective ADEC Table C groundwater cleanup levels.

Given the regulatory concentration threshold exceedances of antimony, arsenic, and trichloroethene found in groundwater samples in the proposed well field area, any discharge must be managed in accordance with regulatory agency requirements to mitigate any potential impacts.

3.6 CONDITIONS NEAR THE FORMER QUARRY PIT

Groundwater monitoring wells MW-27B and MW-87B, and three (3) third-party wells (wells PQW-1, TPW-1, and TPW-2) are in the general vicinity of the former quarry pit.

Various total metals were detected in all wells located near the quarry. Except for arsenic, detected total metals were well below respective ADEC Table C groundwater cleanup levels, where established. Analyses detected arsenic up to 0.0149 mg/L, exceeding ADEC's Table C groundwater cleanup level and APT General Discharge Permit criteria of 0.01 mg/L in TPW-2. Various dissolved metals were also detected in the two (2) monitoring and the three (3) third-party wells at concentrations below respective ADEC Table C groundwater cleanup levels, where established.

Petroleum hydrocarbons including gasoline range (0.359 mg/L, PQW-1) and diesel range (up to 0.354 mg/L, well MW-87B) have been identified in groundwater samples collected within the quarry area. Analyses also detected the presence of benzene up to 0.0677 mg/L, exceeding ADEC's Table C groundwater cleanup level of 0.005 mg/L.

It is likely that a future discharge of a significant volume of water associated with a potential aquifer pump test would mobilize the documented petroleum hydrocarbons, benzene, and arsenic which are found in groundwater above regulatory thresholds at and near the former quarry pit. Any potential discharge will need to be managed in accordance with regulatory agency guidance.

4.0 SUMMARY

Studies completed during the 2014, 2015 and 2016 field investigations have provided good coverage and data collection for the Liquefaction Facility site. Groundwater monitoring wells, aquifer pump test wells and observation wells installed to date span an area of approximately 9,000 feet in the north/south direction by approximately 5,700 feet in the west/east direction. Based on the data collected to date, we conclude the following:

- Three (3) groundwater bearing units have been identified at the Liquefaction Facility site, an unconfined Water Bearing Unit 1 within the upper Killey formation, and a confined or semi-confined Water Bearing Unit 2 and a confined Water Bearing Unit 3 within the underlying Moosehorn formation.
- Shallow groundwater is influenced by surface water bodies, and is found to recharge quickly relative to proximity to those bodies after rain events.
- Four (4) of the wells completed within Water Bearing Unit 1 were dry during both monitoring events completed in 2016, consistent with observations made following initial well installation. This confirms that perched water conditions were present during well installation, and suggests variable depth to water conditions exist within Water Bearing Unit 1. All of the dry wells are located in the western, coastal portion of the Liquefaction Facility site, where the shallow water column decreases in elevation as it approaches its' discharge point at the bluff.
- The water elevation observed at well MW-98B appears to represent a localized perched condition within Water Bearing Unit 1.
- Water elevations within Water Bearing Unit 1 wells declined approximately 2 to 5 feet from data recording inception in December 2014 through approximately October 2015, at which time elevations are observed at their lowest. Water elevations then commence recovery in response to surface water recharge to the aquifer, and reach their apex in February 2016, at which time water elevations are noted to begin their seasonal decline. An overall decrease of approximately 1 foot in water elevation is observed in the 2014-installed wells from December 2014 to December 2015, likely in response to lower year-to-year seasonal precipitation.
- Water Bearing Unit 1 is observed not to be tidally influenced.
- Water Bearing Units 2 and 3 are observed to be tidally impacted at various degrees of correlation. In general, a higher degree of correlation exists closer to the coastline. There are some departures from this general relationship; we attribute these outliers to the heterogeneous nature of the lithologies across the Liquefaction Facility site. A stronger correlation between Cook Inlet tides and potentiometric groundwater elevation is noted in water within well APT-3 (Water Bearing Unit 3) than at co-located well APT-1 (Water Bearing Unit 2).
- There is no discernable reduction in water elevations year-over-year, 2014 to 2015, in the Water Bearing Unit 2 wells.
- Groundwater within Water Bearing Unit 1 and Water Bearing Unit 2 flows at a relatively flat gradient to the west-southwest. There is insufficient data upon which to provide a comment regarding water flow and direction in Water Bearing Unit 3.
- The differences in water surface and potentiometric elevations in co-located wells within Water Bearing Unit 1 and Water Bearing Unit 2 vary significantly. No correlation was noted

between the magnitude of the differing co-located water level readings and the thickness of the aquitard separating the units, nor by geographic location.

- Water elevations in five (5) of the Water Bearing Unit 1 wells and two (2) of the Water Bearing Unit 2 wells exhibited a response to a January 2016 magnitude 7.1 earthquake located in Iniskin area of Alaska, approximately 60 miles west of Homer, based upon Micro Diver water level data retrieved from the wells. Most of the water levels decreased and rebounded to their pre-earthquake elevations within an hour. However, the water level in MW-50B was noted to increase slightly. The response was greatest at the location of well MW-74A, which was noted to drop approximately 3 feet, then rebounded and sustained an approximately 2 feet rise above its' pre-earthquake level.
- A review of the recovery graph generated from well APT-3 development data shows an upward curve at the end of recovery, indicating influence of an impermeable barrier near this well. As there are no known seismic structures in this area, it may be inferred that very stiff sedimentary strata in this area could be acting as a barrier to groundwater flow.
- Although there is likely communication between water within Water Bearing Unit 1 and Water Bearing Unit 2 at the Liquefaction Facility site, there was no measurable decrease in water elevation in nearby Water Bearing Unit 1 wells during the development water removal from wells screened within Water Bearing Unit 2. This may be attributable to the limited nature of the pumping activities, the presence of a relatively competent aquitard separating Water Bearing Unit 1 and Water Bearing Unit 2 in this area, or a combination of these or other possible factors.
- It is evident that good hydraulic communication within Water Bearing Unit 2 exists between the locations of wells APT-1, OW-2, and OW-4. There was no discernable water elevation response at well MW-82A (located approximately 1,450 feet northeast of well APT-1); indicating that there is an impediment to hydraulic communication somewhere between the locations of wells APT-1 and MW-82A and/or the lack of response is a reflection of the shortened development activities which did not stress the aquifer system sufficiently.
- During development water removal from well APT-2, the water elevation recorded within well OW-4 (located approximately 500 feet north of well APT-2) was observed to quickly respond to the water removal activities. Groundwater elevations within well OW-2 (located approximately 1,225 feet north-northwest of well APT-2) did not show a discernable response to well APT-2 groundwater development activities; indicating that there may be an impediment to hydraulic communication somewhere between the locations of wells APT-2 and OW-2, and/or the lack of response is a reflection of the shortened development activities which did not stress the aquifer system sufficiently.
- Water quality found within the three (3) water bearing units varies by unit and laterally within the unit. Total arsenic concentrations within Water Bearing Unit 2 and Water Bearing Unit 3 are up to two orders of magnitude greater than concentrations within Water Bearing Unit 1. Trichloroethene has been detected in Water Bearing Unit 2 and Water Bearing Unit 3 groundwater samples, but not in Water Bearing Unit 1 groundwater samples. pH values measured in Water Bearing Unit 1 groundwater is slightly acidic to neutral; pH Values in Water Bearing Unit 2 and Water Bearing Unit 3 groundwater are neutral to alkaline.
- Groundwater in the proposed well field area is impacted by concentrations of antimony, arsenic, and trichloroethene that exceed the concentrations allowed by the regulatory water quality standards. It is likely that groundwater treatment would be required prior to discharge during a potential future aquifer pump test.

- Groundwater in the former quarry pit area is impacted by concentrations of petroleum hydrocarbons, benzene, and arsenic above regulatory water quality standards. Any potential groundwater discharge will need to be conducted in accordance with regulatory agency review and approval.
- During the installation and development of wells APT-1 and APT-3, no sequences of lithologies conducive to high groundwater yield were encountered within Water Bearing Unit 2 or 3 to the total drilled depth. This may be reflective of geologic processes and conditions found within the northeast-southwest trending geological feature found in this area.

The Liquefaction Facility site hydrogeology is a direct result of the complex depositional environment, and subsurface groundwater conditions vary significantly, both vertically and laterally. Although some hydrogeological parameters of Water Bearing Units 1, 2, and 3 have been observed, evaluated, and documented herein, a full-scale long duration (approximately 10 day) aquifer pump test, as originally planned, is necessary to properly evaluate properties of the water source aquifers below the proposed Project site and their ability to meet LNG project design criteria needs.

Limited groundwater recharge capacity has been observed in the currently proposed production well field area due to a subsurface geologic feature. In addition, the chemical contaminant trichloroethene has been detected in the well field area, and a source has not been identified. Water removal from the currently proposed well field area during well development activities generated contaminated water which was unsuitable for upland discharge and would require additional treatment for long term use.

Investigations in the proposed well field area have not provided evidence of a water bearing unit with sufficient capacity capable to satisfy the design criteria/demand use for the LNG Plant. In addition, groundwater collected from Water Bearing Units 2 and 3 was observed to possess elevated arsenic and trichloroethene concentrations. Before deciding whether Water Bearing Units 2 or 3 should be further evaluated for design criteria/demand use, ADEC should be consulted. Additional information may be found in Resource Report No. 13 pertaining to the hydrogeological conditions at the proposed onshore Liquefaction Facility site.

5.0 ACRONYMS AND TERMS

Term	Definition
ADEC	Alaska Department of Environmental Conservation
Applicant	Alaska Gasline Development Corporation
APT	aquifer pump test
BTOC	below top of casing
bgs	below ground surface
C.F.R.	Code of Federal Regulations
FERC	Federal Energy Regulatory Commission
gpm	gallons per minute
GTP	Gas Treatment Plant
LNGC	Liquefied natural gas carriers
LNG	Liquefied natural gas
MMTPA	million metric tons per annum
MW	monitor well
NAVD88	North Amerixcan Verticle Datum
OW	observation well
PBU	Prudhoe Bay Unit
PTTL	Point Thomson Transmission Line
PTU	Point Thomson Unit
SU	Standard unit
TW	Tesoro Well
VOC	volatile organic compound

6.0 REFERENCES

Alaska Department of Environmental Conservation (ADEC), 2016, 18 AAC 70, Water Quality Standards.

United States Department of the Interior Geologic Survey, 1981, Hydrology and the Effects of IndustrialPumping in the Nikiski Area, Alaska.

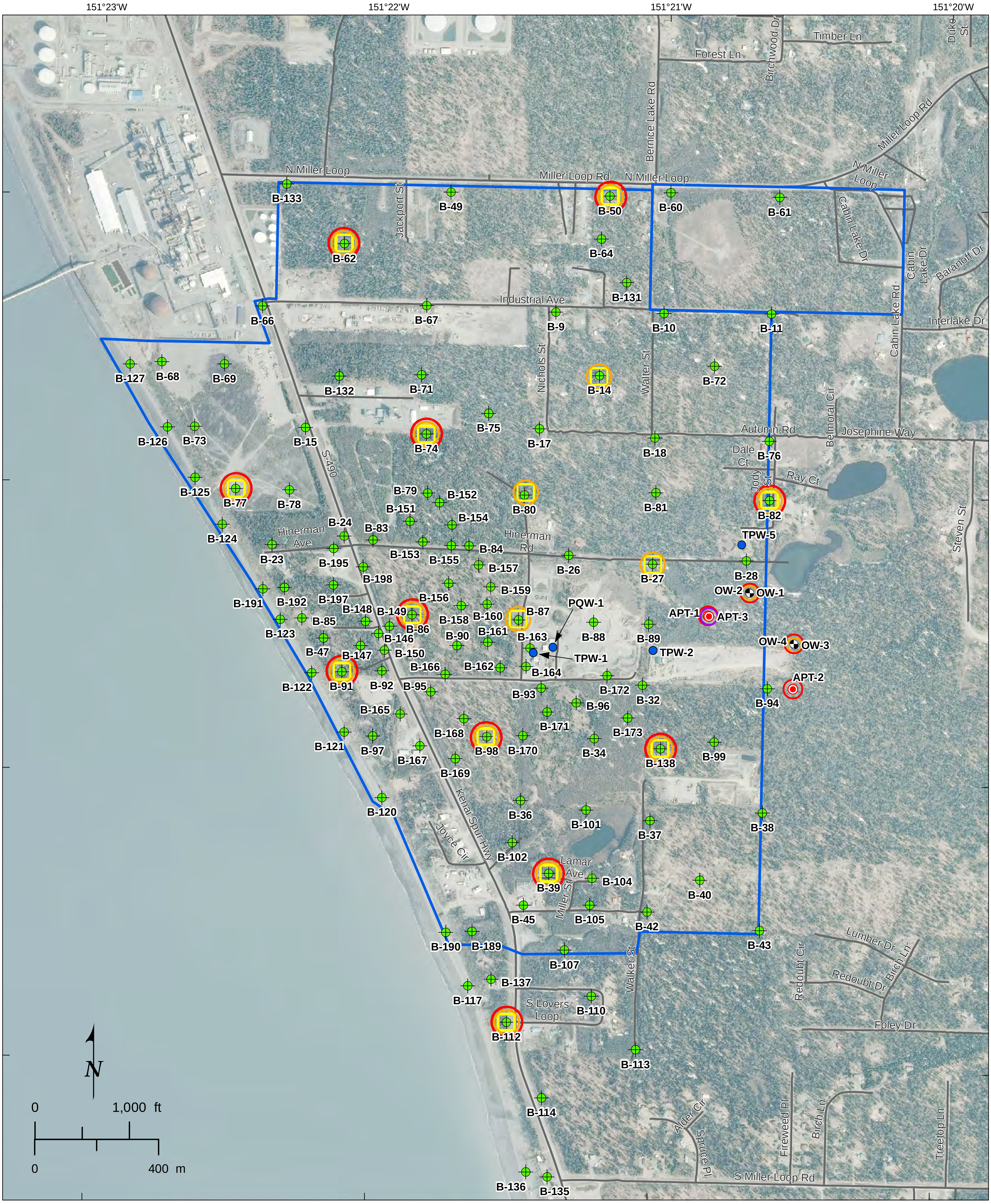
United States Department of the Interior Geological Survey, Water Resources Division, Alaska District, Water Resources of the Kenai-Soldotna Area, Alaska, 1972.

USGS Ground Water Atlas of the United States, Publication HA 730-N.

ATTACHMENT A: SELECTED ILLUSTRATIONS AND LITHOLOGIC CROSS SECTIONS

Liquefaction Facility Investigation Plan

Alaska LNG™ FUGRO



LEGEND

- Onshore Borings (completed)
- Monitoring Well Locations
  Note: co-located well pairs are present at locations B-39, B-50, B-62, B-74, B-77, B-82, B-86, B-91, B-98, B-112, and B-138
- Onshore LNG Facilities Study Area
- APT Well
- Observation Well Pair
- Third Party Well
- Shallow Well - Water Bearing Unit 1
- Intermediate Well - Water Bearing Unit 2
- Deep Well - Water Bearing Unit 3

INVESTIGATION PLAN

ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE 4

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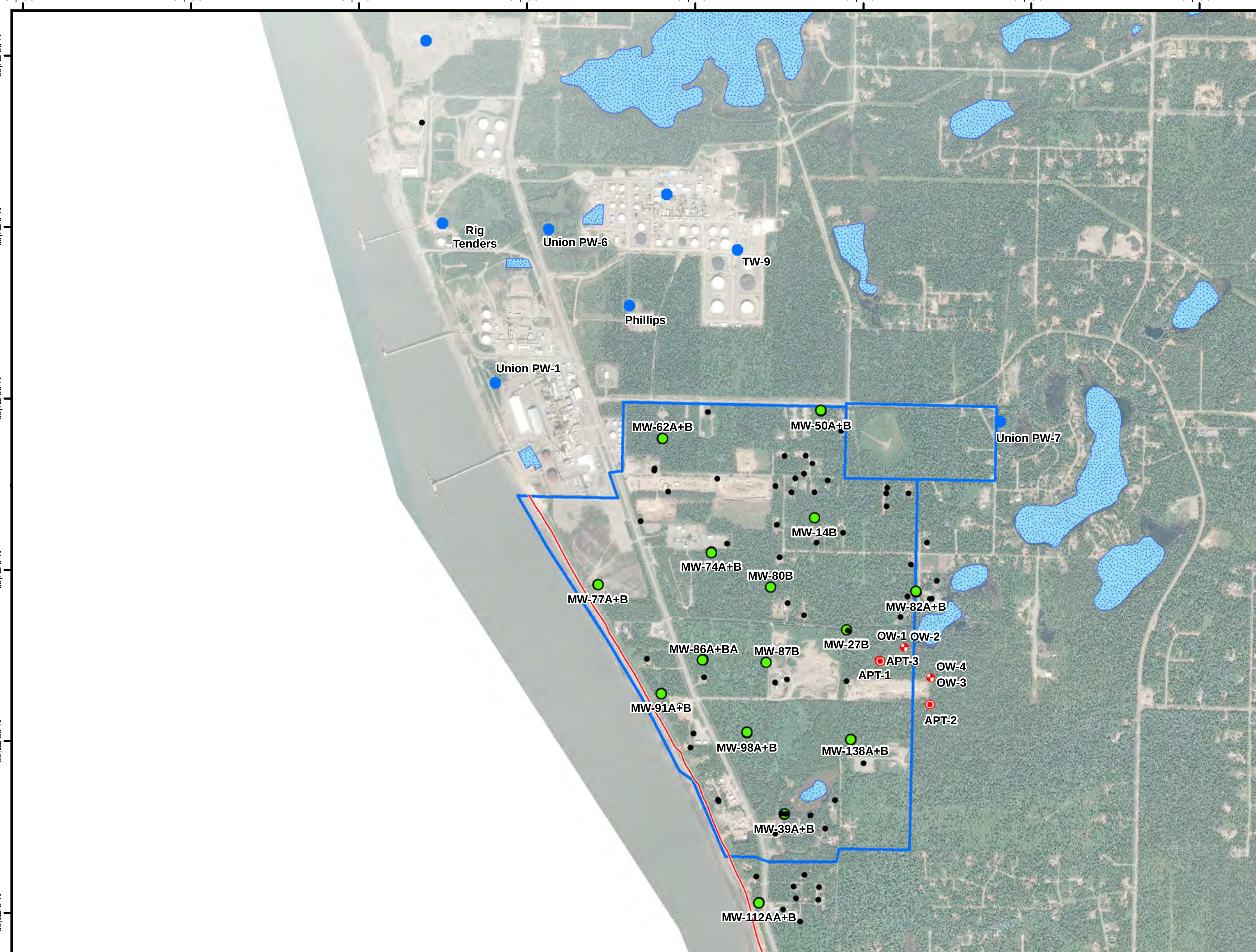
Offsite Production Wells Near the Liquefaction Facility Site

Alaska LNG™ FUGRO



Legend

- Monitoring Wells (Fugro 2014, 2015, 2016)
- Production Water Wells
- Existing Private Wells
- APT Wells (2016)
- Observation Wells (2016)
- Toe of Bluff
- Surface Water Body
- Onshore LNG Facilities Study Area

N

NOTE

1. Production water wells source is from MVE, Alaska SC LNG project, technical evaluation of water cooled LNG plan, September 13th, 2013 with well designation if known.
2. Existing water wells identified by AKLNG and surveyed by McLane, Inc.

0 1,000 2,000 4,000
Feet

OFFSITE PRODUCTION WELLS
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE 5

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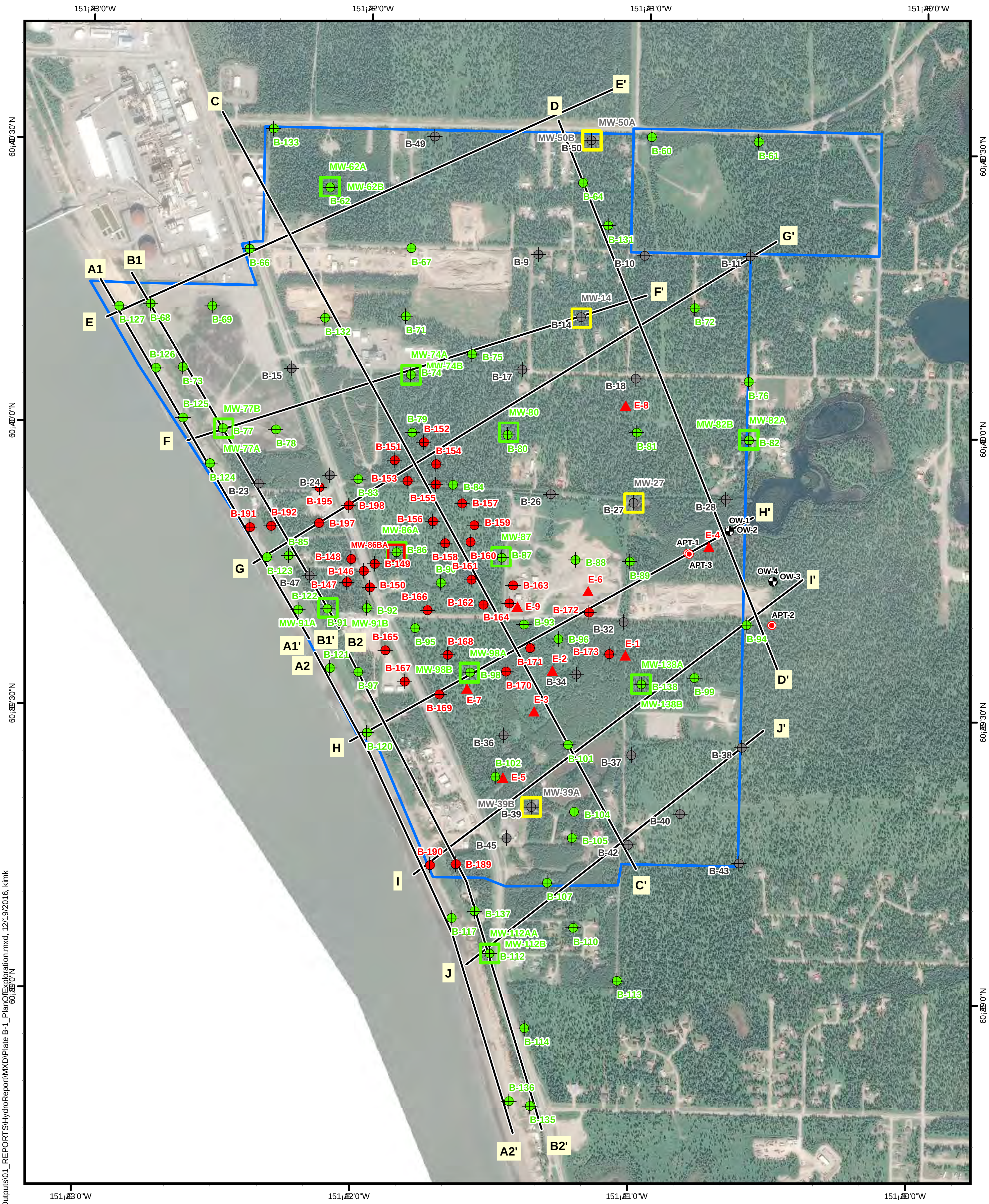

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LEGEND

EXPLORATION

- Boring (2016)
- Boring (2015)
- Boring (2014)
- VES Location (2016)
- Monitoring Well (2016)
- Monitoring Well (2015)
- Monitoring Well (2014)
- APT Well (2016)
- Observation Well (2016)

- Onshore LNG Facilities Study Area
- 1 Cross Section Lines

0 500 1,000 2,000 Feet

PLAN OF EXPLORATIONS

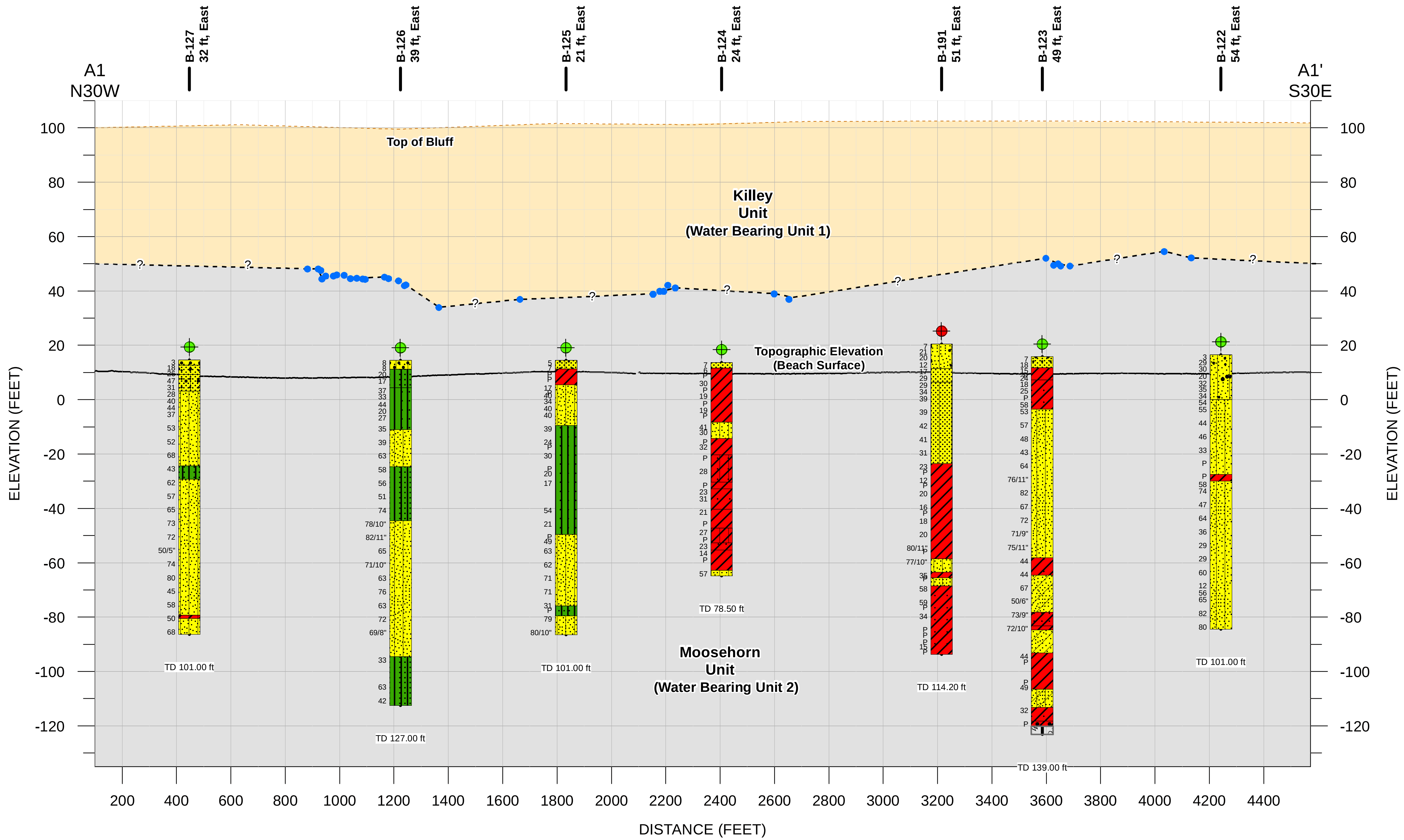
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE A-1

Lithologic Cross Sections

Alaska LNG™

FUGRO



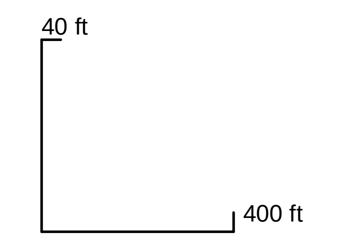
LEGEND

GEOTECHNICAL EXPLORATIONS

- Boring (2016)
- Boring (2015)
- Topographic Elevation (Ground LiDAR)
- KM Contact Points Observed in Bluff

SOIL DESCRIPTIONS

- Lean CLAY (CL)
- Silty CLAY (CL-ML)
- Silty CLAY with Sand (CL-ML)
- Lean CLAY with Sand (CL)
- Sandy Lean Clay (CL)
- Gravelly Lean CLAY (CL)
- SILT with Sand (ML)
- Sandy SILT (ML)
- Poorly-Graded SAND (SP)
- Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND (SP)
- Well-Graded SAND with Silt and Gravel (SW-SM)
- Clayey SAND (SC)
- Clayey to Silty SAND (SC-SM)
- Silty SAND (SM)
- Poorly-Graded GRAVEL with Sand (GP)
- Sandy GRAVEL with Silt (GP-GM)
- Sandy GRAVEL (GP)



Vertical Exaggeration = 10.0X

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is provided by McLane Consulting, Inc.(2015) and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88.
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

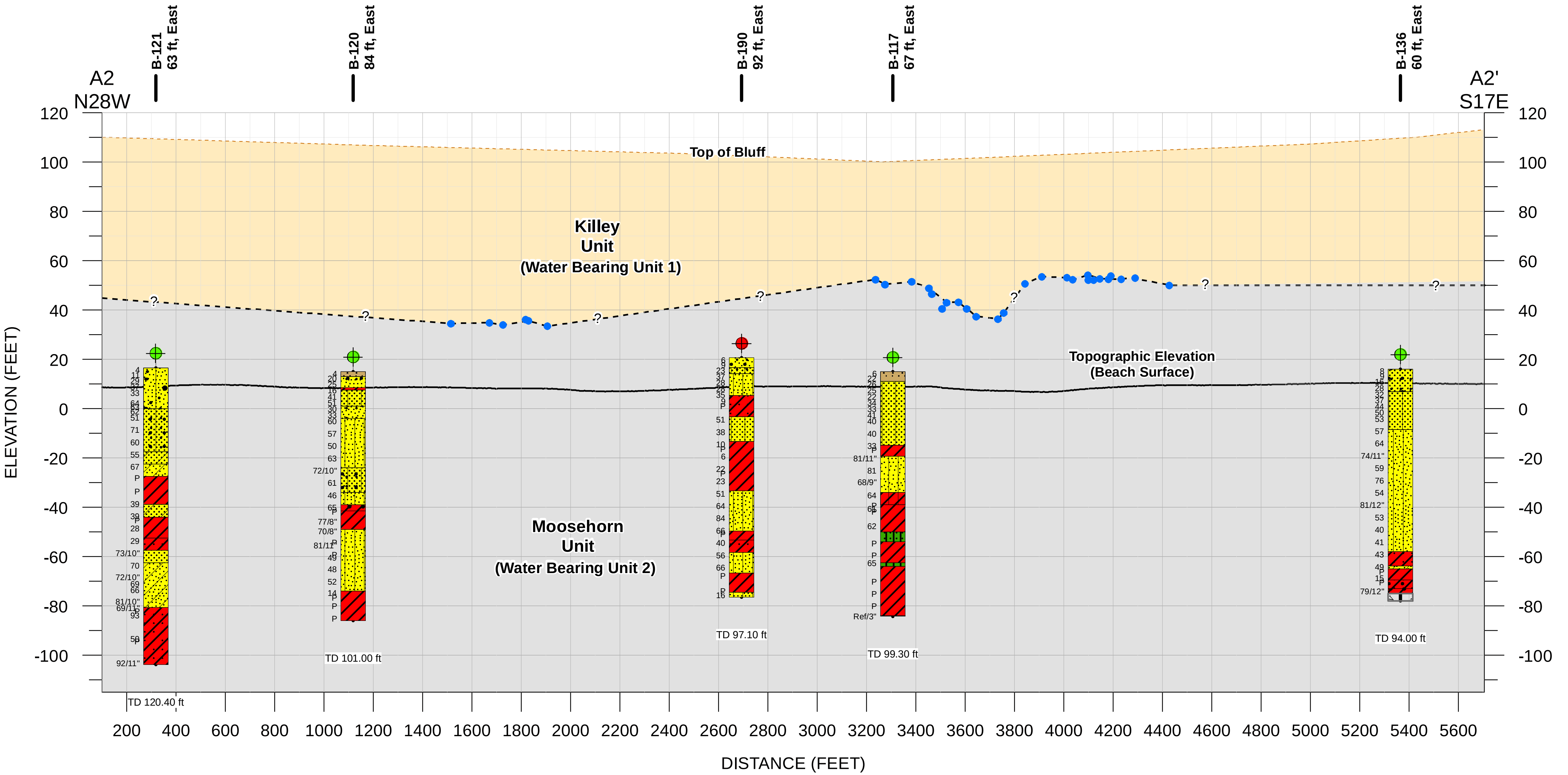
SUBSURFACE CROSS SECTION A1 - A1'
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE A-2

Lithologic Cross Sections

Alaska LNG

FUGRO



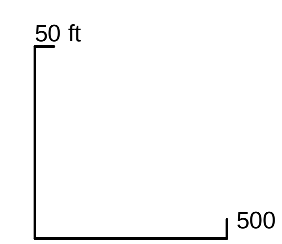
LEGEND

GEOTECHNICAL EXPLORATIONS

- Boring (2016)
- Boring (2015)
- Topographic Elevation (Ground LiDAR)
- KM Contact Points Observed in Bluff

SOIL DESCRIPTIONS

- Lean CLAY (CL)
- Silty CLAY (CL-ML)
- Lean CLAY with Sand (CL)
- Sandy Lean Clay (CL)
- Sandy, Gravelly Lean CLAY (CL)
- Gravelly Lean CLAY (CL)
- Sandy SILT (ML)
- Poorly-Graded SAND (SP)
- Poorly-Graded SAND with Clay (SP-SC)
- Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND (SP)
- Well-Graded SAND with Silt and Gravel (SW-SM)
- Gravelly Well-Graded SAND (SW)
- Clayey SAND (SC)
- Silty SAND (SM)
- Topsoil



Vertical Exaggeration = 10.0X

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is provided by McLane Consulting, Inc.(2015) and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88.
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

SUBSURFACE CROSS SECTION A2 - A2'

ONSHORE LNG FACILITIES

ALASKA LNG PROJECT

NIKISKI, ALASKA

PLATE A-3

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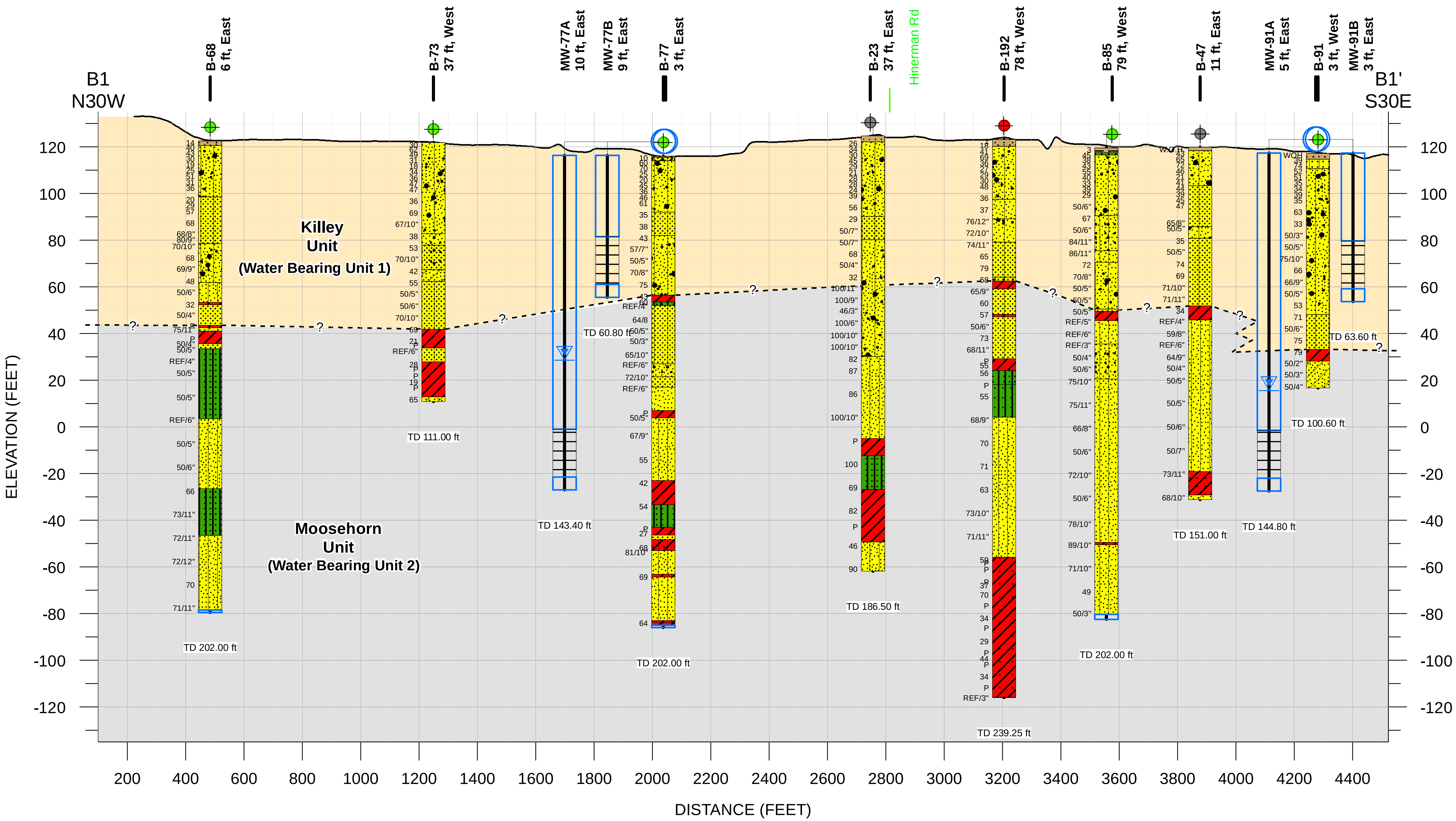
Lithologic Cross Sections

Alaska LNG

FUGRO



LEGEND

GEOTECHNICAL EXPLORATIONS

- Boring (2016)
- Boring (2015)
- Boring (2014)
- Topographic Elevation
- Monitoring Well
- Water Level Reading During Drilling
- Water Level Reading from Monitoring Well on 9/22/16 at 6pm
- Slotted Screen Section of Monitoring Well
- Cross Section Road Crossing

SOIL DESCRIPTIONS

- Lean CLAY (CL)
- Silty CLAY with Sand (CL-ML)
- Lean CLAY with Sand (CL)
- Sandy Lean Clay (CL)
- SILT with Sand (ML)
- Sandy, Gravelly SILT (ML)
- Sandy SILT (ML)
- Poorly-Graded SAND (SP)
- Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND (SP)
- Well-Graded SAND (SW)
- Well-Graded SAND with Silt (SW-SM)
- Well-Graded SAND with Silt and Gravel (SW-SM)
- Gravelly Well-Graded SAND (SW)
- Clayey SAND (SC)
- Clayey to Silty SAND (SC-SM)
- Silty SAND (SM)
- Gravelly Silty SAND (SM)
- Topsoil
- Sandy Well-Graded GRAVEL (GW)
- Sandy, Silty GRAVEL (GM)
- Low-Plasticity Organic (OL)

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" of seating.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is provided by McLane Consulting, Inc.(2015) and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88.
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

50 ft

400 ft

Vertical Exaggeration = 8.0X

SUBSURFACE CROSS SECTION B1 - B1'

ONSHORE LNG FACILITIES

ALASKA LNG PROJECT

NIKISKI, ALASKA

PLATE A-4

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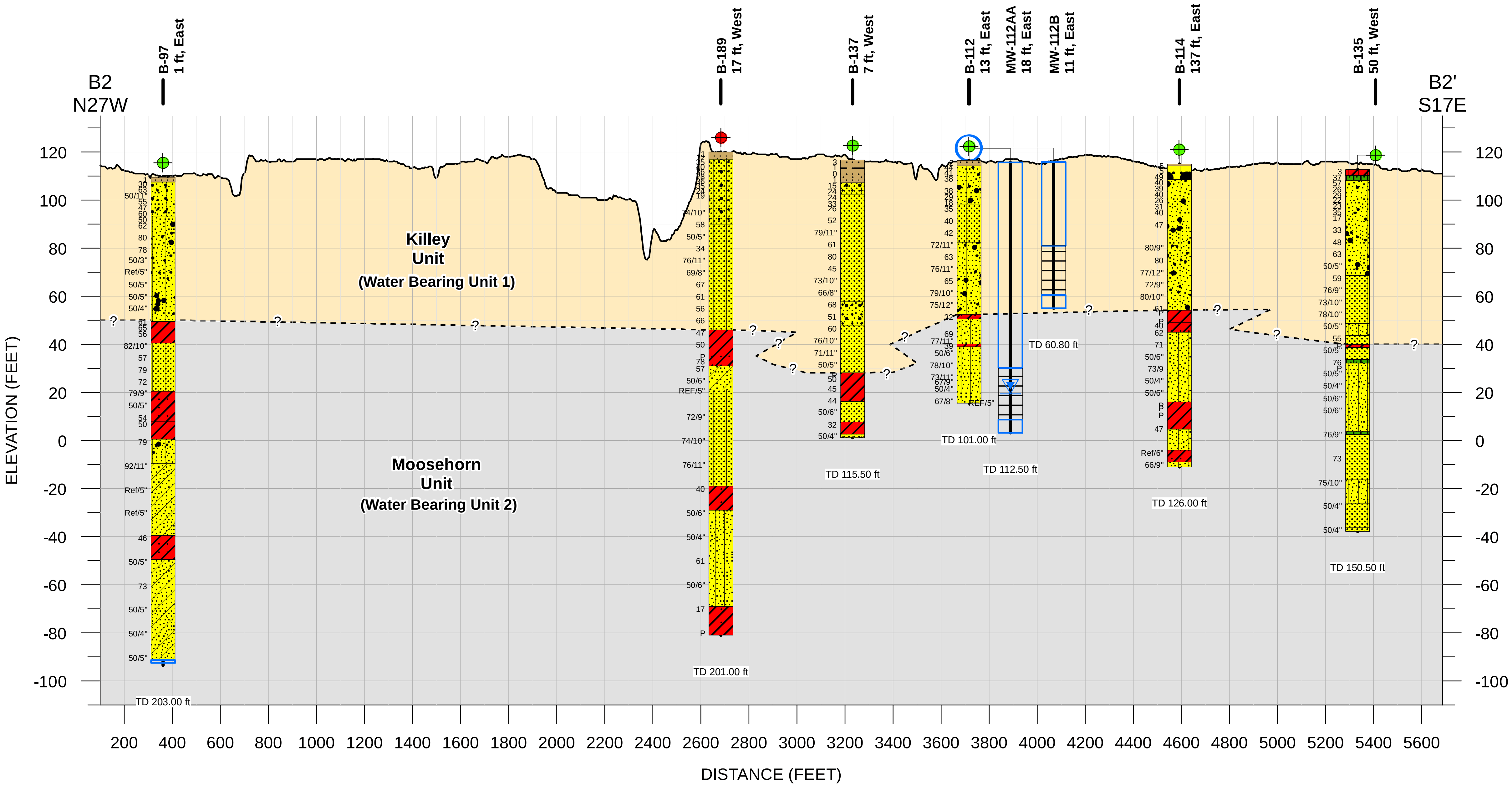
Lithologic Cross Section



LEGEND

GEOTECHNICAL EXPLORATIONS

- Boring (2016)
- Boring (2015)
- Boring (2014)
- Topographic Elevation (KPB, 2008)
- Monitoring Well
- Water Level Reading During Drilling
- Water Level Reading from Monitoring Well on 9/22/16 at 6pm
- Slotted Screen Section of Monitoring Well

SOIL DESCRIPTIONS

- Lean CLAY (CL)
- Silty CLAY (CL-ML)
- Lean CLAY with Sand (CL)
- Sandy Lean Clay (CL)
- Sandy, Gravelly SILT (ML)
- Sandy SILT (ML)
- Poorly-Graded SAND (SP)
- Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND (SP)
- Well-Graded SAND with Silt (SW-SM)
- Well-Graded SAND with Silt and Gravel (SW-SM)
- Gravelly Well-Graded SAND (SW)
- Clayey SAND (SC)
- Silty SAND (SM)
- Gravelly Silty SAND (SM)
- Topsoil
- Well-Graded GRAVEL with Silt and Sand (GW-GM)

50 ft

500 ft

Vertical Exaggeration = 10.0X

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is from Kenai Peninsula Borough LiDAR, collected in 2008 and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88. Data provided by EXP Geomatics (EXP).
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

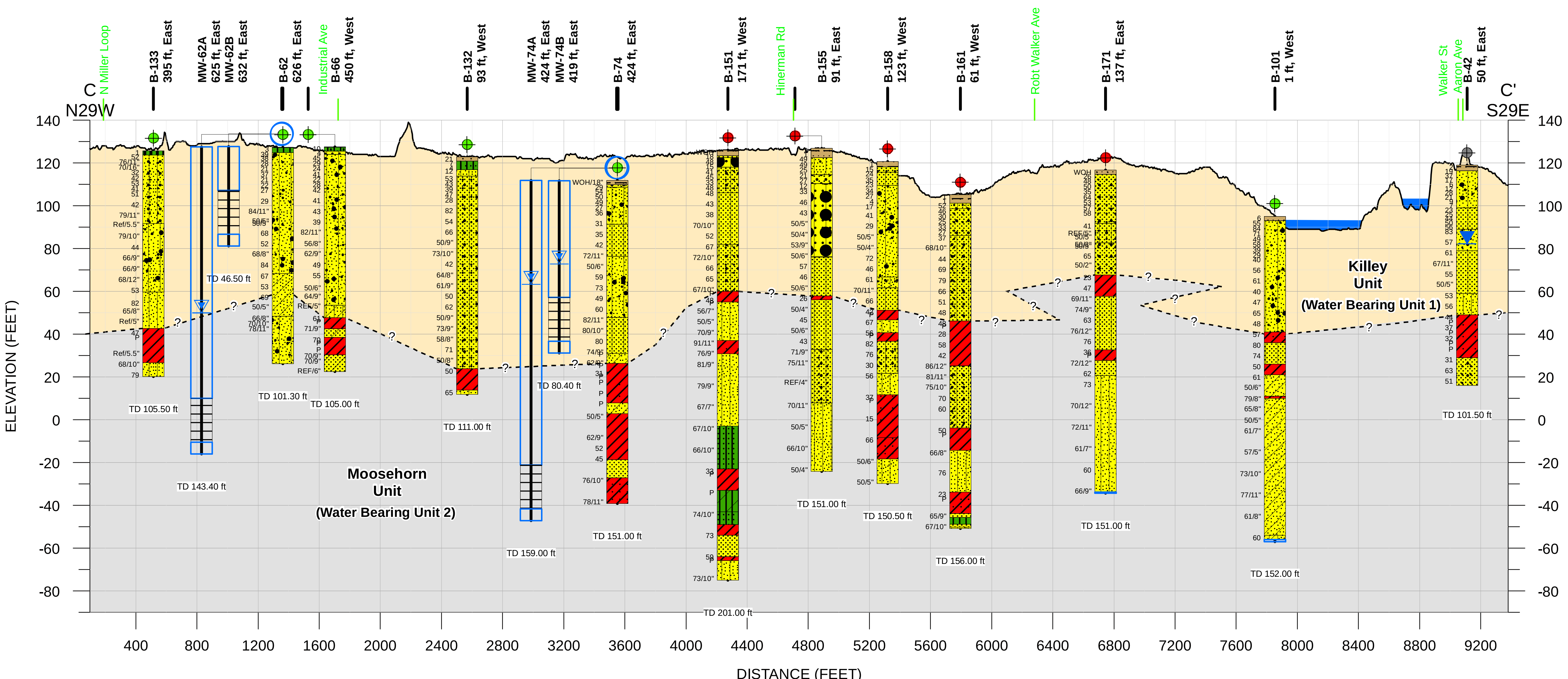
SUBSURFACE CROSS SECTION B2 - B2'
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE A-5

Lithologic Cross Sections

Alaska LNG™

FUGRO



LEGEND

GEOTECHNICAL EXPLORATIONS

- Boring (2016)
- Boring (2015)
- Boring (2014)
- Topographic Elevation (KPB, 2008)
- Monitoring Well
- Cross Section Road Crossing
- Water Level Reading During Drilling
- Water Level Reading from Monitoring Well on 9/22/16 at 6pm
- Slotted Screen Section of Monitoring Well
- Surface Water Body (shown for graphical purposes)

SOIL DESCRIPTIONS

- Lean CLAY (CL)
- Lean CLAY with Sand (CL)
- Sandy Lean Clay (CL)
- Silt (ML)
- Clayey SILT (ML)
- Sandy, Gravelly SILT (ML)
- Sandy SILT (ML)
- Elastic Silt (MH)
- Poorly-Graded SAND (SP)
- Poorly-Graded SAND with Clay (SP-SC)
- Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND (SP)
- Well-Graded SAND with Silt and Gravel (SW-SM)
- Gravelly Well-Graded SAND (SW)
- Clayey SAND (SC)
- Clayey to Silty SAND (SC-SM)
- Clayey to Silty SAND with Gravel (SC-SM)
- Silty SAND (SM)
- Gravelly Silty SAND (SM)
- Topsoil
- Poorly-Graded GRAVEL with Sand (GP)
- Sandy GRAVEL (GP)
- Well-Graded GRAVEL with Silt and Sand (GW-GM)

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is from Kenai Peninsula Borough LiDAR, collected in 2008 and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88. Data provided by EXP Geomatics (EXP).
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

50 ft

700 ft

Vertical Exaggeration = 14.0X

SUBSURFACE CROSS SECTION C - C'

ONSHORE LNG FACILITIES

ALASKA LNG PROJECT

NIKISKI, ALASKA

PLATE A-6

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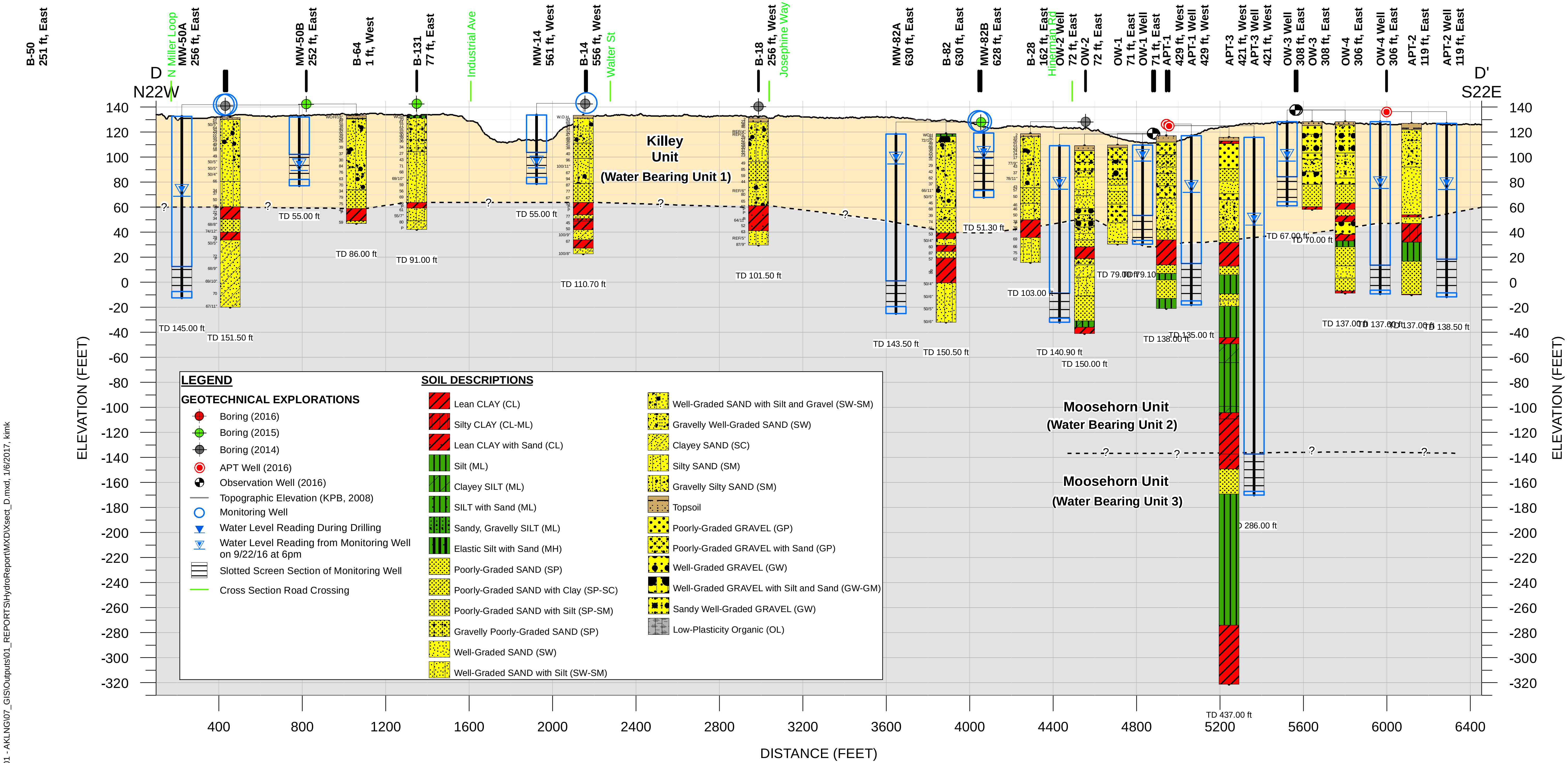
Lithologic Cross Sections



TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" of seating.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is from Kenai Peninsula Borough LiDAR, collected in 2008 and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88. Data provided by EXP Geomatics (EXP).
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

80 ft
480 ft
Vertical Exaggeration = 6.0X

SUBSURFACE CROSS SECTION D - D'
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE A-7

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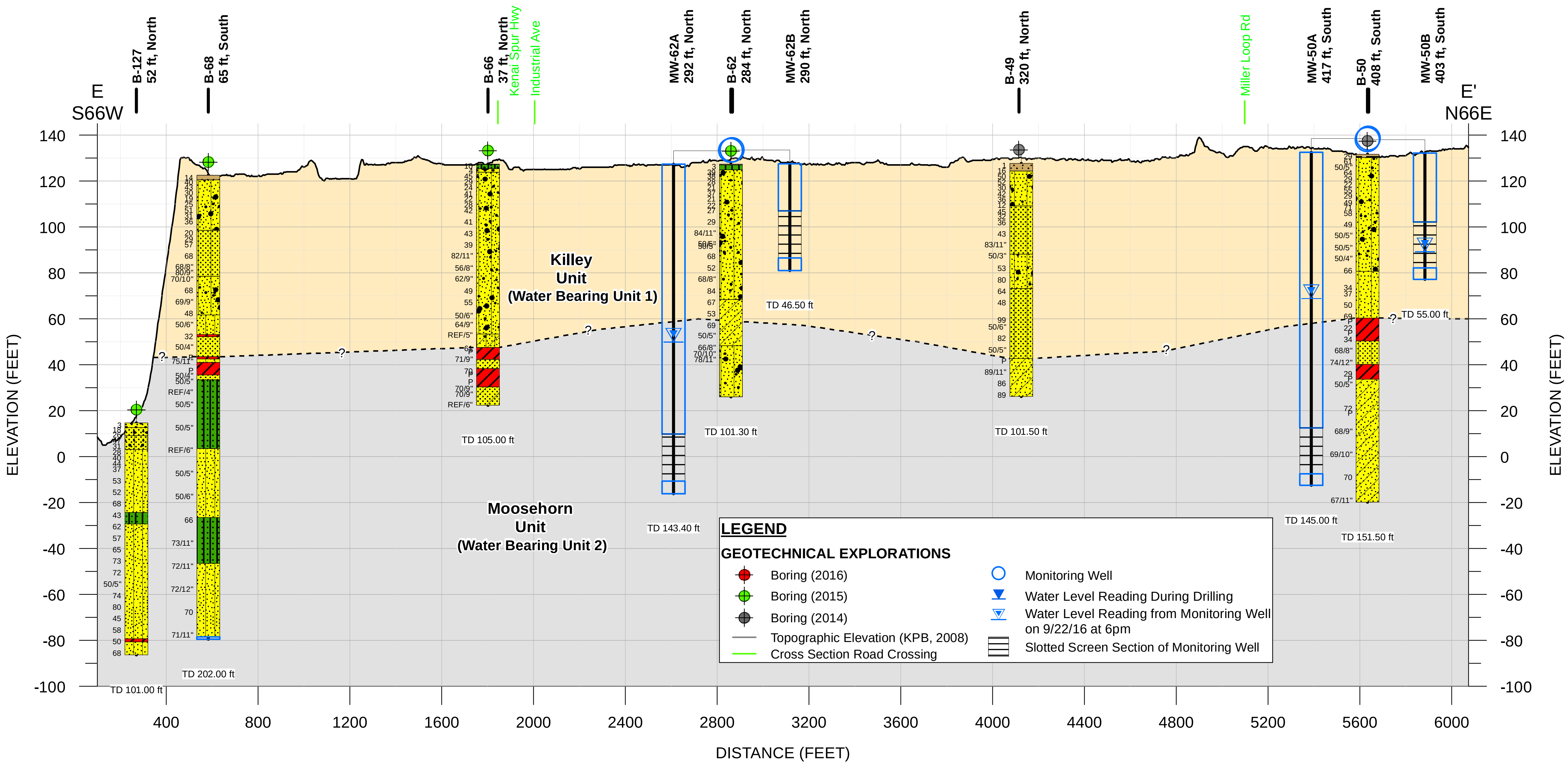
Alaska LNG™ FUGRO



SOIL DESCRIPTIONS

- Lean CLAY (CL)
- Silty CLAY (CL-ML)
- Silt (ML)
- Sandy, Gravelly SILT (ML)
- Sandy SILT (ML)
- Poorly-Graded SAND (SP)
- Poorly-Graded SAND with Clay (SP-SC)
- Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND (SP)
- Well-Graded SAND with Silt (SW-SM)
- Well-Graded SAND with Silt and Gravel (SW-SM)
- Clayey SAND (SC)
- Clayey to Silty SAND with Gravel (SC-SM)
- Silty SAND (SM)
- Topsoil
- Poorly-Graded GRAVEL with Sand (GP)
- Sandy GRAVEL (GP)
- Well-Graded GRAVEL with Silt and Sand (GW-GM)

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" of seating.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is from Kenai Peninsula Borough LiDAR, collected in 2008 and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88. Data provided by EXP Geomatics (EXP).
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

50 ft
500 ft
Vertical Exaggeration = 10.0X

SUBSURFACE CROSS SECTION E - E'
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE A-8

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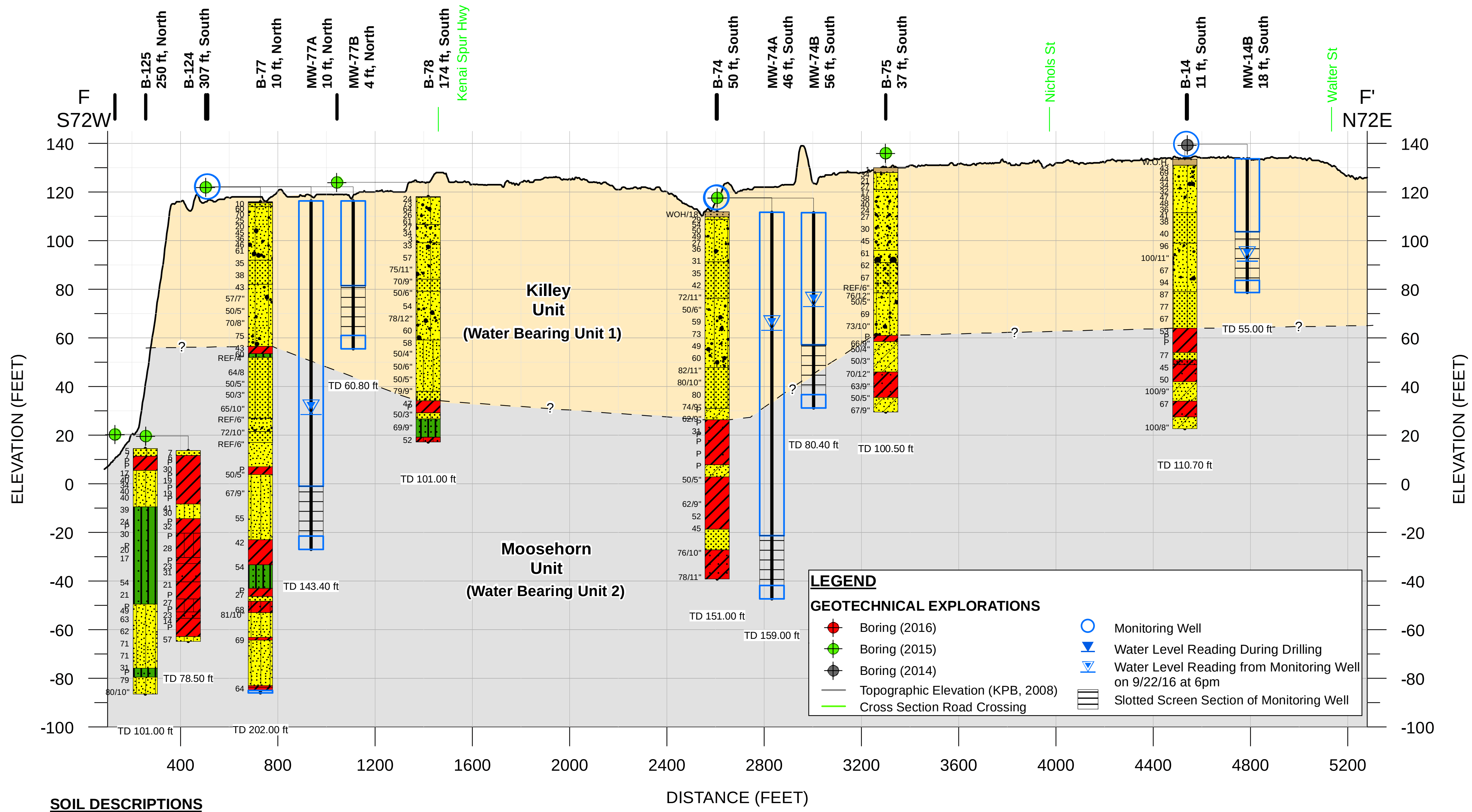
Alaska LNG



SOIL DESCRIPTIONS

- Lean CLAY (CL)
- Silty CLAY (CL-ML)
- Silty CLAY with Sand (CL-ML)
- Lean CLAY with Sand (CL)
- Sandy Lean Clay (CL)
- SILT with Sand (ML)
- Sandy SILT (ML)
- Poorly-Graded SAND (SP)
- Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND (SP)
- Well-Graded SAND (SW)
- Well-Graded SAND with Silt and Gravel (SW-SM)
- Gravelly Well-Graded SAND (SW)
- Clayey SAND (SC)
- Silty SAND (SM)
- Gravelly Silty SAND (SM)
- Topsoil
- Sandy Well-Graded GRAVEL (GW)

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" seating.
W.O.H.	Weight of Hammer

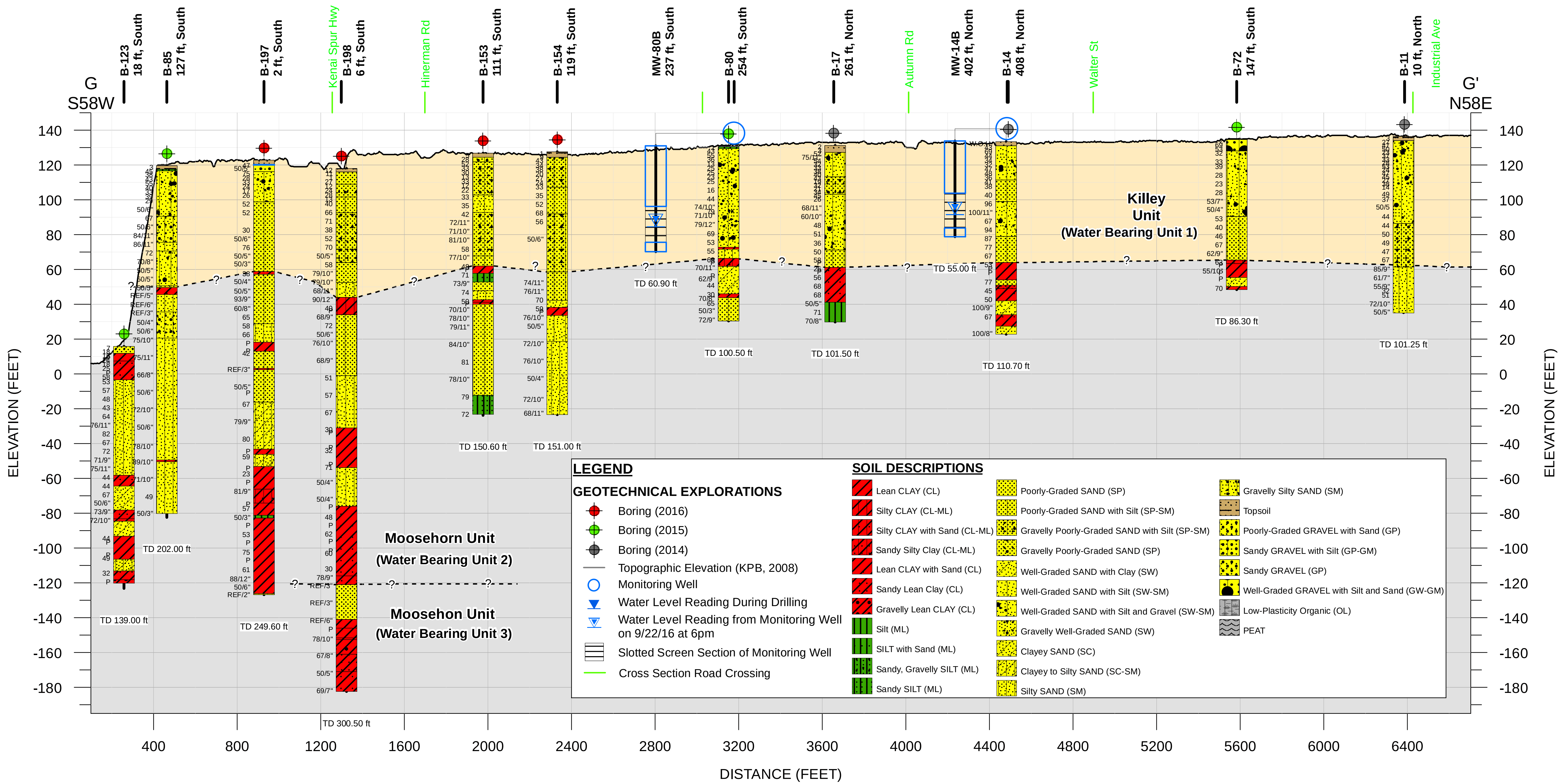
NOTES:

1. Topographic source data is from Kenai Peninsula Borough LiDAR, collected in 2008 and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88. Data provided by EXP Geomatics (EXP).
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

50 ft
500 ft
Vertical Exaggeration = 10.0X

SUBSURFACE CROSS SECTION F - F'
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

Lithologic Cross Sections



TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is from Kenai Peninsula Borough LiDAR, collected in 2008 and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88. Data provided by EXP Geomatics (EXP).
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

60 ft

500 ft

Vertical Exaggeration = 8.3X

SUBSURFACE CROSS SECTION G - G'

ONSHORE LNG FACILITIES

ALASKA LNG PROJECT

NIKISKI, ALASKA

PLATE A-10

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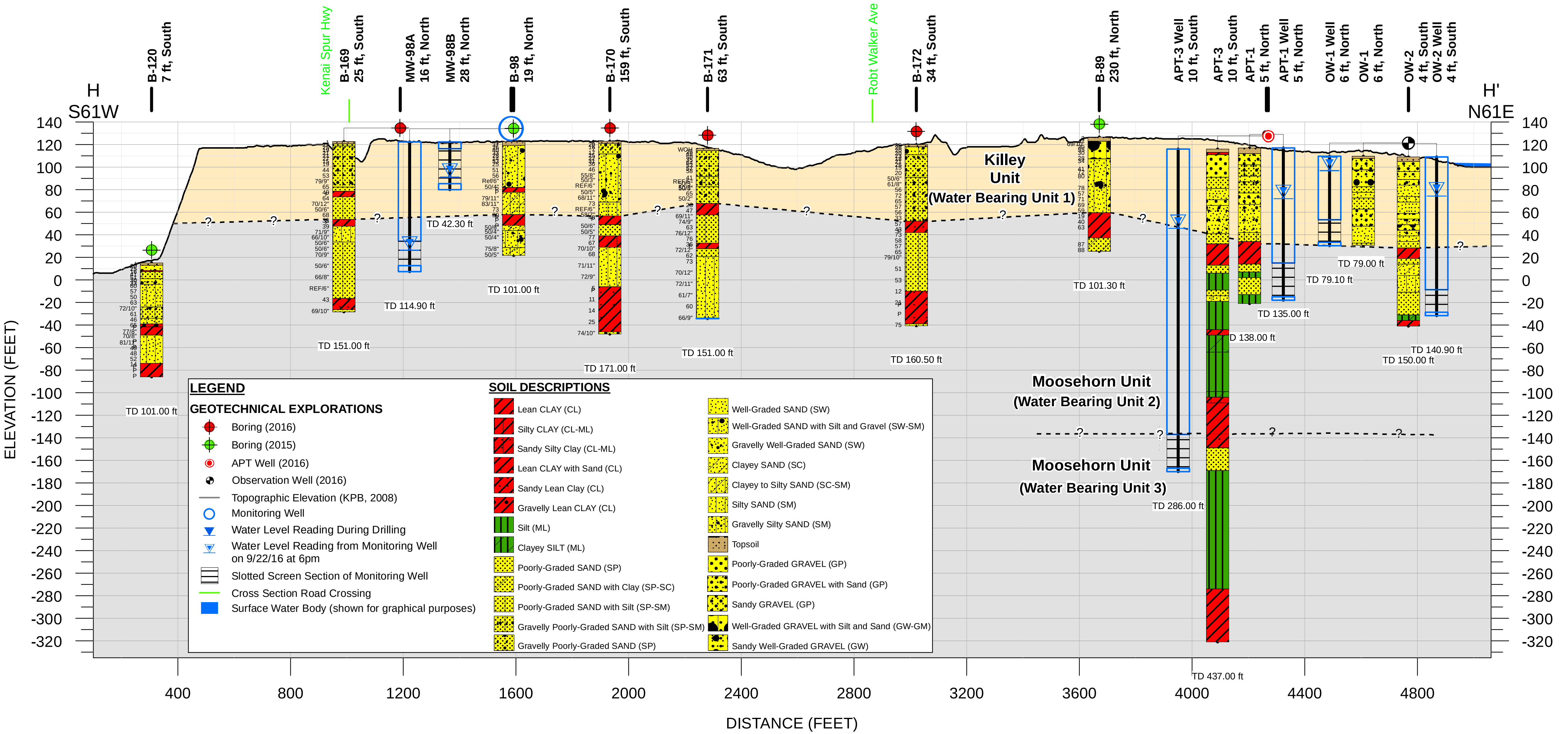
Alaska LNG

FUGRO



TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is from Kenai Peninsula Borough LiDAR, collected in 2008 and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88. Data provided by EXP Geomatics (EXP).
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

100 ft

400 ft

Vertical Exaggeration = 4.0X

SUBSURFACE CROSS SECTION H - H'

ONSHORE LNG FACILITIES

ALASKA LNG PROJECT

NIKISKI, ALASKA

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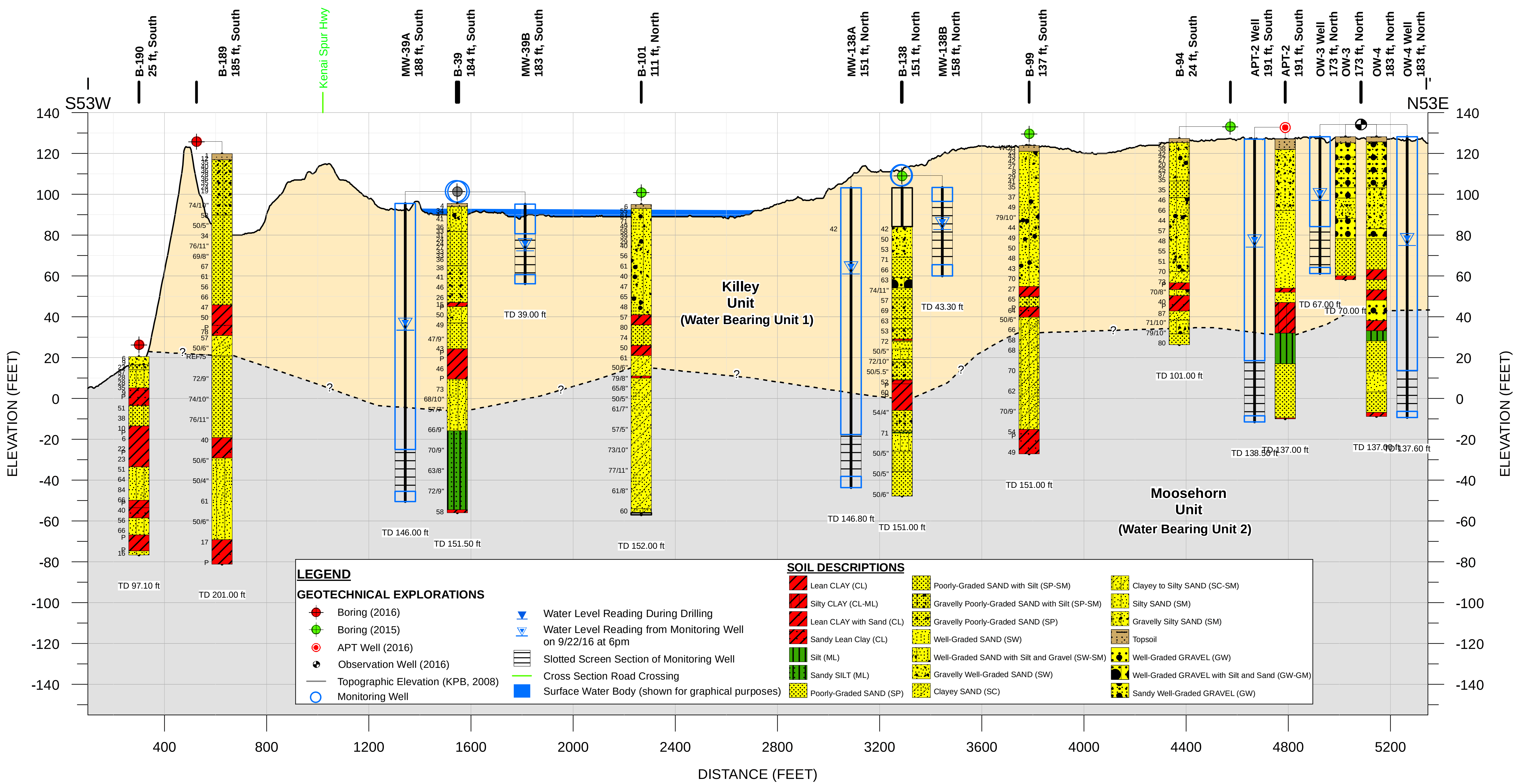
Lithologic Cross Sections

Alaska LNG

FUGRO



TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" seating.
W.O.H.	Weight of Hammer

NOTES:

1. Topographic source data is from Kenai Peninsula Borough LiDAR, collected in 2008 and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88. Data provided by EXP Geomatics (EXP).
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

50 ft

400 ft

Vertical Exaggeration = 8.0X

SUBSURFACE CROSS SECTION I - I'

ONSHORE LNG FACILITIES

ALASKA LNG PROJECT

NIKISKI, ALASKA

PLATE A-12

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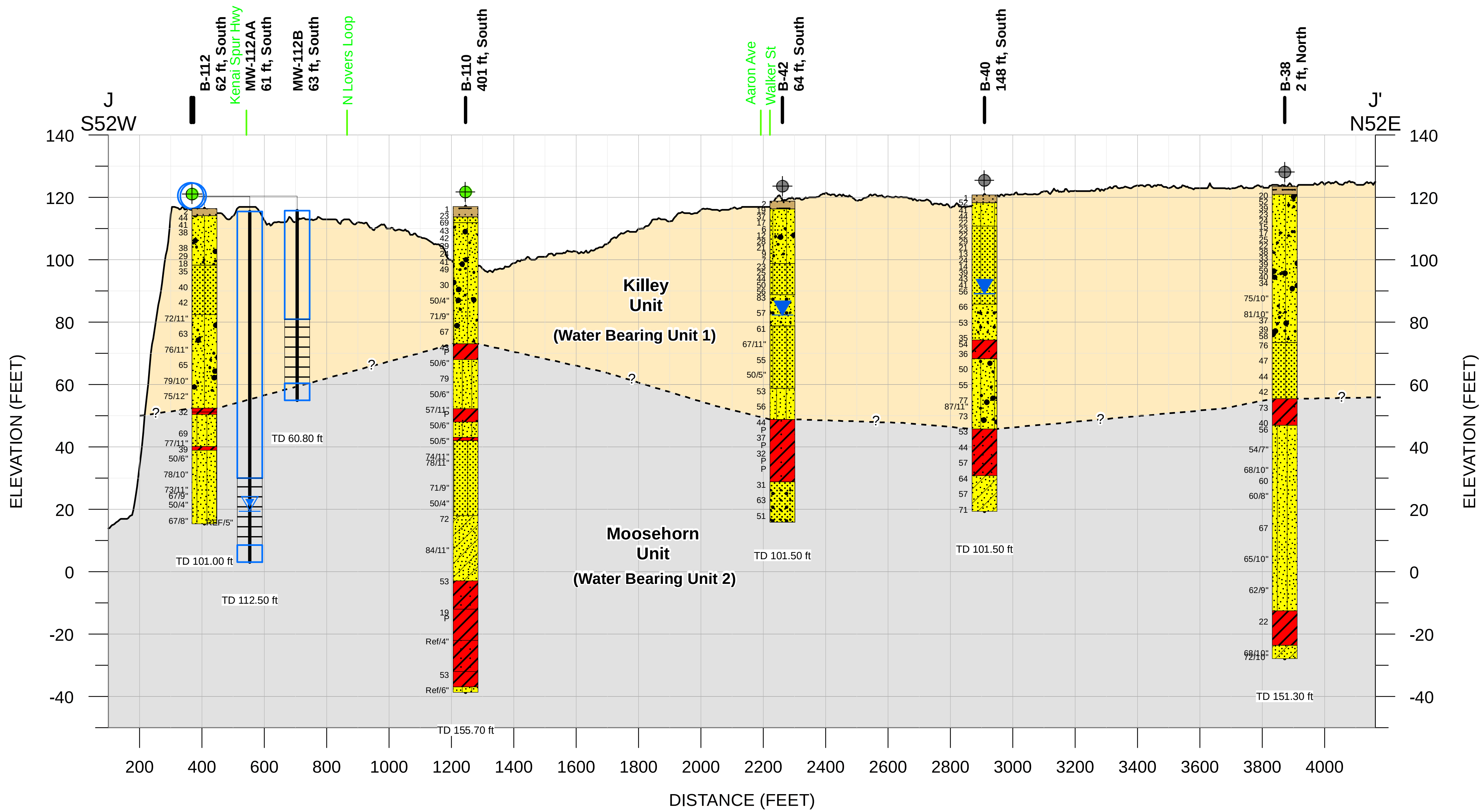
Lithologic Cross Sections

Alaska LNG

FUGRO



LEGEND

GEOTECHNICAL EXPLORATIONS

- Boring (2015)
- Boring (2014)
- Topographic Elevation (KPB, 2008)
- Monitoring Well
- Water Level Reading During Drilling
- Water Level Reading from Monitoring Well on 9/22/16 at 6pm
- Slotted Screen Section of Monitoring Well
- Cross Section Road Crossing

SOIL DESCRIPTIONS

- Lean CLAY (CL)
- Lean CLAY with Sand (CL)
- Sandy Lean Clay (CL)
- Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND (SP)
- Well-Graded SAND with Silt (SW-SM)
- Well-Graded SAND with Silt and Gravel (SW-SM)
- Gravelly Well-Graded SAND (SW)
- Clayey SAND (SC)
- Silty SAND (SM)
- Topsoil

40 ft

400 ft

Vertical Exaggeration = 10.0X

TUBE AND SPT SAMPLES

P	Push thin-walled 3" tube.
20	Number of blows to produce 12" of penetration after the initial 6" of seating.
86/11"	Number of blows required to produce the indicated penetration after an initial 6" seating.
Ref/3"	50 blows produced the indicated penetration during the initial 6" interval.
W.O.H.	Weight of Hammer

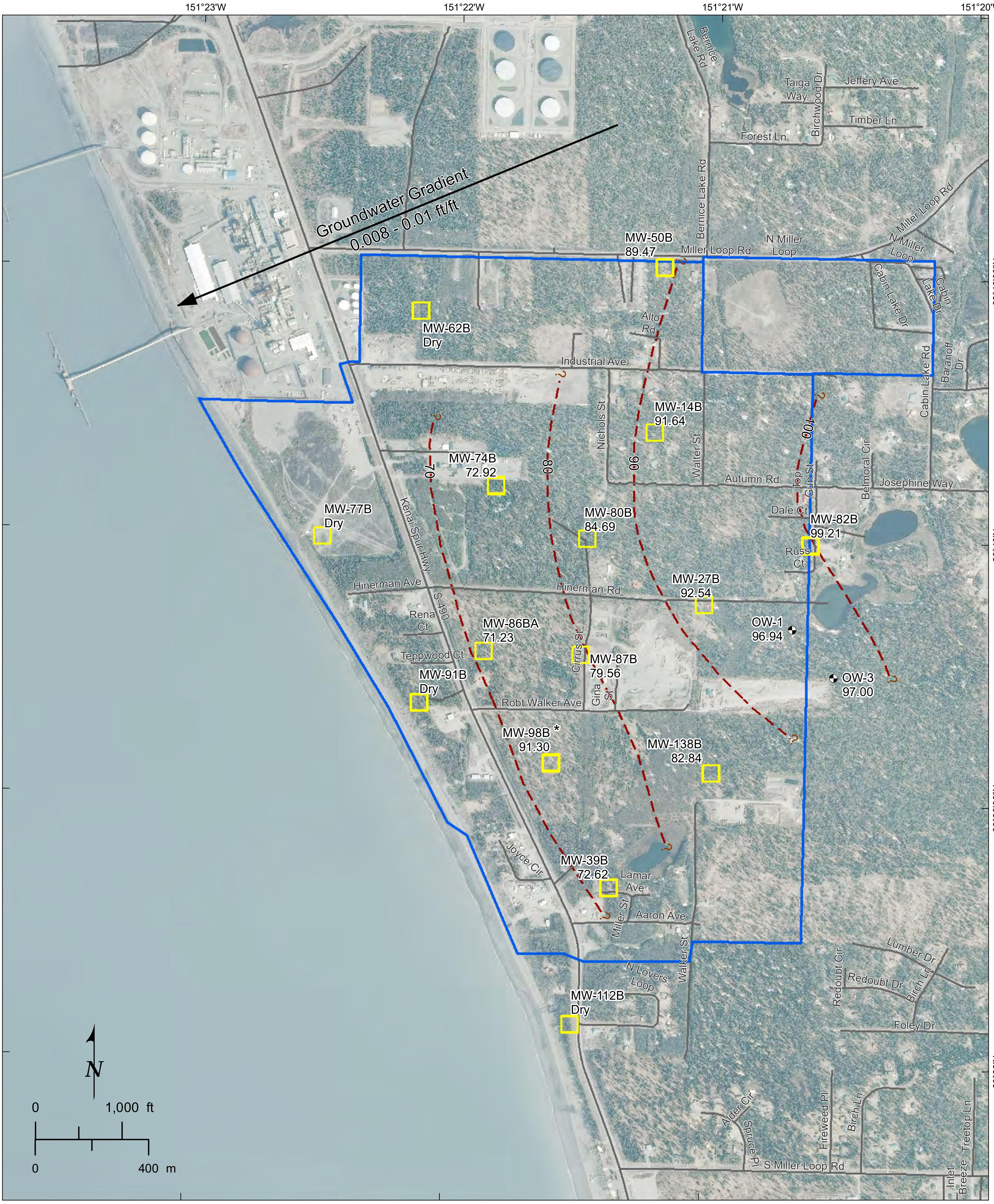
NOTES:

1. Topographic source data is from Kenai Peninsula Borough LiDAR, collected in 2008 and processed using 4 foot bin interval. Topographic elevation is referenced to NAVD88. Data provided by EXP Geomatics (EXP).
2. As-built coordinates of exploration locations provided by JOA Surveying Services, Inc. (2014) and McLane Consulting, Inc.(2015, 2016).
3. Stratigraphic contacts are approximate, and interpreted from borings and field observations. Refer to USAL-FG-GRZZZ-00-002015-004 LNG Facilities Onshore Geologic Field Mapping Report for description of contact. Conditions vary both along and perpendicular to the section line. The lateral extent of the top soil is not known based on the limited borings.
4. Boring data are projected onto the cross section line, therefore, stratigraphic contacts may not correspond to the descriptions (lithology, shear strength, etc.) on the logs.
5. Material descriptions are generalized. Materials may vary within the stratigraphic unit and include layers of material that differ from the general description. Refer to boring logs for detailed descriptions of the materials encountered at the exploration location.
6. See Plate B-1 for location of explorations and cross section lines.
7. See USAL-FG-GRZZZ-00-002015-006 LNG Facilities Onshore Geotechnical Data Report for boring logs.
8. NAVD88 is converted to MLLW using the following equation: MLLW = NAVD88 + 7.32 ft.

SUBSURFACE CROSS SECTION J - J'
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE A-13

Alaska LNG FUGRO



LEGEND

MW-39B 72.64 — Well Locations (labeled with well ID and groundwater elevation, NAVD88, feet, measured September 2016) (* Omitted from contouring)

OW-1 96.94 — Observation Well

80 — Water Bearing Unit 1 Contour Elevations

Onshore LNG Facilities Study Area

Groundwater Flow Direction and Gradient

WATER BEARING UNIT 1
GROUNDWATER ELEVATIONS AND GRADIENT

ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

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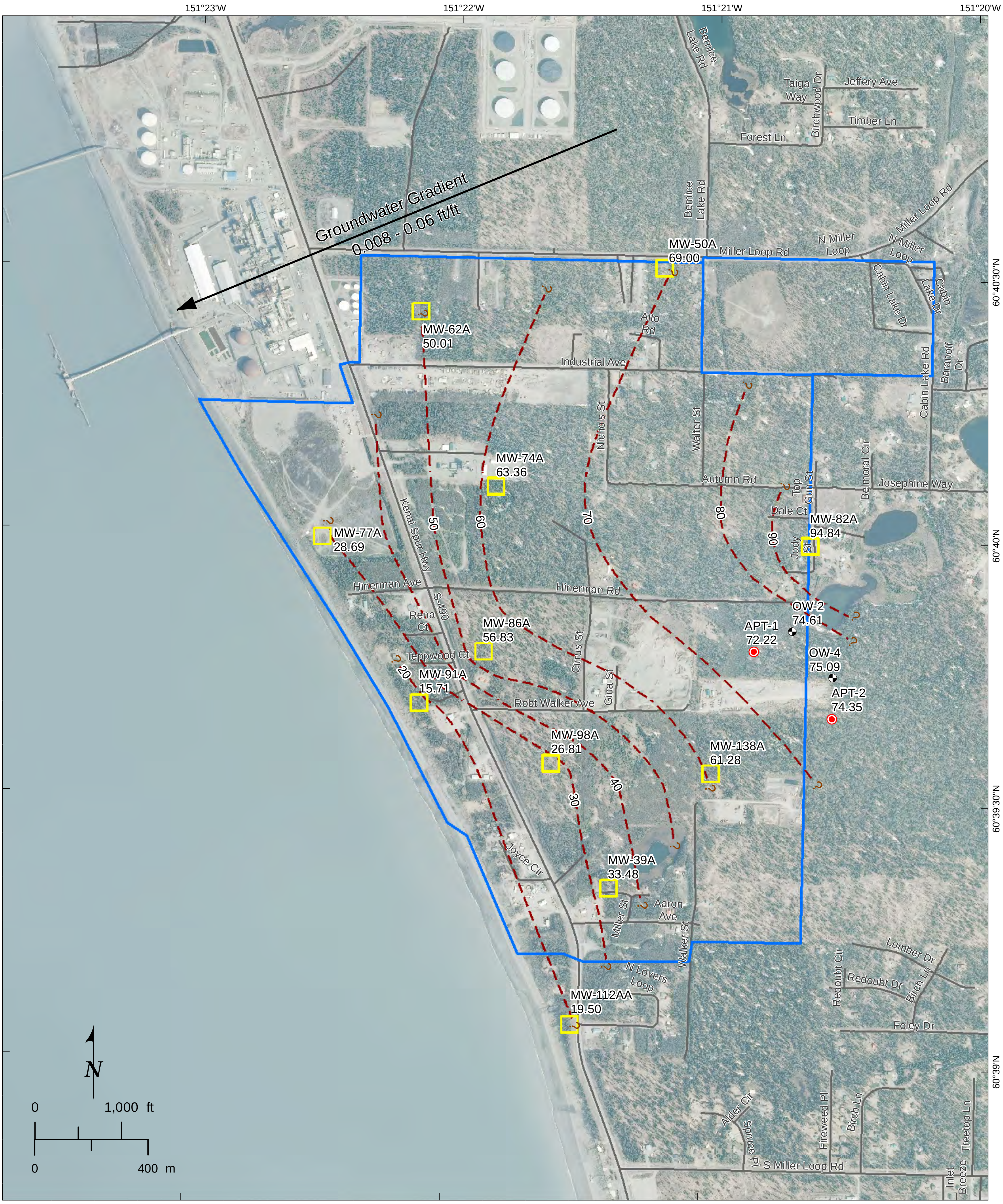
Water Bearing Unit - 2

Alaska LNG FUGRO



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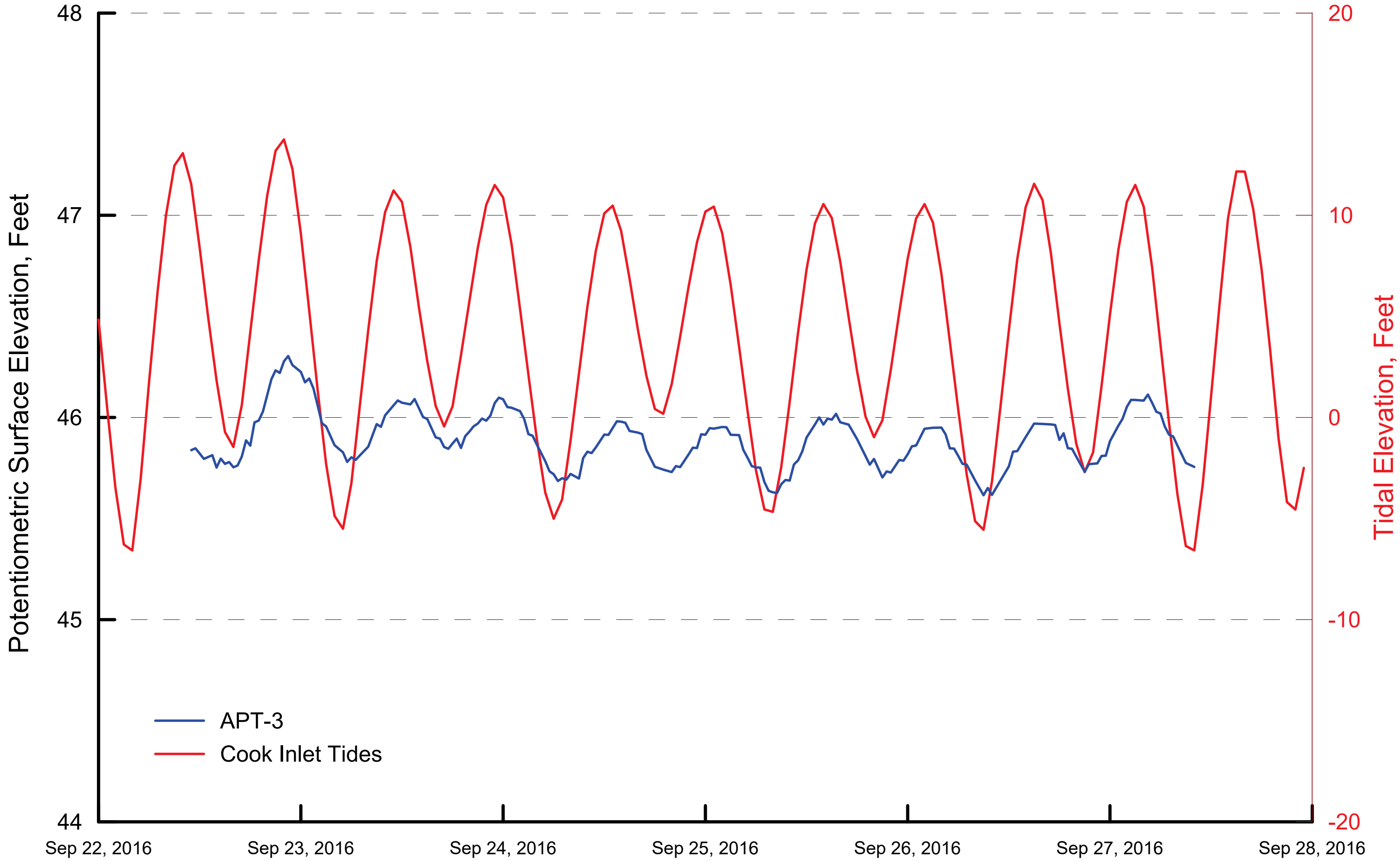
LEGEND

- MW-39A 33.48 — Well Locations (labeled with well ID and groundwater elevation, NAVD88, feet, measured September 2016)
- APT-1 72.22 — APT Well
- OW-2 74.61 — Observation Well Pair
- 80 — Water Bearing Unit 2 Contour Elevations
- Onshore LNG Facilities Study Area
- Groundwater Flow Direction and Gradient

WATER BEARING UNIT 2
POTENTIOMETRIC SURFACE
ELEVATIONS AND GRADIENT

ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

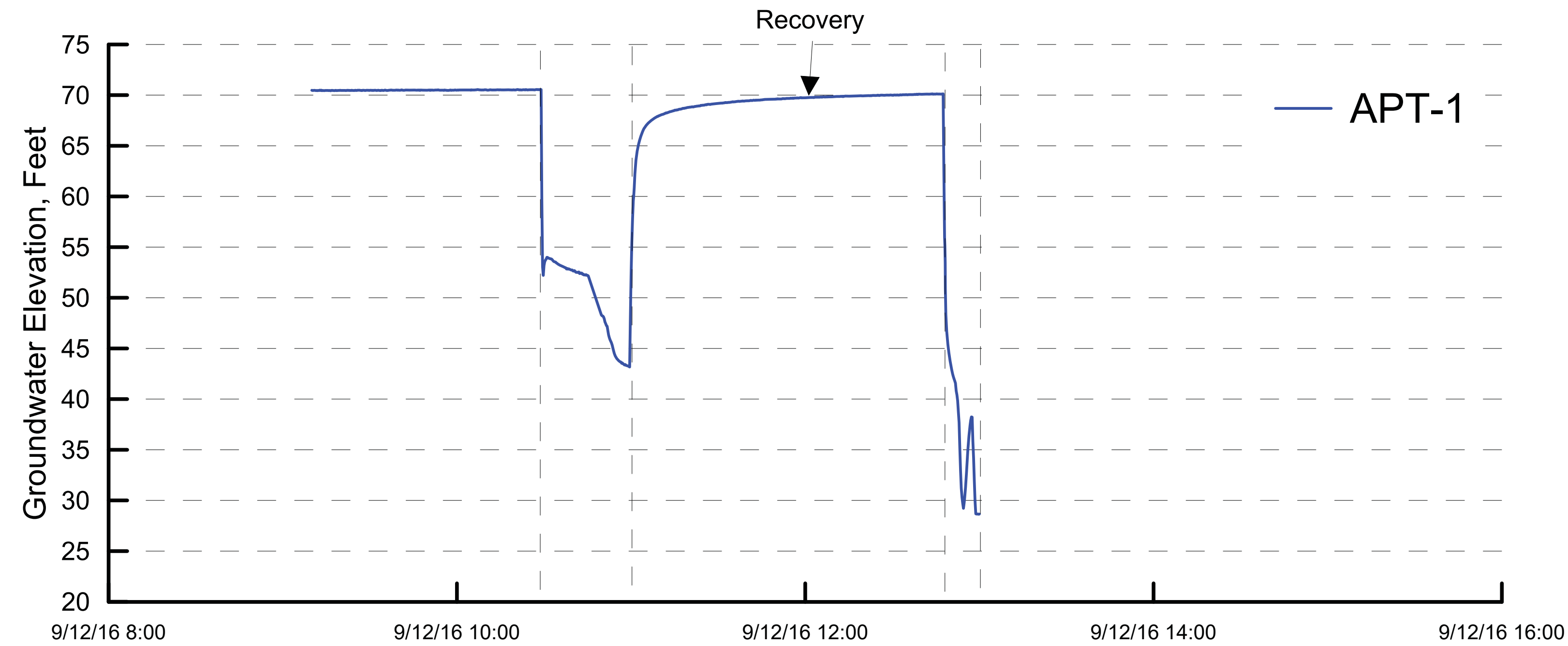
APT-3 Influenced by Cook Inlet Tidal Fluctuations

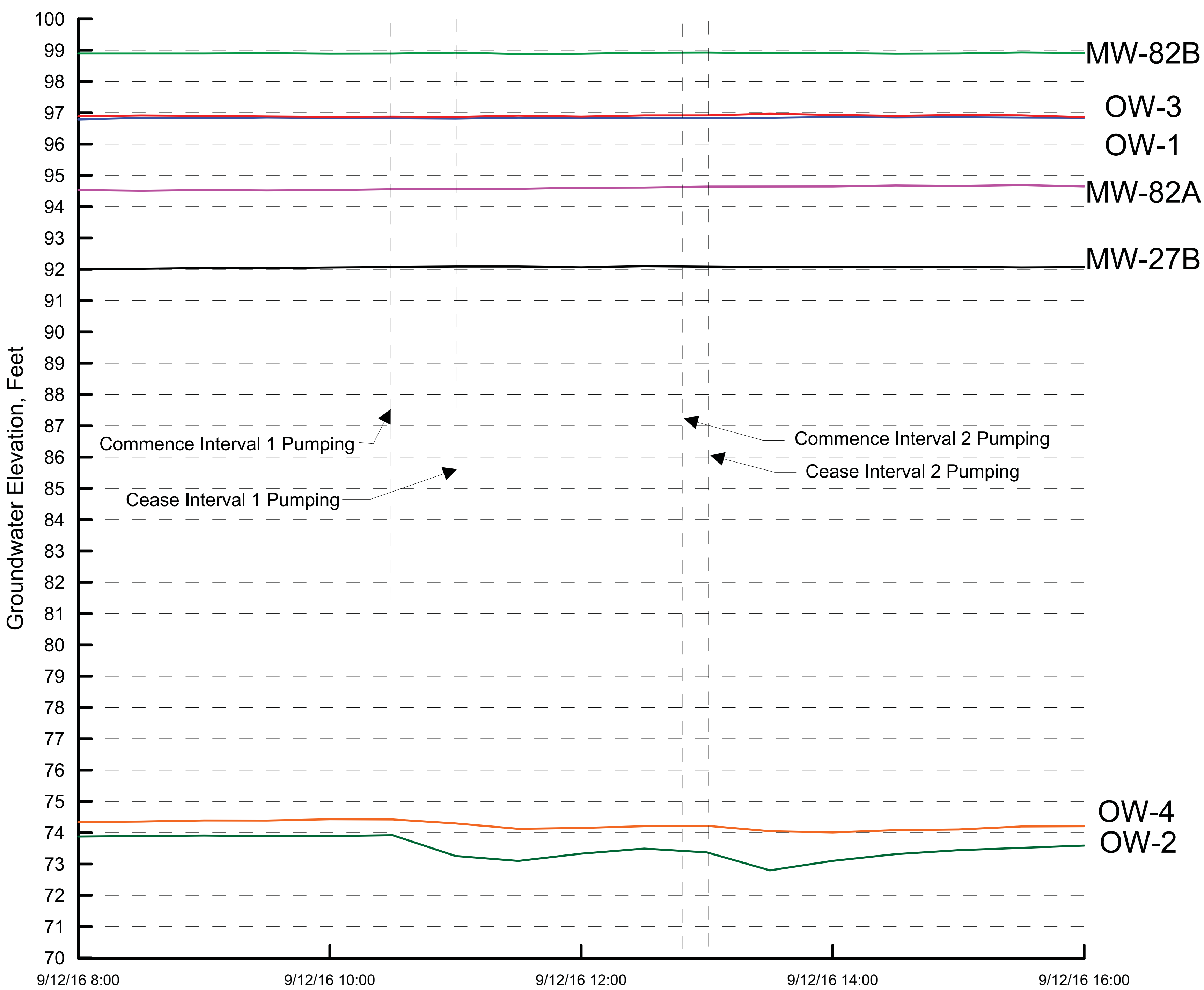


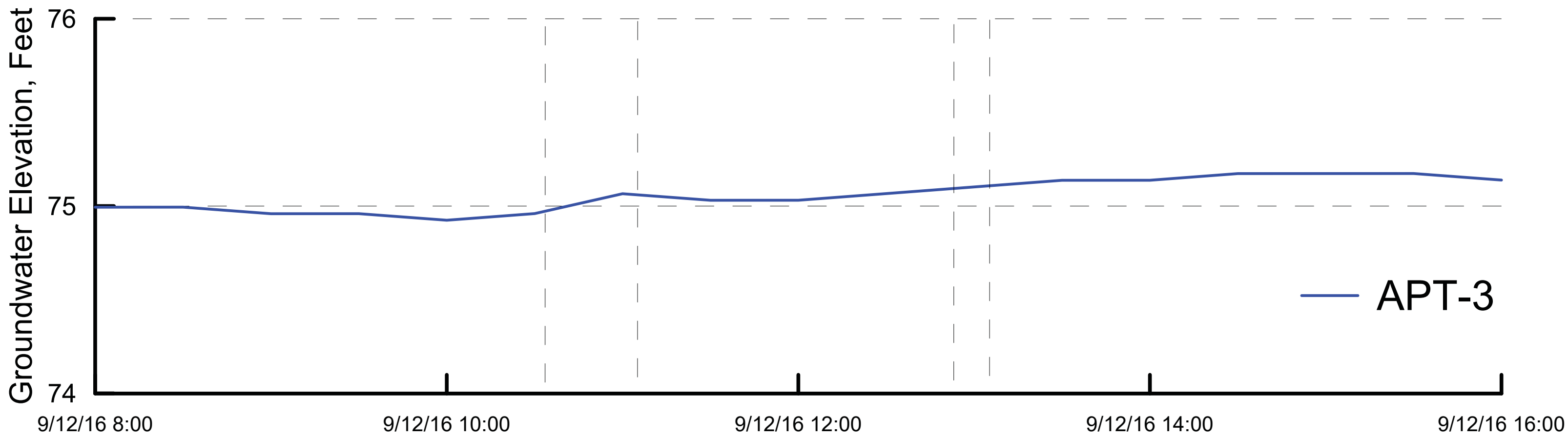
Elevation in feet, NAVD88

POTENTIOMETRIC SURFACE - WATER BEARING UNIT 3
APT-3
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE 40



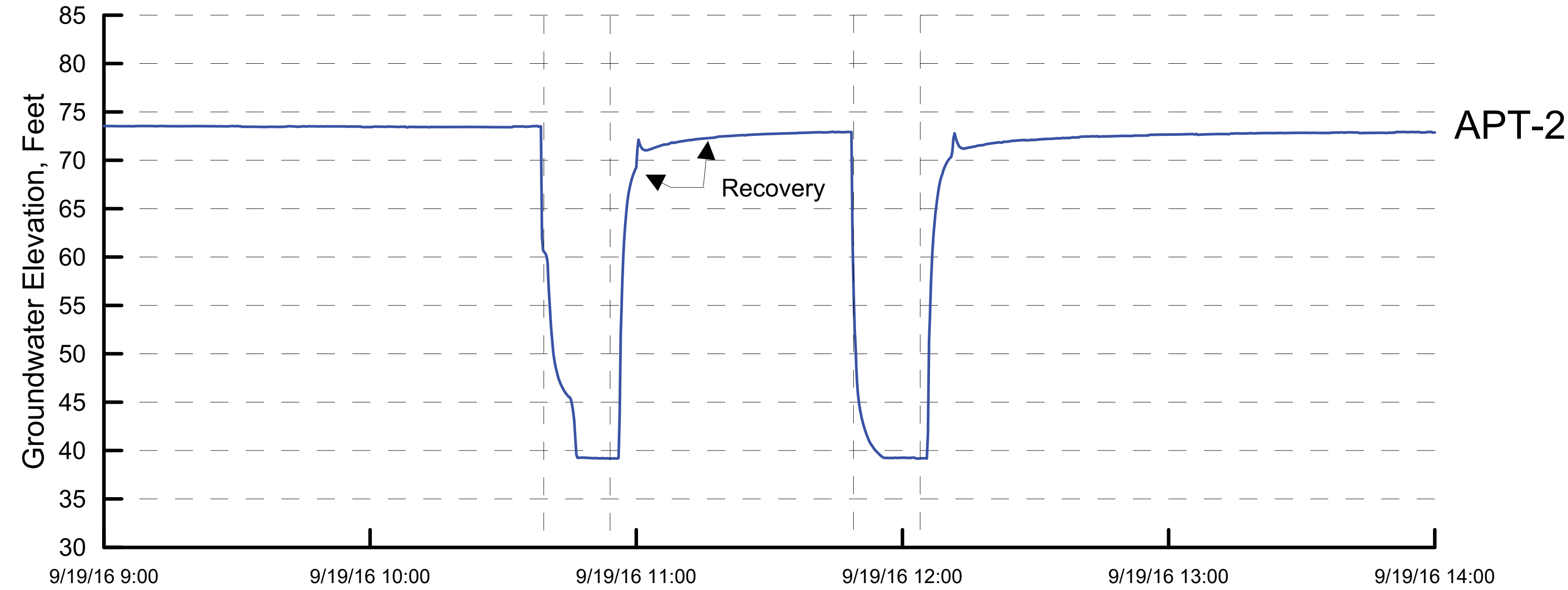


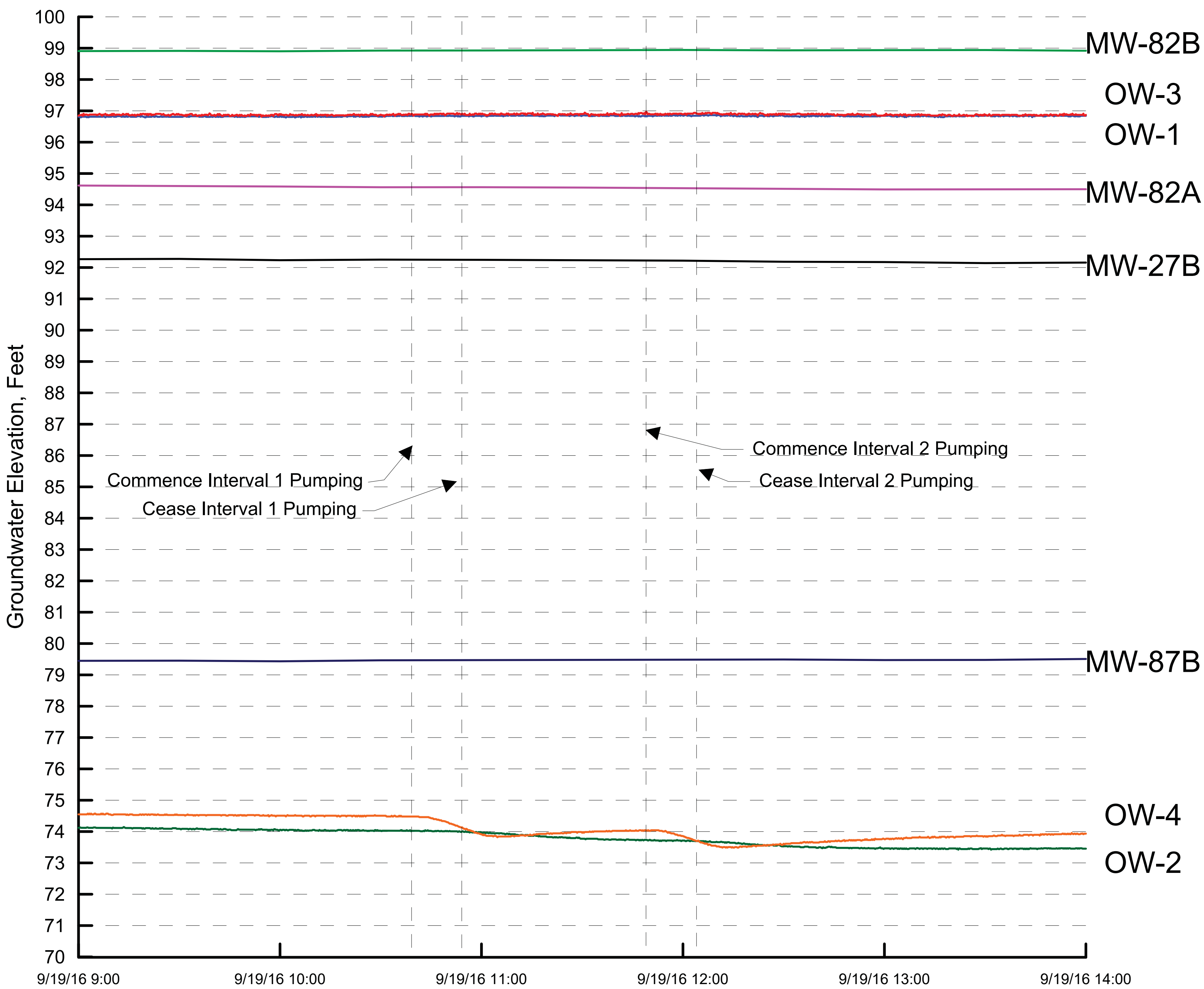


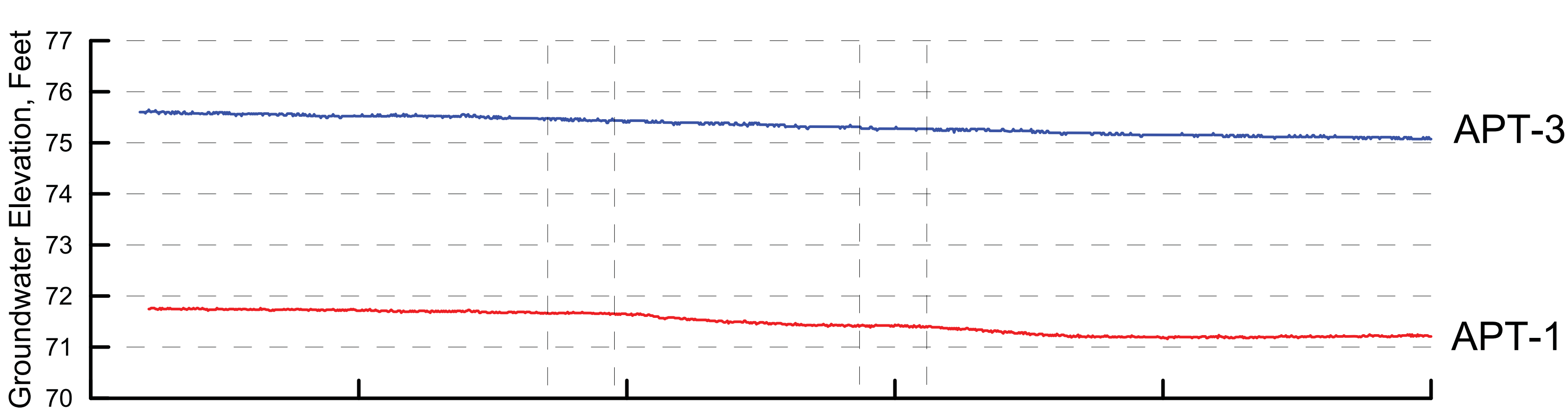
Note: Apparent water level rise due to hydraulic pressure differential.

WATER ELEVATIONS IN SELECT WELLS DURING APT-1 DEVELOPMENT
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

PLATE 44

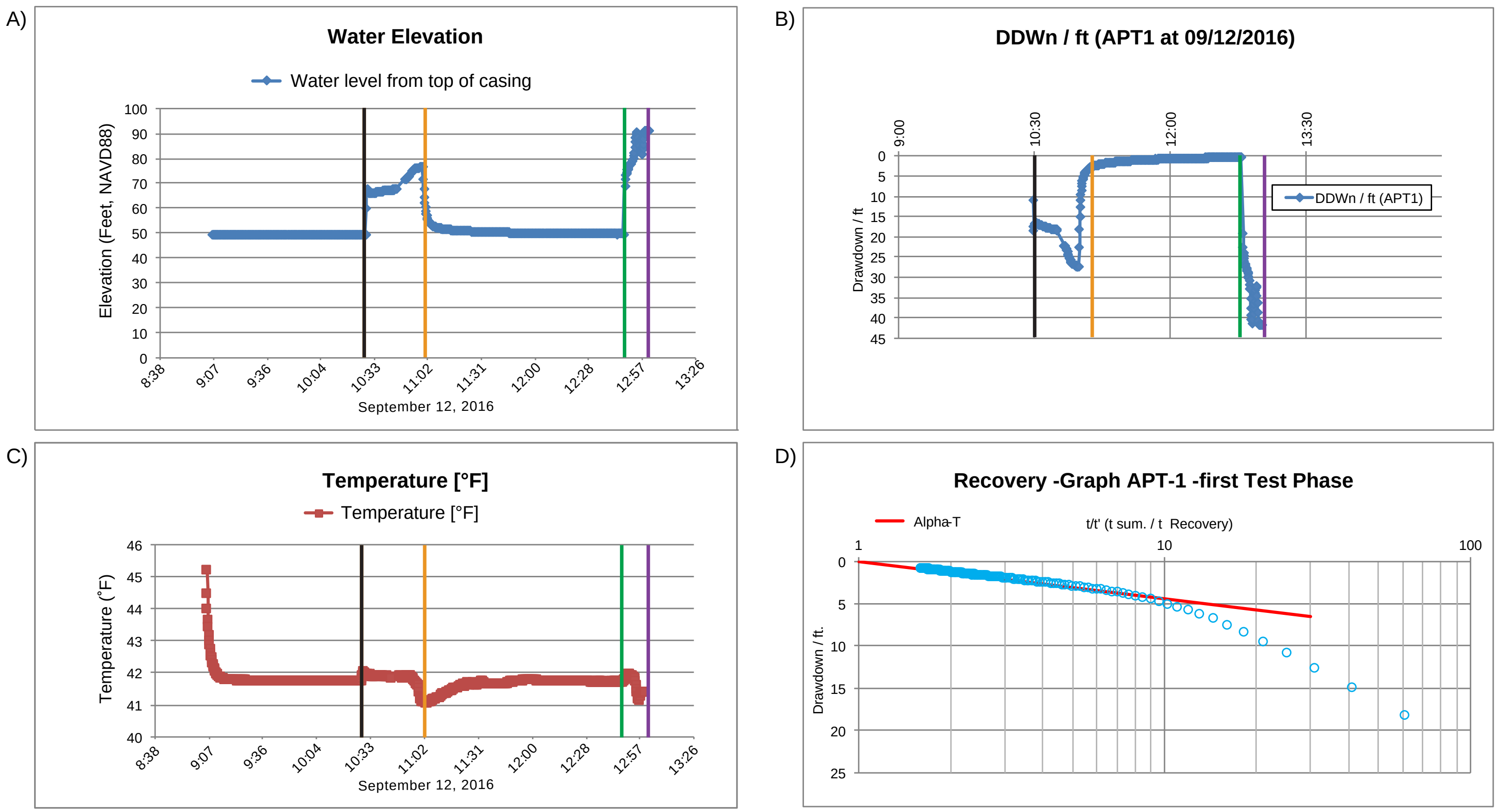






WATER ELEVATIONS IN SELECT WELLS DURING APT-2 DEVELOPMENT
ONSHORE LNG FACILITIES
ALASKA LNG PROJECT
NIKISKI, ALASKA

Aquifer Pump Test - 1



Legend

Commence pumping, interval 1

Cease pumping, interval 1

Commence pumping, interval 2

Cease pumping, interval 2

APT-1 WELL DEVELOPMENT DATA CHARTS

ONSHORE LNG FACILITIES

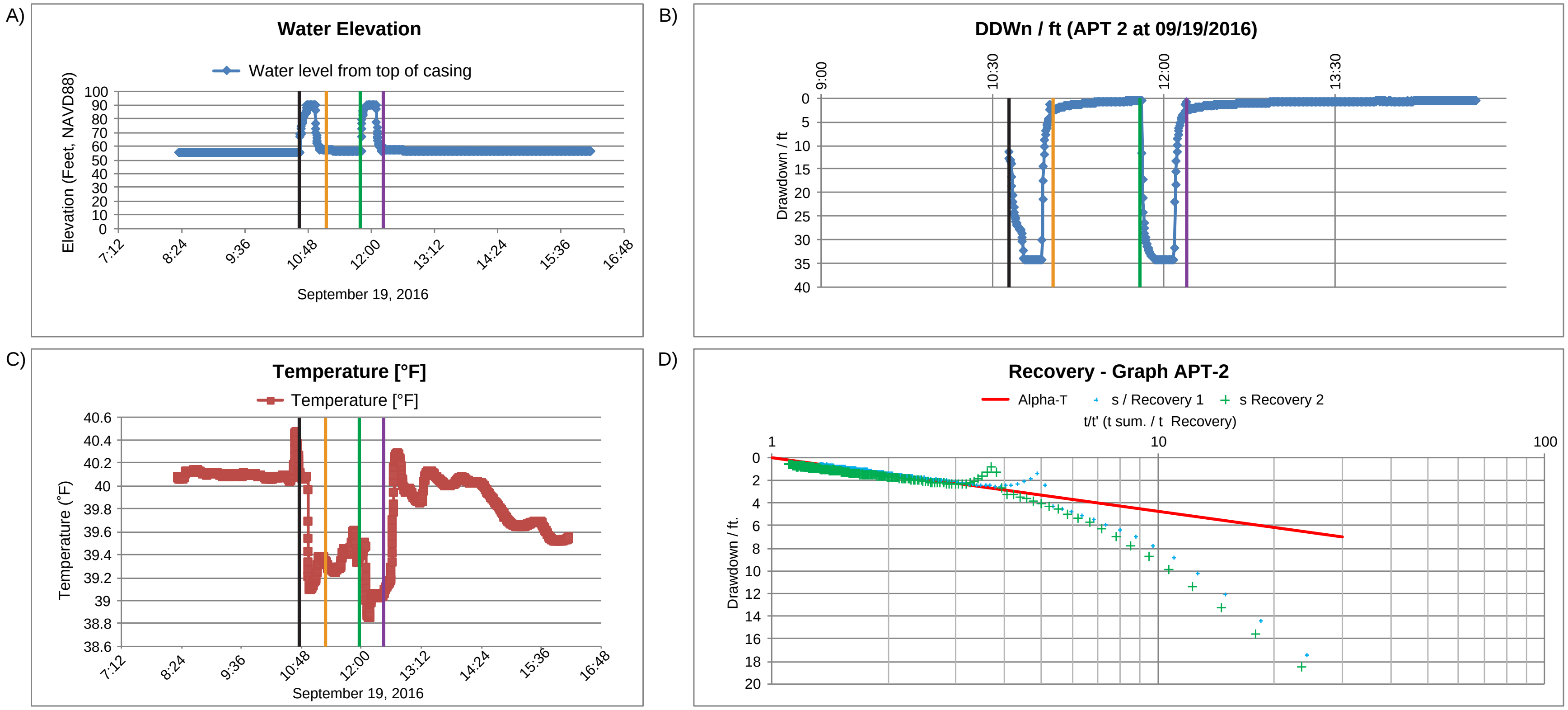
ALASKA LNG PROJECT

NIKISKI, ALASKA

PLATE 46

Aquifer Pump Test - 2

Alaska LNG FUGRO



Legend

- Commence pumping, interval 1
- Cease pumping, interval 1
- Commence pumping, interval 2
- Cease pumping, interval 2

APT-2 WELL DEVELOPMENT DATA CHARTS

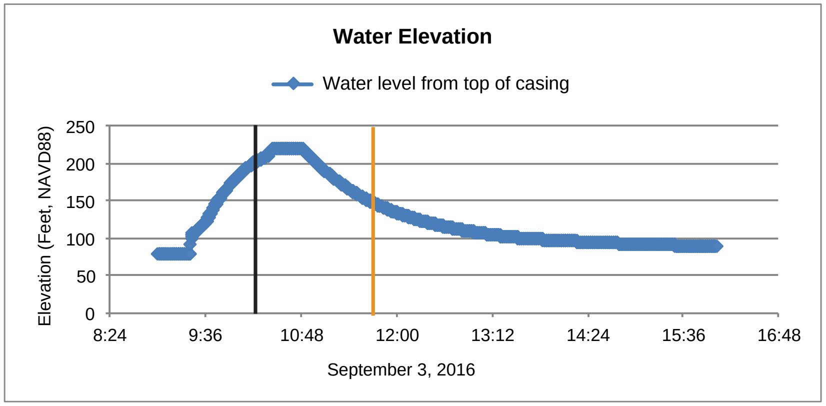
ONSHORE LNG FACILITIES

ALASKA LNG PROJECT

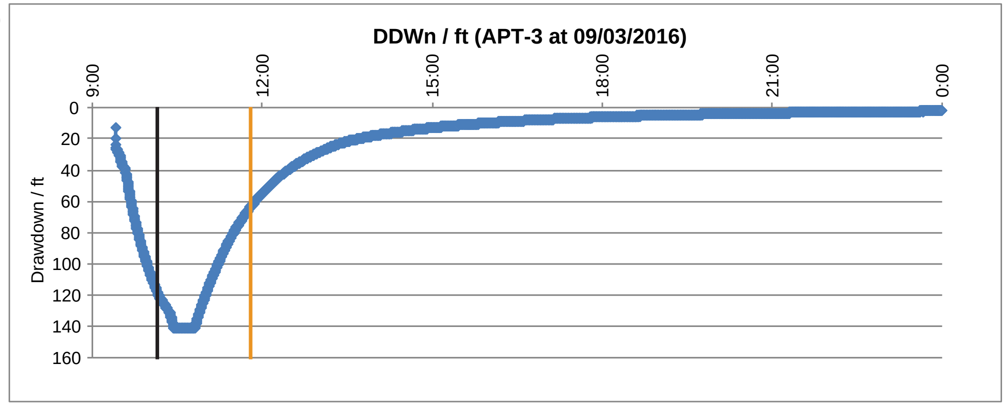
NIKISKI, ALASKA

PLATE 47

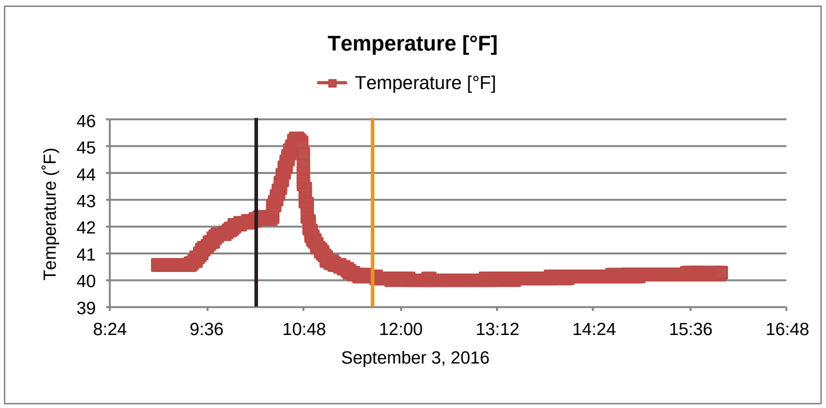
A)



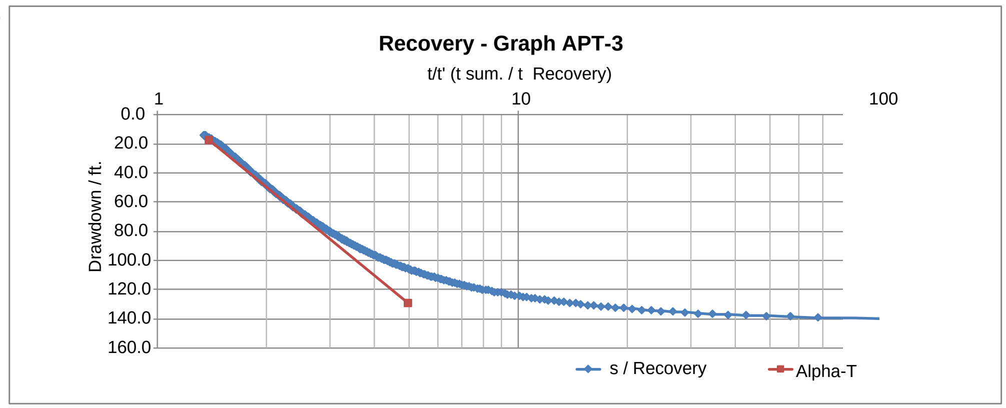
B)



C)



D)



Legend

Commence pumping, interval 1

Cease pumping, interval 1

APT-3 WELL DEVELOPMENT DATA CHARTS

ONSHORE LNG FACILITIES

ALASKA LNG PROJECT

NIKISKI, ALASKA

PLATE 48